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Aggressive leaders

Federico Etro*

I characterize the incentives to undertake strategic investments in markets with Nash competition and endogenous entry. Contrary to the case with an exogenous number of firms, when the investment increases marginal profitability, only a "top dog" strategy is optimal. For instance, under both quantity and price competition, a market leader overinvests in cost reductions and overproduces complement products. The purpose of the strategic investment is to allow the firm to be more aggressive in the market and to reduce its price below those of other firms. Contrary to the post-Chicago approach, this shows that aggressive pricing strategies are not necessarily associated with exclusionary purposes.

1. Introduction

■ In many market settings, a firm can have an incentive to undertake preliminary investments to gain advantage over its competitors. For instance, when Cournot competition takes place between two firms, one of them will usually gain by overinvesting to reduce costs, which allows it to be aggressive in the market, expanding production and inducing its rivals to produce less. Under Bertrand competition, however, the same firm would prefer to underinvest in cost reductions so as to be accommodating, increasing its price so as to induce its rivals to raise their price. More generally, Fudenberg and Tirole (1984) and Bulow, Geanakoplos, and Klemperer (1985), building on a pathbreaking contribution by Dixit (1980), have shown that when a preliminary investment increases marginal profitability, a firm would like to overinvest under strategic substitutability and underinvest under strategic complementarity: the first top dog strategy leads to aggressive behavior in the market (higher production or lower price), while the second "puppy dog" strategy induces accommodating behavior (lower production or higher price).

In this article I show that when entry is endogenous, a firm would always like to undertake investments to be aggressive in the market, that is, to expand production under Cournot competition and decrease prices under Bertrand competition. For instance, a leader will always find it optimal to overinvest in cost reductions (or adopt a similar top dog strategy) to be able to produce more and to reduce its price below the price of its competitors. This outcome emerges in many other contexts with surprising results about investments in quality improvements, production of complementary goods, dumping to exploit a learning curve or create network externalities, strategic vertical restraints, bundling of goods, and so on.

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* University of Milan, Intertic, and Etro Consulting; fetro@intertic.org.

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The intuition for the generalized aggressive behavior of leaders in competitive markets is simple. With a fixed number of firms, the leader is mainly concerned about the reactions of the other firms to its own investments, but these reactions are different under quantity competition or price competition (more precisely, according to whether strategic substitutability or complementarity holds). But when entry is endogenous, the leader is mainly concerned about the effect of its own investment on entry. An investment that induces the leader to be accommodating will attract entry, which makes such a strategy unprofitable. An investment that induces the leader to be aggressive will limit entry and allow the leader to achieve a larger market share and gain from a reduction in the average costs of production. This implies that a dominant position obtained through strategic investments can be the consequence of a competitive market environment and not the result of barriers to entry.[1] The practical implication is that competition policy should focus on promoting endogenous entry rather than fighting against market leaders, their dominant market shares, their aggressive pricing or bundling strategies, and their innovative investments.

The article is organized as follows. In Section 2, I develop a simple example where leadership is associated with a simple first-mover advantage rather than a proper strategic investment; it serves to show, in a simple way, the source of the aggressive behavior of leaders. In Section 3, I present the general model of strategic investment and Nash competition, and in Section 4, I solve it with and without barriers to entry. In Section 5, I study some applications under quantity and price competition with alternative forms of strategic commitments. Section 6 concludes.

2. A simple example

■ In this section I will present a textbook example of Stackelberg competition in quantities and extend it to endogenous entry. The objective is to convey in the simplest terms the mechanism relating endogenous entry to aggressive behavior of the leaders. A more general model of Stackelberg competition with free entry is fully characterized in Etro (2002a).

Consider quantity competition between n firms facing a linear inverse demand $p = a - X$, where $a > 0$ and X is total production in the market, while constant marginal cost is $c \in [0, a)$ and $F > 0$ is the fixed cost. One of the firms is a leader and can choose its production x_L in a first stage before the other firms. Followers choose their quantities x_i playing in Nash strategies between themselves in a second stage.

As is well known, when the number of potential entrants is exogenous, the leader foresees how total production by the followers responds and accordingly decides how much to produce. Hence, as long as the number of firms is small enough, in equilibrium the leader produces $x_L = (a - c)/2$ and each follower produces $x = (a - c)/2n$.

When there is endogenous entry of firms, only a limited number of them enter and produce in equilibrium, and hence their number n is endogenous. In such a case, the leader foresees how the production of each follower and also the number of followers will change with its own production. In particular, given a small enough quantity x_L produced by the leader, each entrant would produce $x = (a - c - x_L)/n$, and the zero-profit constraint would fix the number of followers at $n = (a - c - x_L)/\sqrt{F}$, which is decreasing in the production of the leader. This implies that each one of the followers would produce $x = \sqrt{F}$. Given this, the net profit function perceived by the leader in the first stage, as long as there is some entry of followers (that is for $n \geq 2$ or $x_L \leq a - c - 2\sqrt{F}$), is

$$\pi^L = x_L \sqrt{F} - F.$$

It is now clear that the leader always prefers to produce so that entry is avoided; that is, $x_L = a - c - 2\sqrt{F}$. In other words, there are never followers in equilibrium and total production is

$$X = x_L = a - c - 2\sqrt{F}.$$

[1] In this article I will associate barriers to entry with an exogenous number of firms. Notice that, when I endogenize entry, I am actually endogenizing the role of these barriers in constraining entry.

In conclusion, when the number of potential entrants is low enough, the market is characterized by all these firms being active, while when there are many potential entrants and a free-entry equilibrium is achieved, there is just one firm in equilibrium: the leader.

The outcome is not always so extreme: as I have shown in Etro (2002a), we would have some entry in case of imperfect substitutability between goods, under both quantity competition[2] and price competition, or in the presence of U-shaped cost functions, but in all these cases the leader would still be aggressive, producing more and selling at lower prices than the followers (as long as endogenous entry holds).[3] A similar result emerges when the leader does not have a first-mover advantage but can undertake a preliminary investment that affects its marginal profitability, creating an endogenous asymmetry with respect to the other firms. I now turn to this case.

3. The model

■ In this section I will present a model of Nash competition with strategic investment. Since my main focus is on equilibria with endogenous entry, I need a general model that can account for multiple firms and has profits decreasing when new firms enter. I will present such a general framework and then show that standard models of quantity and price competition are nested in it.

Consider n firms choosing a strategic variable $x_i > 0$ with $i = 1, 2, \ldots, n$. They all compete in Nash strategies, that is, taking as given each other's strategies. These strategies deliver for each firm i the net profit function

$$\pi_i = \Pi(x_i, \beta_i, k) - F, \tag{1}$$

where $F > 0$ is a fixed cost of production. The first argument is the strategy of firm i, and I assume that gross profits are quasi-concave in x_i.

The second argument represents the effects (or spillovers) induced by the strategies of the other firms on firm i's profits, summarized by $\beta_i = \sum_{k=1,k\neq i}^{n} h(x_k)$ for some function $h(x)$ that is assumed positive, differentiable, and increasing. These spillovers exert a negative effect on profits, $\Pi_2 < 0$. In general, the cross effect Π_{12} could be positive, so that we have strategic complementarity (SC), or negative, so that we have strategic substitutability (SS). I will define strategy x_i as aggressive compared to strategy x_j when $x_i > x_j$ and accommodating when the opposite holds. Notice that a more aggressive strategy by one firm reduces the profits of the other firms.

The last argument of the profit function is a profit-enhancing factor ($\Pi_3 > 0$) that for all firms except the leader is constant at a level $\bar{k}$. Only the leader is able to make a strategic precommitment on k in a preliminary stage. For simplicity, the cost of its strategic investment is given by a function $f(k)$ with $f'(k) > 0$ and $f''(k) > 0$. My focus will be exactly on the incentives for this firm to undertake such an investment so as to maximize its total profits,[4]

$$\pi_L(k) = \Pi^L(x_L, \beta_L, k) - f(k) - F, \tag{2}$$

where x_L is the strategy of the leader and $\beta_L = \sum_{j\neq L} h(x_j)$. We may say that the investment makes the leader tough when $\Pi_{13}^L > 0$, that is, an increase in k increases the marginal profitability of its strategy, while the investment makes the leader soft in the opposite case ($\Pi_{13}^L < 0$).

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[2] Consider a slight variation of the above model with inverse demand $a - x_i - b\sum_{j\neq i} x_j$ for firm i, where $b \in (0, 1]$ is an index of substitutability between goods. In this case, for b small enough, it is easy to verify that we have entry in equilibrium and each entrant produces $x = \sqrt{F}$, while the leader produces $x_L = x(2-b)/2(1-b)$. Hence, when goods are only partially substitutable, the leader allows some entry but still produces more than any single entrant, selling its own good at a lower price.

[3] The same aggressive behavior emerges for investment in innovation by leaders in patent races (Etro, 2004). Finally, this aggressive behavior of the leaders improves the allocation of resources compared to a basic Nash equilibrium; the welfare and policy implications of Stackelberg games with free entry are examined further in Etro (2002a).

[4] To avoid confusion, I will add the label L to denote the profit function, the strategy, and the spillovers of the leader.

Most of the commonly used models of oligopolistic competition in quantities and in prices are nested in my general specification.[5] For instance, consider a market with quantity competition so that the strategy x_i represents the quantity produced by firm i. The corresponding inverse demand for firm i is $p_i = p[x_i, \sum_{j \neq i} h(x_j)]$, which is decreasing in both arguments (goods are substitutes). The cost function is $c(x_i)$, with $c'(\cdot) > 0$. It follows that gross profits for firm i are

$$\Pi(x_i, \beta_i) = x_i p(x_i, \beta_i) - c(x_i). \tag{3}$$

Examples include linear and iso-elastic demands and other common cases. This setup satisfies my general assumptions under weak conditions and can locally imply SS (as in most cases) or SC.

Consider now models of price competition where p_i is the price of firm i. Any model with direct demand,

$$D_i = D\left[p_i, \sum_{j=1, j\neq i}^{n} g(p_j)\right] \qquad \text{where } D_1 < 0, D_2 < 0, g'(p) < 0,$$

is nested in my general framework after setting $x_i \equiv 1/p_i$ and $h(x_i) = g(1/x_i)$. This specification guarantees that goods are substitutes in a standard way, since $\partial D_i/\partial p_j = D_2 g'(p_j) > 0$. For instance, following Vives (1999), when utility is iso-elastic as $u = [\sum_{j=1}^n C_j^\theta]^\gamma - \sum_{j=1}^n C_j p_j$, with $\theta \in (0, 1]$ and $\gamma \in (0, 1/\theta)$, demand for good i can be derived as

$$D_i \propto \frac{p_i^{-\frac{1}{1-\theta}}}{\left[\sum_{j=1}^n p_j^{-\frac{\theta}{1-\theta}}\right]^{\frac{1-\gamma}{1-\gamma\theta}}},$$

which is nested in my framework after setting $g(p) = p^{-\theta/(1-\theta)}$, while a logit demand is

$$D_i = \frac{e^{-\lambda p_i}}{\sum_{j=1}^n e^{-\lambda p_j}},$$

which requires $g(p) = e^{-\lambda p}$.[6] Adopting, just for simplicity, a constant marginal cost c, I obtain the gross profits for firm i,

$$\Pi(x_i, \beta_i) = \left(\frac{1}{x_i} - c\right) D\left(\frac{1}{x_i}, \beta_i\right) = (p_i - c)\, D(p_i, \beta_i), \tag{4}$$

which is nested in my general model and, under weak conditions assumed throughout the article, implies SC.

We can now note that a more aggressive strategy corresponds to a higher production level in models of quantity competition and a lower price under price competition. In these models, I can introduce many kinds of preliminary investments, as we will see later on.

4. Strategic investment by the leader

■ I will now solve for the equilibrium in the two-stage model where the leader chooses its preliminary investment in the first stage and all firms compete in Nash strategies in the second stage.

[5] Other models of oligopolistic interaction such as patent races and contests are also nested in my general framework, but I have discussed them elsewhere (Etro, 2002a; 2004). In the following examples I omit the variable k for simplicity.

[6] Other examples include constant expenditure demand functions and the general class of demand functions introduced by Dixit and Stiglitz (1977). Notice that linear demands are not nested in my model.

For a given preliminary investment k by the leader, the second stage where firms compete in Nash strategies is characterized by a system of n optimality conditions. For the sake of simplicity, I follow Fudenberg and Tirole (1984) by assuming that a unique symmetric equilibrium exists and that there is entry of some followers for any possible preliminary investment.[7] Given the symmetry of the model, in equilibrium each follower chooses a common strategy x and the leader chooses a strategy x_L satisfying the optimality conditions

$$\Pi_1\left[x, (n-2)h(x) + h(x_L), \bar{k}\right] = 0 \tag{5}$$

$$\Pi_1^L\left[x_L, (n-1)h(x), k\right] = 0, \tag{6}$$

where I use the fact that in equilibrium the spillovers for each follower are $\beta = (n-2)h(x)+h(x_L)$ and for the leader are $\beta_L = (n-1)h(x)$.

Before analyzing the model with endogenous entry, it is convenient to briefly summarize the results in the presence of an exogenous number of firms, which have been the focus of most of the research in the post-Chicago approach to industrial organization. The system (5)–(6) provides the equilibrium values of the strategies as functions of the preliminary investment, $x(k)$ and $x_L(k)$, whose comparative statics can easily be derived. In the first stage the leader chooses its investment k to maximize

$$\pi_L(k) = \Pi^L\left\{x_L(k), (n-1)h\left[x(k)\right], k\right\} - f(k) - F,$$

and it is immediate to obtain the optimality condition,

$$\Pi_3^L + \frac{h'(x_L)\Pi_{13}^L\Pi_2^L\Pi_{12}}{\Omega} = f'(k), \tag{7}$$

where the second term on the left-hand side represents the strategic incentive to commit to k.[8] The sign of this incentive is the opposite of the sign of $\Pi_{12}\Pi_{13}^L$. Hence, we have the following traditional result: with an exogenous number of firms, (i) when the leader is tough ($\Pi_{13}^L > 0$), strategic overinvestment (underinvestment) occurs under SS (SC), inducing a top dog (puppy dog) strategy; (ii) when the leader is soft ($\Pi_{13}^L < 0$), strategic underinvestment (overinvestment) occurs under SS (SC), inducing a "lean and hungry" ("fat cat") strategy.

The intuition behind this result is important for what follows. Basically, under SS the leader gains from committing to aggressive behavior in the market and can accomplish such a task by overinvesting or underinvesting strategically when the investment promotes aggressive or accommodating behavior. Otherwise, under SC the leader tries to commit to accommodating behavior in the market and can achieve this by adopting the opposite kind of strategy. The ultimate behavior of the leader in the market depends on whether strategies are substitutes or complements.

I will now consider the case of endogenous entry, assuming that the number of potential entrants is great enough that a zero-profit condition pins down the number of active firms, n.[9] The equilibrium conditions in the second stage for a given preliminary investment k are the optimality conditions (5)–(6) and the zero-profit condition for the followers:

$$\Pi\left[x, (n-2)h(x) + h(x_L), \bar{k}\right] = F. \tag{8}$$

I can now prove that a change in the strategic commitment by the leader does not affect the equilibrium strategies of the other firms, but it reduces their equilibrium number. Let us use the

[7] Conditions for existence and uniqueness can be found in the literature on specific games (see Vives, 1999, for a survey). Clearly, when the investment is not very costly, a leader may adopt an extreme strategy to deter entry; such an exclusionary strategy was already pointed out by Fudenberg and Tirole (1984), so I will not focus on it.

[8] Here $\Omega = [\Pi_{11}^L/(n-1)h'(x)][\Pi_{11} + (n-2)h'(x)\Pi_{12}] + \Pi_{12}^L\Pi_{12}$ is positive by the assumption of the stability of the system (5)–(6).

[9] One can think of this as a three-stage game, adding an intermediate stage where potential followers decide whether to enter or not. As is customary in the literature, I will assume n is a real number.

fact that $\beta_L = \beta + h(x) - h(x_L)$ to rewrite the three equilibrium equations in terms of x, β, and x_L:

$$\Pi\left(x, \beta, \bar{k}\right) = F, \quad \Pi_1\left(x, \beta, \bar{k}\right) = 0, \quad \Pi_1^L\left[x_L, \beta + h(x) - h(x_L), k\right] = 0.$$

This system is block recursive and stable under the condition $\Pi_{11}^L - h'(x_L)\Pi_{12}^L < 0$. The first two equations provide the equilibrium values for the strategy of the followers and their spillovers, x and β, which are independent of k, while the last equation provides the equilibrium strategy of the leader $x_L(k)$ as a function of k, with $x_L(\bar{k}) = x$ and

$$x_L'(k) = -\frac{\Pi_{13}^L}{\Pi_{11}^L - h'(x_L)\Pi_{12}^L} \gtreqless 0 \qquad \text{for } \Pi_{13}^L \gtreqless 0.$$

In the first stage, the optimal choice of investment k for the leader maximizes

$$\pi_L(k) = \Pi^L\left\{x_L(k), \beta + h(x) - h\left[x_L(k)\right], k\right\} - f(k) - F,$$

and hence it satisfies the optimality condition

$$\Pi_3^L + \frac{h'(x_L)\Pi_2^L\Pi_{13}^L}{\Pi_{11}^L - h'(x_L)\Pi_{12}^L} = f'(k), \tag{9}$$

where the sign of the second term is just the sign of Π_{13}^L. This implies that the leader has a positive strategic incentive to invest when it is tough ($\Pi_{13}^L > 0$) and a negative one when it is soft.

Since my focus is on the strategic incentive to invest, I will normalize the profit functions in such a way that, in the absence of strategic motivations, the leader would choose $k = \bar{k}$, resulting in a symmetric situation with the other firms.[10] Consequently, we can conclude that a tough leader overinvests compared to the other firms, in the sense that $k > \bar{k}$, while a soft leader underinvests. We also notice that a tough leader is made more aggressive by overinvesting and a soft leader is made more aggressive by underinvesting. Finally, the strategy of the other firms is independent of the investment of the leader. Hence, we can conclude that the leader will always be more aggressive in the market than any other firm. Summarizing, we have the following.

Proposition 1. Under Nash competition with endogenous entry, when the strategic investment makes the leader tough (soft), overinvestment (underinvestment) occurs, but the leader is always more aggressive than the other firms.

Basically, under endogenous entry, the taxonomy of Fudenberg and Tirole (1984) boils down to two simple kinds of investment and an unambiguous aggressive behavior in the market: whenever $\Pi_{13}^L > 0$, it is always optimal to adopt a top dog strategy with overinvestment in the first stage so as to be aggressive in the second stage; when $\Pi_{13}^L < 0$, we always have a lean and hungry look with underinvestment, but the behavior in the second stage is still aggressive. Strategic investment is always used as a commitment to be more aggressive in a market with endogenous entry, and this does not depend on the kind of competition or strategic interaction between the firms. As we will see in the applications of the next section, the result is particularly drastic for markets with price competition. In these markets, leaders are accommodating in the presence of entry barriers (choosing higher prices than their competitors), but they are aggressive under endogenous entry (choosing lower prices). This difference may be useful for empirical research on barriers to entry and may have crucial implications for antitrust policy. For instance, Fudenberg and Tirole (1984) and the following post-Chicago approach have shown that aggressive pricing can only have a predatory purpose in a duopoly with price competition, while I have shown that, when entry is endogenous, aggressive pricing is not necessarily associated with exclusionary

[10] This requires $\Pi_3^L(x, \beta, \bar{k}) = f'(\bar{k})$. Such a normalization does not affect qualitatively the incentives to adopt strategic investments and has a realistic motivation. We can imagine that all firms choose k but only the leader can do it before the others and commit to it, hence only a strategic motivation can induce the leader to choose a different investment.

purposes (see Etro, 2006, for a discussion of the antitrust implications, with particular reference to the Microsoft case).

5. Applications

■ The results above have many applications in both industrial organization and other related fields. For instance, in the theory of trade policy, I can show that export subsidies are always the optimal unilateral trade policy for firms active in third countries where entry is free. Hence, the ambiguous results obtained by Eaton and Grossman (1986) collapse under free entry (which is actually in the interest of the third country). Notice that a subsidy implies $\Pi_{13}^L > 0$ under both quantity and price competition, and the optimal subsidy that maximizes profits of the domestic firm net of the cost of the subsidy plays the same role of an optimal strategic commitment chosen by the same firm.[11]

Here, I will limit the discussion to an overview of applications in the field of industrial organization. The focus will be on investments in technological improvements (which shift the cost function) and quality improvements (which shift the demand function), and I will also describe other related strategic investments. Future research may study other forms of strategic commitment by leaders in competitive markets, since most of the post-Chicago research has abstracted from endogenous entry choices. For instance, even the incentives to *bundling* different products change according to the entry conditions. In a simple example, Whinston (1990) has shown that a monopolist in one market does not have incentives to bundle its product with another one sold in a duopolistic secondary market unless this deters entry in the latter, and that this corresponds to a puppy dog strategy (since bundling makes the monopolist tough). However, under endogenous entry in the secondary market, bundling at a low price may become the optimal top dog strategy without an entry-deterrence purpose. This may have radical implications for competition policy (think of the bundling strategies of Microsoft), since it shows that bundling is an efficient (and also welfare enhancing) strategy by dominant firms.

□ **Cost-reducing investments.** My first application is to a standard situation where a firm can adopt preliminary investments to improve its production technology and hence reduce its cost function. Traditional results on the opportunity of these investments for market leaders are ambiguous under barriers to entry, but, as I will show, they are not when entry is endogenous. From now on, I will assume for simplicity that marginal costs are constant. Here, the leader can invest k and reduce its marginal cost to $c(k) > 0$ with $c'(k) < 0$, while marginal cost is fixed for all the other firms.

Consider first a model of quantity competition. The gross profit of the leader is

$$\Pi^L(x_L, \beta_L, k) = x_L p(x_L, \beta_L) - c(k)x_L. \tag{10}$$

Notice that Π_{12}^L has an ambiguous sign, but $\Pi_{13}^L = -c'(k) > 0$. Hence, the leader may overinvest or underinvest with barriers to entry but, according to Proposition 1, will always overinvest in cost reduction and produce more than the other firms when entry is endogenous.[12]

Consider now the model of price competition where the leader can invest to reduce its marginal costs in the same way and its profit function is

$$\Pi^L(x_L, \beta_L, k) = \left[\frac{1}{x_L} - c(k)\right] D\left(\frac{1}{x_L}, \beta_L\right), \tag{11}$$

where $\Pi_{13}^L = c'(k)D_1/x_L^2 > 0$. Hence, underinvestment in cost reduction emerges when there are barriers to entry, but overinvestment is optimal when there is endogenous entry. Whenever entry

[11] In Etro (2002b) I explicitly derive the optimal positive export subsidies under quantity and price competition, and I also apply the results to other forms of export promotion, as competitive devaluations.

[12] For instance, assuming inverse demand $p = a - \sum x_i$ with $c(k) = c - dk$ and $f(k) = k^2/2$, for d small enough, the leader invests $k = 2d\sqrt{F}/(1 - 2d^2)$ and produces $x_L = \sqrt{F}/(1 - 2d^2)$, while all entrants produce $x = \sqrt{F}$. Notice that for a large enough d the leader would invest more to deter entry and remain alone in the market.

is endogenous, the leader wants to improve its cost function to be more aggressive in the market by selling its good at a lower price. Welfare analysis is beyond the scope of this article, but in this case one can show that leadership improves the allocation of resources: this is due not only to the cost reduction but also to the improved allocation of resources.[13] Summarizing, we have the next proposition.

Proposition 2. Under both quantity and price competition with endogenous entry, a firm always has an incentive to overinvest in cost reduction and to be more aggressive than the other firms in the market.

This result has a number of indirect applications. The theory of strategic vertical restraints suggests that under price competition, a firm has incentives to choose vertical separation and charge its retailer a franchise fee together with a wholesale price above marginal cost to induce an accommodating behavior (Bonanno and Vickers, 1988); however, if entry in the market is free, the optimal strategy is always aggressive and implies a wholesale price below marginal cost.

Other interesting applications are available in the case of multimarket competition, where cost reduction can be obtained indirectly through production in other markets. For instance, if k is production in a separate market and there are economies of scope, in the sense that the marginal cost in one market is decreasing in the production in the other, the leader will always overproduce in both markets to reduce its marginal costs.[14]

Finally, I can apply the results to dynamic models of learning by doing, where the cost function is decreasing in past production. A leader will always overproduce before entry takes place to exploit the learning curve and gain a strategic advantage over the entrants.[15] Contrary to the case with barriers to entry, analyzed by Bulow, Geanakoplos, and Klemperer (1985), these results do not depend on whether SS or SC holds.

□ **Demand-enhancing investments.** Consider now investments that affect the demand function of a firm, such as investment for quality improvements, which tend to increase demand and also reduce the substitutability between goods.[16] Under free entry, the aim of the leader is always to be aggressive in the market, but different strategies emerge under quantity and price competition.

Consider a model of quantity competition characterized by the demand function $p(x_L, \beta_L, k)$ for the leader, where the marginal effect of investment on inverse demand is positive ($p_3 > 0$), while the effect on its slope is negative ($p_{13} < 0$), which implies that a higher investment not only increases demand but also makes it more inelastic. Its gross profit becomes

$$\Pi^L(x_L, \beta_L, k) = x_L\left[p(x_L, \beta_L, k) - c\right]. \tag{12}$$

Hence, we have $\Pi_{13}^L = p_3(1-\eta)$, where $\eta \equiv -x_L p_{31}/p_3$ is the elasticity of the marginal effect of investment on demand with respect to production. As long as this elasticity is less than unitary (investment does not make demand too inelastic), we have $\Pi_{13}^L > 0$. Consequently, while under barriers to entry the investment choice of the leader depends on many factors, under endogenous entry overinvestment takes place if and only if $\eta < 1$.[17] Whether this is the case or not, the leader ends up selling more than any other firm.[18]

[13] In Etro (2002a) I show that a Stackelberg equilibrium with free entry improves the allocation of resources compared to a Marshallian equilibrium, that is, a Nash equilibrium for models of quantity and price competition and patent races where entry is free.

[14] Notice, however, that the opposite result (underproduction) holds in the presence of joint diseconomies.

[15] The opposite result (underproduction) holds, however, when initial production increases future marginal cost (which is the case of natural resource markets).

[16] Investment in informative advertising has a similar role, so my conclusions apply to that case as well.

[17] The model can also be reinterpreted in terms of product differentiation when inverse demand for the leader is $p[x_L + b(k)\beta_L]$, where $b(k)$, with $b'(k) < 0$, is an index of substitutability between the goods of the leader and all the others. In this case, it can be verified that $\eta < 1$ if and only if strategic substitutability holds.

[18] An analogous result applies in dynamic models with network effects creating demand externalities, where demand is enhanced by past production and the consequent diffusion of the product across customers. For instance, if

Under price competition we have demand for the leader $D(1/x_L, \beta_L, k)$ with $D_3 > 0$ and $D_{13} > 0$, and the gross profit becomes

$$\Pi^L(x_L, \beta_L, k) = \left(\frac{1}{x_L} - c\right) D\left(\frac{1}{x_L}, \beta_L, k\right), \tag{13}$$

where $\Pi^L_{13} = -[D_3 + (1/x_L - c)D_{13}]/x_L^2 < 0$. In this case, under barriers to entry the leader would overinvest in quality improvements to increase its price and exploit the induced increase in the price of the competitors. However, under endogenous entry the behavior of the leader radically changes and there is always underinvestment in quality improvements so as to reduce the price below that of the followers. Summarizing, we have the final proposition.

Proposition 3. Under quantity competition with endogenous entry, a firm has an incentive to overinvest in quality as long as this does not make demand too inelastic; under price competition with endogenous entry, the leader always has an incentive to underinvest in quality.

Finally, notice that these results apply also in the presence of multimarket competition with demand complementarities between separate markets. The bottom line for all these applications is that endogenous entry overturns common wisdom obtained by models with barriers to entry, especially under price competition.

6. Conclusions

■ I have studied market structures with market leaders engaging in preliminary investments. When there are barriers to entry, the optimal behavior of the leaders depends on whether strategic investment makes the followers more or less aggressive, which is ultimately an empirical question for each single market. However, when entry is endogenous, the optimal behavior of leaders is much simpler: they should always adopt preliminary investments that allow them to be more aggressive in the market.

An interesting finding is that a market can be dominated by a leader and yet be competitive. I have shown that, under price competition, in the presence of barriers to entry a leader would underinvest in cost reduction so as to maintain high prices in the market, while the opposite happens if entry is endogenous. This kind of result suggests that the priority of antitrust authorities should be fighting barriers to entry rather than aggressive market leaders.

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inverse demand for the leader is $p(x_L + \beta_L)\phi(k)$, where $\phi(k)$ is some increasing function of past production k, we have $\eta < 0$, so the leader will overproduce before entry takes place to create network effects.