MERGER POLICY IN R&D INTENSIVE INDUSTRIES*

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A B S T R A C T

We analyze merger policy in an industry where firms participate in a non-tournament R&D competition. We conclude that merger policy should be, in general, less restrictive in high technology markets (pharmaceuticals and telecoms), because mergers reduce the wasteful duplication of R&D expenditures. However, merger policy should become more strict in (very) asymmetric market structures. In this case, competition provides incentives for R&D, but, at the same time, duplication is avoided.

KEYWORDS: Mergers; Antitrust; Research and Development.

1 Introduction.

In the last years, we have observed an increase in the number of mergers in different sectors of economic activity. These processes are motivated by different strategic responses to a changing environment: "(M)any of today's (mergers) are defensive. Frightened by contracting markets (the defensive industry); by falling commodity prices (oil); by excess capacity in key markets (cars); by the uncertainties of technological change (banks and telecoms); or by the soaring costs of research (pharmaceuticals): companies in many industries think they are more likely to prosper if they are huge than merely large" (The Economist 9th January 1999)).

These phenomena demands a clear policy from antitrust authorities. This task is not easy, because antitrust laws were originally designed to apply to traditional manufacturing industries and it is not far from controversy if they can be used to deal with high technology markets. In the traditional sectors, the main question is to compare the effect on price with possible cost reductions induced by the merger. This is the basic trade-off analyzed in the US Merger Guidelines. The question is whether this framework can be used to analyze the welfare impact of mergers in high technological sectors where other factors, like the quality of goods and the pace of innovation, come into play. These new factors are important because in those industries firms not only compete in prices but in the level of R&D as well.

The way merger policy should be adapted in R&D intensive industries is not clear. The effect of competition on the welfare impact of R&D expenditure is uncertain. Sometimes, competition may induce an excessive expenditure in R&D (Lee and Wilde (1980)), but we may also have situations where the lack of competition reduce the incentives to innovate. The antitrust authority should decide which of the two effects dominates in each case.

We carry our analysis in two different models: the strategic and the nonstrategic case. In the non-strategic case, R&D decisions are only driven by cost reducing considerations. In the strategic case, they will also be used to affect the decisions of the competitors. By comparing the two contexts, we can isolate the strategic role played by R&D expenditures. These two scenarios are common in the literature dealing with R&D competition, for example, Tandon (1984) models competition as in the first scenario and Okuno-Fujiwara and Suzumura (1993) as in the second scenario.

We want to analyse these models in a context where firms have different cost structures (*asymmetric context*). We also want to analyse the effect of the number of firms on the optimal merger policy. For this reason, we propose a model where firms have identical cost structures (*symmetric context*).

Despite the diversity of environments we analyse, a clear conclusion arises: merger policy should be less restrictive in R&D intensive industries. This idea common among practitioners and managers, shares the schumpeterian view that concentration has a positive effect on technological progress (Acs and Audretsch (1988)).

The main advantage that mergers have in these sectors is that the more concentrated the market the more easily firms can appropriate the returns of their R&D investments (Levin, Cohen and Mowery (1985)). In other words, mergers induce a lower duplication of R&D expenditures by allowing merging firms to concentrate their innovation activities.

An important exception to the previous general idea appears in the strategic case when firms are asymmetric. In this case, the merger between an efficient and an inefficient firm reduces welfare. The reason being that the inefficient firm stimulates the R&D expenditure of the efficient one. At the same time, this reduces the R&D made by the inefficient firms which avoids the duplication of R&D expenditures. In this case, competition increases welfare, because we have that R&D expenditure is stimulated but not duplicated. The fact that the existence of (very) inefficient firms can increase welfare departs from the traditional point of view of merger policy.

The asymmetric and symmetric contexts are analysed respectively in Sections 2 and 3. In each Section, the strategic and nonstrategic models are analyzed in different subsections. Finally, conclusions are presented in Section 4

2 The Asymmetric Model

We have two firms, firm 1 and 2, competing in a market with inverse demand given by $p = A - Q$ where Q is total output and p is price. Firm i's cost function is assumed to be of the form:

$$C_i(x_i, q_i) = (c_i - x_i) q_i + \gamma x_i^2$$

where x_i and q_i denote the level of R&D[1] and the production of firm i respectively. We assume that Firm 1 is more efficient, $c_1 < c_2$. This cost function corresponds to the one used in d'Aspremont and Jacquemin (1988) for the case without spillovers[2].

It is assumed that $\gamma \geq 1$. This guarantees that the second order conditions are satisfied. Observe that γ represents the effectiveness of R&D investment. When γ increases the expenditure to obtain a given cost reduction also increases.[3] The

[1]If goods were differentiated, the present formulation could be reinterpreted as if R&D affected the quality of goods. This extension is left for future research.

[2]Introducing spillovers will lead us naturally to consider intermediate forms of competition as Research Joint Ventures. To focus on the comparison between full competition and full cooperation, we prefer to suppress spillovers in the specification of the cost function.

[3]The present model can accomodate the introduction of a parameter (β) that reflects R&D productivity (see Barros and Nilssen (1998)). Suppose that the cost function is given by:

$$C_i(x_i, q_i) = (c_i - \beta y_i) q_i - \delta y_i^2$$

where y_i is the level of R&D.

case without R&D investment is obtained in the limit case when γ tends to infinity.

Firms decide both the level of R&D and the level of output. We will consider two different scenarios depending on the timing of the decisions. In the first scenario (Non Strategic model), R&D and output are chosen by both firms simultaneously. In the second scenario (Strategic model), R&D is decided prior to output.

The Non Strategic model consists of a game where all decisions are taken in the same stage. In the Strategic model we have a two stage game where in a first stage, the R&D decisions are taken and once they are publicly known, output decisions are taken in a second stage. The difference between both models lies in the role played by R&D decisions. In the first model, they are driven only by cost reducing considerations. In the second, we must also take into account the influence they have on market competition in the second stage. These two scenarios are common in the literature dealing with R&D competition, for example, Tandon (1984) models competition as in the first scenario and Okuno-Fujiwara & Suzumura (1993) as in the second scenario.

We are interested in the effect on welfare of market structure. Therefore we have to study what happens when both firm merge to form a monopoly. In this case, both scenarios coincide. However we have to specify the cost function of the merged entity.

If we define $x_i = \beta y_i$, the cost function can be rewritten as:

$$C_i(x_i, q_i) = (c_i - x_i) q_i - \frac{\delta}{\beta^2} x_i^2$$

This is exactly the formulation presented in the text if $\gamma = \frac{\delta}{\beta^2}$. Therefore, increases in γ can also be interpreted as decreases in R&D productivity.

We consider that the cost structure is not altered by the merger[4], that is

$$C(x_1, x_2, q_1, q_2) = (c_1 - x_1) q_1 + (c_2 - x_2) q_2 + \gamma \left(x_1^2 + x_2^2\right)$$

This implies that R&D and production will be concentrated in the most efficient technology. The merged firm will optimally choose $q_2 = 0$ and $x_2 = 0$.[5]

To study the duopoly case we define the profits of firm 1 and 2. They are given respectively by:

$$\Pi_1 = (A - c_1 + x_1 - q_1 - q_2) q_1 - \gamma x_1^2$$

$$\Pi_2 = (A - c_2 + x_2 - q_1 - q_2)_2 - \gamma x_2^2$$

They can be rewritten the following way:

$$\Pi_1 = (A - c_1)^2 \left[\left(1 + \frac{x_1}{A - c_1} - \frac{q_1}{A - c_1} - \frac{q_2}{A - c_1}\right) \frac{q_1}{A - c_1} - \gamma \left(\frac{x_1}{A - c_1}\right)^2\right]$$

$$\Pi_2 = (A - c_1)^2 \left[\left(1 - t + \frac{x_2}{A - c_1} - \frac{q_1}{A - c_1} - \frac{q_2}{A - c_1}\right) \frac{q_2}{A - c_1} - \gamma \left(\frac{x_2}{A - c_1}\right)^2\right]$$

$$\text{where } t = \frac{c_2 - c_1}{A - c_1}.$$

Higher values of t represent higher asymmetries between firms.

To compute the equilibrium of the model becomes simpler if firms are assumed to choose $X_i = \dfrac{x_i}{A - c_1}$ and $Q_i = \dfrac{q_i}{A - c_1}$ and to maximize:

$$\pi_1 = (1 + X_1 - Q_1 - Q_2)Q_1 - \gamma X_1^2$$

$$\pi_2 = (1 - t + X_2 - Q_1 - Q_2)Q_2 - \gamma X_2^2$$

This way of solving the model highlights the fact that the relevant parameters of the model can be reduced to γ (the effectiveness of R&D) and t (the degree of asymmetry between firms).

[4]Observe that this means that the research developed in firm 2 can not be used to reduce the cost of producing the good in firm 1.

[5]See footnote 11 in d'Aspremont and Jacquemin (1988).

2.1 Non Strategic model

In equilibrium, the quantities and R&D investment are:

$$q_1^N = \frac{(A - c_1)\, 2\gamma\, (-1 + 2\gamma\, (1 + t))}{1 - 8\gamma + 12\gamma^2}$$

$$q_2^N = \frac{(A - c_1)\, 2\gamma\, (-1 + 2\gamma + t\, (1 - 4\gamma))}{1 - 8\gamma + 12\gamma^2}$$

$$x_1^N = \frac{(A - c_1)\, (-1 + 2\gamma\, (1 + t))}{1 - 8\gamma + 12\gamma^2}$$

$$x_2^N = \frac{(A - c_1)\, (-1 + 2\gamma + t\, (1 - 4\gamma))}{1 - 8\gamma + 12\gamma^2}$$

when $t \leq \dfrac{2\gamma - 1}{4\gamma - 1}$. Otherwise, we have the same situation as with merger. These results are obtained solving the following equilibrium conditions

$$\left.\begin{array}{l} \dfrac{\partial \Pi_i}{\partial q_i} = 0 \text{ when } i = 1, 2 \\ \dfrac{\partial \Pi_i}{\partial x_i} = 0 \text{ when } i = 1, 2 \end{array}\right\} \tag{1}$$

The efficient firm invests in R&D more than the inefficient one. The difference between the level of investments increases with the degree of asymmetries (t). When $t = \dfrac{2\gamma - 1}{4\gamma - 1}$, the inefficient firm does not invest and does not produce.

Social welfare is assumed to be the sum of consumer surplus and firms profits. Given outputs q_1 and q_2, and R&D levels x_1 and x_2 is given by:

$$W(q_1, q_2, x_1, x_2, \gamma) = \int_0^{q_1 + q_2} (A - y)\, dy - (c_1 - x_1)\, q_1 - (c_2 - x_2)\, q_2 - \gamma\, (x_1)^2 - \gamma\, (x_2)^2 =$$

$$= A\, (q_1 + q_2) - \frac{(q_1 + q_2)^2}{2} - (c_1 - x_1)\, q_1 - (c_2 - x_2)\, q_2 - \gamma x_1^2 - \gamma x_2^2$$

Therefore the social Welfare in the non-strategic equilibrium where both firms active amounts to :

$$W^N = \frac{(A - c_1)^2 \left(\gamma \left(2\, (1 - t)\, (1 - 2\gamma)^2\, (-1 + 8\gamma) + t^2\, (-1 + 14\gamma - 60\gamma^2 + 88\gamma^3)\right)\right)}{\left((1 - 6\gamma)^2\, (1 - 2\gamma)^2\right)} \tag{2}$$

2.2 Strategic model

We solve first the case where both firms are active. This will be the case when firms are not very asymmetric $\left(t \leq \frac{3\gamma - 2}{2(-1+3\gamma)}\right)$. Equilibrium occurs where each firm maximizes its profit with respect to own production given the production of its rival. The solution to the first order conditions depends on x_1 and x_2. Therefore, in the second stage, firms will produce:

$$q_1 = \frac{(A - c_1)((1+t) + 2x_1 - x_2)}{3}$$

$$q_2 = \frac{(A - c_1)((1-2t) - x_1 + 2x_2)}{3}$$

In the first stage (or R&D stage) the optimal level of R&D is given by:

$$x_1^S = \frac{(A - c_1)(-4 + 6(1 + t\gamma))}{4 - 24\gamma + 27\gamma^2}$$

$$x_2^S = \frac{(A - c_1)(-4 + t(4 - 12\gamma) + 6\gamma)}{4 - 24\gamma + 27\gamma^2}$$

These levels of R&D depend on the degree of asymmetries (t) and the effectiveness of R&D (γ).

Therefore the quantity produced in equilibrium is:

$$q_1^S = \frac{(A - c_1)\,3\gamma(-2 + 3(1+t)\gamma)}{4 - 24\gamma + 27\gamma^2}$$

$$q_2^S = \frac{(A - c_1)\,3\gamma(-2 + t(2 - 6\gamma) + 3\gamma)}{4 - 24\gamma + 27\gamma^2}$$

The efficient firm invests in R&D more than the inefficient one. The difference between the level of investments increases with the degree of asymmetries (t). When $t = \frac{3\gamma - 2}{2(-1+3\gamma)}$, the inefficient firm does not invest and does not produce. Observe that the inefficient firm is expelled from the market for a lower value of t in the strategic case than in the non strategic case. The reason for this is that now the R&D decisions have a strategic dimension: the efficient overinvest in order to reduce the output sold in Stage 2 by firm 2.

Social Welfare in equilibrium is given by:

$$W^S = \frac{(A - c_1)\gamma\left(8(1-t)(2-3\gamma)^2 + t^2(16 - 78\gamma + 99\gamma^2)\right)}{2(2-3\gamma)^2(-2+9\gamma)} \tag{3}$$

When $\frac{3\gamma - 2}{2(-1+3\gamma)} \leq t \leq \frac{-1+2\gamma}{-1+4\gamma}$ firm 1 invest in R&D to expel firm 2 from the market. In this case

$$x_2^S = q_2^S = 0$$

and

$$x_1^S = (A - c_1)(1 - 2t) \text{ and } q_1^S = (A - c_1)(1 - t)$$

$$W^S = \frac{3}{2} - 3t + \frac{3}{2}t^2 - \gamma + 4t\gamma - 4\gamma t^2. \tag{4}$$

When $t \geq \frac{1-2\gamma}{-1+4\gamma}$, we have the same situation as with merger.

2.3 Monopoly

In equilibrium, it will produce:

$$q^M = \frac{2\gamma(A - c_1)}{4\gamma - 1}$$

and the optimal level of R&D is:

$$x^M = \frac{(A - c_1)}{4\gamma - 1}.$$

Social Welfare in equilibrium is given by:

$$W^M = \frac{(6\gamma - 1)\gamma(A - c_1)^2}{(4\gamma - 1)^2} \tag{5}$$

2.4 Comparing Welfare in Monopoly and Duopoly

In this section we derive the main results of the paper that refer to the optimal merger policy in the two scenarios. In both cases when $t \geq \frac{-1+2\gamma}{-1+4\gamma}$ we have monopoly independently of the number of firms. Therefore merger policy is not an issue so that results below concentrate on the remaining values of t.

In the non strategic case, the optimal policy results from comparing expression (5) with (2) leading to the results stated in proposition 1

Proposition 1 *In the non strategic case merger increase welfare when asymmetries are high enough,* $t \geq t^N(\gamma)$ *where* $\frac{dt^N(\gamma)}{d\gamma} > 0$ *and*

$$t^N(\gamma) = \frac{1 - 16\gamma + 80\gamma^2 - 144\gamma^3 + 80\gamma^4}{1 - 18\gamma + 116\gamma^2 - 328\gamma^3 + 352\gamma^4}.$$

.

This proposition confirms the result obtained in markets without R&D that inefficient firms are prejudicial for welfare[6](Lahiri and Ono (1988)). In these cases, welfare will increase if inefficient firms merge with more efficient firm. However, merger policy should be adapted in R&D intensive industries because the greater the effectiveness of R&D, the smaller the degree of asymmetry between firms needed for a merger to increase welfare. This result comes from the fact that $\frac{dt^N(\gamma)}{d\gamma} > 0$.

In the strategic case the optimal policy results from comparing expression (5) with (7) for $t \leq \frac{3\gamma - 2}{2(3\gamma - 1)}$ and (5) with (4) for $\frac{3\gamma - 2}{2(3\gamma - 1)} \leq t \leq \frac{2\gamma - 1}{4\gamma - 1}$. These comparisons leads to the results stated in proposition 2.

[6]Observe that the case without R&D can be obtained in our model by letting γ tend to infinity. In this case merger increase welfare when $t \geq \frac{5}{22}$.

Proposition 2 *In the strategic case merger increases welfare for the intermediate values of the asymmetries* $\underline{t}(\gamma) \leq t \leq \overline{t}(\gamma)$

$$\overline{t}(\gamma) = \frac{(-2+3\gamma)(8-44\gamma+48\gamma^2) + \sqrt{2\gamma(-20+136\gamma-243\gamma^2+162\gamma^3)}}{(-1+4\gamma)(16-78\gamma+99\gamma^2)}$$

$$\underline{t}(\gamma) = \frac{(-2+3\gamma)(8-44\gamma+48\gamma^2) - \sqrt{2\gamma(-20+136\gamma-243\gamma^2+162\gamma^3)}}{(-1+4\gamma)(16-78\gamma+99\gamma^2)}$$

Observe that in the strategic case the presence of very inefficient firms can have a positive effect on welfare. In monopoly, the level of R&D is insufficient. Then, the competition provided by an inefficient firm has a positive effect. On the one hand, it stimulates the R&D of the inefficient firm. On the other hand, the asymmetry guarantees that this is done without duplication of R&D, because the inefficient firm as it produces very little has very little incentives to spend in R&D.

Observe that for $\frac{3\gamma-2}{2(3\gamma-1)} \leq t \leq \frac{2\gamma-1}{4\gamma-1}$, even though firm 2 does not produce in the duopoly equilibrium the merger would reduce welfare. This is the extreme case of what we are saying: firm 2 stimulates the R&D investment of firm 1 and we have no duplication, because firm 2 does not invest in R&D.

Comparing the two previous results we have that merger policy should be more restrictive in the strategic case. It is possible to check that $t^N(\gamma) < \underline{t}(\gamma)$. The reason is that welfare in duopoly is greater in the strategic case than in the non-strategic case. This result was identified by Brander and Spencer (1983) for the symmetric case.[7] We check that it also holds in the asymmetric case.

Our result that product market competition positively affects the investment in R+D is in accordance with the results in d'Aspremont and Jacquemin (1988). The main message of this paper is that, although cooperation in R+D may be beneficial, collusion in the product market reduces both output and investment in R+D.

[7]Proposition 5 shows that this is no longer true if the number of firms is greater than 2.

3 The symmetric model

Now, we are interested in studying the effect of changes in the number of firms on the efficient merger policy (so far we have only looked at the effect of firm size). To be able to derive results as a function of n we assume that all firms are symmetric. In this case the cost function of firms is given by:

$$C(x_i, q_i) = (c - x_i) q_i + \gamma x_i^2$$

where x_i and q_i denote the level of R&D and the production of firm i respectively.

The equations above also represents the cost function of merged entities, because as before we assume that merger does not affect the cost structure of firms. Therefore, firms will optimally concentrate all their R&D expenditures in only one location. For these reasons, equilibria are symmetric both premerger and postmerger. This allows to write all equilibria conditions as a function of n as in Salant et al (1983).

3.1 The non strategic model

Solving for the equation system (1) for $i = 1...n$ and $c_i = c$ we obtain the equilibrium decisions of firms that are given by:

$$q^N = \frac{2\gamma (A - c)}{2(n+1)\gamma - 1}$$

$$x^N = \frac{(A - c)}{2(n+1)\gamma - 1}$$

We obtain that the level of R&D per firm increases with market concentration. Therefore, in our model the schumpeterian idea that concentration pushes innovation holds (Levin, Cohen and Mowery (1985)). Observe that the marginal cost of firms in the second stage decreases with concentration. Nevertheless, we have still the standard effect that price increases with concentration.

Social welfare given that all firms produce q and x is given by:

$$W(q,x,\gamma) = \int_0^{nq} (A-y)\,dy - (c-x)\,nq - n\gamma x^2 =$$

$$= Anq - \frac{(nq)^2}{2} - (c-x)\,nq - n\gamma x^2$$

Therefore the social welfare in equilibrium with n independent firms is given by

$$W^{NS} = \frac{(A-c)^2\, n\gamma\,(-1+2\,(2+n)\,\gamma)}{(1-2\,(1+n)\,\gamma)^2}.$$

This function is maximized in $\widehat{n} = \dfrac{8\gamma^2 - 6\gamma + 1}{2\gamma}$. This allows to derive the optimal merger policy in the following proposition.

Proposition 3 *A merger that does not reduce the number of independent firms below* $int[\widehat{n}+1]$ *increases welfare.*

In the limit case when γ tends to infinity we obtain that all mergers reduce welfare, because $\widehat{n}$ tends to infinity. This is the same result as in the symmetric model without R&D.

The previous Proposition is useful if one thinks that the Government has the power to affect market structure through sponsoring mergers. However, in many countries, for example the US, compulsory action or subsidies to encourage mergers go against the normal practice of antitrust policy. In this case, the antitrust authority can only accept or reject mergers that are proposed. Then a sufficient condition for a merger to increase welfare is that its effect on consumers and competitors (external effect of a merger) be positive, because it is logical to assume that mergers that are proposed are profitable. This approach to resolve merger cases was proposed by Farrell and Shapiro (1990).[8]

[8] If applied in Section 2, all mergers would have to be forbidden, because they reduce consumers surplus.

Suppose that in a N firm industry, $k+1$ firms propose to merge. This implies that the merger is profitable. When

$$\pi(N-k) < (k+1)\pi(N)$$

profitability is obtained by assuming that there are savings in fixed costs. The external effect of this merger is given by:

$$W(N-k) - \pi(N-k) - (W(N) - (k+1)\pi(N)) \tag{6}$$

The following Proposition finds when (6) is positive.

Proposition 4 *In a N firm industry the external effect of a merger is positive iff the market share of merging firm is lower than $h(\gamma)$. We have that $h'(\gamma) < 0$.*

Proof. Define:

$$M(k) = W(N-k) - \pi(N-k) - (W(N) - (k+1)\pi(N))$$

$M(k) = 0$ if $k = 0, k = k_1$ and $k = k_2$. As $k_2 > N-1$ and $M'(0) > 0$, we have that the external effect is positive if $0 < k < k_1$.

$$h(\gamma) = \frac{k_1+1}{N} =$$

$$\frac{1-2(5+n)\gamma+4(5+4n)\gamma^2-\sqrt{1-4(7+n)\gamma+4(51+14n+n^2)\gamma^2-16(35+17n)\gamma^3+48(11+8n)\gamma^4}}{4n\gamma(-1+4\gamma)}$$

Then we have $h'(\gamma) < 0$. ■

This proposition confirms the result obtained in markets without R&D that the external effect of mergers is positive if the market share of merging firms is low enough (Farrell and Shapiro (1990)). However, as in Proposition 1, merger policy should be adapted in R&D intensive industries because the higher the effectiveness of R&D, the higher the market share of merging firms needed for the external effect to be negative. This result comes from the fact that $h'(\gamma) < 0$.

3.2 The strategic model

In the second stage, firm i profits, given that its R&D investment has been x_i and each competitor has invested x, are:

$$\Pi_i^* = \left(\frac{(A - n(c - x_1) + (n-1)(c - x))}{(n+1)} \right)^2 - \gamma x_i^2$$

In the first stage given a symmetric strategy from the competitors (x) firm i will maximize

$$\Pi_i^*.$$

The first order condition is given by:

$$\frac{\partial \Pi_i^*}{\partial x_i} = 0.$$

Imposing symmetry ($x_i = x$) in the first order condition the equilibrium is obtained.

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

In the first stage the optimal level of R&D is given by:

$$x^{SS} = \frac{(A - c)\, n}{n^2\gamma + 2n\gamma + \gamma - n}$$

Therefore the quantity produced in equilibrium is:

$$q^{SS} = \frac{(A - c)(n+1)\gamma}{n^2\gamma + 2n\gamma + \gamma - n}$$

As in the non strategic case, we have that R&D investment per firm and price increase with concentration.

Social Welfare in equilibrium is given by:

$$W^{SS} = \frac{n\gamma(A - c)^2 \left(2\gamma + 5n\gamma + n^3\gamma + n^2(-2 + 4\gamma)\right)}{2\left(\gamma + n^2\gamma + n(-1 + 2\gamma)\right)^2} \tag{7}$$

Proposition 5 *If $\gamma > \widehat{\gamma}$ mergers reduce welfare, where $\widehat{\gamma} = 3.74$.*

Proof.

$$\frac{\partial W^{SS}}{\partial n} = \frac{\gamma\left(3n^2\left(-1+\gamma\right)\gamma+\gamma^2+n\gamma\left(1+3\gamma\right)+n^3\left(1-4\gamma+\gamma^2\right)\right)}{\left(-n+\gamma+2n\gamma+n^2\gamma\right)^3},$$

it is positive for $\gamma > \widehat{\gamma}$ because then $1-4\gamma+\gamma^2 > 0$. ∎

Comparing propositions 3 and 5 we have that when the effectiveness of the R&D is low ($\gamma > \widehat{\gamma}$), merger policy should be more strict in the strategic case than in the nonstrategic case. In the former case, mergers always reduce welfare while in the latter case, they increase welfare whenever there are more than $int[\widehat{n}+1]$ firms in the postmerger equilibrium. However, when the effectiveness of the R&D is high, it is no longer true that merger policy should be more strict in the strategic case. For example, when $\gamma = 2$, in the strategic case mergers increase welfare whenever there are more than 3 firms in the postmerger equilibrium, while in the nonstrategic case the threshold increases up to 5.

Comparing the strategic and non strategic case we have that welfare is greater in the latter case for $n \geq 3$ (see Proposition 6 below). This is the opposite result that Brander and Spencer (1983) obtained for the case with two firms.

Proposition 6 *Welfare is greater in the non strategic case than in the strategic case for $n \geq 3$.*

Proof.

$$sign\{W^{SS} - W^{NS}\} = sign\{T(n)\}$$

$$where\ T(n) = 2n + n^2 - 4n^3 + n^4 + \gamma(-6n - 4n^2 + 8n^3 + 4n^4 - 2n^5)$$

$$T'(n) = 2 + 2n - 12n^2 + 4n^3 + \gamma(-6 - 8n + 24n^2 + 16n^3 - 10n^4)$$

If $n \geq 3$,

$$T'(n) < \gamma(4n^3 + 24n^2 + 16n^3 - 20n^3 - 30n^2) < 0$$

As $T(3) = -12\gamma^2$, the result of the Proposition follows. ∎

4 Conclusions

The result that increases in concentration may increase social welfare due to the reduction in the duplication of R&D expenditures, connects our paper with the schumpeterian theories. It has been studied in previous papers. Therefore, we consider that our main contribution to the literature is the idea that this approach may fail in asymmetric market structures.

When we have an efficient and an inefficient firm, it is convenient to preserve competition (forbid the merger). In monopoly, the level of R&D is insufficient. Then, the competition provided by an inefficient firm has a positive effect. On the one hand, it stimulates the R&D of the inefficient firm. On the other hand, the asymmetry guarantees that this is done without duplication of R&D, because the inefficient firm as it produces very little has very little incentives to spend in R&D.

As the asymmetric setting looks more intriguing, it looks promising to generalize it in several directions:

The most obvious one is to try to solve the model for more than two firms. This will allow us to study the type of mergers that are more likely to increase social welfare: either the ones with symmetric partners or the ones with asymmetric ones.

One can also introduce product differentiation. In this case, while keeping the present formulation, the expenditure in R&D could be reinterpreted as if it affected the quality of goods. Furthermore, product differentiation will allow us to consider the case of Bertrand competition.

One could also introduce the possibility that the expenditure in R&D is used either to reduce costs (process innovation) or to increase the quality of goods (product innovation). This can be used to test the empirical evidence that shows that big firms invest more in process innovation inventions while small firms are more inclined to carry out product innovations investments (Rosen (1991) and Yin and Zuscovitch (1998)).

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