ANALYSIS OF ENTRY DETERRENCE MODELS

AUTHOR: Madhavi Moni Kumudhini

AFFILIATION: Department of Economics, Hansraj College, University of Delhi, Delhi, India; madhavimoni@hrc.du.ac.in

Abstract

The study embarks on an analytical journey through the complexity of competition between firms within an industry. Firms compete for survival and dominance and the understanding of the strategies involved is the objective of this paper. We analyse the nuanced strategies of incumbents to deter entry, highlighting the importance of innovation in the market, review subsequent studies, including the seminal work by Dixit (1980). With difference between the roles and strategies of incumbent new firms, this paper discusses the strategic interplay that usually exists within an industry.

1. INTRODUCTION

Firms, within an industry, compete with each other to sustain and survive. Price, non – price, capacitated, non – capacitated, etc. are strategies that form the medium of competition, which can be deterring or accommodating. We analyze several entry deterrence models based on the classic paper of "Role of Investment in Entry Deterrence" (Dixit 1980). This paper stresses on the strategy of limiting output as the optimal strategy at the incumbent's disposal.

Firms in any industry strive to capture and examine new markets for their products. This is challenging especially with already existing incumbent firms. Incumbent firms are not insulated against any new entry and thus must innovate strategies to keep any new entrant at bay. The challenge is for both, the incumbent and the entrant. Strategies with capacities are extant in literature, which thereafter shapes their strategies. Wang et al. (2016) consider the price competition between firms that initially are

monopolies in their markets and one of them decides to enter the other market. They differentiate between the incumbent and entrant in terms of capacities, the latter with limited capacity. They consider two price competition models, Stackelberg and Nash, and study the effect of capacity size on entry deterrence. Mukherjee and Zhao (2017) relax the assumptions in Dixit (1980) concerning Cournot competition and symmetric incumbent firms. They assume that with entry, firms behave as Stackelberg leaders otherwise competing in Cournot and also that Stackelberg competition is both practical and significant. We begin our discussion by outlining the assumptions and describing the Dixit model. Throughout our discussion, we shall label the incumbent as Firm 1 and entrant as Firm 2.

Research Objective

To analyze several entry deterrence models based on the classic paper by Dixit titled "Role of Investment in Entry Deterrence".

Dixit Model

The post-entry game in this model is assumed to be Cournot with homogenous output. It is further assumed that cost functions for both firms are the same. Each firm has a unit cost of capacity expansion i.e. r and variable cost of output i.e. w. Since Firm 1 is already in the market, it has the advantage of investing in some capacity level, k, which is final and cannot be reversed but can be increased, if needed. This decision of installing capacity before entry becomes the strategic decision of the incumbent. Since the firms play with quantity after entry and given that quantities are strategic substitutes, each firm's marginal revenue decreases in other firm's quantity. Dixit also assumes that the exit of Firm 1 is not possible as its maximum profit is positive. The assumption contrasts with the analysis of the Hartl & Kort model, wherein the incumbent may exit given the technology competition by the entrant. We describe the decision to install capacity prior to entry as *strategic* since it allows Firm 1 to amend the marginal cost curve and equilibrium subsequent to entry. Consequently, the incumbent firm can threaten the entrant with non-positive profits. It can also use this benefit to exert limited leadership.

Incumbent's marginal cost is controlled by the level of capacity installed. Supposing that Firm 1 installs k_1 level of capacity then MC is as below:

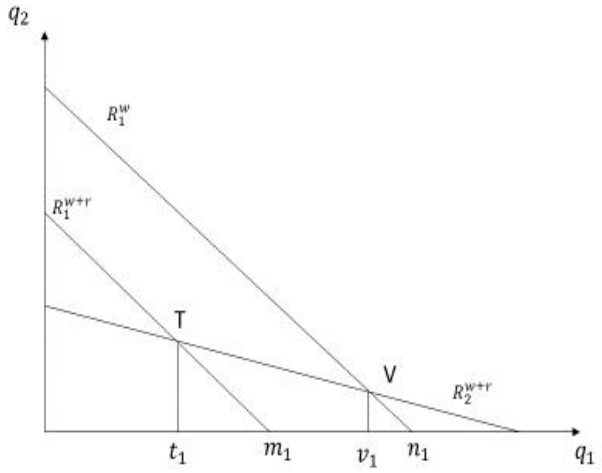
$$\text{If } q_1 \leq k_1 \rightarrow \text{w and if,}$$

$$q_1 > k_1 \rightarrow \text{w} + \text{r}$$

For Firm 2, MC is fixed at w + r.

The above implies the following: For a high q_2, Firm 1 finds it optimal, in terms of profit, to produce at $k_1 = q_1$, implying no capacity constraints. And, for a low q_2, MR > w+ r and hence, finds it optimal to install additional capacity or expand capacity. The Fig.1 below is a comprehensive description of the model.

FIG 1. DIXIT MODEL



$R_1^w \rightarrow$ Reaction function of Firm 1 when capacity costs do not matter

$R_1^{w+r} \rightarrow$ Reaction function of Firm 1 when capacity costs matter

$R_2^{w+r} \rightarrow$ Reaction function of Firm 2

For a random k_1, there are two possible Nash equilibria →

- T, where markets are symmetrical, and firms' face similar marginal costs and output.
- V, where Firm 1 has a higher market share

Thus, we can deduct from the above three possible cases:

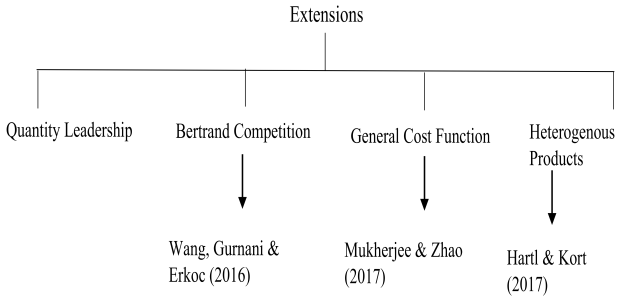
- If $k_1 \leq t_1$, Firm 1 will want more capacity whether entry occurs or not i.e. Firm 1 will **expand the capacity**. With entry, T will be the post-entry equilibrium, and without, it would want to produce at least the monopoly level of output i.e. m_1.
- If $k_1 \geq v_1$, V will be the post-entry equilibrium and hence there exists an **excess capacity**
- If $t_1 \leq k_1 \leq v_1$, **adequate or full capacity utilization** and firm 1 will be at k_1 with Firm 2 producing as the Stackelberg follower.
- If $k_1 > n_1$, Firm 2 will be certain about securing a Nash equilibrium and hence any capacity beyond n_1 will be a non-credible threat.

Therefore, T-V is the range in which the incumbent can exercise limited leadership as mentioned above. To reiterate, since it is assumed that firm 1 makes positive profits, the strategic choices rely on the sign of firm 2's profits. Hence, there are three choices for Firm 1:

1. $\pi_2 < 0$ at T → Irrespective of whether capacity has been installed or not, Firm 1 fears no threat of entry and behaves like an unconstrained monopolist. This situation is called the Blockaded monopoly.
2. $\pi_2 > 0$ at V → The maximum quantity Firm 1 can produce is at V. Therefore, it must accommodate firm 2 and produce Stackelberg outcome at k_1.
3. $\pi_2 > 0$ at T and $\pi_2 < 0$ at V → Entry deterrence or accommodation depending upon the profitability. Firm 1 can discourage entry either by producing monopoly output or by maintaining output above that.

Firm 1's ability to impede entry is contingent on its capital costs, and firm 2's economies of scale that stem from the presence of fixed cost. Dixit completes the discussion on entry deterrence with possible three extensions. First, if the order of the game is changed to quantity leadership by the entrant i.e. after entry, it now chooses a point where profit is maximised on the incumbent's reaction curve. Nevertheless, the situation can still be exploited by the incumbent, to its own benefit by presenting an appropriate reaction curve to the entrant. Although, we do not explore this extension fully, however, we consider a case where the model is analyzed from the entrant's point of view. Second, the author considers price competition post entry instead of quantity. We consider a paper by Wang et al. (2016) to ascertain the above two modifications. Third, Dixit allows for a general cost function but maintaining the assumption about similar cost functions between the two. Mukherjee and Zhao (2017) tweak that assumption wherein they consider differential marginal costs for incumbent and entrant. Most of the papers on entry deterrence consider output to be homogenous. Hartl and Kort (2017) allows us to consider a heterogenous product market set up and its inferences on the incumbent's strategic decision regarding deterrence and accommodation. Fig 2. presents the schematic representation of the extensions we consider in this paper.

Fig 2. Dixit Model – Possible Extensions



Price Competition

Wang et al.(2016) considers price as the

strategy for the incumbent for competing with the entrant. Along with the price, they also illustrate a non-price strategy like *Branding*, which along with price strategy would have an edge for the incumbent over the entrant. Thus, the optimal strategy is both price and non-price which influences the entrant's behavior. Besides, one distinct feature of their study is that the model is examined from the entrant's perspectives, in contrast to the incumbent's. They achieve this by relaxing an assumption extant in literature, i.e., an entrant has no resource constraints. The decision to enter is vital as the entrant faces resource constraints while the incumbent is endowed with enough capacity. Therefore, a firm contemplating entry into another market must decide on capacity allocation between two markets. The authors consider both Stackelberg and Nash price models with again considering a simple duopoly model. Incumbent behaves as the Stackelberg leader and sets the price first. The follower, entrant, in this case, set prices in both his own and the incumbent's market. The model observes that both firms benefit in Stackelberg setting vis-à-vis Nash competition.

Fig 3. Price Competition Model

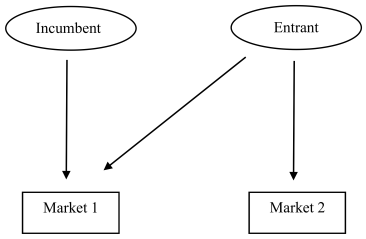


Figure 3 describes the model in the paper. The authors study the effects of the entrant's capacity size on its decision to enter the incumbent's market or not. Demand for each firm's product is negatively related to its own price and positively to other firm's price, as a result of the existence of substitution effect on demand, θ . With entry, Firm 2's demand function is,

$$q_2 = \alpha_2 - p_2$$

$$q_t = (1-\mu)\alpha_1 - p_t + \theta p_1$$

Where $\alpha_1 \rightarrow$ market size of firm 1, $\mu \rightarrow$ market preference and $q_2 + q_t \leq k$. The constraint implies that Firm 2's capacity is constrained. Demand function for firm 1 is,

$$q_1 = \mu\alpha_1 - p_1 + \theta p_t$$

Authors describe both kinds of price competition, Stackelberg and Nash competition. Considering Stackelberg competition first, Firm 1 behaves like a price leader. It sets the market 1 price, which is observed by the potential

entrant. Given entry, Firm 2's profit maximization problem is as below:

$$\max \pi_2 = (p_2 - c_2)(\alpha_2 - p_2) + (p_t - t - c_2)[(1-\mu)\alpha_1 - p_t + \theta p_1)$$

Own market Firm 1's market

$$s.t.\ \ (\alpha_2 - p_2) + (1-\mu)\,\alpha_1 - p_t + \theta p_1 \leq k$$

Solving the optimization problem, we get p_1, p_t from which q_t is obtained,

$$q_t(p_1) = \frac{2k - t - \alpha_2 + \alpha_1 + p_1\theta - \alpha_1\mu}{4}$$

Clearly as seen above, entrant's produce in the incumbent's market is a dependent on the price and is positively related. Thus, there exists some k for which incumbent can choose some price, p_1 s.t. $q_t \leq 0$. The incumbent would adopt such a strategy if it is profitable for him/her to do so, leading to entry deterrence. Therefore, capacity size k for the entrant has a vital role to influence the incumbent's price and hence strategy decision. Wang et al. (2016) claim that in equilibrium there exist three capacity level thresholds that define the entrant's action. The thresholds with four regions are:

1. $k \leq k_1$: Firm 2's capacity is so small that allocating any capacity for producing output in other market will be inconsequential. Thus, entrant does not enter and like Dixit (1980) defined, it's a situation of *Blockaded entry*.
2. $k_1 < k \leq k_2$: Dixit (1980), while illustrating the strategy of the incumbent's strategy, makes use of Bain's terminology of *Effectively impeded entry*. Authors here define this region similarly, wherein the entrant's capacity lies between two thresholds, and $q_t > 0$. Given, q_t is positive, firm 1 can strategically decide to lower the price of the product, which will make q_t approach zero. Therefore, firm 1 has a strong reason to do so for deterring entry.
3. $k_2 < k \leq k_3$: *Ineffectively impeded entry*. Firm 1 cannot continue with the strategy of lowering the price as it will eventually yield lower profits. Therefore, it would be desirable to allow entry/accommodate.
4. $k_3 < k$: In this region, Firm 2's capacity is *unlimited*. With such levels of capacity, it can enter market 1 without worrying about capacity allocation, and holding a stance to sell more quantity by lowering the price.

However, this would be detrimental to both of their profits.

In Dixit model (1980), the existing firm has the first-mover advantage with regards to installing the capacity. In the price competition model too, the incumbent has the first-mover advantage for setting the price after observing the entrant's capacity. Nonetheless, the entrant's profits are higher in the Stackelberg competition when compared with the Nash competition. The consumers would be worse off as prices are higher.

As mentioned in the introduction, an incumbent engages in non-price competition, such as *Branding*. Investing in branding involves a cost, but also leads to a rise in market preferences and share. Ergo, he/she can engage in increasing prices to stop entry and enjoy the benefits of being a monopolist. This strategy may turn futile if the entrant has unlimited capacity, in which case, it would be best to accommodate. Therefore, the incumbent's strategy to deter/accommodate entry is contingent on the entrant's capacity levels and not his/her own. A result directly in contrast to Dixit's model. Another entry deterrence model, in contrast to Dixit, is advanced by Hartl and Kort (2017), wherein they consider heterogenous products and differing stages of capacities for the incumbent and entrant.

Quantity competition with heterogenous products

It is very interesting to note that, of the two models exhibited above, one analyses the strategies for entry deterrence from the incumbent's lenses and other from the entrant's as far as the capacity levels are concerned. This model is eccentric as it assumes that both possess access to capacity/technology but that differs in stages i.e. Incumbent with a standard technology while entrant with advanced technology. Strategic actions are not a function of the *level* of capacity but since such advanced technology exists, and the entrant is certainly in a superior position. Authors use the Hotelling model to illustrate the difference between a standard and advanced technology, and to represent the heterogenous model. Standard assumptions of the model hold true for the analysis for.eg. consumers are uniformly located on the line with density one, every consumer buy utmost one unit.

With the standard technology, the consumer pays a transportation cost while the advanced technology could match the consumer preference and product location. An important digression is the existence of an advanced technology can force the incumbent to exit the

market. Before entry, incumbent's utility function and the Hotelling line with n products is as below,

$u - v|x - \theta|$, where

$\theta \rightarrow$ taste of consumer or product specification and $v \rightarrow$ degree of horizontal differentiation

Fig 4. Hotelling line without entry

By contrast, utility function of the entrant is just u, and the associated profit function is,

$\pi_\varepsilon = (p_\varepsilon - \alpha)\, q_\varepsilon - K$, where $\alpha \rightarrow$ unit cost and assuming $\alpha > w$, a variable cost;

K $\rightarrow$ new technology. Firm 2 will enter with this advanced technology only if $\pi_\varepsilon \geq 0$. Assuming, Firm 1 offers n products with product 1 located at $1/2n$. The authors then compare consumer's utility when purchasing the product from both the firms. Hence, an indifferent consumer.

Utility from Firm 1 $\rightarrow u - v\left|\frac{1}{2n} - \theta\right| - p_I$

Utility from Firm 2 $\rightarrow u - p_\varepsilon$

So, $\theta = \frac{1}{2n} \pm \frac{p_\varepsilon - p_I}{v}$ and the Hotelling line post-entry is represented by Figure 5. below,

Fig 5. Hotelling line post-entry

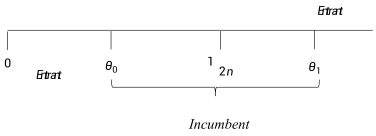


Fig 5. Hotelling line with entry with the entrant in the market, the Hotelling line above demonstrates the strategic area of operation. θ_0 and θ_1 are the product locations where consumer is indifferent to buy from the incumbent or the entrant. The incumbent's and the entrant's demand functions are computed and utilized to establish the objective functions to obtain equilibrium prices and outputs. After these calculations, $q_I > 0$. However, Firm 2's demand is positive only when v is large enough or when firm 1 does not provide many products i.e. n is less. Therefore, for minimal product differentiation, firm 1 employs a deterrence policy, where it produces a large variety of products, making entry unprofitable. Conversely, for maximum product differentiation, intense competition emerges between both the firms resulting in firm 1 exiting the market due to its inferior technology.

Entry and Profits: Two incumbents and an entrant

Mukherjee and Zhao (2017) in their paper discuss the effect of entry on the profit levels of the incumbents. The model assumes two incumbents and an entrant, each with different marginal costs (differing in efficiencies). The incumbents have the advantage of Stackelberg position over the entrant. Without entry, they compete as duopolies and enjoy unconstrained capacities. Hence, entry is certain.

Considering the output of the incumbents, entrant maximizes his/her profit function. The study finds that although efficient firm is better off, in terms of output and profit, with entry; inefficient firm's profit goes down. This happens as firms internalize the strategic actions of new entrants' i.e. high demand. Thus, efficient firm raises its output. Since, outputs are strategic substitutes, inefficient firms output and hence, profit goes down. The result may not be robust if the exogenous Stackelberg structure assumption is dropped and established firms behaved liked Cournot oligopolists post-entry.

Conclusion

Discussion on obstacles to market entry are not new and are prominent since the 1950s. Firms have exploited their dominant market positions and stifled new competitions. Examples are many to cite but the one in online travel industry, where Oyo's strategies have made business difficult for Fab hotels and Treebo is quite significant. Some of the strategic actions taken by Oyo that helped gain its share in the market are as below:

1. A capital boost through investment by SoftBank.
2. Exclusive agreement with Make My Trip (MMT) and thereby deterring market entry to others
3. Predatory pricing
4. Poaching employees of its competitors etc.

The models analyzed above argue theoretically the strategic actions of dominant/incumbent firms for deterring entry. Each of them differs in the assumptions and deliberation. However, all reasonings culminate to one understanding, that the entry of a new firm impacts the profits of an established firm and hence, it will be in the interest of such a firm to consider any barriers to entry. We summarize the analysis of the four models discussed above in a tabular form below:

Table 1: Entry Deterrence Models

Assumptions	Dixit Model	Wang et al	Hartl & Kort	Mukherjee & Zhao
No. of Incumbents	One	One	One	Two
Cost structure	Symmetric	Asymmetric	Asymmetric	Asymmetric
Post-entry game	Cournot	Bertrand	Cournot	Cournot
Product	Homogenous	Homogenous	Differentiated	Homogenous
Capacity investment undertaken by	Incumbent	Entrant	Both	None
Deterrence Strategy	Limit output	Limit Pricing	Large variety of products	Entry is certain

References

1. Dixit, A. K. (1980), The Role of Investment in Entry-Deterrence, *The Economic Journal*, Vol. 90, No. 357, pp. 95-106.
2. Hartl, Richard and Kort, Peter. (2017), Possible market entry of a firm with an additive manufacturing technology, *International Journal of Production Economics*, 194 (2017) 190-199.
3. Mukherjee, A. and Zhao, L. (2017), Profit Raising Entry, *The Journal of Industrial Economics*, Vol. 65, 214-219.
4. Wang, H., Gurnani, H. and Erkoc, M. (2016), Entry Deterrence of Capacitated Competition using Price and Non-Price Strategies, *Productions and Operations Management,* Vol. 25, 719-735.