"MERGER POLICY IN R&D INTENSIVE INDUSTRIES"*

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Abstract

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.

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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).

For the benefit of consumers it is important that antitrust authorities can fully evaluate the costs and benefits of mergers. This task is not easy when considering high technology industries. Indeed, antitrust laws are more suited to traditional manufacturing industries and it is not clear whether they can be used to deal with high technology markets. Mergers can lead to cost reductions, which could benefit the consumers, but also affect the market structure by softening competition. Antitrust lawyers consider this trade-off to allow or impede a merger. For the particular case of high technological sectors, other factors, like the final goods’ quality and the pace of innovation, come into play. These new factors are important because in those industries firms not only compete in prices but also in the level of R&D. And consumers benefit from both types of competition.

We study the impact of market structure on the incentives of making R&D. Therefore, we consider a model where merger decisions are taken before investments in R&D. We could consider the case where R&D decisions are taken before merger decisions as in Cabolis et al (2008). However, we think that the timing we propose is more reasonable, because mergers involve a more long run decision than R&D decisions. Furthermore, in this way, antitrust policy has to consider the effect of mergers on two decisions: output and investment decisions. This is the main goal of the paper to see how antitrust policy should adapt in industries where R&D decisions play an important role in the
working of an industry, like in pharmaceuticals or telecoms.

In this paper, we investigate how should merger policies be modified to fit R&D intensive industries. As mentioned above, aside from the impact on prices, the antitrust authorities must consider the impact of a merger on R&D expenditures. On the one hand, competition, which is preserved by impeding the merger, may induce an excessive expenditure in R&D (Lee and Wilde (1980)). On the other hand, allowing the merger and giving the firm a monopolistic position, may reduce the incentives to innovate below the socially efficient level.

Our analysis considers two different models: the strategic and the non-strategic case. In the non-strategic case, R&D decisions are only driven by cost reducing considerations. In the strategic case, firms set first their R&D expenditures and then their production levels (both non-cooperatively). In that situation, the firms can use their R&D investments to affect the decisions of the competitors. By comparing the two contexts, we isolate the strategic role played by R&D expenditures\(^1\).

Despite the diversity of environments, 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.

Stenbacka (1992) also studies the effect of merger decisions on the level of cost-reducing investments by firms. He considers a duopoly but only one firm can invest. Then, the merger has not the beneficial effect it has in our setting of avoiding the

\(^1\)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.
duplication of investments and he obtains that all mergers reduce social welfare.

An important exception appears in the strategic case when firms have asymmetric marginal costs. 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 firm when they compete. 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 persistence of (very) inefficient firms can increase welfare departs from the traditional point of view of merger policy (Lahiri and Ono (1988)).

The asymmetric context is analysed in Sections 2. The strategic and nonstrategic models are analyzed in different subsections. Merger and the optimal merger policy are studied respectively in Section 3 and subsection 3.1. Finally, conclusions are presented in Section 4.

2 The 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 and the production of firm $i$ respectively. The R&D is a process (cost-reducing) innovation that by spending $\gamma x_i^2$ in R&D, the marginal cost of production will be reduced from $c_i$ to $c_i - x_i$, and the firm faces a trade-off between paying a lump-sum cost of $\gamma x_i^2$ and benefiting a lower marginal cost of $c_i - x_i$.

\footnote{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.}
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\(^3\), \(^4\).

It is assumed that $\gamma \geq 1$. This guarantees that the second order conditions are satisfied. Observe that $\gamma$ represents the effectiveness of R&D investment. When $\gamma$ increases the expenditure to obtain a given cost reduction also increases. The case without R&D investment is obtained in the limit case when $\gamma$ 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.

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.

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

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

\[
\Pi_2 = (A - c_2 + x_2 - q_1 - q_2) q_2 - \gamma x_2^2
\]

They can be rewritten the following way:

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

\(^3\)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.

\(^4\)Davidson and Ferrett (2007) analyze a similar problem, with the possibility of spillovers and product differentiation.
\[ \Pi_2 = (A - c_1)^2 \left[ \left( 1 - t + \frac{(x_2 - q_1 - q_2)}{A - c_1} \right) \frac{q_2}{A - c_1} - \gamma \left( \frac{x_2}{A - c_1} \right)^2 \right] \]

where \( t = \frac{c_2 - c_1}{A - c_1} \).

Higher values of \( t \) represent higher asymmetries between firms.

This way of writing profits highlights the fact that the relevant parameters of the model can be reduced to \( \gamma \) (the effectiveness of R&D) and \( t \) (the degree of asymmetry between firms). \( (A - c_1) \) will only have a scale effect.

### 2.1 Non Strategic model

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

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

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

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

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

when \( t \leq \frac{2\gamma - 1}{4\gamma - 1} \). Otherwise, we have the same situation as with merger.

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 \( t = \frac{2\gamma - 1}{4\gamma - 1} \), 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:

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

### 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 \( t \leq \frac{3\gamma - 2}{2(-1 + 3\gamma)} \). Given the investments in the first stage \( x_1 \) and \( x_2 \), outputs of firms in the second stage will be:

\[
q_1 = \frac{(A - c_1)((1 + t) + 2x_1 - x_2)}{3}
\]
\[
q_2 = \frac{(A - c_1)((1 - 2t) - x_1 + 2x_2)}{3}
\]

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 \( \gamma \).

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
\[ t = \frac{3\gamma - 2}{2(-1 + 3\gamma)}, \text{ the inefficient firm does not invest and does not produce. Observe that the inefficient firm is expelled from the market for a lower value of } t \text{ in the strategic case than in the non strategic case. The reason for this is that now the R&D decisions have a strategic dimension: the efficient firm overinvests in order to reduce the output sold in Stage 2 by firm 2.} \]

Social Welfare in equilibrium is given by:

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

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

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

\[ W^S = \frac{3}{2} - 3t + \frac{3}{2}t^2 - \gamma + 4t\gamma - 4\gamma t^2. \] (3)

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

3 Merger

To study what happens when both firm merge to form a monopoly, we have to specify the cost function of the merged entity.

We consider that the cost structure is not altered by the merger\(^5\), that is

\[ C(x_1, x_2, q_1, q_2) = (c_1 - x_1)q_1 + (c_2 - x_2)q_2 + \gamma(x_1^2 + x_2^2) \]

\(^5\)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.
This implies that R&D and production will be concentrated in the most efficient firm. The merged firm will optimally choose $q_2 = 0$ and $x_2 = 0$.

In equilibrium the merged entity will produce:

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

and the optimal level of R&D will be:

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

The merger increases the level of R&D with respect to the level of investment of Firm 1 in the nonstrategic case. In the strategic case, the merger reduces the investment of firm 1 if

$$\left( \frac{1}{6\gamma} \right) \left[ \frac{4 - 24\gamma + 27\gamma^2}{\gamma - 1} + 4 - 6\gamma \right] < t.$$ i.e. if firm 2 is inefficient enough. There has been a long debate on the effect of competition on innovation. We obtain that the effect is positive if the degree of asymmetries between firms is high enough. Nevertheless, in any case the merger increases market price.

Social Welfare with merger is given by:

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

### 3.1 Optimal merger policy

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. 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 (??) with (??) leading to the results stated in proposition ??
Proposition 1 In the non strategic case merger increases 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 firms. 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 (??) with (??) for \( t \leq \frac{3\gamma - 2}{2(3\gamma - 1)} \) and (??) with (??) for \( \frac{3\gamma - 2}{2(3\gamma - 1)} \leq t \leq \frac{2\gamma - 1}{4\gamma - 1} \). These comparisons lead to the results stated in proposition ??.

Proposition 2 In the strategic case merger increases welfare for the intermediate values of the asymmetries \( l(\gamma) \leq t \leq \bar{t}(\gamma) \)

\[
l(\gamma) = \frac{(3\gamma - 2) \left( 48\gamma^2 - 44\gamma + 8 \right) + \sqrt{2\gamma (-20 + 136\gamma - 243\gamma^2 + 162\gamma^3)}}{-1 + 4\gamma} \frac{16 - 78\gamma + 99\gamma^2}{(16 - 78\gamma + 99\gamma^2)^2}
\]

\[
\bar{t}(\gamma) = \frac{(3\gamma - 2) \left( 48\gamma^2 - 44\gamma + 8 \right) - \sqrt{2\gamma (-20 + 136\gamma - 243\gamma^2 + 162\gamma^3)}}{-1 + 4\gamma} \frac{16 - 78\gamma + 99\gamma^2}{(16 - 78\gamma + 99\gamma^2)^2}
\]

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 efficient firm. On the other hand, the asymmetry guarantees

\(^6\)Observe that the case without R&D can be obtained in our model by letting \( \gamma \) tend to infinity. In this case merger increase welfare when \( t \geq \frac{2}{27} \).
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 $\hat{t}(\gamma) < \frac{3\gamma - 2}{2(3\gamma - 1)} \leq t \leq \frac{2\gamma - 1}{4\gamma - 1}$, 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 $t^N(\gamma) < \mathcal{L}(\gamma)$. 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. We check that it also holds in the asymmetric case.

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 efficient 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 setting looks 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)).
5 References


13
Quarterly Journal of Economics 98, 185-199.

