COMPETITION POLICY AND MARKET LEADERS

Ilir Maçi
Krešimir Žigić

CERGE-EI

Charles University
Center for Economic Research and Graduate Education
Academy of Sciences of the Czech Republic
Economics Institute

WORKING PAPER SERIES (ISSN 1211-3298)
Electronic Version

375

Working Paper Series 375
(ISSN 1211-3298)

Competition Policy and Market Leaders

Ilir Maçi
Krešimir Žigić

CERGE-EI
Prague, November 2008

ISBN 978-80-7343-175-4 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-164-7 (Národohospodářský ústav AV ČR, v.v.i.)

Competition Policy and Market Leaders*

Ilir Maçi[†]
CERGE–EI[‡]

Krešimir Žigić[§]
CERGE–EI and INTERTIC

November 2008

Abstract

We study the potential loss in social welfare and changes in incentives to invest in R&D that result when the market leading firm is deprived of its position. We show that under plausible assumptions like free entry or repeated market interactions there is a social value of market leadership and its mechanical removal by means of competition policy is likely to be harmful for society.

Abstrakt

Studujeme potencionální ztrátu v bohatství společnosti a změny v motivaci provádět R&D v případě, kdy se zbavıime vůdce na trhu. Ukazujeme, že v případě určitých rozumných podmínek, jako je volný vstup či opakovaná tržní interakce, dostaneme z přítomnosti vůdce na trhu. Jeho mechanické odstranění může být pro společnost škodlivé.

Keywords: Market Leaders, Competition Policy, Innovation
JEL classification: F12, F13, L11, L13, L16, K21

*We thank A. Dixit, E. Kováč, D. Piccinin, and J. Sutton for comments and helpful suggestions during discussion.

[†]Email: `ilir.maci@cerge-ei.cz`

[‡]A joint workplace of the Center for Economic Research and Graduate Education, Charles University, Prague, and the Economics Institute of the Academy of Sciences of the Czech Republic. Address: CERGE–EI, P.O. Box 882, Politických vězňů 7, Prague 1, 111 21, Czech Republic

[§]Email: `kresimir.zigic@cerge-ei.cz`

1 Introduction

One of the key objectives of competition policy is to affect market structure and market conduct if they are deemed to be socially undesirable. When, for instance, market concentration exceeds a certain threshold, government usually undertakes measures to decrease the concentration by banning mergers or requiring large firms to divest. Such an approach, however, may yield an opposite outcome to the desired one. The reason is that the traditional approach, in which usually the height of Herfindhal-Hirschman index determines whether market concentration is "excessive" or not, is often too rough and it does not lie on solid theoretical grounds (see more on this in Motta, 2004).

Based on rigorous game theoretic analysis, Sutton (1991) and Etro (2007) demonstrated that high market concentration is in fact an outcome of tough (both price and non-price) competition rather than an indicator of market power and lack of competitive forces when conditions of free (or more generally, endogenous) entry prevail.[1] The presence of a market leader can further enhance the competitive pressure and the toughness of price competition. Thus, in a recent empirical paper by Czarnitzki, Etro, and Kraft (2008), the authors show that market leaders under free entry invest more intensively in R&D than their followers or a firm in a market without free entry. Hence, shifting market structure and related market conduct away from market leadership may soften competition and, consequently have undesirable social welfare effects. This is especially likely in dynamic markets (like, for example, the software market) characterized by investment in R&D and free entry. One way the government can engineer such a shift is to deprive the leading firm of its patented product or of its superior technology by forcing it to reveal secret pieces of information to its competitors. In the software industry, for

[1]Note that the assumption of free entry is a reasonable one in characterizing of the long run equilibria.

instance, by forcing a dominant firm to reveal the source code of the most popular operating system (through compulsory licensing), the government may, among other things, strip the firm of its leading market position. So in the longer run, there will be firms of similar power competing in the market. In terms of market conduct, this situation could be described as a change from Stackelberg leadership to an ordinary oligopoly of firms with more evenly distributed market power.

In this paper we aim to study a positive and normative aspect of the above situation in which the dominant firm is deprived of its leading position by means of competition policy. Our analysis is motivated by an actual decision of the European Commission (EC) recently confirmed by the European Court of First Instances, to impose a legal requirement on a firm with a dominant position (Microsoft) to license its proprietary technology and intellectual property rights (IPR) to its competitors so that they can incorporate that same technology into their own competing products.[2] This verdict is based on the reasoning that industry-wide innovation will be boosted in the long-run if the leading firm is deprived of its exclusive intellectual property rights. More specifically, according to the EC, this is justified when "on balance, the possible negative impact of an order to supply on Microsoft's incentives to innovate is outweighed by its positive impact on the level of innovation of the whole industry (including Microsoft)."[3] Thus, the EC decision seems to establish a new balancing test under which they can order compulsory licensing. However, it seems that there is no underlying economic analysis on the side of the EC that would support the above claims.

The above considerations motivate our paper. We analyze two otherwise identical setups: one in which there is a technological and market leader and the other in which all firms are identical. Our paper is divided into two parts, each with its own setup outlining plausible scenarios where leadership is beneficial both to social

[2]Commission decision in Case COMP/C-3/37.792, *EC Commission v. Microsoft.*

[3]See footnote 2.

welfare and R&D.

The natural analytical framework to tackle the effects of market leadership is the Stackelberg leader-followers model. We use this framework in section 2. Reviving and refreshing this modeling approach, Etro (2004, 2007, 2008) has recently provided us with important insights about the behavior of market leaders when entry in the market is endogenous, and has applied his approach to analyze, among other things, some positive and normative aspects of the dynamic markets of the New Economy (see chapters 4 and 6 in Etro, 2007).[4]

Since we are interested in technological leadership as well, we extend Etro's approach by allowing the market leader to also have the first mover advantage in conducting innovations. That is, the leader is not only assumed to choose its market variable (like price or quantity) as the first but also has the technological first mover advantage in selecting its strategic variable like R&D investments.

The whole Stackelberg concept, however, rests on the idea that the market (and in our case) technological leadership is given without questioning its origin. Moreover, the features of dynamic markets of the New Economy might require a more dynamic modeling approach like repeated market interactions. Therefore, in section 3 we also look for an alternative approach where i) leadership could arise endogenously and ii) there are repeated interactions in the market among the firms.

Boone (2002, 2004) has shown that in the presence of repeated interactions and cost asymmetries the most cost efficient firms have incentives to assume a leadership role in the market.[5] Thus, in the second part of our paper we adopt Boone's (2004) approach, which we modify to allow the firms to invest in R&D

[4]Entry in a market is considered to be endogenous when in the long run equilibrium there are no profitable opportunities to be exploited by potential entrants and the author argues convincingly that this is the standard situation in the vast majority of contemporary markets.

[5]Damme and Hurkens (1999) and Boone, 2002 and (2004) have shown that firms with lower costs may assume the role of leader for sufficiently asymmetric costs. Similary, Rotemberg and Saloner (1990) and Deneckere, Kovenock, and Lee (1992) have shown, respectively, that with better information or a bigger share of loyal customers a firm can also assume leadership. See also Hamilton and Slutsky (1990) and Syropoulos (1994, 1996).

improve their production technology. Some firms, however, might be more efficient than the others in this process and that, in turn, may change the distribution of unit costs and create asymmetries among them. This asymmetry is exactly at the heart of the Boone's (2004) insight. He argues that casual observation and theoretical and empirical evidence suggests that the presence of significant differences in cost efficiency levels among the firms (and their repeated interactions) induce the most efficient firms to act aggressively and impose an outcome that is more beneficial for them. To make things very simple, we assume one of the firms to be more efficient than the others in the R&D process in order to explicitly model the issue of technological and market leadership.

2 Theory of Market Leaders: Cournot *versus* Stackelberg with R&D and Free Entry

In our first scenario we explore the classical Stackelberg leadership concept accompanied by free entry. In order to mimic the above situation where the leader is artificially deprived of its leading position, we first consider the *ex post* situation where firms are on an even technological level (symmetric Cournot equilibrium) and compare it with the *ex ante* (before enacted competition policy) situation when there exists a technological and market leader (Stackelberg equilibrium). We use a simple dynamic setup of two- and three-stage games where all firms invest in R&D and where there is endogenous number of firms. The latter assumption captures the notion of long run equilibrium. We will only consider symmetric equilibria.

Apart from the first mover advantage of the leader in the Stackelberg case, the markets are identical. The firms compete in quantities of imperfect substitutes. The inverse demand facing each firm i is $P_i(q_i, q_{-i}) = a - q_i - b\sum_{j\neq i} q_j$, where $b \in (0, 1)$ captures the degree of substitutability. Furthermore, all firms must pay fixed setup cost $F > 0$ to enter, and they incur $c - x_i$ marginal cost, where $c > 0$ is *constant* and x_i is R&D investment of firm i.[6] The cost of this investment is x_i^2/γ , where γ measures the efficiency of R&D.

2.1 Cournot Competition

The structure of the game in this environment is the following:

- There is a large number of potential entrants who decide whether to enter by incurring a setup cost of F or not.

- All entrants choose their investments x_i and their output quantities q_i simultaneously. So, to simplify the analysis, we assume that R&D investments are not chosen strategically to affect the subsequent competition in quantities but are simply set to minimize total cost, $TC(x_i) = (c - x_i)q_i(x_i) + x^2/\gamma + F$. Allowing for strategic choice of investment will make the analysis less transparent and will not change its main insights.

By backward induction we first find the optimal strategy of a firm if n firms have decided to enter. After that we compute total output, price and profits to determine the equilibrium number of firms, n^*.

In the last stage each firm solves

$$\max_{q_i, x_i} \Pi^i(q_i, x_i, q_{-i}) = (P_i - c + x_i)q_i - x_i^2/\gamma - F. \tag{1}$$

Taking the first order conditions of equation (1) and solving for symmetric output and investment we obtain

$$q_i^*(n) = \frac{2(a-c)}{2b(n-1) + 4 - \gamma}, \qquad x_i^*(n) = \frac{\gamma(a-c)}{2b(n-1) + 4 - \gamma}. \tag{2}$$

[6]Note that x can also be interpreted as the investment in marketing and product development that enhances the size of the market captured by the parameter a.

Notice that the levels of q and x are always proportional to each other in equilibrium, namely $x_i = (\gamma/2)q_i$. This result carries over to all firms in the market; hence, it is also valid for aggregate market output and R&D. Plugging (2) into the inverse demand and profit functions, we can solve for π_i^C as a function of n:

$$\Pi_i^C(n) = \frac{(4-\gamma)(a-c)^2}{[2b(n-1)+4-\gamma]^2}. \tag{3}$$

Finally, to find the equilibrium number of entrants we impose the condition that each firm's gross profit must justify its entry costs, that is, $\pi_C^i(n) \geq F$. For simplicity we will solve for a continuous n^* and use equality

$$n^* = \frac{(a-c)\sqrt{4-\gamma} - \sqrt{F}(4-\gamma-2b)}{2b\sqrt{F}}. \tag{4}$$

Hence, by plugging n^* into (2) we can solve for equilibrium firm output and investment:

$$q_i^* = \frac{2\sqrt{F}}{\sqrt{4-\gamma}}, \qquad x_i^* = \frac{\gamma\sqrt{F}}{\sqrt{4-\gamma}}.$$

The corresponding market output and investment are

$$\begin{aligned} Q_C^* &= \frac{(a-c)\sqrt{4-\gamma} - \sqrt{F}(4-\gamma-2b)}{b\sqrt{4-\gamma}}, \text{ and} \\ X_C^* &= \frac{\gamma[(a-c)\sqrt{4-\gamma} - \sqrt{F}(4-\gamma-2b)]}{2b\sqrt{4-\gamma}}. \end{aligned}$$

Finally, the equilibrium price charged by firm i is given by

$$P_i^C = c + \frac{\sqrt{F}(2-\gamma)}{\sqrt{4-\gamma}}. \tag{5}$$

In the next section we will solve for the Stackelberg equilibrium and compare the outcomes with the ones we just reached.

2.2 Stackelberg Competition

In this setup firm l (the leader) invests in technology improvement before any other firm and enters the market before the others.[7] This, in turn, enables the firm to assume the role of the market leader. More formally, the timing of the game is now the following:

- The leader enters and pays setup cost, F, and immediately chooses investment x_l and output q_l.
- The other firms, the followers, decide whether to enter by paying F each.
- Those who enter decide on their x_i and q_i simultaneously.

By backward induction, we solve the followers' problem taking the leader's output q_l and the number of followers, m, as given. After that we solve for m as a function of q_l and finally we use this "response" of the number of entrants and each q_i as conditions in the leader's problem. Hence, each follower's problem is

$$\max_{q_i, x_i} \Pi^i(q_i, x_i, q_{-i}, q_l) = (P_i - c + x_i)q_i - x_i^2/\gamma - F. \tag{6}$$

Taking the first order conditions and solving for the symmetric equilibrium we get

$$q_i^*(m, q_l) = \frac{2(a - c - bq_l)}{2b(m-1) + 4 - \gamma}, \qquad x_i^*(m, q_l) = \frac{\gamma(a - c - bq_l)}{2b(m-1) + 4 - \gamma}. \tag{7}$$

We can now find the profit of each follower and solve for the number of followers as a function of the leader's strategy, $m(q_l)$. Much like in section 2.1, we use the zero profit condition to obtain

$$m(q_l) = \frac{(a - c - bq_l)\sqrt{4 - \gamma} - \sqrt{F}(4 - \gamma - 2b)}{2b\sqrt{F}}. \tag{8}$$

[7] In addition, $F \leq (a - c)^2/16$ for this entry to take place.

Not surprisingly, the number of followers falls with q_l, the more aggressively the leader behaves, the less room there is in the market for followers. It is interesting however, to see how the output of each firm changes with the leader's output, because there are two opposite effects at work. The first is the direct response effect because $\partial q_i^*(m, q_l)/\partial q_l$ is negative as seen from (7). However, at the same time an increase in the leader's output reduces the numbers of followers in equilibrium and thus has positive effect on the follower's output since $(\partial q_i^*(m, q_l)/\partial m)(dm/dq_l) > 0$. We can plug (8) into (7) to get the net response in both follower strategies:

$$q_i^*(q_l) = \frac{2\sqrt{F}}{\sqrt{4-\gamma}}, \qquad x_i^*(q_l) = \frac{\gamma\sqrt{F}}{\sqrt{4-\gamma}}.$$

We note two features of this result: first, the two above described effects exactly offset each other so the followers' actions do not change with the leader's strategy. Second, their strategies (outputs) are the same as in the Cournot game under free entry that we solved earlier. The finding that the equilibrium strategy of a follower is not affected by the leader's strategy when entry is free holds for a rather general setup and for a large variety of market conducts (see Etro, 2008). Hence, q_l will only affect the total output of the followers through m, not q_i^*.

We can now come to the final set of equations that will be derived by the leader's problem:

$$\max_{q_l, x_l} \Pi^l(q_l, x_l) = \{[a - bm(q_l)q_i^* - q_l] - c + x_l\}q_l - x_l^2/\gamma - F. \tag{9}$$

Taking first order conditions and solving them, we obtain the equilibrium values

$$q_l^* = \frac{2(4-\gamma-2b)\sqrt{F}}{(4-\gamma-4b)\sqrt{4-\gamma}}, \qquad x_l^* = \frac{\gamma(4-\gamma-2b)\sqrt{F}}{(4-\gamma-4b)\sqrt{4-\gamma}}.$$

By substituting them into (9) we get the leaders equilibrium profit

$$\Pi_l^S = \frac{4b^2 F}{(4-\gamma)(4-4b-\gamma)}.$$

In order to obtain positive values for q_l^* and x_l^*, $4-\gamma-4b > 0$ has to hold.[8] Comparing the leader's output and R&D with the followers', we see that the leader produces and researches more than each follower:

$$\frac{q_l^*}{q_i^*} = \frac{x_l^*}{x_i^*} = \frac{4-\gamma-2b}{(4-\gamma-4b)} > 1.$$

We can now also solve for the equilibrium number of followers m^* by plugging q_l^* in (8) and compute the difference between the number of firms, n^*, in the Cournot setup and number of firms, m^*+1, in the Stackelberg setup:

$$n^* - (m^*+1) = \frac{2b}{4-\gamma-4b} > 0$$

Hence, we have found that when one firm has a first mover advantage, we observe fewer firms in equilibrium. Furthermore, if we compare the total output[9] and R&D investment in Stackelberg and Cournot equilibria, we see that they are equal:

$$\begin{aligned} Q_S^* = Q_C^* &= \frac{(a-c)\sqrt{4-\gamma} - \sqrt{F}(4-\gamma-2b)}{b\sqrt{4-\gamma}}; \\ X_S^* = X_C^* &= \frac{\gamma[(a-c)\sqrt{4-\gamma} - \sqrt{F}(4-\gamma-2b)]}{2b\sqrt{4-\gamma}}. \end{aligned}$$

[8]Nonnegativity of production costs places a more stringent restriction on parameters. We elaborate on this in Appendix C.

[9]Etro (2007) showed that aggregate output in both the Stackelberg and Cournot framework is the same in a rather general setup provided that entry is endogenous.

Finally, to compare with (5), here are the equilibrium prices of follower i and the leader:

$$P_i^S = c + \frac{\sqrt{F}(2-\gamma)}{\sqrt{4-\gamma}}, \tag{10}$$

$$P_l^S = c + \frac{\sqrt{F}(4-\gamma-2b)(2-\gamma-2b)}{\sqrt{4-\gamma}(4-\gamma-4b)}. \tag{11}$$

A comparison of equations (5) with (10) and (11) reveals that Stackelberg followers charge the same price as Cournot firms, while the leader charges a lower price. Hence, despite the lower number of varieties in the Stackelberg setup, there are gains in consumer surplus since the lower price of the leader more than compensates for it. This result is formally shown in Appendix A.

The above results are obtained under the implicit assumption that entry deterrence is not a preferable strategy for the leader. As is well known, when the products get less differentiated, the entry deterrence eventually becomes an optimal strategy (see Appendix C). However, unlike in the standard Stackelberg setup with exogenously given number of potential entrants, the leader's accommodation profit in our setup is increasing in differentiation parameter b (see Appendix C). The intuition is that when products get more alike, competition becomes tougher, and, as a consequence, fewer firms enter in equilibrium. In other words, the leader can afford to squeeze more potential entrants out of the market as products become less differentiated.[10] Consequently, increasing product differentiation (letting b move towards zero), leads to the non-standard but intuitive result. In this case, the number of firms entering the market tends to infinity and the profit of the leader goes to zero as well (see Appendix B). Thus in the limit, we obtain a (kind of) long-run monopolistic competition outcome with the leader earning zero profits

[10] By the same token, and again completely opposite from the case with an exogenous number of firms, the leader's accommodation profit increases in setup costs parameter F, since it also leads to a lower number of entrants in equilibrium.

rather than a monopoly outcome as would be the case with an exogenous number of firms and b tending to zero (see Dixit (1979) for the latter).

2.3 Long Run *versus* Short Run

The above characterizations are aimed at portraying two long-run equilibria: a Stackelberg as one before the policy implementation and a Cournot after the policy was in place for a long time. However, we should also be able to tell more about the intermediate situation that occurs soon after the leader has been deprived of its position but before the industry adjusts to its long run equilibrium. This intermediate or short run situation can be described as a Cournot equilibrium with exogenous number of firms. Recall that in a Stackelberg equilibrium there is one leader and m^* followers. Now assume that as a result of the government intervention, the leader loses its advantage and, hence, the market transforms itself into a Cournot-like setup with $m^* + 1 < n^*$ firms. From the results in (2), treating the number of firms as exogenously set to $n = m + 1$, one can clearly see that now each firm will produce less output and invest less intensively in R&D compared to the setup with the leader and endogenous entry. Thus the statement of the EU Commission does not hold in our setup: "[...] on balance, the possible negative impact of an order to supply on Microsoft's incentives to innovate is *not* outweighed by an increase in the R&D intensity of other firms. Consequently, there is *no* [...] positive impact on the level of innovation of the whole industry (including Microsoft)."[11] However, positive profits would reemerge for each follower in this interim period, but the total social welfare would be still lower than in the initial setup with the leader and free entry.

Thus, the considered action of the antitrust authorities will clearly help the competitors of (the former) leader since they will now be able to generate positive

[11] See footnote 2.

profits (at least in the short run) while the consumers will be definitely worse off.

3 Market Leadership in Repeated Interactions

As already indicated, in this section of the paper we consider a somewhat different market scenario based on Boone (2002) and (2004). We now assume that there is repeated market competition in prices but the produced goods are assumed to be homogeneous. All firms move at the same time to choose their R&D expenditure and post their market price. One of the firms, however, has an advantage over the others in terms of R&D productivity. We will call this firm the leader, because, although the game is played simultaneously each period, this advantage will enable it to assume technological and market leadership. Note that in this case we do not have the same type of (classic) leadership we had in section 2, where the leader was the only firm allowed to move first. In this case the advantage in R&D technology will translate into assumed leadership.

As for the solution of such a repeated game, Boone (2004) developed an equilibrium refinement that focuses on outcomes Preferred by Efficient Players (PEP). To apply the PEP refinement, we must distinguish between two types of deviations. The first type is the classical strategy of one firm slightly lowering its price to gain the whole market, in which case the other firms would retaliate to punish the deviant. Otherwise, a firm can lower the price to such levels that it can only be matched by some of the firms. The survivors would gain from this change and accept it as a new equilibrium. Hence, the most efficient firms act as market leaders.

Following Boone (2002), we further assume that firms collude on one price from the interval of sustainable prices. When firms are similar in efficiency and the second type of deviation is not viable, they will all agree to charge high prices. If it is possible to exclude some firms from the market to the benefit of all who remain, however, the latter will price more aggressively. Thus, using the PEP refinement on collusion strategies, the toughness of the market is endogenous and it depends on the heterogeneity in efficiency levels.

All firms who enter choose a price p_i and a level of R&D expenditure x_i. Each firm faces a constant marginal cost $c_i(x_i)$, where $c_i > 0$, $c_i' < 0$ and $c_i'' > 0$ at all levels of x_i. The leader's cost function differs from the other firms by $c_L(x) < c_F(x)$ for all $x > 0$ and $c_L(0) = c_F(0)$. The demand is $D(p)$ where $D' < 0$. Finally, the firms compete in prices over an infinity of periods and discount the future by a rate r. In such setup, the Folk theorem predicts that there is a multitude of potential equilibria. We, however, invoke the above PEP refinement to focus on a unique equilibrium. For that purpose we also assume that there is sufficient difference in R&D efficiencies between the leader and followers, which will enable the leader to undercut all other firms, and that this equilibrium is more profitable for the leader.

3.1 Market without Leader

Much like in the previous section, we are interested to see what happens in this market if the leader loses its advantage over other firms. If all firms are identical there is a perfect "balance of power", so the firms will reach a tacit collusion and the above PEP refinement suggests that they will charge a monopoly price.[12] We now assume that the cost function is the same $c_L(x_i)$ for all firms.[13] Under this strategy, all firms keep to the monopoly price unless one of them undercuts it. In that case all charge $p = c(x)$ for all remaining periods, that is, the equilibrium reverts to a standard Bertrand outcome on the market with homogenous goods. Hence, each potential deviant is caught between a full monopoly profit in this period and none

[12] Such a collusive outcome can also be sustained in standard infinitely repeated games by grim trigger strategy if the discount r is low enough.

[13] The same outcome will be supported by PEP even if firms have different unit costs with variance lower than the critical level that triggers aggressive behavior of the more efficient firm(s).

afterwards or an infinite stream of shared monopoly profits.[14] For the collusion equilibrium to be sustainable and assuming that there are n identical firms, we need

$$D(p^m)[p^m - c_L(x_i)]/(rn) - x_i \geq D(p^m)[p^m - c_L(x_i)] - x_i, \tag{12}$$

which holds if and only if $r \leq 1/n$. We will assume henceforth that this condition holds, that is, a market where all firms are identical would result in them charging monopoly price p^m. Each firm chooses a level of R&D, x^a that maximizes

$$x^a = \arg\max_x \{D(p^m)[p^m - c_L(x)]/n - x\}.$$

Taking the first order conditions we find the following rule that implicitly defines x^a:

$$c'_L(x^a) = -\frac{n}{D(p^m)}. \tag{13}$$

3.2 Market with Leader

Now we return to the assumption that one firm, the leader, has a cost advantage for all positive values of x. Assuming x_L is positive in equilibrium, if this advantage is large enough, it would be optimal for the leader to charge a price that would exclude all n followers and still make a profit. The leader would have to charge a price p^d that is defined by

$$\max_x \{D(p^d)[p^d - c_F(x)] - x\} = 0. \tag{14}$$

But even if charging p^d and selling to the whole market produces a positive profit, it would have to produce more profit than the alternative solution: accommodating the followers' entry and sharing the monopoly profits. Hence, the leader

[14] The deviant would only undercut marginally, therefore getting (slightly less than) a monopolist's profits for a single period.

will deter entry if and only if

$$\max_x\{D(p^d)[p^d - c_L(x)] - x\} \geq \max_x\{D(p^m)[p^m - c_L(x)]/n - x\}. \qquad (15)$$

Again, for the sake of our argument, we will assume this condition to hold. That is, if there is a firm that has a (large enough) cost advantage, it will deter all the other firms from entry by charging $p^d < p^m$ and assume the market leadership position. Note that from here we can already say that the leader will produce a higher consumer surplus due to the lower deterrence price. Moreover, the ensuing market structure is closer to the competitive equilibrium which entails larger social welfare.

The leader's optimal choice of R&D in these circumstances is

$$x^d = \arg\max_x\{D(p^d)[p^d - c_L(x)] - x\}.$$

The first order condition gives us the implicit rule for the optimal R&D

$$c_L'(x^d) = -\frac{1}{D(p^d)}. \qquad (16)$$

Comparing equations (13) and (16) we can see that $x^d > x^a$ because $c_L'(x^d)$ is equated to a smaller (in absolute value) number than $c_L'(x^a)$ and $c_L'' > 0$.[15] However, it remains unclear whether the single firm spends more on R&D or less than the n collusive firms. That is, whether $x^d > nx^a$ or the other way around depends on the properties of $c_L(x)$ and the demand function. In the case of linear demand and the standard "R&D production function" displaying decreasing returns (like the one of the form $c_L(x) = c - \sqrt{\gamma x}$), the setup with the technological leader and $n-1$ followers results in higher R&D investment and more innovation than the

[15] The number is smaller for two reasons. First, the numerator of the derivative of (13) is n instead of 1. Second, its denominator $D(p^m)$ is lower than $D(p^m)$ because $p^m > p^d$.

corresponding symmetric setup without the leader.[16] Furthermore, as proven in Appendix E, a sufficient condition for the leader spending more on R&D than the other firms is that the elasticity of $c'_L(x) \in [-1, 0)$.

4 Conclusion

The main message of our analysis is that under plausible assumptions like free entry or repeated market interactions, there is a social value of market leadership and its mechanical removal by means of competition policy is likely to be harmful for society. As stated in Economic Focus of *The Economist* sometime ago "...antitrust authorities should be especially careful when trying to stamp out monopoly power in markets that are marked by technical innovation. It could still be that firms like Microsoft are capable of using their girth to squish their rivals; the point is that continued monopoly is not cast-iron evidence of bad behavior [...] The fact that a dominant firm remains on top might actually be strong evidence of vigorous competition. [...] The very ease of entry, and the aggressiveness of the competitive environment, are what spur monopolists to innovate so fiercely." ("Slackers or Pace-setters," 2004)

In section 2 we showed that the Stackelberg leadership outcome mimics that of the Cournot as far as total output and R&D investments are concerned but with a smaller number of firms and with leader charging a lower price than the followers. This corresponds to a higher social welfare in the Stackelberg leader setup due to fewer setup costs to be paid and higher consumer surplus. Furthermore, we have also shown that there is further social welfare loss in the aftermath of an applied policy that removes the leadership position. As the industry moves from one long run equilibrium to the other, output and investment are lower and the price is higher. Consequently, the only beneficiaries of such a policy are the competitors

[16] See Appendix D.

that benefit at the expense of consumers and the leader.

An interesting byproduct of our analysis in section 2 is the comparative static of the key parameter, b, that measures the degree of product differentiation. Unlike in the standard Stackelberg setup with barriers to entry (that is, with the number of firms exogenously given), the leader's accommodation profit in our setup increases in b. The reason is that competition becomes tougher when products get more alike, and consequently, fewer firms enter in equilibrium. Even more interestingly, increasing product differentiation (letting b move towards zero) results in the number of firms entering the market going to infinity and the profit of the leader going to zero. Thus, in the limit, we obtain a monopolistic competition outcome rather than the standard monopoly outcome that occurs with exogenous number of firms.

In section 3 we study the effect of leadership on research intensity with competition in prices when there are repeated interactions among the potentially different firms. We show that when there is a distinctive technological leader, it converts its technological advantage into market leadership. The leader behaves aggressively, charges lower price, generates larger social welfare, and (under plausible conditions) invests more in R&D than would be the case in a similar setup without the technological and market leader. As a consequence, entry is deterred and the followers are forced to leave the market.

References

Boone, J. (2002). 'Be nice, unless it pays to fight': A new theory of price determination with implications for competition policy. *WZB Discussion Paper FS IV 02-18*.

Boone, J. (2004). Balance of power. *CEPR Discussion Paper 4733*.

Czarnitzki, D., Etro, F., & Kraft, K. (2008). The effect of entry on R&D investment of leaders: Theory and empirical evidence. *mimeo, INTERTIC*.

Damme, E. van, & Hurkens, S. (1999). Endogenous stackelberg leadership. *Games and Economic Behavior*, *28*(1), 105-129.

Deneckere, R. J., Kovenock, D., & Lee, R. (1992). A model of price leadership based on consumer loyalty. *Journal of Industrial Economics*, *40*(2), 147-56.

Dixit, A. (1979). A model of duopoly suggesting a theory of entry barriers. *Bell Journal of Economics*, *10*(1), 20-32.

Etro, F. (2004). Innovation by leaders. *Economic Journal*, *114*(495), 281-303.

Etro, F. (2007). *Competition, innovation and antitrust: A theory of market leaders and its policy implications*. Berlin & New York: Springer Verlag.

Etro, F. (2008). Stackelberg competition with endogenous entry. *Economic Journal*, *forthcoming*.

Hamilton, J. H., & Slutsky, S. M. (1990). Endogenous timing in duopoly games: Stackelberg or cournot equilibria. *Games and Economic Behavior*, *2*(1), 29-46.

Motta, M. (2004). *Competition policy: Theory and practice*. Cambridge: Cambridge University Press.

Rotemberg, J. J., & Saloner, G. (1990). Collusive price leadership. *Journal of Industrial Economics*, *39*(1), 93-111.

Slackers or pace-setters? Monopolies may have more incentives to innovate than economists have thought. (2004, May 22). The Economist, Economic Focus.

Sutton, J. (1991). *Sunk cost and market structure.* Massachusetts: MIT Press.

Syropoulos, C. (1994). Endogenous timing in games of commercial policy. *Canadian Journal of Economics*, *27*(4), 847-64.

Syropoulos, C. (1996). Nontariff trade controls and leader-follower relations in international competition. *Economica*, *63*(252), 633-48.

A The Difference in Consumer Surplus with and without Leader

In this appendix we show that the consumer surplus is greater in the free entry Stackelberg equilibrium than in the Cournot equilibrium. Since we are dealing with several horizontally differentiated markets, we have to add the surplus of each market. We will compute consumer surplus as the area under each demand function.

Due to the symmetry between firms, in the Cournot equilibrium (section 2.1) we have

$$CS^C = n^* \int_{P_i^C}^{P_0} D_i[P_i, Q_{-i}]dP_i, \tag{17}$$

where D_i is the demand facing firm i that depends on its own price P_i and the equilibrium output of all other firms Q_{-i}. The price where $D_i = 0$ is denoted by P_0.

By the same token, the total consumer surplus in the Stackelberg equilibrium (section 2.2) is given by

$$CS^S = m^* \int_{P_i^S}^{P_0} D_i[P_i, Q_{-i}]dP_i + \int_{P_l^S}^{P_0^l} D_l[P_l, m^* q_i^*]dP_l, \tag{18}$$

where D_l is the leader's demand and P_0^l is the price where $D_l = 0$. The price P_0 and Q_{-i} are the same as for firm i in the Cournot setup because in equilibrium their individual outputs as well as the total industry output are identical (compare q_i^* from sections 2.1 and 2.2 and also Q_C^* with Q_S^*). Indeed, the consumer surplus generated by each firm (product) is the same for firm i in the Cournot equilibrium and for follower i in the Stackelberg equilibrium.

Hence, the difference between the total consumer surplus under each setup (expression (18) less expression (17)) is

$$CS^S - CS^C = (m^* - n^*)\int_{P_i^S}^{P_0} D_i[P_i, Q_{-i}]dP_i + \int_{P_l^S}^{P_0^l} D_l[P_l, m^* q_i^*]dP_l. \qquad (19)$$

After some straightforward algebra this expression is reduced to

$$CS^S - CS^C = \frac{4bF(4-\gamma-2b)}{(4-\gamma)(4-\gamma-4b)^2},$$

which is always positive for our initial condition $4 - \gamma - 4b > 0$.

B The Number of Followers in Stackelberg Equilibrium

In this appendix we show some properties of the equilibrium number of firms in the Stackelberg setup, m^*. Our main purpose is to show that m^* is decreasing in the differentiation parameter b and that it behaves as expected.

To begin with, below is the full form of m^* (in the text we only show its relationship to n^*, the Cournot equilibrium number of firms)

$$m^* = \frac{(a-c)\sqrt{F(4-\gamma)} - \frac{F(4-2b-\gamma)^2}{4-4b-\gamma}}{2bF}.$$

Ignoring γ for the moment we can show that $\partial m^*/\partial b < 0$ for all $b \in [0,1]$. The expression for m^* is now

$$m^* = \frac{a-c}{b\sqrt{F}} - \frac{2-b}{2(1-b)} - \frac{b}{2} + 1.$$

The derivative with respect to b is then

$$\frac{\partial m^*}{\partial b} = \frac{1}{b^2}\left[\frac{(2-b)(2-3b)}{(1-b)^2} - \frac{2(a-c)}{\sqrt{F}}\right],$$

so the sign of the derivative is the same as the sign of the expression in brackets. We will label the term in brackets as B for simplicity of notation.

Note that B attains maximal value at the limit value of $b = 0$ since the first part of B is clearly positive and increases as b tends to zero while the second part does not depend on b at all. To see this we label the first part of B as B_1 so

$$B_1 = \frac{(2-b)(2-3b)}{(1-b)^2}$$

and its first derivative is

$$\frac{dB_1}{db} = \frac{2b}{(b-1)^3} < 0.$$

Taking the limit of B when b tends to zero we obtain

$$\lim_{b\to 0} = 4 - \frac{2(a-c)}{\sqrt{F}}. \tag{20}$$

Despite the fact that (20) is the highest value of B, it has to be still negative given our assumption. Namely negativity of (20) would imply that

$$F < (a-c)^2/4.$$

However, from footnote 2 we recall that

$$F < (a-c)^2/16$$

for an equilibrium to be viable. Thus $B(0) < 0$ and therefore $B(b) < 0$ for all values of b and that consequently $\partial m^*/\partial b < 0$.

Alternatively, negativity of (20) also implies that $\sqrt{F} < (a-c)^2$, that is, the optimal output of a monopolist has to be bigger than the output of a follower in a free entry equilibrium.

From here it is easy to show that the above analysis generalizes to other values of $\gamma > 0$ because the introduction of R&D only changes the number of firms insignificantly. Figure 1 illustrates this result, where values of m^* for $\gamma = 0.4$ (in grey solid line) and $\gamma = 0.7$ (in black dashed line) almost overlap (the other parameters were set to $a = 10$, $c = 3$ and $F = 4$).

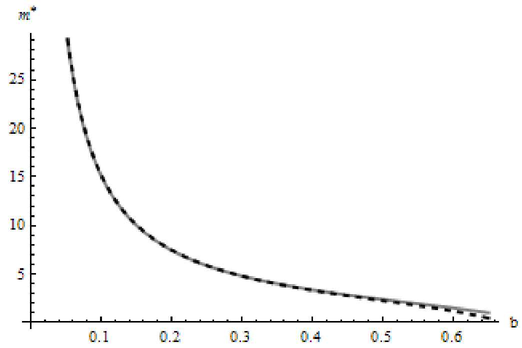

Figure 1: The equilibrium number of followers, m^*.

C Complete vs. Partial Entry Deterrence

In an endogenous entry setting, like our section 2 model, the leader always manages the number of followers to some extent. Therefore, in these cases we always have deterrence of some competitors. What we intend to discuss in this appendix is whether the leader would prefer to deter entry completely, that is, not allow any followers to enter. For simplicity we will refer to this scenario as entry deterrence.

But before we move on to the leader's choice over entry, we must consider another restriction on our parameters. This restriction comes from the nonnegativity of production costs, $c - x_i$. Since we know that the leader is the one who invests most heavily in research, the relevant condition is $c - x_l^* \geq 0$. Perhaps the best

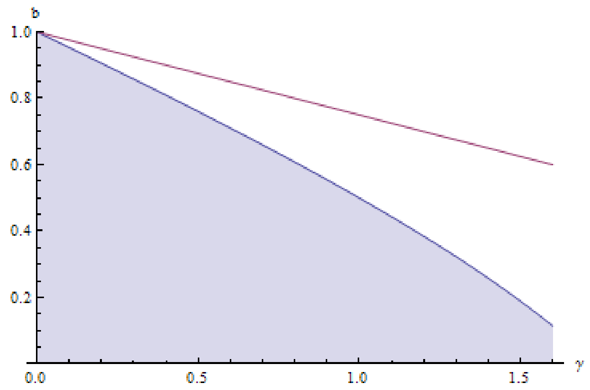

Figure 2: Set of feasible values of b.

way to represent this restriction on parameters would be in the form of a *critical* b,

$$b^c = \frac{(4-\gamma)(c\sqrt{4-\gamma} - \gamma\sqrt{F})}{4c\sqrt{4-\gamma} - 2\gamma\sqrt{F}},$$

where for given parameters γ, F and c, any feasible b has to be such that $b < b^c$.

Figure 2 shows graphically the feasible set of parameter b plotted against γ (filled) and our other constraint $4 - \gamma - 4b > 0$ to show that nonnegativity of production costs imposes harder restrictions than nonnegativity of output. To draw the graph we have used the following values: $a = 10$, $F = 3$ and $c = 2$. We will use the same parameters in other graphs unless stated otherwise.

Having established the feasible range of parameters, we go on to compare the profit of the maximizing leader (internal solution) to the profit of the leader who maximizes his profit by producing enough output to make it unprofitable for even one follower to enter (corner solution). Formally, to find the entry deterring output from the leader, we use q_l^D that solves

$$m(q_l^D) = 1,$$

because by definition of $m(\cdot)$, this will set the profit of a single follower to zero.

The algebraic expressions, while well defined and straightforward to compute, are too cumbersome to be represented here, therefore we will limit ourselves including some graphs of profit levels as a function of the differentiation parameter b. Figure 3 shows the monopoly profit (dotted), the accommodating leader's profit (solid) and the deterring leader's profit (dashed) as functions of b over the feasible range (for $\gamma = 0.5$).

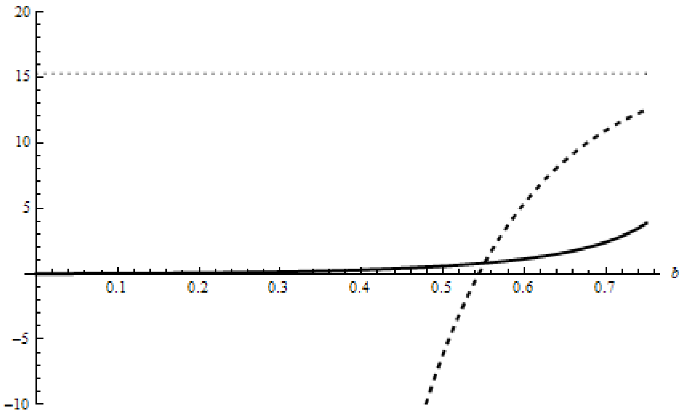

Figure 3: Difference in profit of leader.

As it is clearly seen from the graph in Figure C, the leader chooses to allow entry when b is smaller than some limit value. Our analysis in section 2 is valid for these values of b where there is no complete entry deterrence.

D Repeated Price Competition with Linear Demand and Quadratic Research Costs

In this appendix we show that in the special case of linear demand and quadratic research costs (that we adopted in section 2), the single deterring firm in a repeated price competition setting ("leader" of section 3) will spend more on R&D than in the symmetric equilibrium.

In order to make the models comparable we need to compute the R&D production function that leads to the quadratic costs. We have to do this because in section 2, x_i represents the amount of research (the fall in production costs) whereas in section 3, x_i refers to the R&D expenditure.

From section 2 the cost of decreasing the production marginal cost by x is x^2/γ. Inverting this to get a production function (and redefining x as *R&D expenditure* to fit section 3) we find that by spending x a firm will have marginal production cost of $c - \sqrt{\gamma x}$.

Using this R&D technology and a linear demand, the symmetric firm in a market with n firms will maximize

$$\max_{x_i} \Pi^i = (a - p^m)[p^m - (c - \sqrt{\gamma x_i})]/n - x_i - F. \tag{21}$$

We set the monopoly price to $p^m = [a - (c - \sqrt{\gamma x_i})]/2$ and solve the first order condition to get the optimal expenditure

$$x^a = \frac{\gamma(a-c)^2}{(4n-\gamma)^2}.$$

In the case when one firm has an advantage in R&D technology, it may decide to keep every other firm out of the market. In our example we will assume these other firms (from here "followers") have $c - \sqrt{\gamma_f x_i}$ production costs for x_i spent on research, where $\gamma_f < \gamma$.[17] When this deterrence is optimal, the leader will solve

$$\max_{x_L} \Pi^L = (a - p^d)[p^d - (c - \sqrt{\gamma x_L})] - x_L - F, \tag{22}$$

where $p^d < p^m$ is the deterrence price, that is the market price that makes $\Pi^i = 0$. Taking the first order condition and solving it we get

$$x^d = \frac{\gamma\{2(a-c)[a-c+\sqrt{(a-c)^2 - F(4n-\gamma_f)}] - F(4n-\gamma_f)\}n^2}{(4n-\gamma_f)^2}.$$

[17] Note that the leader has the same technology as the case with symmetric firms. We do this to show that the difference in research is only due to market structure and not higher R&D efficiency.

It is straightforward to check that $x^d > nx^a$.

E A Sufficient Condition for Higher R&D Expenditure by a Single Firm

For R&D to be higher under a single (leader) firm than under n identical collusive firms, we need $x^d > nx^a$. Furthermore, as already discussed in the paper, at optimum

$$n|c'_L(x^d)| \leq |c'_L(x^a)|.$$

To simplify our analysis, we ignore the difference in denominators between (13) and (16). The previous inequality in that case holds with equality. This condition is weaker than what we already have because a lower $|c'_L(x^d)|$ would imply an even bigger x^d. Thus, for the leader to be producing more, we would need that at least an n times higher x is necessary to produce an n times lower $|c'_L(x)|$. Formally

$$\frac{|c'_L(x_1)|}{|c'_L(x_2)|} \leq \frac{x_2}{x_1}$$

must hold for all $0 < x_1 < x_2$. Taking the log of both sides and rearranging,

$$-[\log|c'_L(x_2)| - \log|c'_L(x_1)|] \leq \log x_2 - \log x_1.$$

For infinitesimal differences between x_2 and x_1, we have

$$\epsilon_{c'_L} = \frac{d\log|c'_L(x)|}{d\log x} \geq -1. \tag{23}$$

One type of marginal cost function that yields this result is $c_L(x) = a - bx^{1+\epsilon}$ where $\epsilon \in (-1, 0)$ is the desired (constant) elasticity of $c'_L(x)$. For unit elasticity $c'_L(x)$, the function is $c_L(x) = a - b\ln x$. These marginal cost functions are not positive everywhere, but a and b can be set such that the marginal cost is positive for all the relevant levels of R&D.

Individual researchers, as well as the on-line and printed versions of the CERGE-EI Working Papers (including their dissemination) were supported from the following institutional grants:

- Center of Advanced Political Economy Research [Centrum pro pokročilá politicko-ekonomická studia], No. LC542, (2005-2009),
- Economic Aspects of EU and EMU Entry [Ekonomické aspekty vstupu do Evropské unie a Evropské měnové unie], No. AVOZ70850503, (2005-2010);
- Economic Impact of European Integration on the Czech Republic [Ekonomické dopady evropské integrace na ČR], No. MSM0021620846, (2005-2011);

Specific research support and/or other grants the researchers/publications benefited from are acknowledged at the beginning of the Paper.

Published by
Charles University in Prague, Center for Economic Research and Graduate Education (CERGE)
and
Economics Institute ASCR, v. v. i. (EI)
CERGE-EI, Politických vězňů 7, 111 21 Prague 1, tel.: +420 224 005 153, Czech Republic.
Printed by CERGE-EI, Prague
Subscription: CERGE-EI homepage: http://www.cerge-ei.cz

Editors: Directors of CERGE and EI
Managing editors: Deputy Directors for Research of CERGE and EI

ISSN 1211-3298
ISBN 978-80-7343-175-4 (Univerzita Karlova. Centrum pro ekonomický výzkum a doktorské studium)
ISBN 978-80-7344-164-7 (Národohospodářský ústav AV ČR, v. v. i.)

CERGE-EI
P.O.BOX 882
Politických vězňů 7
111 21 Praha 1
Czech Republic
http://www.cerge-ei.cz