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MARKET LEADERS AND INDUSTRIAL POLICY

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Abstract

This article provides an overview of recent progress in the theory of market structure, of the role of market leaders and the scope of industrial policy, presents new results through simple examples of quantity competition, price competition and competition for the market and develops new applications to the theory of competition in presence of network externalities and learning by doing, of strategic debt financing in the optimal financial structure, of bundling as a strategic device, of vertical restraints through interbrand competition, of price discrimination and to the theory of innovation. Finally, it draws policy implications for antitrust issues with particular reference to the approach to abuse of dominance and to the protection of IPRs to promote innovation.

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1 Introduction

This article provides an overview of recent progress in the theory of market structure, of the role of market leaders and the scope of industrial policy, presents new results through simple examples of quantity competition, price competition and competition for the market and develops new applications to the theory of competition in presence of network externalities and learning by doing, to the theory of strategic debt financing in the optimal financial structure, to the theory bundling as a strategic device and to other issues.

The core of this theoretical framework concerns the behaviour of market leaders facing endogenous entry of competitors, that is a situation in which, given the demand and supply conditions, firms endogenously decide to enter in the market as long as positive profits can be made, a reasonable assumption for many markets. This behaviour has been surprisingly neglected in the literature on strategic investment, which has been mostly focused on the behaviour of a market leader facing a single exogenous competitor: even if entry of such a competitor was endogenous, there was no consideration of the endogenous entry of other competitors. The crucial difference is that, while a leader may be accomodating or aggressive in front of a single follower (Dixit, 1980; Fudenberg and Tirole, 1984; Bulow *et al.*, 1985), the leader is always aggressive when entry is fully endogenous, and this happens not only when entry deterrence is optimal but also when entry is not deterred.

In Section 2 of the paper I develop a few simple examples to deliver this basic result when a firm is a Stackelberg leader and faces free entry. For instance, I fully describe the entry deterrence strategy that a Stackelberg leader adopts in a market with quantity competition and linear demand and costs. I also extend this same model taking into account U shaped cost functions and product differentiation, showing that under these conditions, the Stackelberg leader still has an incentive to produce more output than the followers, but not enough to deter entry. Finally, I propose a simple example of price competition that can be fully solved analytically, an example based on a Logit demand function and constant marginal costs: here, while a Stackelberg price leader would be accomodating (setting higher prices) in front of a single follower, it is aggressive (setting lower prices) in front of endogenous entry of followers.

Of course, these simple examples can be criticized on the ground of credibility: it can be hard to commit to quantity or price strategies. Hence, I move on developing a more general model of strategic investment by leaders with standard Nash competition. Section 3 of the paper shows a general result due to Etro (2006a), for which whenever a firm faces endogenous entry of rivals, there is an incentive to undertake strategic investments that induce an aggres-

sive behaviour in the market. Hence, the final outcome of the simpler models of Stackelberg competition with endogenous entry are preserved when leaders do not commit to a strategy, but do commit to a preliminary strategic investment. Section 4 applies this principle to a number of cases, showing that standard results obtained for simple duopolies collapse when entry is endogenous. First, I show that a firm overinvests always in cost reducing activities, while strategic investment in demand enhancing activities depends on a number of market features. An application of this result implies that under standard conditions, in presence of learning by doing and network externalities a firm has always an incentive to overproduce strategically initially so as to be more aggressive when endogenous entry takes place in the future.

A novel application concerns the theory of corporate finance: starting from the literature on the relation between optimal financial structure and product market competition (Brander and Lewis, 1986) I examine the incentives to adopt strategic debt financing for markets with free entry. It turns out that under quantity competition there is always a strategic bias toward debt financing, while under price competition there is only when uncertainty affects costs, but not when it affects demand. In general, departing from the standard Modigliani and Miller (1958) neutrality result, a financial tool as debt is useful when it constraints equity holders to adopt more aggressive strategies in the market, and this is the case when positive shocks increase marginal profits.

Another new application developed in detail here concerns discrete commitments. I examine the case of bundling strategies. In an influential paper, Whinston (1990) has studied bundling in a market for two goods. The primary good is monopolized by one firm, which competes with a single rival in the market for the secondary good. Under price competition in the secondary market, the monopolist becomes more aggressive in its price choice in case of bundling of its two goods. Since a more aggressive strategy leads to lower prices for both firms as long as both are producing, the only reason why the monopolist may want to bundle its two goods is to deter entry of the rival in the secondary market. This conclusion can be highly misleading because it neglects the possibility of further entry in the market. I show that, if the secondary market is characterized by endogenous entry, the monopolist would always like to be aggressive in this market and bundling may be the right way to commit to an aggressive strategy: bundling would not necessarily exclude entry in this case, but may increase competition in the secondary market and reduce prices.

Other applications concern vertical restraints and price discrimination. The results lead me to draw some conclusions for the economic approach to antitrust issues, and in particular those concerning abuse of dominance. Following Etro (2006b) I show that the theory of market leaders points out major problems in the usual association of market shares and market power. Moreover, while the post-Chicago approach (largely based on theories of the behaviour of an incumbent facing a single entrant) typically associates aggressive strategies by leaders with exclusionary purposes, my results suggest that aggressive strategies

by leaders are their normal strategies in front of endogenous entry.

In Section 5 I show that the theory of market leaders can also be used to provide new results on industrial policy for exporting firms. Contrary to the ambiguous results of strategic trade policy under barriers to entry in a third market due to Brander and Spencer (1985) and Eaton and Grossman (1986), following Etro (2006c) I show that it is always optimal to subsidize exports as long as entry is free (under both strategic substitutability and complementarity) and I present explicit expressions for the optimal export subsidies under both Cournot and Bertrand competition.

Finally, in Section 6 I turn to competition for the market within a simple model of a contest with Stackelberg leadership and free entry. The main result, whose first derivation in a more general context was in Etro (2004), is that while incumbent monopolist patentholders do not invest in R&D when facing free entry (Arrow, 1962), as long as they have a leadership in the technological race, they invest so much to deter entry. This result has radical implications for our way to look at the innovative behaviour of market leaders, for the same persistence of the leadership in high-tech sectors and for the theory of endogenous growth (Etro, 2006d).

The paper is organized as follows. Section 2 presents simple models where our main results emerge clearly. Section 3 presents the general model of strategic investment and Nash competition and solves it with and without barriers to entry. Section 4 studies some applications under quantity and price competition with alternative forms of strategic investments including debt financing and bundling, relates the general results to those under pure Stackelberg competition. Section 5 applies the results to the theory of export promotion. Section 6 is about competition for the market and innovation. Section 7 concludes.

2 Simple examples for new results

Let us consider the simplest market one can think of. Imagine a homogenous good with inverse demand $p = a - X$, where total production by all the firms is the sum of individual productions $X = \sum_{i=1}^n x_i$. Each firm can produce the good with the same standard technology. Producing x units requires a fixed cost of production $F \geq 0$ and a variable cost cx where $c \geq 0$ is a constant unitary cost, or marginal cost of production.¹ Hence the general profit function of a firm i is the difference between revenue and costs:

$$\pi_i = \left(a - \sum_{i=1}^n x_i \right) x_i - cx_i - F \quad (1)$$

¹We will assume that c is small enough to allow profitable entry in the market. In particular $c < a - 2\sqrt{F}$ is enough to allow that at least one firm in the market (a monopolist) can make positive profits.

In Nash equilibrium with n firms, output per firm is:

$$x(n) = \frac{a - c}{n + 1}$$

If we assume that entry takes place as long as profits can be made, an equilibrium should be characterized by a number of firms n satisfying a no entry condition $\pi(n + 1) \leq 0$, and a no exit condition $\pi(n) \geq 0$. When the fixed cost of production is small enough, this equilibrium number is quite large. In this cases it is natural to take a short cut and approximate the endogenous number of firms with the real number satisfying the zero profit condition $\pi^C(n) = 0$, that is:

$$n = \frac{a - c}{\sqrt{F}} - 1$$

This allows to derive the equilibrium output per firm under Marshall competition:

$$x = \sqrt{F}$$

and the equilibrium price $p = c + \sqrt{F}$, which implies a mark up on the marginal cost to cover the fixed costs of production.²

As well known, in a Stackelberg equilibrium with n followers playing Nash, if the fixed costs are small enough, the optimal strategy for the leader is $x_L = (a - c)/2$, which in this particular example corresponds to the monopolistic production. Each one of the followers will end up producing $x(n) = (a - c)/2n$.

Let us finally move to the case in which there is still a leadership in the market but the leader is facing endogenous entry of competitors: this is the focus of our research. Formally, consider the following sequence of moves:

- 1) in the first stage, a leader chooses its own output, say x_L ;
- 2) in the second stage, after knowing the strategy of the leader, all potential entrants simultaneously decide “in” or “out”: if a firm decides “in”, it pays the fixed cost F ;
- 3) in the third stage all the followers that have entered choose their own strategy x_i (hence, the followers play Nash between themselves).

In this case, the leader has to take into account how its own commitment affects not only the strategy of the followers but also their entry decision. As we have seen, in the last stage, if there are $n \geq 2$ firms in the market and the leader produces x_L , each follower produces:

$$x(x_L, n) = \frac{a - x_L - c}{n}$$

²Adopting the standard definition of welfare which here corresponds to the consumer surplus (since all firms earn no profits), we have:

$$W = \frac{X^2}{2} = \frac{(a - c - \sqrt{F})^2}{2}$$

This implies that the profits of each follower are:

$$\pi(x_L, n) = \left(\frac{a - c - x_L}{n} \right)^2 - F$$

which are clearly decreasing in the number of firms. This would imply that further entry or exit does not take place when $\pi(x_L, n+1) \leq 0$ and $\pi(x_L, n) \geq 0$. Moreover, no follower will find it optimal to enter in the market if $\pi(x_L, 2) \leq 0$, that is if not even a single follower can make positive profits given the output of the leader. This is equivalent to:

$$x_L \geq a - c - 2\sqrt{F}$$

If the leader adopts an aggressive strategy producing enough, entry will be deterred, otherwise, the number of entrants will be endogenously determined by a free entry condition. In this last case, ignoring the integer constraint on the number of firms (in the next section we provide an analysis which takes this constraint in consideration), we can approximate the number of firms as a real number again setting $\pi(x_L, n) = 0$, which implies:

$$n = \frac{a - c - x_L}{\sqrt{F}}$$

When this is the endogenous number of firms, each one of the followers is producing:

$$x \left(x_L, \frac{a - c - x_L}{\sqrt{F}} \right) = \sqrt{F}$$

that is independent of the strategy of the leader. Hence, the higher the production of the leader, the lower the number of entrants, while the production of each one of them will be the same. This would imply also a constant level of total production $X = a - c - \sqrt{F}$ and a constant price $p = c + \sqrt{F}$, which would be equivalent to those emerging under Marshall competition.

After having derived the behaviour of the followers, it is now time to move to the first stage and examine the behaviour of the leader. Remembering that entry takes place only for a production level which is not too high, if this is the case, the profits of the leader must be:

$$\pi_L = px_L - cx_L - F = x_L\sqrt{F} - F \quad \text{if } x_L < a - c - 2\sqrt{F}$$

In other words, when entry takes place, the market price is perceived as given from the leader, which is aware that any increase in production crowds out entry maintaining constant the equilibrium price. However, when the leader is producing enough to deter entry, its profits become:

$$\pi_L = x_L(a - x_L) - cx_L - F \quad \text{if } x_L \geq a - c - 2\sqrt{F}$$

It can be immediately verified that the profit function is linearly increasing in the output of the leader for $x_L < a - c - 2\sqrt{F}$ and after this cut off it jumps upward and then decreases. Consequently the optimal strategy for the leader is to produce just enough to deter entry:

$$X = x_L = a - c - 2\sqrt{F} \quad (2)$$

which is equivalent to set the limit price $p = c + \sqrt{F}$. The profits of the leader are then:

$$\pi_L = 2\sqrt{F} (a - c - 2\sqrt{F}) - F$$

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. While the price is kept higher than in the Marshall equilibrium (the mark up $p - c$ is doubled from \sqrt{F} to $2\sqrt{F}$), welfare as the sum of consumer surplus and profits is now always higher than in the Marshall equilibrium.³

2.1 Taking care of the integer constraint

In the derivation of the Stackelberg equilibrium with endogenous entry, homogeneous goods and constant marginal costs we simplified things assuming that the number of firms was a real number. Here we verify that the equilibrium is exactly the same even if we consider more realistically that the number of firms in the market must be an integer number.

Given the production of the leader x_L and the number of firms n , the reaction function and the profits of each follower are the same as before. However, the number of firms is a step function of the output of the leader. In particular, the number of firms is given by the integer number $n \geq 2$ when the output of the leader is between $s(n)$ and $s(n - 1)$, where these cut-offs are defined as:

$$s(n) \equiv a - c - (n + 1)\sqrt{F}$$

while only the leader can be profitably in the market ($n = 1$) when $x_L > s(1)$. Remembering that for any exogenous number of firms the profits of the leader

³Indeed, it can be now calculated as:

$$\begin{aligned} W^S &= \frac{X^2}{2} + \pi_L = \frac{(a - c - 2\sqrt{F})^2}{2} + 2\sqrt{F} (a - c - 2\sqrt{F}) - F = \\ &= \frac{(a - c)^2}{2} - 3F \end{aligned}$$

It can be verified that welfare is higher under Stackelberg competition with endogenous entry for any $F < 4(a - c)^2/49$, which always holds under our regularity assumption $F < (a - c)^2/16$, which guarantees that the market is not a natural monopoly.

is maximized at the monopolistic output $(a - c)/2$ and hence it is increasing before and decreasing afterward, we can determine the behaviour of the profits of the leader in function of its output distinguishing three regions.

The high output region, emerges for a small enough number of firms n such that $s(n) > (a - c)/2$. In such a case, the profit of the leader is decreasing in its output and it must be that in any interval $x_L \in [s(n), s(n - 1)]$ profits are locally maximized for $x_L = s(n)$. In correspondence of this production, each one of the n followers must supply:

$$x(s(n), n) = \frac{a - s(n) - c}{n} = \left(\frac{n + 1}{n}\right) \sqrt{F}$$

Hence, we can rewrite the profits of the leader as a function of the number of firms allowed to enter in the market:

$$\begin{aligned} \pi_L(n) &= s(n) [a - s(n) - (n - 1)x(s(n), n)] - cs(n) - F = \\ &= \left(a - c - (n + 1)\sqrt{F}\right) \left[(n + 1)\sqrt{F} - (n - 1)\left(\frac{n + 1}{n}\right)\sqrt{F}\right] - F = \\ &= \left(a - c - (n + 1)\sqrt{F}\right) \left(\frac{n + 1}{n}\right)\sqrt{F} - F = \\ &= \left(\frac{n + 1}{n}\right) (a - c)\sqrt{F} - \frac{(n + 1)^2}{n} F - F \end{aligned}$$

It can be easily verified that when n increases $\pi_L(n)$ decreases, hence it is optimal to choose a production that maximizes profits with $n = 1$, that is exactly the entry deterrence output $s(1) = a - c - 2\sqrt{F}$ and which delivers the profits $\pi_L(1)$.

The low output region emerges for any high enough number of firms n such that $s(n - 1) < (a - c)/2$. This implies that the profits of the leader are always increasing in the output. Trivially, it is never optimal to produce less than the monopolistic output.

The third case emerges for a number of firms, say m , such that $s(m) < (a - c)/2 < s(m - 1)$, or, solving for the number of firms:

$$m \in \left(\frac{a - c}{2\sqrt{F}} - 1; \frac{a - c}{2\sqrt{F}}\right)$$

In the interval of production $x_L \in [s(m), s(m - 1)]$ it is optimal for the leader to choose the monopolistic output level, because in this interval (only) profits have an inverted U shape. In this interval, the leader produces $(a - c)/2$ and each one of the $m - 1$ followers produce $(a - c)/2m$ as in a standard Stackelberg model with an exogenous number m of firms. The usual profits of the leader are then:

$$\pi_L(m) = \frac{(a - c)^2}{4m} - F$$

and we need to verify that these are always smaller than what the leader can obtain with the entry deterrence strategy. Since:

$$\pi_L(1) \gtrless \pi_L(m) \quad \Leftrightarrow \quad m \gtrless \frac{(a-c)^2}{8\sqrt{F}(a-c-2\sqrt{F})}$$

the profit maximizing choice of the leader could be in this region if there is a number of firms m that belongs to the set derived above and that is lower than the cut-off just obtained. However, this is impossible since:

$$\frac{(a-c)^2}{8\sqrt{F}(a-c-2\sqrt{F})} < \frac{a-c}{2\sqrt{F}} - 1 \quad \text{iff} \quad F > \frac{(a-c)^2}{16}$$

and we assumed $F > (a-c)^2/16$ to exclude the case of natural monopolies. In conclusion the global optimum for the leader is always entry deterrence.

2.2 U-shaped cost functions

In many markets, marginal costs of production are increasing at least beyond a certain level of output. Jointly with the presence of fixed costs of production, this leads to U-shaped average cost functions. Since technology often exhibits this pattern, it is important to analyse this case, and I will do it assuming a simple quadratic cost function.

In particular, the general profit for firm i becomes:

$$\pi_i = x_i \left(a - x_i - \sum_{j=1, j \neq i}^n x_j \right) - \frac{dx_i^2}{2} - F \quad (3)$$

where $d \in [0, 1]$ represents the degree of convexity of the cost function (when $d = 0$ we are back to the case of a constant marginal cost). The efficient scale of production can be derived formally as $\hat{x} = \sqrt{2F/d}$. Let us look now at the different forms of competition with free entry. Under Marshall competition each firm would produce:

$$x = \sqrt{\frac{2F}{2+d}} < \hat{x}$$

with a number of firms approximated by:

$$n = a\sqrt{\frac{2+d}{2F}} - d - 1$$

Notice that the equilibrium production level is below the cost minimizing level. This is not surprising since imperfect competition requires a price above marginal cost and free entry requires a price equal to the average cost. Since the average cost is always decreasing when it is higher than the marginal cost, it must be that individual output is smaller than the efficient scale.

Consider now Stackelberg competition with endogenous entry. In the last stage an entrant chooses $x(x_L, n) = (a - x_L)/(n + d)$, but the zero profit condition delivers a number of firms:⁴

$$n = (a - x_L) \left(\sqrt{\frac{2 + d}{2F}} \right) - d$$

each one producing the same output as with Marshall competition. Of course this happens when there is effective entry, that is when $n \geq 2$ or $x_L < a - (2 + d)\sqrt{2F/(2 + d)}$. In such a case, total production is:

$$X = a - (1 + d)\sqrt{\frac{2F}{2 + d}}$$

and the price becomes

$$p = (1 + d)\sqrt{\frac{2F}{2 + d}}$$

which are both independent from the leader's production. The gross profit function of the leader in the first stage, can be derived as:

$$\pi_L = px_L - \frac{d}{2}x_L^2 - F = (1 + d)\sqrt{\frac{2F}{2 + d}}x_L - \frac{d}{2}x_L^2 - F$$

which is concave in x_L . As long as d is large enough, we have an interior optimum and in equilibrium the leader prefers to allow entry producing:

$$x_L = \frac{1 + d}{d}\sqrt{\frac{2F}{2 + d}} > \hat{x} \quad (4)$$

so that the equilibrium number of firms is:

$$n = a\sqrt{\frac{2 + d}{2F}} - \left(\frac{1 + d}{d} + d \right)$$

and total output and price are the same as in the Marshall equilibrium (but total welfare must be higher since the leader makes positive profits).

Notice that the leader is producing always more than each follower. While followers produce below the efficient scale, the leader produces more than the efficient scale. Again the intuition is straightforward. Followers have to produce at a price where their marginal revenue equates their marginal cost, but free

⁴Here and in what follows, we will assume that n is a real positive number. Notice that this implies a real approximation since in equilibrium the number of firms (when larger than 1) is derived from an optimality condition and not from a free entry condition. Indeed, I was not able to prove that the exact equilibrium number of firms should be the largest integer that is smaller than the equilibrium value. Nevertheless, our analysis remains a good approximation when the number of firms is large enough, that is when the fixed costs are small enough.

entry implies also that the price has to be equal to the average cost. Since marginal and average costs are the same at the efficient scale, the followers must be producing below the efficient scale. The equilibrium price represents the perceived marginal revenue for the leader, and the leader must produce where this perceived marginal revenue equates the marginal cost, which in this case can only be above the efficient scale.

2.3 Product Differentiation

We now move to another simple extension of the basic model introducing product differentiation and hence imperfect substitutability between the goods supplied by the firms. We retain the initial assumptions of constant marginal costs and competition in quantities.

For simplicity, consider the inverse demand function for firm i $p_i = a - x_i - b \sum_{j \neq i} x_j$, where $b \in (0, 1]$ is an index of substitutability between goods (for $b = 0$ goods are perfectly independent and each firm sells its own good as a pure monopolist, while for $b = 1$ we are back to the case of homogeneous goods). In this more general framework the profit function for firm i is:

$$\pi_i = x_i \left(a - x_i - b \sum_{j=1, j \neq i}^n x_j \right) - cx_i - F \quad (5)$$

The main equilibria can be derived as usual. In particular in the Marshall equilibrium each firm would produce:

$$x = \sqrt{F}$$

with a number of firms:

$$n = 1 + \frac{a - c}{b\sqrt{F}} - \frac{2}{b}$$

Under Stackelberg competition with free entry, as long as substitutability between goods is limited enough (b is small) there are entrants producing $x(x_L, n) = (a - bx_L - c)/[2 + b(n - 2)]$. Setting their profits equal to zero the endogenous number of firms results in:

$$n = 2 + \frac{a - bx_L - c}{b\sqrt{F}} - \frac{2}{b}$$

implying once again the same production as under Marshall equilibrium for each follower. Plugging everything into the profit function of the leader, we have:

$$\begin{aligned} \pi_L &= x_L [a - x_L - b(n - 1)x] - cx_L - F = \\ &= x_L [(2 - b)\sqrt{F} - (1 - b)x_L] - F \end{aligned}$$

that is maximized when the leader produces:

$$x_L = \frac{2-b}{2(1-b)}\sqrt{F} > x \quad (6)$$

As long as b is small enough, this strategy leaves space to the endogenous entry of firms so that the total number of firms in the market is:

$$n = 2 + \frac{a-c}{b\sqrt{F}} - \frac{2}{b} - \frac{2-b}{2(1-b)}$$

Notice that the leader will offer its good at a lower price than the followers, namely:

$$p_L = c + \left(1 - \frac{b}{2}\right)\sqrt{F} < p = c + \sqrt{F}$$

but the leader will also produce more than each follower and so it will earn positive profits. Again one should remember that this outcome emerges if the degree of product differentiation is high enough, while for b large enough the only possible equilibrium implies entry deterrence, with the production of the leader $x_L = (a-c-2\sqrt{F})/b$ and the limit price $p_L = [c - (1-b)a + 2\sqrt{F}]/b$.

As we have seen, product differentiation allows different prices to emerge in the market. This leads us to the need to explicitly consider the choice of prices, that is to models of price competition.

2.4 A Simple Model of Competition in Prices

In many markets, especially under relevant product differentiation, firms compete in prices rather than in quantities. One of the simplest cases to analyse emerges when the demand function is log-linear. A direct demand which is often used for empirical studies is the Logit demand, which in its simplest form is $D_i = e^{-\lambda p_i} / \left[\sum_{j=1}^n e^{-\lambda p_j}\right]$ where of course p_i is the price of firm i , while $\lambda > 0$ is a parameter governing the slope of the demand function.⁵ Since we focus on substitute goods, such a demand for firm i is decreasing in the price of the same firm i and increasing in the price of any other firm j . The general profit function for a firm facing this demand and, once again, a constant marginal cost c is:

$$\pi_i = D_i(p_i - c) = \frac{e^{-\lambda p_i}}{\sum_{i=1}^n e^{-\lambda p_j}}(p_i - c) \quad (7)$$

In a Nash-Bertrand equilibrium each firm chooses its own price taking as given the prices of the other firms. The first order condition for the optimal price of a single firm i simplifies to:

$$p_i = c + \frac{1}{\lambda(1 - D_i)}$$

⁵We assume the regularity condition $F < 1/\lambda$.

While this is an implicit expression (on the right hand side the demand of the firm i depends on the price of the same firm), it emphasizes quite clearly that the price is set above marginal cost. Moreover, since an increase in the price of any other firm j , p_j , increases demand for firm i , D_i , it also increases the optimal price of firm i . Formally we have strategic complementarity: $\partial p_i / \partial p_j > 0$. This important property, which holds virtually in all models of competition in prices, suggests that a higher price by one firm induces other firms to increase their prices as well. In other words, an accomodating behaviour of one firm leads other firms to be accomodating too. In a symmetric equilibrium we must have $D = 1/n$, and under free entry a Marshall equilibrium implies the number of active firms:

$$n = 1 + \frac{1}{\lambda F}$$

with a price:

$$p = c + \frac{1}{\lambda} + F$$

Let us now move to models of price leadership. Of course it can be even harder for a firm to commit to a price rather than to a different strategy as the quantity of production. In the next section we will face this problem in a deeper way and we will suggest that there are realistic ways in which a strategic investment can be a good substitute for a commitment to a strategy, including a price strategy. However, here we will assume that a firm can simply commit to a pricing strategy and analyse the consequence of this.

For the Stackelberg equilibrium we do not have analytical solutions. However, the leader is aware that an increase in its own price will lead each other follower to increase its own price, hence, the commitment possibility is generally used to adopt an accomodating strategy: the leader chooses a high price to induce its followers to choose high prices as well.⁶ The only case in which this does not happen is when fixed costs of production are high enough and the leader finds it profitable to deter entry, which can only be done adopting a low enough price: hence, the leader can only be aggressive for exclusionary purposes. However, this standard result emphasizes a possible inconsistency within this model, at least when applied to describe real markets. We have suggested leaders are accomodating when fixed costs of production (or entry) are small, because in such a case an exclusionary strategy would require to set a very low price and would be too costly. But these are exactly the conditions under which other firms may want to enter in the market: fixed costs are low and exclusionary strategies by incumbents are costly. Hence, the assumption that the number of firms, and in particular of followers, is exogenous becomes quite unrealistic. In these cases, it would be useful to endogenize entry.

⁶Nevertheless, the followers will have incentives to choose a lower price than the leader, and each one of them will then have a larger demand and profits than the leader: there is a second-mover advantage rather than a first-mover advantage.

Let us look at the Stackelberg equilibrium with endogenous entry. The solution in this case is slightly more complex, but it can be fully derived. First of all, as usual, let us look at the stage in which the leader as already chosen its price p_L and the followers enter and choose their prices. As before, their choice will follow the rule:

$$p_i = c + \frac{1}{\lambda(1 - D_i)}$$

where the demand on the right hand side depends on the price of the leader and all the other prices as well. However, under free entry we must have also that the markup of the followers exactly covers the fixed cost of production, hence:

$$D_i(p_i - c) = F$$

If the price of the leader is not too low or the fixed cost not too high, there is indeed entry in equilibrium and we can solve these two equations for the demand of the followers and their prices in symmetric equilibrium:

$$p = c + \frac{1}{\lambda} + F, \quad D = \frac{\lambda F}{1 + \lambda F}$$

Notice that neither the one or the other endogenous factors depend on the price chosen by the leader. Hence, it must be that the strategy of the leader is going to affect only the number of followers entering in equilibrium, but not their prices or their equilibrium production.

The leader is going to perceive this because its demand can now be calculated as:

$$D_L = \frac{e^{-\lambda p_L}}{\sum_{i=1}^n e^{-\lambda p_j}} = \frac{e^{-\lambda p_L}}{e^{-\lambda p}} D$$

Since neither p or D depend on the price of the leader, its demand is a simple function of its own price, and the profits of the leader can be derived as:

$$\pi_L = (p_L - c)D_L = (p_L - c)e^{-\lambda p_L} \left[\frac{e^{\lambda(c+F)+1}}{1 + 1/\lambda F} \right]$$

where we used our previous results for p or D . Profit maximization by the leader provides its equilibrium price:

$$p_L = c + \frac{1}{\lambda} < p \tag{8}$$

which is now lower than the price of each follower. Finally the number of firms active in the market is:

$$n = 2 + \frac{1}{\lambda F} - e^{\lambda F}$$

Rather than being accommodating as in the Stackelberg equilibrium, the behaviour of the leader in a Stackelberg equilibrium with endogenous entry is

radically different: the leader is aggressive since it chooses a lower price and ends up selling more of its products. However, some followers enter in the market, and they have to choose a higher price than the leader without earning any profits.⁷

3 Strategic Commitments

In this section, following Etro (2006a), I will present a general model of Nash competition with strategic investment by a leader. Since my main focus is on equilibria with endogenous entry, I need a general model which can account for multiple firms and has profits be 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 $i = 1, 2, \dots, n$. They all compete in Nash strategies, that is taking as given the strategies of each other. These strategies deliver for each firm i the net profit function:

$$\pi_i = \Pi(x_i, \beta_i, k) - F \quad (9)$$

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 quasiconcave in x_i .

The second argument represents the effects (or spillovers, even if this is not the proper term) 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 $h(x)$ which 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, k is a profit enhancing factor ($\Pi_3 > 0$) which 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 and we will assume that k is chosen as a continuous variable (but our results can be extended to the case of discrete choices). The cost of its strategic investment is given by the function $f(k)$ with $f'(k) > 0$ and $f''(k) > 0$. Our focus will be exactly on the incentives for this firm to undertake such an investment so as to maximize its total profits:⁸

$$\pi_L(k) = \Pi^L(x_L, \beta_L, k) - f(k) - F \quad (10)$$

⁷Also in this case, if the fixed cost is high enough, it may be optimal for the leader to fully deter entry, choosing a price $p_L = c + 1/\lambda + F - (1/\lambda) \log(1/\lambda F)$.

⁸To avoid confusion, I will add the label L to denote the profit function, the strategy and the spillovers of the leader.

where x_L is the strategy of the leader and $\beta_L = \sum_{j \neq L} h(x_j)$. We will 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 ($\Pi_{13}^L < 0$).

3.1 Market structures nested in the model

Most of the commonly used models of oligopolistic competition in quantities and in prices are nested in our general specification.⁹ 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 $p_i = p \left[x_i, \sum_{j \neq i} h(x_j) \right]$ 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:

$$\Pi(x_i, \beta_i) = x_i p(x_i, \beta_i) - c(x_i) \quad (11)$$

Examples include linear demands, as those of Section 2 and other common cases. This set up satisfies our 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:

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

is nested in our 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 $\partial D_i / \partial p_j = D_2 g'(p_j) > 0$. Examples include models of price competition with Logit demand as the one used in Section 2, isoelastic demand and constant expenditure demand (see Vives, 1999, for a survey of these models)¹⁰ and other demand functions as in the general class due to Dixit and Stiglitz (1977). Adopting, just for simplicity, a constant marginal cost c , we obtain the gross

⁹In the following examples I omit the variable k for simplicity.

¹⁰For instance, consider a isoelastic utility like $u = \left[\sum_{j=1}^n C_j^\theta \right]^\gamma - \sum_{j=1}^n p_j C_j$, where $\theta \in (0, 1]$ 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 our framework after setting $g(p) = p^{-\theta/(1-\theta)}$. The Logit demand requires $g(p) = e^{-\lambda p}$. Notice that linear demands are not nested in our model.

profits for firm i :

$$\Pi(x_i, \beta_i) = \left(\frac{1}{x_i} - c\right) D\left(\frac{1}{x_i}, \beta_i\right) = (p_i - c) D(p_i, \beta_i) \quad (12)$$

which is nested in our general model and, under weak conditions assumed through the paper, implies SC.

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

3.2 Strategic investment by the leader

We 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.

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. 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:

$$\Pi_1[x, (n-2)h(x) + h(x_L), \bar{k}] = 0 \quad (13)$$

$$\Pi_1^L[x_L, (n-1)h(x), k] = 0 \quad (14)$$

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

As well known, when n is exogenous, we have the following traditional result due to Fudenberg and Tirole (1984): with an exogenous number of firms: 1) when the leader is tough ($\Pi_{13}^L > 0$), strategic over (under)-investment occurs under SS (SC), inducing a “top dog” (“puppy dog”) strategy; 2) when the leader is soft ($\Pi_{13}^L < 0$), strategic under (over)-investment occurs under SS (SC), inducing a “lean and hungry” (“fat cat”) strategy.

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 . The equilibrium conditions in the second stage for a given preliminary investment k are the optimality conditions (13)-(14) and the zero profit condition for the followers:

$$\Pi[x, (n-2)h(x) + h(x_L), \bar{k}] = F \quad (15)$$

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

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

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:

$$x'_L(k) = -\frac{\Pi_{13}^L}{\Pi_{11}^L - h'(x_L)\Pi_{12}^L} \begin{cases} \geq 0 & \text{for } \Pi_{13}^L \geq 0 \\ < 0 & \text{for } \Pi_{13}^L < 0 \end{cases}$$

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

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

and hence it satisfies the optimality condition:

$$\Pi_3^L + \frac{h'(x_L)\Pi_2^L\Pi_{13}^L}{\Pi_{11}^L - h'(x_L)\Pi_{12}^L} = f'(k) \quad (16)$$

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 our focus is on the strategic incentive to invest, I will normalize the profit functions in such a way that, in absence of strategic motivations, the leader would choose $k = \bar{k}$ resulting in a symmetric situation with the other firms. 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 noticed 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 be always more aggressive in the market than any other firm. Summarizing, we have:

Proposition 1. Under Nash competition with endogenous entry, when the strategic investment makes the leader tough (soft), over (under)-investment 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 behaviour 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; while when $\Pi_{13}^L < 0$ we always have a “lean and hungry” look with underinvestment, but the behaviour 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 a fixed number of firms (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 anti-trust policy.

4 Applications and Policy Implications

I will now present some applications of the general principle we just derived. First, I will deal with standard industrial organization issues. The focus of Sections 4.1 and 4.2 is on investments in technological improvements (which shift the cost function) and quality improvements (which shift the demand function), while Section 4.3 will develop applications to dynamic markets with network effects or learning by doing. Section 4.4 is about corporate finance strategies and Section 4.5 about discrete strategic choices as bundling. In Section 4.6 I will briefly show that the aggressive behaviour of leaders emerges in general also in case of pure Stackelberg competition with free entry under both quantity and price competition: this simpler set up, which can be seen as a reduced form of our model with strategic investments, allows to make some welfare comparisons. Finally, Section 4.7 draws conclusions for antitrust policy with particular reference to abuse of dominance issues.

4.1 Cost reducing investments

Our 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 free. 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:

$$\Pi^L(x_L, \beta_L, k) = x_L p(x_L, \beta_L) - c(k)x_L \quad (17)$$

Notice that Π_{12}^L has an ambiguous sign, but $\Pi_{13}^L = -c'(k) > 0$. Hence, the leader may overinvest or underinvest when the number of followers is exogenous,

but, according to Prop. 1, will always overinvest in cost reduction and produce more than the other firms when entry is endogenous. For instance, assuming perfect substitutability and, once again, a linear 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:

$$k = \frac{2d\sqrt{F}}{1 - 2d^2}$$

and produces:

$$x_L = \frac{\sqrt{F}}{1 - 2d^2}$$

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 (exactly as in the example of Section 2).

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:

$$\Pi^L(x_L, \beta_L, k) = \left[\frac{1}{x_L} - c(k) \right] D\left(\frac{1}{x_L}, \beta_L\right) \quad (18)$$

where $\Pi_{13}^L = c'(k)D_1/x_L^2 > 0$. Hence, underinvestment in cost reduction emerges when there is a fixed number of firms, but overinvestment is optimal when there is endogenous entry. Whenever this is the case, the leader wants to improve its cost function to be more aggressive in the market by selling its good at a lower price. Summarizing, we have:¹¹

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

Our results can also be used to re-interpret models of predatory pricing through *cost signaling*. In a classic work, Milgrom and Roberts (1982) have studied the entry decision of an entrant in a duopoly with an incumbent that is already active in the market, and have introduced incomplete information: since informational asymmetries are beyond the scope of this book, we will just sketch their idea to emphasize the similarities with our approach. Imagine that the entrant does not know the cost of the leader, that can be a high cost or a low cost, but would like to enter only when facing a high cost leader. They study under which conditions preliminary strategies of the leader induce entry deterrence. For instance, a low cost leader can signal its own efficiency

¹¹Welfare analysis is beyond the scope of this paper, but in this case one can show that leadership improves the allocation of resources. This is not due only to the cost reduction, but also to the reduction in the number of firms as long as Cournot and Bertrand equilibria with free entry are characterized by excessive entry, together with the low equilibrium price induced by the entry threat.

through initial overproduction (associated to a sacrifice of profits) as long as this is relatively cheaper for the low cost leader compared to the high cost one. This sorting or single crossing condition is respected here exactly because the marginal profitability of production decreases with the marginal cost: in our terminology, if a low cost leader has a higher k and hence a lower marginal cost $c(k)$, we have $\Pi_{13}^L > 0$. Then, in a separating equilibrium a low cost leader is initially aggressive overproducing enough to signal its efficiency and induce the follower not to enter, while a high cost leader does not imitate such a strategy because it is more profitable to behave monopolistically initially and accommodate entry subsequently. This result shows that cost reductions can have a strategic role also in presence of incomplete information about costs.¹²

Notice that even without exclusionary purposes, a leader may like to signal its own type to affect post-entry competition with incomplete information on costs. Under competition in quantities and SS, a low cost leader may signal its efficiency to reduce the equilibrium output of the entrant and increase its own, but under price competition it is a high cost leader that wants to signal its inefficiency to induce high prices by the entrant and high profits for both, a point first made by Fudenberg and Tirole (1984). Without developing the argument in technical details, we can point out that when entry is endogenous there can only be a gain from signaling efficiency, since signaling a high cost would not soften price competition, but just induce further entry. In the spirit of our model, we can conclude suggesting that also under incomplete information about costs, there is a positive role for a positive strategic investment in cost reductions whenever entry in the market is endogenous.

4.2 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 to reduce the substitutability with other goods.¹³ Under endogenous 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 on its slope is negative ($p_{13} < 0$), which implies that a higher investment not only increases demand, but it also makes it more inelastic. Its gross profit becomes:

$$\Pi^L(x_L, \beta_L, k) = x_L [p(x_L, \beta_L, k) - c] \quad (19)$$

¹²When the probability that the leader is low cost is high enough a pooling equilibrium occurs. In such a case, the high cost leader produces the same monopolistic output of the low cost leader, and the entrant does not enter anyway.

¹³Notice that investment in *informative advertising* has a similar role, so our conclusions apply to that case as well.

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 free entry overinvestment takes place if and only if $\eta < 1$.¹⁴ Whether this is the case or not, the leader ends up selling more than any other firm.

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:

$$\Pi^L(x_L, \beta_L, k) = \left(\frac{1}{x_L} - c\right) D\left(\frac{1}{x_L}, \beta_L, k\right) \quad (20)$$

where $\Pi_{13}^L = -[D_3 + (1/x_L - c)D_{13}]/x_L^2 < 0$. In this case with an exogenous number of firms 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 behaviour of the leader radically changes and there is always underinvestment in quality improvements so as to reduce the price below the price of the followers. Fudenberg and Tirole (1984) have introduced a simple example of investment in advertising that is nested in our framework and derived from Schmalensee (1982). Imagine that firms compete in prices on the same customers, but the leader, through a costly investment in advertising k , can obtain an extra demand $D(k)$ from new customers, with $D'(k) > 0$. This simple stylized set up delivers a profit function for the leader:

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

while the profits for the other firms are the same as before. The cross effect is now $\Pi_{13}^L = -(1/x_L^2)D'(k) < 0$. Hence, as Fudenberg and Tirole (1984) noticed in the case of two firms, “if the established firm chooses to allow entry, it will advertise heavily and become a fat cat in order to soften the entrant’s pricing behavior”, but when entry of firms is endogenous, the leader may allow entry of some firms but underinvest in advertising to keep low prices. Summarizing we have:

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 has always an incentive to underinvest in quality.

These results apply also in 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 a fixed number of firms, especially under price competition.

¹⁴The model can also be reinterpreted in terms of *product differentiation*.

4.3 Debt financing

We can also apply our results to the theory of corporate finance to study the strategic role of the financial structure. As shown by Brander and Lewis (1986, 1988) and Showalter (1995, 1999) in models of duopolies with uncertainty, when the strategies in the product market are managed by the equity holders, debt makes these more aggressive. Hence, there can be a bias toward debt financing in the optimal financial structure, departing from the standard neutrality results of Modigliani and Miller (1958).¹⁵ Once again, the outcome depends on the kind of competition and also on the kind of uncertainty.

Here we will extend this analysis to multiple firms and to endogenous entry of firms. For finance to play a role we need to introduce uncertainty on profits. Imagine that the financial structure of the followers is given, and for simplicity it implies no debt. The leader, however, can adopt a different financial structure by issuing positive debt at a preliminary stage. Afterward, equity holders choose their market strategies, uncertainty is solved and payoffs for equity holders and debt holders are assigned.

Consider a model where the profit functions are disturbed by a random shock $z \in [\underline{z}, \bar{z}]$ independently and identically distributed according to the cumulative function $G(z)$ with density $g(z)$ affects profits of firm i . For simplicity, imagine that the total financing requirement is fixed and the leader can just decide its debt level k to be repaid out of gross profits, if these are sufficient. Once this choice is taken, competition takes place and finally uncertainty is revealed and each firm obtains its own profits net of the debt or goes bankrupt.

If the gross profits of the leader can be written as $R(x_L, \beta_L, z)$ with the usual notation, the value of equity, corresponding to the expected profits net of debt repayment can be written as:

$$\mathbf{E}(k) = \Pi^L(x_L, \beta_L, k) - F = \int_{\hat{z}}^{\bar{z}} [R(x_L, \beta_L, z) - k] g(z) dz - F \quad (21)$$

where the lower bound \hat{z} is such that gross profits are zero:

$$R(x_L, \beta_L, \hat{z}) = k + F$$

which implies $d\hat{z}/dk = 1/R_z(x_L, \beta_L, \hat{z})$. We assume usual properties for the profit function ($R_{xx}(x_L, \beta_L, z) < 0$), and we also assume, without loss of generality in our conclusions, that the random variable is chosen so that $R_z(x_i, \beta_i, z) > 0$: this implies that the cut-off level of the shock below which bankruptcy occurs is increasing in the debt level, $d\hat{z}/dk > 0$.

For instance, we could think of a model of competition in quantities where:

$$R(x_i, \beta_i, z) = x_i p(x_i, \beta_i, z) - c(x_i, z)$$

¹⁵See Tirole (2006, Ch. 7) for a survey.

and $p_z(x_i, \beta_i, z) > 0$, $c_z(x_i, z) < 0$: a positive shock increases demand or reduces costs. In case of a stochastic linear demand $p = z - \sum x_j$ and no costs, we would have $\hat{z} = (k + F)/x_L + \sum x_j$, which is of course increasing in the debt level. We can also have a models of competition in prices with:

$$R(x_i, \beta_i, z) = \left[\frac{1}{x_i} - c(z) \right] D \left(\frac{1}{x_i}, \beta_i, z \right)$$

and we allow explicitly for an impact of uncertainty on both demand and costs. Our assumptions are compatible with $D_z(1/x_i, \beta_i, z) > 0$ and $c_z(z) < 0$: a positive shock increases demand or reduces costs.

In general we have:

$$\Pi_1^L(x_L, \beta_L, k) = \int_{\hat{z}}^{\bar{z}} R_x(x_L, \beta_L, z) g(z) dz - [R(x_L, \beta_L, \hat{z}) - k] \frac{d\hat{z}}{dk}$$

whose last term is zero by the definition of \hat{z} . In any equilibrium, the optimal behaviour of each firm would require that the expectation of its marginal profit is set equal to zero. But notice that what is relevant for a firm with a positive debt, are the expected profits conditional on these being positive after debt repayment, and this affects substantially the marginal profits as well. When $R_{xz}(x_L, \beta_L, z)$ is positive, marginal profit increases in \hat{z} and hence in the debt level, and the opposite happens when $R_{xz}(x_L, \beta_L, z)$ is negative. As always, it is crucial to derive the sign of the cross effect:¹⁶

$$\begin{aligned} \Pi_{13}^L(x_L, \beta_L, k) &= -R_x(x_L, \beta_L, \hat{z}) \frac{d\hat{z}}{dk} = \\ &= \frac{-R_x(x_L, \beta_L, \hat{z})}{R_z(x_L, \beta_L, \hat{z})} \stackrel{\geq}{<} 0 \text{ if } R_{xz}(x_L, \beta_L, z) \stackrel{\geq}{<} 0 \end{aligned}$$

This implies that when the number of firms is exogenous, under SS, there is a strategic incentive to issue debt when a positive shock increases marginal profits ($R_{xz}(x_L, \beta_L, z) > 0$) and under SC in the opposite case ($R_{xz}(x_L, \beta_L, z) < 0$). For instance, under competition in quantities there is a strategic role for debt financing whenever SS holds (Brander and Lewis, 1986), while under competition in prices with SC there is a role for debt financing only in presence of demand uncertainty but not of cost uncertainty (Showalter, 1995). Things are however different when entry takes place until expected profits are zero. In this case we can conclude that:

Proposition 4. Under endogenous entry, a firm has an incentive to adopt debt financing to be more aggressive in the competition whenever a positive shock increases marginal profits.

¹⁶The sign of the marginal profit at its bounds \hat{z} and \bar{z} depends on the sign of $R_{xz}(x_L, \beta_L, z)$. In particular $R_x(x_L, \beta_L, \hat{z}) \stackrel{\leq}{\geq} 0$ if $R_{xz}(x_L, \beta_L, z) \stackrel{\geq}{<} 0$.

In general, under quantity competition there is always a strategic bias toward debt financing (under both SS and SC), while under price competition there is only when uncertainty affects costs, but not when it affects demand, the opposite as before. The intuition is again related with the role of debt financing in inducing a more aggressive behaviour in the competition, which is always desired for the leader facing endogenous entry. Under price competition and demand uncertainty, for instance, a higher debt increases the marginal profitability of a higher price strategy, hence it helps implementing a more accommodating strategy in the market: just what a leader would like to do when facing exogenous entry, but the opposite of what would be desirable in front of endogenous entry. On the other side, under cost uncertainty, more debt induces lower price strategies, which is suboptimal with exogenous entry and optimal with endogenous entry.

To complete our analysis, notice that a leading firm would actually choose debt to maximize its overall value, that is the equity value $\Pi^L(x_L, \beta_L, k)$ plus the debt value:

$$\mathbf{D}(k) = \int_{\underline{z}}^{\hat{z}} R(x_L, \beta_L, z)g(z)dz + k[1 - G(\hat{z})] \quad (22)$$

where the first term represents the expected repayment in case of bankruptcy and the second one the repayment in case of successful outcome for the firm. The value of the firm is then:

$$\mathbf{V}(k) = \mathbf{E}(k) + \mathbf{D}(k) = \int_{\underline{z}}^{\bar{z}} R(x_L, \beta_L, z)g(z)dz - F \quad (23)$$

which corresponds to the expected profits of the firm.¹⁷ Of course, if the strategies were not affected by the debt level, there would be no impact of the latter on the value of the firm, and we would obtain the traditional neutrality result of Modigliani and Miller (1958). But we have seen that the debt level affects product market competition and that it can induce the leader to be more aggressive in it. For this reason here, the optimal financial structure can require a bias toward debt financing whenever there is a strategic role for the debt, that is whenever a positive shock increases marginal profitability of an aggressive strategy.

4.4 Learning by doing and network externalities

Consider now dynamic models where profitability depends on past strategies. For instance, learning by doing implies that the cost function is decreasing

¹⁷The model can be easily extended to take bankruptcy costs and taxes into account. We leave this for future research.

in past production,¹⁸ while network externalities imply that demand is enhanced by past production and the consequent diffusion of the product across customers.¹⁹ In these contexts it is natural to think in terms of quantity competition and, for simplicity, following Bulow *et al.* (1985), I will focus on two period models with the leader alone in the market in the first period and facing free entry in the second period. In case of learning by doing the leader will always overproduce initially to exploit the learning curve.²⁰ In case of demand externalities the leader will overproduce initially to create network effects, which broadly matches pricing strategies by leaders in high tech sectors characterized by network externalities.

To formalize these results in the simplest setting, assume perfectly substitute goods. Imagine that in the first period the leader produces k facing the inverse demand $p(k)$ and a marginal cost c . In the second period other firms compete in quantities and the leader faces the inverse demand $p(x_L + \beta_L)\phi(k)$ where $\phi(k)$ is some increasing function of past production, which is a measure of the diffusion of the product across consumers (and induces the network externality), while the marginal cost $c(k)$ is decreasing in past production (because of learning by doing). The profit function for the leader becomes:

$$\Pi^L(x_L, \beta_L, k) = kp(k) - ck + \delta [p(x_L + \beta_L)\phi(k) - c(k)]x_L \quad (24)$$

where $\delta < 1$ is the discount factor. In this case in equilibrium we have $\Pi_{13}^L = \delta [\phi'(k)/c(k)\phi(k) - c'(k)] > 0$ which already suggests that the initial monopolist will overproduce to be more aggressive when the market opens up. Moreover, the choice of initial production will satisfy:

$$p(k) + kp'(k) = c - \delta x_L [p\phi'(k) - c'(k)] - \delta x_L c(k) [\phi'(k)/\phi(k) - c'(k)/c(k)]$$

which equates marginal revenue to effective marginal cost. The latter includes the myopic marginal cost c , a second term which represents the direct benefit due to the network effects on future demand and costs and a last term representing the indirect (strategic) benefits due to the commitment to adopt a more aggressive strategy in the future. Summarizing:

Proposition 5. Under learning by doing and network externalities a firm has always an incentive to overproduce initially so as to be more aggressive when endogenous entry takes place in the future.

Notice that the leader may engage in *dumping* (pricing below marginal cost) in the first period (if the discount factor is large enough), but this may well be beneficial to consumers in both periods.

¹⁸This is the typical case of the aircraft industry (Boeing, Airbus), the production of chips (Intel) and many other sectors with a fast technological progress.

¹⁹This may be the case of the markets for operating systems and general softwares (Microsoft), computers (IBM, Hewlett Packard) or wireless and broadband communications (Nokia, Motorola).

²⁰Notice however, that the opposite result (underproduction) holds when initial production increases future marginal cost (which is the case of *natural resource markets*).

4.5 Bundling and discrete commitments

Our general result applies also in case of discrete choices. An important example is the choice between bundling or not two goods, which is the subject of this section. According to the traditional leverage theory of tied good sales, monopolists would bundle their products with others for competitive or partially competitive markets to extend their monopolistic power. Such a view as been criticized by the Chicago school because it would erroneously claim that a firm can artificially increase monopolistic profits from a competitive market. Bundling should have different motivations, as price discrimination or creation of joint economies, whose welfare consequences are ambiguous and sometimes even positive. Whinston (1990) and others exponents of the post-Chicago approach have changed the terms of the discussion trying to verify how a monopolist can affect strategic interaction with competitors in another market by bundling. His main finding is that the only reason why a monopolist could bundle is to deter entry (as in Dixit, 1980), which has typically negative effects on welfare. His analysis is based on price competition between two firms, hence strategic complementarity holds, and it can be extended in many directions, especially including complementarities between products.

We go beyond Whinston's analysis and consider a more general model where there may be more firms and alternative market structures. In particular, under free entry, bundling may become the optimal aggressive strategy. In this case, bundling does not need to have an exclusionary purpose as assumed by the leverage theory, and the reduction in the price of the two bundled goods together can also benefit consumers.

To make our point in a neat way, let us follow the example by Tirole (1988), who has shown that a monopolist in one market does not have incentives to bundle its product with another one sold in a duopolistic market (unless this deters entry in the latter), and that this corresponds to a "puppy dog" (accommodating) strategy (see Fudenberg and Tirole, 1984). I will show that when entry in the secondary market is endogenous bundling may become the optimal "top dog" (aggressive) strategy.

Imagine that a monopolistic market is characterized by zero costs of production and unitary demand at price v , which corresponds to the valuation of the good. For simplicity, there are no complementarities with a good produced in another market which is characterized by standard price competition, a fixed cost F and a constant marginal cost c .

Gross profits for the monopolist without bundling are:

$$\Pi^M(p_M, \beta_M) = v + (p_M - c) D(p_M, \beta_M) - F \quad (25)$$

while profits for the other firms are:

$$\Pi^i(p_i, \beta_i) = (p_i - c) D(p_i, \beta_i) - F \quad (26)$$

In Bertrand equilibrium with n firms we have that $p_i = p$ for all firms satisfying:

$$pD_1 [p, (n-1)g(p)] + D [p, (n-1)g(p)] = cD_1 [p, (n-1)g(p)]$$

If endogenous entry holds, the number of firms is pinned down by the free entry condition $(p-c)D [p, (n-1)g(p)] = F$, so that the monopolist enjoys just the profits $\Pi^M = v$.

Under bundling, demand for the monopolist is constrained by demand for the other good, which is assumed less than unitary. Given a bundle price corresponding to $P_M = v + p_M$, profits for the monopolist become:

$$\Pi^{MB} (p_M, \beta_M, \text{Bundling}) = (P_M - c) D(P_M - v, \beta_M) = (p_M + v - c) D(p_M, \beta_M)$$

while the other firms have the same objective function as before. In equilibrium the monopolist chooses the price P_M satisfying:

$$p_M D_1 [p_M, (n-1)g(p)] + D [p_M, (n-1)g(p)] = (c-v)D_1 [p_M, (n-1)g(p)]$$

while each one of the other firms chooses p satisfying:

$$pD_1 [p, g(p_M) + (n-2)g(p)] + D [p, g(p_M) + (n-2)g(p)] = cD_1 [p, g(p_M) + (n-2)g(p)]$$

If endogenous entry holds, the number of firms satisfies also a free entry condition $(p-c)D [p, g(p_M) + (n-2)g(p)] = F$, so that the profit of the monopolist becomes $\Pi^{MB} = (p_M + v - c) D [p_M, (n-1)g(p)]$.

Clearly bundling is optimal if $\Pi^{MB} > \Pi^M$, and we need to verify under which conditions this happens. The first element to take in consideration is the way in which bundling changes the strategy of the monopolist. Since:

$$\Pi_1^{MB} - \Pi_1^M = vD_1 < 0 \quad (27)$$

bundling makes the monopolist tough. This implies that the monopolist is led to reduce the effective price in the other market by choosing a low price of the bundle. Since strategic complementarity holds, a price decrease by the monopolist induces the other firms to decrease their prices. When the number of firms is fixed, as in the duopoly considered by Whinston (1990), this reduces profits of all firms in the other market, hence bundling is never optimal unless it manages to deter entry. When entry is endogenous, however, result can change: bundling can now be an effective device to outplace some of the other firms without deterring entry but creating some profits for the monopolist in the other market through an aggressive strategy. In particular, bundling is optimal if the low price of the bundle increases profits in the competitive market more than it reduces them in the monopolistic one. It is easy to verify that bundling is optimal if:

$$(p_M - c)D [p_M, (n-1)g(p)] - F > v \{1 - D [p_M, (n-1)g(p)]\}$$

whose left hand side is the gain in profits in the competitive market and whose right hand side is the loss in profits in the monopolistic market. In conclusion:

Proposition 6. Bundling is the optimal aggressive strategy for a monopolist in the primary market facing endogenous entry in the secondary market and it does not need to have an exclusionary purpose as when there is an exogenous number of firms in the secondary number.

Notice that the reduction in the price of the two bundled goods together can also benefit consumers. This is even more likely when they are complements. This may have radical anti-trust implications since it shows that bundling is an efficient strategy by leaders in competitive markets.

Bundling is an example of a discrete strategy: a firm either bundle two goods or not. A similar story can be used to evaluate a related discrete strategy, the choice of product compatibility and system compatibility, or *interoperability*: as Tirole (1988, p. 335) has correctly noticed, “a manufacturer that makes its system incompatible with other systems imposes a de facto *tie-in*.” Typically product compatibility softens price competition because consumers can mix and match products of different firms: these products endogenously become complement, while they would be substitutes in case of incompatibility. Since price cuts are more profitable when competing products are substitutes rather than complements, interoperability softens price competition.

Hence, according to the standard outcome under price competition with an exogenous number of competitors, the only reason why a leader would choose a low level of interoperability would be to induce their exit from the market. On the contrary, if entry in the market is endogenous, a leader would always favour a low level of interoperability for a different purpose than entry deterrence: just because this strategy would strengthen price competition and enhance the gains from a low pricing strategy in the system competition, that is the competition between alternative systems. This may shed some light on the reason for which market leaders as IBM or Microsoft have been often accused by their competitors of limiting interoperability with their products: followers typically dislike strategies that strengthen price competition and like strategies that soften price competition.

4.6 Vertical restraints

Vertical restraints are agreements or contracts between vertically related firms. They include *franchise fees*, that specify a non-linear payment of the downstream firm for the inputs provided by the upstream firm with a fixed fee and a variable part (so that the average price is decreasing in the number of units bought), quantity discounts and various forms of rebates, that often play a similar role to the one of the franchise fees, exclusivity clauses and other minor

restraints. When these restraints improve the coordination of a vertical chain, they are typically welfare improving, however, when they affect *interbrand competition*, that is competition between different products and different vertical chains, they can induce adverse consequences on consumers: namely they can be used to keep high prices. This is the standard result of the theory of strategic vertical restraints in interbrand competition (Bonanno and Vickers, 1988), which suggests that, as long as firms compete in prices, a firm has incentives to choose vertical separation and charge his retailer a franchise fee together with a wholesale price above marginal cost to induce an accomodating behaviour.

Consider an upstream firm that delegates production to a downstream firm through a contract implying a fee Υ and a wholesale price w for the input. The downstream firm chooses the price p_D to maximize net profits:

$$\pi_D = (p_D - w)D(p_D, \beta_D) - \Upsilon - F$$

while the other firms, that are vertically integrated and face a cost c for the input, have the standard profit function:

$$\pi_i = (p_i - c)D(p_i, \beta_i) - F$$

The upstream firm can preliminarily choose the optimal contract, meaning the wholesale price and the fee that maximize net profits:

$$\pi_U = (w - c)D(p_D, \beta_D) + \Upsilon$$

It is always optimal to choose w such that the profits of the downstream firm are maximized, and the fee that fully expropriates these profits. If competition is between an exogenous number of firms, it is also optimal to choose a high wholesale price $w > c$ to soften competition in the market, and increase prices compared to the outcome in which the firm is vertically integrated. This is an example of anti-competitive vertical restraints adopted by a market leader. As well known in the literature, analogous results can be obtained removing intrabrand competition through exclusive territories for downstream retailers (these would feel free to set higher prices softening competition) or, under certain conditions facilitating collusive outcomes through resale price maintenance (that reduce the efficacy of secret wholesale price cuts).

However, when entry in the market is endogenous, the market leader cannot operate in such a way, because high wholesale prices would put the downstream firm out of the market. A market leader can still gain from delegating pricing decisions, but the optimal contract is now radically different. In particular, we now that competition in prices with endogenous entry between the downstream firm and the other firms would lead to a price $p_D(w)$ increasing in the wholesale price for the downstream firm, a price for the other firms p and an endogenous value for β that are both independent from w , and $\beta_D(w) = \beta + g(p) - g(p_D(w))$.

It is easy to verify that the optimal contract which solves the problem:

$$\begin{aligned} \max_{\{w, \Upsilon\}} \pi_U &= (w - c)D[p_D(w), \beta_D(w)] + \Upsilon \\ \text{s.v.} \quad &: \quad \pi_D = [p_D(w) - w]D[p_D(w), \beta_D(w)] - \Upsilon - F \geq 0 \end{aligned}$$

requires a wholesale price for the retailer smaller than the marginal cost and implicitly given by:²¹

$$w^* = c + \frac{(p_D - c)D_2g'(p_D)}{D_1} < c$$

which, of course, generates an lower equilibrium price for the downstream retailer than for the other firms. We can summarize :

Proposition 7. Under price competition with endogenous entry, it is optimal to delegate distribution to a downstream retailer with a franchise fee contract involving a wholesale price below marginal cost so as to be more aggressive.

In such a case, the vertical restraint leads to a lower price for the consumers and there is no ground for conjecturing any anti-competitive behaviour.²² Hence, also in case of vertical restraints affecting interbrand competition, entry conditions are crucial to derive proper conclusions.

4.7 Price discrimination

When firms sell the same good at different prices for different consumers, they are adopting a policy price discrimination. Typically this increases profitability, but requires a certain commitment, because similar goods must be sold not just at different prices, but also in different packages and with different advertising for different consumers. In theory, when firms can set a price equal to the maximum willingness to pay of each consumer, firms can fully extract the consumer surplus, something known as first degree price discrimination. A large literature has focused on the more realistic case of incomplete information, in which firms offer different deals and customers choose their favourite: a typical example of this second degree price discrimination involves price-quantity bundles. When firms discriminate on the basis of observable characteristics, we talk about third degree price discrimination. We can provide a simple example of the role of this form of price discrimination within our framework.

For simplicity, imagine that all firms compete for a common set of consumers, whose demand is $D(p_i, \beta_i)$ for each firm i , while the leader also serves a local

²¹One can verify that in the case of out Logit demand function, the optimal contract requires $w^* = c - F$.

²²A similar result emerges also in models of competition in quantities, but this is less surprising since it confirms the outcome of delegation games with an exogenous number of competitors (at least as long as SS holds).

market with demand $\tilde{D}(p_i)$ (and we assume that has to serve both markets). The leader can adopt uniform pricing for both markets, or can commit to a policy of price discrimination, choosing two prices p_L and \tilde{p}_L for the same good sold at different kind of customers. The marginal cost of production is c for all firms and all customers. The profit of the leader are then:

$$\pi_L = p_L D(p_L, \beta_L) + \tilde{p}_L \tilde{D}(p_i) - c[\tilde{D}(p_i) + D(p_L, \beta_L)] - F$$

Consider the case of an exogenous number of firms first. Choosing price discrimination, the leader sets the prices p_L and \tilde{p}_L^* and obtains monopolistic profits in the local market and the same profits as the other firms in the symmetric Bertrand equilibrium for the common market. Assume that $p_L > \tilde{p}_L^*$. Choosing uniform pricing, the leader chooses a price between \tilde{p}_L and p_L^* in Bertrand equilibrium, and SC implies that also the other firms will reduce their equilibrium prices. Ultimately, the leader reduces its profits in the local market and strenghtens competition in the common market. Clearly, in this case, price discrimination is optimal since it allows to maximize profits in the local market and to soften competition in the common one.

Consider endogenous entry now. Under price discrimination, all firms will choose the same price p_L in the common market and entry will drive profits to zero, while the leader will enjoy only its monopolistic profits in the local market setting the optimal price \tilde{p}_L^* . Assume again $p_L > \tilde{p}_L^*$. In this case, adopting uniform pricing, the leader will choose again an intermediate price between \tilde{p}_L and p_L^* , and will obtain two results: on one side profits in the local market will decrease because pricing is above monopolistic pricing, on the other side, profits in the common market will increase because the leader is endogenously committed to aggressive pricing, which is always optimal in a market where entry is endogenous. If the former loss is smaller than the latter gain, it is optimal to adopt uniform pricing rather than committing to price discrimination.²³

This simple example is just aimed a suggesting that price discrimination can have a role in softening price competition inducing negative consequences for consumers: this effect, however, is less likely to emerge in markets where entry is endogenous.

4.8 Stackelberg competition with endogenous entry

As we have suggested in the simple example of Section 2, the spirit of our result holds also in a simpler set-up where the leader cannot undertake a strategic investment but can simply precommit to its strategy before the other firms, in other words under pure Stackelberg competition. While such a commitment is

²³Notice that this can be quite likely since the loss from a small deviation from monopolistic pricing is a second order loss, while the gain in the common market is first order.

notoriously problematic to depict long run situations, it can provide an accurate description of the competitive advantage of incumbents in markets with a short horizon or when strategies are costly to change.²⁴ In Etro (2002) I fully characterize Stackelberg equilibria for a general model as the one adopted in this paper, confirming our result for which leaders are always aggressive when entry is endogenous: hence one can see Stackelberg competition as a reduced form for our more general model with strategic investment by the leader.

Imagine that a leader chooses its strategy first, then followers decide whether to enter or not and they finally play Nash between themselves. Adopting the same notation as before (and ignoring the investment k which can be assumed exogenous for all firms), a Stackelberg equilibrium must be characterized by a strategy for the leader x_L , a strategy for the followers x and a total number of firms n such that the followers maximize their profits given x_L :

$$\Pi_1 [x, (n-2)h(x) + h(x_L)] = 0 \quad (28)$$

a zero profit condition pins down the number of firms n :

$$\Pi [x, (n-2)h(x) + h(x_L)] = F \quad (29)$$

and the leader chooses its strategy to maximize its profits. Once again, the system of the above two equations implies that the strategy of each follower x is independent from x_L , while the number of firms is decreasing in the strategy of the leader with $dn/dx_L = -h'(x_L)/h(x) < 0$.²⁵ Hence, unless it is optimal to adopt an entry deterrence strategy, the interior equilibrium condition for the leader can be derived as:

$$\Pi_1^L [x_L, (n-1)h(x)] = \Pi_2^L [x_L, (n-1)h(x)] h'(x_L) \quad (30)$$

Since the right hand side is negative, it is easy to conclude that the leader is going to choose always $x_L > x$, that is an aggressive strategy. Formally, one can prove:

Proposition 8. Under Stackelberg competition both in quantities and prices with endogenous entry the leader is aggressive compared to each follower, and each follower either does not enter or chooses the same strategy as under Nash competition.

Once again, this is independent from strategic substitutability or complementarity, and it holds also in presence of some heterogeneity between firms or between the leader and the followers and with multiple leaders (see Etro, 2002).

²⁴For instance, in some seasonal markets firms choose their production level at the beginning of the season and it is hard to change such a strategic choice afterward (think of the fashion industry). In other markets, prices are sticky in the short run due to small menu costs or because a price change can induce adverse reputational effects on the perception of the customers: being the first mover in the price choice provides the leader with a credible commitment in the short run.

²⁵This can be verified totally differentiating the system (28)-(29).

Under quantity competition, one can easily derive the conditions under which entry deterrence takes place. In the typical case of perfect substitutability between goods, Etro (2002) shows that it all depends on the cost function. In particular we can generalize our example with constant marginal costs of Section 2 proving:

Proposition 9. Under perfect substitutability and constant or decreasing marginal costs, Stackelberg competition in quantities with free entry always delivers entry-deterrence with only the leader in the market.

Hence, under quite common assumptions on the production function (constant or increasing returns to scale) competitive markets are perfectly compatible with just one active firm.²⁶ However, if (and only if) the cost function is convex enough, the leader is going to allow entry, while still selling more than each follower (as we have seen in an example of Section 2). In this case one can verify, just applying the conditions (28)-(29)-(30), that the equilibrium price will equate the average cost of the followers (by the free entry condition) and the marginal cost of the leader (by its optimality condition). When we depart from perfect substitutability between products, entry deterrence becomes less likely and leaders tend to allow entry (as we have also seen in Section 2.4), while still selling more than the followers and at lower prices.²⁷

Also under price competition the leader is going to choose a lower price than the followers, exactly the opposite of what would happen under barriers to entry. In Section 2 we have seen an example of this for the case of a Logit demand. As well known price commitments can face credibility problems, but it is important to be aware that the traditional implications of Stackelberg competition in prices are totally reversed when entry is endogenous.

²⁶Tesoriere (2006) generalizes this result to sequential and endogenous entry.

²⁷The analysis of Stackelberg competition with endogenous entry is somewhat related with three older theoretical frameworks. The first is the initial literature on entry deterrence associated with Bain (1956), Sylos Labini (1957) and Modigliani (1958), who took in consideration the effects of entry on the behaviour of market leaders, they were not developed in a coherent game theoretic framework and were substantially limited to the case of competition with perfectly substitute goods and constant or decreasing marginal costs (which not by chance, as we saw in Section 2, are sufficient conditions for entry deterrence). The second is the *dominant firm theory*, which tries to explain the pricing decision of a market leader facing a competitive fringe of firms taking as given the price of the leader. The third is the *theory of contestable markets* by Baumol, Panzar and Willig (1982), which shows that, in absence of sunk costs of entry, the possibility of “hit and run” strategies by potential entrants is compatible only with an equilibrium price equal to the average cost. One of the main implications of this result is that “one firm can be enough” for competition when there are aggressive potential entrants. Of course none of these frameworks provides indications on the behaviour of market leaders in other contexts than the basic one with homogenous goods, and they lack a game theoretic foundation, but they have been quite helpful in providing insights on the role of competitive pressure in markets with leaders. In a sense, our analysis tries to provide a general game-theoretic foundation for these models.

Finally, since a theory of the market structure able to provide policy implications for welfare (and potentially antitrust) analysis should address the role of market leaders, our model can be used for this purpose. In Etro (2002) I show that comparing a Stackelberg equilibrium with endogenous entry and a Nash equilibrium with endogenous entry, social welfare is higher in the former under both quantity and price competition. Basically, market leaders constrained by the threat of entry are aggressive enough improve welfare by selling at low enough prices and by reducing the number of active firms and so waste fewer resources in fixed costs (but not enough to reduce excessively the number of active firms).

4.9 Antitrust policy

In this section we will review the implications of the above theories for antitrust policy (see also Etro, 2007). A main point emerging from our analysis of the behaviour of market leaders facing or not facing free entry is that standard measures of the concentration of a market have no relation with its competitive structure and may lead to misleading welfare comparisons.

This outcome is quite clear in the simplest environment we studied, that of competition in quantities with homogenous goods, linear demand, constant marginal costs and a fixed cost of production. Such a simple structure approximates the situation in many sectors where product differentiation is not very important but there are high costs to starting production (this is typical of energy and telecommunication industries and some high-tech sectors). In such a case, as long as the number of firms is exogenously given and the fixed costs of production are not too high, a market leader is aggressive but leaves space for other firms to be active in the market. As external observers, we would look at this market as a market characterized by a firm with a market share larger than its rivals, but with a certain number of competitors whose supply reduces the market price. The higher is the number of followers, the lower would be the price: lower concentration would be associated with a higher welfare as well.

In this same market, when entry is completely free and only technological constraints limit it, we have seen that the equilibrium outcome would be quite different: the leader would expand production until no one of the potential entrants has incentives to supply its goods on the market. The intuition is simple. The leader is aware that its output exactly crowds out the output of the competitors leaving unchanged the aggregate supply and hence the equilibrium price. However, at this price the leader can increase its profits by increasing its output and reducing the average costs, hence it is always optimal to produce enough to crowd out all output by the competitors. These economies of scale allow the leader to enjoy positive profits even if no entrant could obtain positive profits in this market. As external observers, in this case, we would just see a single firm obtaining positive profits in a market where no one else enters, and, following traditional paradigmas, we could associate this situation with a

monopolistic environment, or at least with a dominant position derived by some barriers to entry. But this association is not correct, since entry is indeed free in this market, and we have also seen that this equilibrium with entry deterrence by the leader is associated with a higher welfare than the free entry equilibrium without a leadership, which would involve many firms active in the market and earning zero profits. Of course, network externalities and learning by doing strengthen the aggressiveness of the leader.

When marginal costs are substantially increasing in the production level or, more generally, when the average costs have a U-shape, a market leader facing free entry of competitors may not have incentives to deter entry, but would still behave in an aggressive way. In such a case all the entrants price above the marginal cost, but free entry imposes a price that is just high enough to cover the fixed costs of production: this generates a production below the efficient scale. The leader has to take as given this price, and finds it optimal to produce as much to equate its marginal cost to the price, which generates a production above the efficient scale and associated with positive profits. In this case the strategy of the leader does not even affect the market price, which is fully determined by free entry of firms. Nevertheless, the leader obtains a larger market share than its rivals and positive profits. We have shown that the aggressive behaviour of the leader, that prices its good at its marginal cost, improves the allocation of resources compared to the same market with free entry and no leadership. A similar situation emerges when goods are not homogeneous but they differ in quality.

The crucial lesson from this analysis is that we should be careful in drawing any conclusion from index of concentration or from the market shares. We have seen examples in which a single firm in the market enjoying positive profits is the equilibrium outcome of a market with free entry, and other examples where the outcome is less drastic but not too different. Notice that in all these cases, the market leader was adopting extremely aggressive strategies which were reducing entry but increasing welfare nevertheless. Hence, it is also important to notice that strategies that are aimed at reducing entry are not necessarily negative for consumers, especially when entry is not deterred, but simply limited due to a low level of the prices, so that some competitors are still active in the market and able to exert a competitive pressure on the leader.²⁸

Another important implication of the theory of market leaders emerges under competition in prices. In this typical situation, the traditional analysis of Stackelberg oligopolies shows that dominant firms are either accomodating (setting high prices) or they try to exclude rivals by setting low enough prices. Such an outcome implies the risk of erroneously associating any aggressive price

²⁸Of course, a complete analysis of the consequences of entry deterrence would require a dynamic model taking into account the behaviour of the leader before and after deterrence, which is beyond the scope of this paper. Our point here is simply to warn against the risk of directly associating aggressive price strategies that reduce entry with welfare reducing strategies.

strategy with an entry deterring strategy. As we have seen, when we endogenize entry in the market, market leaders never adopt accommodating pricing strategies while they are always aggressive. Again, in equilibrium with free entry, leaders increase their market shares and obtain positive profits. Of course an aggressive pricing strategy will still reduce entry, even if it will not exclude all rivals, but we now have to be more careful in associating aggressive pricing with predatory purposes. The reason why predatory strategies are anti-competitive is that they exclude competition in the future allowing the dominant firm to behave in a monopolistic fashion once competitors are out of the market. Of course, if an aggressive pricing strategy is aimed at excluding some but not all competitors, this anti-competitive element is more limited.

The same care in judging aggressive strategies is needed in case of complementary strategies that virtually induce aggressive behaviours. One of these is bundling. As we have seen, in an influential paper, Whinston (1990) has studied bundling in a market for two goods. The primary good is monopolized by one firm, which competes with a single rival in the market for the secondary good. Under price competition in the secondary market, the monopolist becomes more aggressive in its price choice in case of bundling of its two goods. Since a more aggressive strategy leads to lower prices for both firms as long as both are producing, the only reason why the monopolist may want to bundle its two goods is to deter entry of the rival in the secondary market. This conclusion can be highly misleading because it neglects the possibility of further entry in the market. As we have seen, if the secondary market is characterized by endogenous entry, the monopolist would always like to be aggressive in this market and bundling may be the right way to commit to an aggressive strategy. Bundling would not necessarily deter entry in this case, but may increase competition in the secondary market and reduce prices with positive effects on the consumers.

The bottom line of this discussion is that in evaluating market structures and the behaviour of market leaders we should be especially careful to the entry conditions. Standard results emerging for markets with an incumbent and an entrant can change in radical ways when we take in consideration the possibility of entry of other firms.

5 Export promoting policy

Another important application of our results is about industrial policy for exporting firms. Indeed, our basic model of strategic investment can be easily extended to situations where the government (rather than the same firm) can adopt a policy which provides a strategic advantage to a domestic firm in international markets: this is often the case of trade policy for exporting firms.

Common wisdom on the benefits of export subsidization largely departs from the implications of trade theory, which is hardly in its favour. In the standard neoclassical theory with perfect competition it is optimal to tax exports to

improve the terms of trade. In case of imperfect competition, a second aim of strategic trade policy is to shift profits toward the domestic firms, hence a large body of literature has studied models with a fixed number of firms competing in a third market with positive profits. Here, the optimal unilateral policy is an export tax under price competition, or whenever strategic complementarity holds (Eaton and Grossman, 1986). Under quantity competition, an export subsidy can be optimal (Spencer and Brander, 1983; Brander and Spencer, 1985), but only under restrictive conditions (Dixit, 1984). The ambiguity of these results represents a major problem to derive policy implications for trade policy.

In Etro (2006c) I have provided a possible solution, studying a model of trade policy for a foreign market with free entry for international firms. Notice that free entry is a realistic assumption since a foreign country without a domestic firm in the market can only gain from allowing free entry of international firms. Under free entry, export subsidization is always the best unilateral policy both under quantity and price competition, or, more generally, under strategic substitutability and strategic complementarity.²⁹ More generally, we can establish a simple application of our Prop. 1:

Proposition 10. **Under free entry in the foreign market, when the export policy increases (decreases) the marginal profitability of the domestic firm, there is (not) a strategic incentive to export promotion.**

It is immediate to verify that under both quantity and price competition an export subsidy increases marginal profitability of the domestic firm ($\Pi_{13} > 0$ in our terminology), hence export subsidies are optimal. One can also explicitly derive the export subsidy that maximizes welfare, which is given by the profit of the domestic firm net of the cost of subsidies. This optimal subsidy reproduces a Stackelberg equilibrium in the third market where the domestic firm is the leader. Hence, as a consequence of Prop. 9, when the marginal cost is constant or decreasing and/or goods are close substitutes, the optimal subsidy deters entry of foreign firms. However, when this is not the case, we can easily derive neat expressions for the optimal subsidy. For instance, under quantity competition with perfectly substitute goods, the optimal specific subsidy is:

$$s^* = \frac{p_L}{\epsilon} > 0 \quad (31)$$

where p_L is the price of the domestic firm and $\epsilon = -(p_L/x_L)(dx_L/dp_L)$ the corresponding elasticity of demand. The optimal export subsidy under price competition is:

$$s^* = \frac{(p_L - c)D_2(p_L, \beta_L)g'(p_L)}{[-D_1(p_L, \beta_L)]} > 0 \quad (32)$$

²⁹For these results to apply we need to assume that one domestic firm is active in the third market. Clearly export subsidies would attract further domestic firms in this market in the long run, but our results should at least matter in the short run.

For instance, with the Logit demand, which we already encountered, this would be $s^* = F$.³⁰ At this point, the intuition for the general optimality of export subsidies should be straightforward. While firms are playing some kind of Nash competition in the foreign market, a government can give a strategic advantage to its domestic firm with an appropriate trade policy. When entry is free, an incentive to be accommodated is always counterproductive, because it just promotes entry by other foreign firms and shifts profits away from the domestic firm. It is instead optimal to provide an incentive to be aggressive, that is to expand production or (equivalently) lower the price, since this behaviour limits entry increasing the market share of the domestic firm. As usual, this is only possible by subsidizing its exports.

The same argument can be applied to other forms of indirect export promotion, as policies which boost demand or decrease transport costs for the exporting firms, or to R&D subsidies. Even competitive devaluations can be studied in this framework: following the pioneeristic work by Dornbusch (1987), one can evaluate the strategic incentives to exchange rate devaluations in a model where the incidence of exchange rate variations on prices is endogenous (but strategic effects of devaluations emerge only when firms produce at home, not if they directly produce in the foreign market). While under barriers to entry competitive devaluations may be a bad idea to provide a strategic advantage to domestic exporters, especially under price competition, under free entry there is always a strategic incentive to depreciate the currency to promote exports.

If we interpret globalization as the opening up of new markets to international competition we can restate the main result as follows: in a globalized world, there are strong strategic incentives to conquer market shares abroad by promoting exports. As well known, however, if all countries were going to implement their optimal unilateral policies, an inefficient equilibrium would emerge. This may explain why international coordination tends to exclude both export subsidies and competitive devaluations.

6 Competition for the Market

Following the strategy of Section 2, we are going to study competition for the market in a simple example inspired by Etro (2004). In many sectors of the New Economy and in general in high tech sectors, this is becoming a main form of competition, since the life of a product is quite short and R&D investment strategies to conquer future markets are much more important than price or production strategies in the current markets.

Competition for the market works as a sort of contest. Firms invest to innovate and especially to arrive first in the contest. It may be that the first

³⁰In Etro (2006c) I also derive the optimal export subsidy for a general isoelastic demand (and I also derive, for the same demand function, the optimal export tax which applies when there are barriers to entry). For related analysis see Boone, Ianescu and Zigic (2006).

innovator can obtain a patent on the invention and exploit monopolistic profits for a while on its innovation, it maybe that the same innovator just keeps it secret and exploits its leadership on the market until an imitator replaces it. Anyway, the expected gain from an innovation is what drives firms to invest in R&D. Also in this case we can study alternative market structure depending on the timing of moves and on the entry conditions.

Consider a simple contest between firms to obtain a drastic innovation which has an expected value $V < 1$ for the winner and generates no gains for the losers. Each contestant i invests resources $z_i \in [0, 1)$ to win the contest. This investment has a cost and we will assume that it is quadratic for simplicity, that is $z_i^2/2$. The investment provides the contestant with the probability z_i to innovate. The innovator wins the contest if no other contestant innovates, for instance because in case of multiple winners competition between them would drive profits away. Hence the probability to win the contest is $\Pr(i \text{ wins}) = z_i \prod_{j=1, j \neq i}^n [1 - z_j]$, that is its probability to innovate multiplied by the probability that no one else innovates. In conclusion, the general profit function is:³¹

$$\pi_i = z_i \prod_{j=1, j \neq i}^n [1 - z_j] V - \frac{z_i^2}{2} - F$$

Consider first Nash equilibrium. The first order condition for the optimal investment by a firm i is:

$$z_i = \prod_{j=1, j \neq i}^n [1 - z_j] V$$

which shows that when the investment of a firm increases, the other firms have incentives to invest less: $\partial z_i / \partial z_j < 0$. In case of two firms, each one would invest $z = V/(1 + V)$ in equilibrium, while with n firms, the equilibrium investment would be implicitly given by:

$$z = (1 - z)^{n-1} V$$

In a Marshall equilibrium we must also take into account the free entry condition:

$$z(1 - z)^{n-1} V - z^2/2 = F$$

and solving the system of the two conditions we have the number of agents:

$$n = 1 + \frac{\log(V/\sqrt{2F})}{\log[1/(1 - \sqrt{2F})]}$$

³¹We assume $V \in (\sqrt{2F}, 1)$, which guarantees profitable entry for at least one firm. Indeed, a single firm would invest $z = V < 1$ expecting $\pi = V^2/2 - F > 0$. Hence, investing $z = 1$ and innovating for sure can be profitable, but it is not optimal.

and the investment:

$$z = \sqrt{2F}$$

Consider now a Stackelberg equilibrium. As already noticed, remember that when the investment by one firm is higher, the other firms have incentives to invest less: then in a Stackelberg equilibrium the leader exploits its first mover advantage by investing more than the followers, so as to reduce their investment and increase its relative probability of winning. For instance, in a Stackelberg duopoly the leader invests $z_L = V(1 - V)/(1 - 2V^2)$ and the follower invests $z = V(1 - V - V^2)/(1 - 2V^2)$.

In a Stackelberg equilibrium with endogenous entry, as long as the investment of the leader z_L is small enough to allow entry of at least one firm, the first order conditions and the free entry conditions are:

$$\begin{aligned} (1 - z)^{n-2}(1 - z_L)V &= z \\ z(1 - z)^{n-2}(1 - z_L)V &= z^2/2 + F \end{aligned}$$

which deliver the same investment choice by each entrant as in the Marshall equilibrium, $z = \sqrt{2F}$, and the number of firms:

$$n(z_L) = 2 + \frac{\log \left[(1 - z_L)V/\sqrt{2F} \right]}{\log \left[1/(1 - \sqrt{2F}) \right]}$$

Putting together these two equations and substituting in the profit function of the leader, we would have:

$$\begin{aligned} \pi_L &= z_L(1 - z)^{n-1}V - \frac{z_L^2}{2} - F = \\ &= \frac{z_L}{1 - z_L}\sqrt{2F} \left(1 - \sqrt{2F} \right) - \frac{z_L^2}{2} - F \end{aligned}$$

which has not an interior optimum: indeed, it is always optimal for the leader to deter entry investing enough. This requires a slightly higher investment than the one for which the equilibrium number of firms would be $n = 2$. Since $n(z_L) = 2$ requires $\log \left[(1 - z_L)V/\sqrt{2F} \right] = 0$, we can conclude that the leader will invest:

$$z_L(V) = 1 - \frac{\sqrt{2F}}{V}$$

which is increasing in the value of innovations and decreasing in their fixed cost. Hence, in a contest with a leader and free entry of participants, the leader invests enough to deter investment by the other firms and is the only possible winner of the contest.

6.1 The Arrow's Paradox

Until now we investigated a form of competition for the market where all firms are at the same level. Often times, competition for the market is between an incumbent leader that is already in the market with the leading edge technology or with the best product and outsiders trying to replace this leadership. In such a case the incentives to invest in innovation may be different and it is important to understand how. Arrow (1962) was the first to examine this issue and he found that incumbent monopolists have lower incentives than outsiders to invest. His insight was simple but powerful: while the gains from an innovation for the incumbent monopolist are just the difference between profits obtained with the next innovation and those obtained with the current one, the gains for any outsiders are the full profits from the next innovation. Hence the incumbent has lower incentives to invest in R&D. The expected gains of the incumbent are even diminished when the number of outsiders increases. And when the latter arrives to the point that expected profits for the outsiders are zero, the incumbent has no more incentives at all to participate to the competition. Such a strong theoretical result is of course too drastic to be realistic. Many technological leaders invest a lot in R&D and try to maintain their leadership, often managing: persistent leadership are not so unusual. However, before offering a theoretical explanation for this dilemma, we will extend the model to include an asymmetry between an incumbent monopolist and the outsiders.

Imagine a two period extension of the model. In the first period an incumbent monopolist can exploit its technology to obtain profits $K \in (0, V]$. We can think of K as the rents associated with an initial leading technology or some other exogenous advantage. If this rents are constrained by a competitive fringe of firms, we can also think that an increase in the intensity of competition reduces K . In the first period any firm can invest to innovate and conquer the gain V from the next innovation to be exploited in the second period. If no one innovates, the incumbent retains its profits K also in the second period. This happens with probability $\Pr(\text{no innovation}) = \prod_{j=1}^n [1 - z_j]$. Then, assuming no discounting, the expected profits of the incumbent monopolist, that we now label with the index M , are:

$$\pi_M = K + z_M \prod_{j=1, j \neq M}^n [1 - z_j] V + (1 - z_M) \prod_{j=1, j \neq M}^n [1 - z_j] K - \frac{z_M^2}{2} - F$$

in case of positive investment in the contest, otherwise expected profits are given only by the current profits plus the expected value of the current profits when noone innovates. The profits of the other firms are the same as before. Before analysing alternative forms of competition, notice that when the monopolist is assumed alone in the research activity, its optimal investment is $z_M = V - K$. Hence, an incumbent monopolist (with $K > 0$) has lower incentives to invest than a firm without current profits (with $K = 0$): the *Arrow effect* is in action.

Moreover, if we think that the intensity of product market competition has a negative impact on the current profits K , while it has no impact on the value of the innovation since this is drastic (the innovator will not be constrained by product market competitors), it clearly follows that an increase in the intensity of competition reduces K and increases the investment of the monopolist and the probability of innovation z_M . Aghion and Griffith (2005) put a lot of emphasis on this effect, which they label *escape competition effect*: “competition reduces pre-innovation rents...but not their post innovation rents since by innovating these firms have escaped the fringe. This, in turn induces those firms to innovate in order to escape competition with the fringe.”³²

Now, consider a Nash equilibrium with a general number of firms. If the incumbent does not invest, the equilibrium is the same of the symmetric model, but the expected profit of the monopolist $\pi_M(z_M)$ must be:

$$\pi_M(0) = K + \frac{\sqrt{2F}(1 - \sqrt{2F})K}{V}$$

which is increasing in K (decreasing in the intensity of competition) and decreasing in the value of the innovation V (since this increases the incentives of other firms to innovate and replace the monopolist).

If the monopolist is investing, however, the first order conditions for the monopolist and for the other firms in Nash equilibrium would be:

$$\begin{aligned} z &= (1 - z)^{n-2}(1 - z_M)V \\ z_M &= (1 - z)^{n-1}V - (1 - z)^{n-1}K \end{aligned}$$

which always implies a lower investment of the monopolist because of the Arrow effect. For instance, with two firms we have:

$$z_M = \frac{(1 - V)(V - K)}{1 - V(V - K)} \quad z = \frac{(1 - V)(V - K) + K}{1 - V(V - K)}$$

It is interesting to verify what is the impact of an increase in the intensity of product market competition, which lowers current profits K without affecting the value of the drastic innovation V : this increases the investment of the incumbent according to the escape competition effect, but it decreases the investment of the outsider.

When entry of firms is free, investors enter as long as expected profits are positive, that is until the following zero profit condition holds:

$$z(1 - z_M)(1 - z)^{n-2}V = z^2/2 + F$$

³²See Aghion and Griffith (2005, pp. 55-56). An increase of the intensity of competition is there associated with a lower price of the competitive fringe or with a higher probability of entry of equally efficient firms.

This implies that each one of the other firms invests again $z = \sqrt{2F}$, while the monopolist should invest less than this, according to the rule:

$$z_M(1 - z_M) = \sqrt{2F}(1 - \sqrt{2F})(V - K)/V$$

which also implies that the optimal investment of the monopolist should decrease with K : from the same level as for the other firms $z_M = \sqrt{2F}$ when $K = 0$ toward zero investment $z_M = 0$ when approaching $K = V$. The profits of the monopolist in case of positive investment would be:

$$\pi_M(z_M) = K + \frac{\sqrt{2F}(1 - \sqrt{2F})}{V} \left[\frac{(V - K)z_M + K}{1 - z_M} \right] - \frac{z_M^2}{2} - F$$

where z_M should be at its optimal level derived above. Notice that for $K = 0$ these expected profits are $-F$, so the monopolist prefers not to invest at all, and for $K = V$ the expected profits tend to $K + \sqrt{2F}(1 - \sqrt{2F}) - F$, which is again lower than the expected profits in case the monopolist does not invest at all. It can be verified that this is always the case for any $K \in (0, V)$,³³ hence the monopolist always prefers not to invest and decides to give up to any chance of innovation. Notice that the escape competition effect disappears: an increase in the intensity of competition does not affect the investment of the incumbent or of any outsider and even the aggregate probability of innovation. Perfect competition for the market eliminates any impact of competition in the market on innovation when the Arrow effect eliminates investment by the incumbent.³⁴

In this simple example, the lack of incentives to invest for the monopolist emerges quite clearly. On the basis of this theoretical result, it is often claimed that monopolistic markets or markets with a clear leadership are less innovative. We will now see that this is not entirely true.

6.2 Innovation by leaders

It can be reasonable to imagine that an incumbent monopolist with the leading edge technology may invest to replace this same technology with a better one and may commit to such an investment even before other firms. In other words we can associate a strategic advantage in the competition for the market to the current leader.

Consider Stackelberg competition where the incumbent monopolist is the first mover. The reaction of the other firms to the investment of the leader is

³³This immediate after comparing profits for the monopolist in case of zero and positive investment in Nash equilibrium as functions of K .

³⁴Not by chance, Aghion and Griffith (2005) obtained the escape competition effect in a model where the incumbent is exogenously the only investor. In the next section we present a model where the incumbent is endogenously the only investor to verify that both the Arrow effect and the escape competition effect disappear in that case.

still governed by their equilibrium first order condition:

$$z = (1 - z)^{n-2}(1 - z_L)V$$

where now z_L is the known investment of the leader, which is known at the time of the choice of the other firms. The above rule cannot be solved analytically but it shows again that the investment of the outsider firms must be decreasing in that of the leader, $\partial z/\partial z_L < 0$: the higher is the investment of the leader, the smaller is the probability that noone innovates and hence the expected gain from the investment of the followers. This implies that the leader has an incentive to choose a higher investment to strategically reduce the investment of the followers. However, the investment of the leader does not need to be higher than the investment of the other firms, because the Arrow effect is still pushing in the opposite direction. For instance, with two firms we have:

$$z_L = \frac{VK + (1 - V)(V - K)}{1 - 2V(V - K)} \quad z = \frac{VK + (1 - V)V - V^3}{1 - 2V(V - K)}$$

and the investment of the monopolist because the Arrow effect prevails on the Stackelberg effect whenever $K > V^3/(1 - V)$. Again, an increase in the intensity of product market competition increases the investment of the incumbent according to the escape competition effect, but it decreases the investment of the outsider. More in general, competition for the market weakens the escape competition effect.

When entry is endogenous, however, things are simpler. As long as the investment of the leader is small enough to allow entry of at least one outsider, the free entry condition is:

$$z(1 - z)^{n-2}(1 - z_L)V = z^2/2 + F$$

which delivers again the investment $z = \sqrt{2F}$ for each outsider. Putting together the two equilibrium conditions in the profit function of the leader, we would have:

$$\begin{aligned} \pi_L &= K + z_L(1 - z)^{n-1}(V - K) - \frac{z_L^2}{2} - F = \\ &= K + \frac{z_L}{1 - z_L}\sqrt{2F}(1 - \sqrt{2F}) + \frac{K}{V}\sqrt{2F}(1 - \sqrt{2F}) - \frac{z_L^2}{2} - F \end{aligned}$$

whose third element, the one associated with the current profits obtained in case no one innovates, is independent from the choice of the leader. Hence, the choice of the leader is taken exactly as in our earlier model (with $K = 0$) and requires an investment:

$$z_L(V) = 1 - \frac{\sqrt{2F}}{V}$$

such that no other firm invests in innovation. Consequently, the profits of the leader can be calculated as a function of the value of the innovation:

$$\pi_L(V) = K + z_L(V)V + [1 - z_L(V)]K - \frac{z_L(V)^2}{2} - F$$

Welfare comparisons are ambiguous: on one side the aggregate probability of innovation is lower under Stackelberg competition with free entry rather than in the Marshall equilibrium, on the other side expenditure in fixed and variable costs of research is lower in the first than in the second case. However, in a dynamic environment where the value of the innovation is endogenous, things would change. While without a leadership of the monopolist, the value of innovation would be just the value of expected profits from this innovation (the innovator will not invest further), with a leadership by the monopolist, the value of innovation should take into account the option value of future leadership and future innovations: this would endogenously increase the value of being an innovator and would increase the aggregate incentives to invest.

Moreover, notice that when the monopolist is leader in the competition for the innovation, the Arrow effect disappears, since the choice of the monopolist is independent from the current profits. The leadership in the competition for the market radically changes the behaviour of a monopolist: from zero investment to maximum investment. This result, proved in Etro (2004), can be generalized as follows:³⁵

Proposition 11. Under competition for the market with endogenous entry the leader invests more in R&D than any other firm and innovates with higher probability.³⁶

This result has implications for industrial policy. In a sense, IPRs drive competition through innovation in high-tech markets and induce technological progress led by incumbent monopolists under two conditions: their leadership in the contest to innovate and free entry of outsiders in this same contest. In particular, we have seen that, according to traditional theories, in absence of strategic advantages, a technological leader that is also an incumbent monopolist in its

³⁵This result is unrelated with that of Gilbert and Newbery (1982), who studied an auction for a non drastic innovation, and noticed that the incumbent is willing to pay for the innovation up to the difference between the value of being the new monopolist, say V^W , and the value of sharing a duopoly with an outsider that obtains the innovation, say V^L , while an outsider is willing to pay up to its value of sharing a duopoly with the current incumbent, say V^E . Since the value of a duopoly cannot be larger than the value of a monopoly, that is $V^W \geq V^L + V^E$, the incumbent must win the auction. This framework sterilizes the Arrow effect since an innovation occurs for sure, and requires non-drastic innovations to work, but it fails in more realistic patent races with uncertainty. Our argument, instead, works with uncertain races and drastic innovations, and even when the Arrow effect is relevant and strong.

³⁶This result is at the basis of theories of endogenous growth driven by monopolists (Etro, 2006,d). For related theoretical investigations on growth and patent races see Zeira (2003), Denicolò and Zanchettin (2006), Impullitti (2006), Minnitti (2006) and especially Segerstrom (2006).

market, would have less incentives to invest in R&D compared to other firms, since its relative gain from improving its own technology is smaller. However, we have also seen that when this monopolist is the leader in the contest for innovating, under the pressure of a competitive fringe of entrants, the monopolist will have incentives to commit to higher investment than any other firm. The competitive environment spurs investment by leaders and consequently induces a chance that their leadership persists. Moreover, we have also suggested that when the leadership persists because of the endogenous investment in R&D by the leaders, the same value of becoming a leader is increased, which increases even further the incentives to invest for any firm. Paradoxically, the persistence of a leadership in high-tech sectors is sign of effective dynamic competition for the market, which leads to a faster rate of technological progress in the interest of consumers.

Of course, it could be dangerous to take literally these results, and this is not our objective. What we would like to emphasize is the importance of free entry in the market for innovations. Industrial policy, including antitrust policy, should primarily promote, and possibly subsidize, investment in R&D, while it should be less relevant whether incumbent monopolists or new comers invest in R&D and innovate once entry is free. On the other side, the protection of IPRs should be established at a legislative level (possibly even at an international level) because its stability is essential to foster investments, and the discretionary activity of antitrust authorities should not affect the basic principle of IPRs protection. Once again, the above results can be seen as strenghtening our initial claim that standard indexes of market concentration or market shares should not be related to the degree of competition in a market. In high-tech markets where competition is mostly for the market, it is natural that better products conquer large shares of a market.

7 Conclusions

I have studied market structures with market leaders engaging in preliminary investments. When there are barriers to entry, the optimal behaviour 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 free, the optimal behaviour of leaders is much simpler: they should always adopt preliminary investments which allow them to be more aggressive in the market.

This principle has many applications to industrial organization issues and to other fields as well. While I investigated some of them, many others remain to be studied. Clearly the drastic predictions of the model for the behaviour of market leaders with and without barriers to entry should be tested in empirical and experimental work: this is probably the main subject for the future research

on this topic.

Here I want to conclude summarizing what I believe are the strongest implications of the theory of market leaders for industrial policy:

1) market leaders always adopt aggressive pricing strategies (set lower prices and hence have higher market shares) when entry is endogenously constrained: hence, under these conditions, a large market share for an industry leader is more likely to be a symptom of a competitive environment rather than of market power;

2) markets characterized by high fixed costs and constant variable costs (or, more generally, by decreasing average costs), generate absolute or close to absolute dominance by leaders facing endogenous entry: hence, under these conditions, even an apparently monopolistic market share may not be a reliable indication of market power, but instead evidence of a competitive environment;

3) aggressive introductory pricing, debt financing, bundling strategies and over-investments in complementary markets are part of the natural competitive behaviour of leaders in markets where entry is endogenous: hence, under these conditions, aggressive pricing and other aggressive strategies are not likely to have an exclusionary purpose but instead generally have a purely competitive purpose;

4) dominant firms invest more in R&D when threatened by competitive pressure, while they tend to stifle innovation in the absence of such pressure: hence, under these conditions, the persistence of a leadership position in high-tech sectors is consistent with effective dynamic competition for the market, which leads to a faster rate of technological progress in the interest of consumers.

5) when domestic firms compete in foreign markets where entry of international firms is free, it is always optimal to support them with positive export subsidies or other policies of strategic export promotion.

While some of these statements and their policy implications may appear quite extreme compared to the traditional approaches, I hope I have managed to show that the new theory of market leaders offers an alternative reading of antitrust cases and suggests the need of a more careful economic analysis for markets where entry can be regarded as an endogenous phenomenon. The relevance of these results probably depends on whether one believes or not that entry in markets is an endogenous choice.

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