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Demand Growth and Strategically Useful Idle Capacity

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Abstr ct

This paper presents a mo el

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 an that i le capacity might arise if capacity is only one of the entry eterence instruments available to the incumbent.[5] However, these mo els work with only a single perio , an so assume away the possibility of eman growth. Consequently, the relationship between eman growth an strategically useful i le capacity suggeste by Justice Han can not be present. In this paper, I show that in the face of growing eman , entry eterence may necessitate the maintenance of i le capacity. This result requires neither strategic complements, nor the presence of a itional eterence instruments. Rather, it follows from an entrant's willingness to take early losses in or er to gain a foothol in a market an make profits in later stages. Knowing the value of a foothol , the incumbent firm recognizes that eterence requires sufficient capacity to make both the current an future perio s unprofitable for the potential entrant. If eman is growing, then this might require maintaining i le capacity.

Beyon the Alcoa Case, these arguments she some light on the case of Dupont's allege attempts to achieve an maintain market ominance in titanium ioxi e. Dupont's a vantage was base upon lower costs from learning by oing (see e.g. Gilbert an Harris (1981).) However, part of the accusation levele at Dupont involve the preemption of their rival's capacity investment. In particular, Dupont built a plant in DeLisle Mississippi " espite the acknowle gment that the complete facility might

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Tirole (1983), alop (1979), chmalensee (1981), and pence (1979).

[5] Basu and ingh (1990) use a *Stackelbe g pe fect* equilibrium to capture the commitment value of the Incumbent's other instruments.

have to be hel in rea iness for operation ... until market con itions ha sufficiently improve ."[6] Hence, my analysis she s light on at least a portion of Dupont's behavior.

The formal mo el is a two perio game with an incumbent an a potential entrant. In both perio s, firms have an opportunity to buil a itional capacity, after which they engage in Cournot quantity competition. In the first perio , the incumbent firm sets capacity before the potential entrant may o so. However, the incumbent maintains this first mover a vantage in the secon perio only if there is no entry in the first perio . Otherwise the two firms set secon perio capacity simultaneously. That is, the value of a toehol is mo ele as the negation of the incumbent's first mover a vantage. 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 eterence requires the presence of i le capacity. With linear eman , one can emonstrate the existence of cases in which entry eterence with i le capacity is a subgame perfect equilibrium.

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

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

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 the Alcoa ecision, an fin s that a ominant firm mo el (Ky lan , 1977) oes the best job of replicating the persistent i le capacity in that market.[8]

The remain er of the paper is organize as follows: the mo el is presente in Section 2, an analyze in Section 3. Section 4 conclu es. Many proofs are containe in the appen ix.

2 Model

The mo el presumes that an incumbent firm has a first mover a vantage only until the entrant establishes a toehol in the in ustry. The timing of the mo el in perio one is: 1) the incumbent (I) sets capacity. 2) The entrant (E) makes his entry ecision, an sets capacity (if he enters,) an 3) firms in the market set output simultaneously at the intersection of their reaction functions.[9] If there is still only a single firm in the market at the beginning of the secon perio , then the timing in the secon perio mimics that in the first. However, if there was entry in perio one, then in the secon perio firms

[7] Eaton and Lipsey suggest that there is *excess* capacity in tT91l05ethecapacinex0T17eofin t39ac(ess)T7clrbr82Tc(2))T

set (increases) capacity simultaneously after which they simultaneously set output.

Throughout, subscripts will enote time perio s, $t = 1, 2$, an superscripts will enote either players $i = I, E$ or special outcomes. For example, q_t refers to firm i's output in perio t. In perio t, for an aggregate output Q, prices are etermine by a inverse eman $P_t(Q)$. Deman in both perio s is assume to satisfy: $P_t' + P_t'' \cdot Q > 0$. Deman growth is formalize by requiring that $P_2(Q) > P_1(Q)$ an that $|P_2'| \leq |P_1'|$ for all aggregate outputs Q. This is satisfie , for example, with linear eman s: $P_t = a_t - bQ$ with $a_2 > a_1$. These assumptions guaran 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 ominant firm 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 etering 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 $\underline{R}^E$ (pl(Nf8n8.0002-0.1l)s0020 [illegible]

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capacity. In the current analysis, it is not a priori clear which firm will set the largest capacity. In fact, as Proposition 8 (Appen ix) emonstrates, there are a continuum of secon perio equilibrium continuations following first perio entry. In particular, consi er the outcome if the incumbent (resp. entrant) has a first mover a vantage in the secon perio . If both firms anticipate this outcome, then they are both choosing a best response. Hence, an outcome in which either of the firms has the ability to commit to his secon perio capacity is a equilibrium when the firms choose simultaneously. Further there is a full range of equilibria 'in between' these two cases which might be thought to correspon to interme iate istributions of commitment power. I make the following assumption to avoi multiplicity of equilibria.

Assumption E In an entry equilibrium:1) $q_2 = \Omega$ for $i = I, E$,

2) $K_1^E \geq q_1^E$.

Part 2 of Assumption E is innocuous, an merely serves to make the statement of Propositions easier.[13] Un er Assumption E1, output in both perio s of an entry equilibrium is etermine by the first perio capacity choice. 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 (an the other firm's reaction function) etermine secon perio capacity. That is, secon perio output is chosen as if there were no secon perio capacity ecision.[14] This reflects the i ea that capacity is a commitment evice,

[13] ee Proposition 9 in the Appendix.

[14] The ability to set capacity in the second still plays a role, in that it limits the incumbent's ability

an once entry occurs, the incumbent has lost his first mover a vantage, an hence his commitment a vantage. In Section 4, I argue that Assumption E Part 1 rules out implausible equilibria, an captures the esirable aspects of a forwar in uction argument (as in Bagwell an Ramey, 1996.)

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 only be built if it has commitment value, in either the first or secon perio . 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, $\hat{S}_1$

incumbent's first perio capacity to have a consequence in the secon perio , it must be greater than N^I

perio , an commit to an output in the secon . In this case, the incumbent chooses K_1^I such that $\hat{S}_1^I \leq q_1^I = K_1^I = q_2^I \leq \hat{S}_2^I$.[17] Entrant outputs are at $\underline{R}_t^E(K_1^I)$.

We are now rea y to turn to the paper's central issue, un er what con itions can i le capacity occur in 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 2) only if the incumbent maintains i le capacity. 3) It is possible to eter entry in the secon perio . 4) The incumbent prefers entry eterence to being a Stackelberg lea er, an 5) given that entry has not occurre in the first perio , the incumbent prefers to eter it in the secon perio as well. The first three of these con itions are statements about the Entrant's payoffs in ifferent situations. They might be restate as 1') $\pi_1^E(\tilde{S}_1) + \pi_2^E(W_2) \leq \bar{F} + 2F$, 2') $\pi_1^E(W_1) + \pi_2^E(\quad N_2) \geq \bar{F} + 2F$, an an 3') $\pi_2^E(W_2) \leq \bar{F} + 2F$. These con itions can be translate to $\pi_1^E(\tilde{S}_1) + \pi_2^E(W_2) \leq \bar{F} + 2F \leq \pi_1^E(W_1) + \pi_2^E(\quad N_2)$ an $F \leq [\pi_2^E(\quad N_2) - \pi_2^E(W_2)] + \pi_1^E(W_1)$. Since $\pi_1^E(W_1) \equiv \pi_1^E(\tilde{S}_1)$, $\pi_2^E(W_2) < \pi_2^E(\quad N_2)$ an $0 < [\pi_2^E(\quad N_2) - \pi_2^E(W_2)] + \pi_1^E(W_1)$, one can choose $\bar{F}$, an F such that con itions 1,2 an 3 hol . This yiel s:

Proposition 4 *Under Assumpt on G, one can find find values for F and $\bar{F}$ such that a deterence equ l r um requ res dle first per od capac ty.*

Observe that Proposition 4 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. To

[17] If $S_t^I < W_t^I$ in both periods, then it follows that $S_1^I < q_1^I = K_1^I = q_2^I < S_2^I$.

emonstrate that such equilibria actually exist, one must show that the entrant prefers eterence through i le capacity over being a Stackelberg lea er. Because it is not so straight forwar 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 still remains the problem that the payoffs for etering entry epen crucially upon fixe costs. Hence in comparing payoffs, it is convenient to fix upon a particular case. Specifically, let us presume for now eterence to type 1 Stack

in the first perio , if an only if the incumbent maintains at least capacity K^L. Since $K^L > \ N_2^I$, an Assumption G hol s, this involves i le capacity. $\pi_2^E(\hat{S}_2) \leq \bar{F} + F$ assures that eterence in the secon perio is feasible, an never requires more than the monopoly level of capacity. Hence, elaye en ments for entry   eterence. Consequently, Another possibility woul be to select equilibria through a forwar in uction argument (as in Bagwell an Ramey, 1996.) In this case, because there are multiple equilibrium continuations in the secon perio , the entrant has a secon mover a vantage. That is, forwar in uction requires that if entry occurs in the first perio , then the entrant must be planning a continuation in the secon perio that woul yiel him positive profits. Clearly for entry eterence to be forwar in uction rational requires that there be no continuations which yiel the entrant positive profits. Since the entrant's most preferre continuation is when the incumbent oes not increase her capacity, the requirements for eterence woul remain unchange . However, the entrant's secon mover a vantage might have a ramatic consequence in entry equilibria. For example, it might be the only continuations which give the entrant positive profits are those in which the entrant acts as a Stackelberg lea er in the secon perio . This woul clearly make a toehol in the in ustry worth more than a simple negation of the incumbent's first mover a vantage. On the other han , because there are many cases in which many equilibria woul survive forwar in uction, the question of selection woul remain.

5 Appendix

Proof of Proposition 1

If $K_1 > \Omega$ then $K_2 \geq K_1 > \Omega \geq q_2$ since the only thing that can move secon perio output away from Ω is if firm $j \neq i$ increases capacity which will weakly ecrease firm

i's equilibrium output. Also the only way that $\Omega \ > W_2^I$ is if $K_1 > W_2^I$, which implies $K_2 > W_2^I$ an $K_2^j = \tilde{S}_2^E$ an firm i will be left with $K_2 > q_2$. Since we know that $K_2 \leq q_2$ the Proposition follows. ♣

Proposition 8 *Presume entry n per od one, and fix per od one capac t es such that they sat sfy Propos t on 1. A cho ce of second per od capac t es and outputs are a second per od equ l r um f and only f* $K_1 \leq K_2 \leq W_2^I$ *(*$i = I, E$*) and one of the follow ng cond t ons holds.*

1) ($K_2^I \geq K_2^E$*)* $q_2^I = K_2^I = S_2^I$ *and* $K_2^E \leq q_2^E = \hat{S}_2^E$

2) ($K_2^I \geq K_2^E$*)* $N_2^I \leq q_2^I = K_2^I \leq S_2^I$ *and* $K_2^E = q_2^E = \underline{R}_2^E(K_2^I)$

3) ($K_2^I \leq K_2^E$*)* $q_2^E = K_2^E = S_2^I$ *and* $K_2^I \leq q_2^I = \hat{S}_2^I$

4) ($K_2^I \leq K_2^E$*)* $N_2^E \leq q_2^E = K_2^E \leq S_2^I$ *and* $K_2^I = q_2^I = \underline{R}_2^I(K_2^E)$

Proof: Assume without loss of generality Sbya8(of:)]TJΩ(8204980TDΩ(K)TjΩT71TfΩ84.0002-33TDΩ(I)Tj

Proposition 9 *Let Assumpt on E1 hold. If there s an entry equ l r um n wh ch $q_1^E > K_1^E$, then there s another equ l r um n wh ch all outputs are unchanged, firms rece ve the same profits, and $q_1^E = K_1^E$.*

Proof: That $K_1^E < q_1^E$ implies that first perio output is on $\underline{R}_1^E$ an that $q_1^E \leq$ N_1^E. Hence increasing K_1^E to q_1^E will not change the intersection of first perio reaction functions, nor will it result in $K_1^E >$ N_2^E. Hence, the output in neither perio will change. Since capacity is only a commitment to pay costs that must be pai if pro uction takes place, an outputs have not c implies that capacity less than the secon perio Cournot has no consequence in the secon perio . ♣

Lemm 5. *Let Assumpt on E Part 1 hold. In an entry equ l r um, f* $N_2^I \leq K_1^I \leq W_2^I$*, 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 is (hol ing $K_2^I = K_1^I$) $\underline{R}_2(K_1^I)$ which he will receive even if $K_1^E = 0$ (Assumption E1) Hence he sets $K_1^E \leq q_1^E$.♣

The point of the following two Lemmas is to rule out the case where the ominant firm wishes to act like a Stackelberg follower in the secon perio , an hence chooses a low capacity to in uce the entrant to chooses a 'lea er' capacity. Hence in these proofs there is a possibility that the ominant firm sets his capacity at say $\tilde{S}_1^E$.

Lemm 5.3 *Let Assumpt on E Part 1 hold. Presume that there s an entry equ l r um n wh ch the ncum ent chooses* $K_1^I < N_2^I$*, ut the entrant chooses* $K_1^E > N_2^I$*.*

1) If $K_1^E \leq W_1^I$ *then* $K_1^I \leq \underline{R}_1(K_1^E)$ *or* $K_1^I = \underline{R}_2(K_1^E) > \underline{R}_1(K_1^E)$*.*

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 the 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

6 Linear Appendix

I provi e here algebraic expressions for the values efine in section 2. Since these are base upon the one perio mo el, I rop the time subscript. When I mention points in q^I, q^E space, the q^I value is liste first.

$$N = (\frac{a-c}{3b} \frac{a-c}{3b}) \tag{1}$$

$$V = (\frac{a+c}{3b}, \frac{a-2c}{3b}) \tag{2}$$

$$U = (\frac{a}{3b}, \frac{a}{3b}) \tag{3}$$

$$S = (\frac{a-c}{2b}, \frac{a-c}{4b}) \tag{4}$$

$$\tilde{S} = \begin{cases} (\frac{a+2c}{4b}, \frac{a-2c}{2b}) & \text{if } a \leq 6c \\ U & \text{if } a \geq 6c \end{cases} \tag{5}$$

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

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

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

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

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

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