“Effects of "Anti-competitive" Mergers in R&D Intensive Industries”

CHAPTER 1
MACROECONOMIC PROCESSES AND REGIONAL ECONOMIES MANAGEMENT

Effects of "Anti-competitive" Mergers in R&D Intensive Industries[1]

James H. Cardon[2], Dan Sasaki[3]

Abstract

The effect of merger among competing firms in the same industry is twofold. It increases concentration, which has a negative effect on welfare unless the merger substantially lowers production costs. If products are differentiated, however, there is another effect: before the product is marketed, rationally foresighted firms will choose R&D strategies which will defer price competition at the marketing stage. In the presence of exclusive patent rights, the firms are more likely to "cluster" (i.e. develop the same product) when owned separately, each firm attempting to pre-empt its competitors so as to monopolize the market, as opposed to when controlled jointly. Therefore mergers among firms at the R&D stage are potentially welfare-enhancing. We show that the dominance relation between these two effects, which determines the welfare-optimality of the shareholding structure, is *non-monotone* in R&D costs as well as *in intertemporal preferences*.

Key words: ownership, patent, product differentiation, effort duplication.
JEL classification: L13, D43, O31.

1. Introduction

ANTITRUST REGULATIONS often restrict or prohibit merger between multiple firms which are otherwise independently competing in the same industry. The reason for such regulations is the concern about anti-competitive *market behavior* which could possibly result from the market power enhanced by merger. On the other hand, in product development, it is well-known that cooperative R&D can enhance efficiency and welfare by eliminating or reducing effort duplication (Katz, 1986; d'Aspremont and Jacquemin, 1988, 1990; Kamien, Muller and Zang, 1992; Suzumura, 1992; *inter alia*). This is the reason why antitrust authorities often encourage joint ventures in product development, while they explicitly prohibit market collusion (see the U.S. National Cooperative Research Act; EC Commission, 1990; Goto and Wakasugi, 1988).

However, such policy measures inevitably face two incentive problems which are as follows. First, although an R&D joint venture (RJV henceforth) is supposed to maximize the *joint* discounted future profits of *all* the participant firms, this objective may be jeopardized by each participant firm's private incentives. Once product development is completed, these firms are required to dissolve the joint venture and to start competing in the product market. If firms are rationally foresighted, then even at the R&D stage, they can take into account the fact that they will eventually start to seek separate interests in the future at the marketing stage, and thus will alter their R&D decisions accordingly (selfishly) from supposedly "joint" profit maximisation.

---

[1] This research has benefited from seminar presentations at Exeter (UK, 2000) and Birkbeck (UK, 2001). Generous financial assistance from the Ministry of Education (Japan, 2002) and Grant-in-Aid for Scientific Research (Japan, 2003) are also gratefully acknowledged. The usual disclaimer applies.

[2] Associate Professor, Department of Economics, Brigham Young University, USA.

[3] Associate Professor, Institute of Social Science, University of Tokyo, Japan.

Second and conversely, a RJV may contaminate firms' competitive incentives in the ensuing product market. Shapiro and Willig (1990) examine the welfare tradeoffs involved in research joint ventures, warning that contact between firms involved in an RJV may facilitate anti-competitive behavior in the product market. More recently, the effects of cooperative R&D have also been studied by Motta (1992) in the context of possible product differentiation[1], and by Martin (1995) and Cabral (1996) by analysing the strategic effects of a RJV aimed at achieving a process innovation for an existing product.

There is an inherent conflict between the development stage, at which cooperation between firms is often socially beneficial, and the market stage, at which it is probably harmful. The incentives facing firms in joint development/market decisions are very complex. If firms merge permanently, their incentive structures become much clearer. A natural question springs up: what if firms were allowed to merge freely *only* in R&D intensive industries? In this paper we analyse social desirability of mergers in R&D intensive industries, where effort-saving effects in product innovation for newly patentable products are made possible by merger, affecting both the firms' incentives as well as social welfare. These effort-saving effects emerge in two ways. First, there may be some exogenous economies of scale enabled by merger. Second, even in the absence of such economies of scale, there may also be a strategic effect. Namely, if independent firms are foresighted, they will choose those R&D *paths* that soften the ensuing product market competition. The resulting welfare in such a market may be different from (in fact lower than) what a static model might predict. We argue that merger at the R&D stage (or in R&D intensive industries) should not be treated separately from its interactive effects at the ensuing marketing stage. As we show throughout the paper, the welfare appraisal either for or against merger hinges upon (i) the degree of product differentiation (and whether firms' products are substitutes or complements), (ii) the cost of product development, (iii) the discount factor, and obviously (iv) the economies of scale in R&D.

Section 2 provides a simple duopoly model comparing two cases. In one case both firms are controlled by a common owner, and in the other the two firms are owned separately. Section 3 presents an extension taking into account the (exogenous) economies of R&D cooperation made possible by merger. Section 4 concludes the paper. To avoid confusion with terminology, throughout this paper we consistently use the term "firm" referring to a firm *before* merger. Namely, even after two firms merge, they remain two "firms" according to our terminology, albeit "jointly (or commonly) owned".

2. Merger without economies of R&D cooperation

2.1. The model

Two *a priori* identical firms are entering the same market. There are two different potential products which, when developed, are separately patentable. Development takes exactly one period, and costs C per period, per firm. Assume, for simplicity, that each firm can develop only one product at a time, and that the two firms undertake their product development mutually independently. The time discount factor $\delta \in (0,1)$ (per period) is common to the two firms.

Firms start development simultaneously. At the end of the first period, each firm completes its first product. If the firms develop two different products, they register a patent and start selling their products as *duopolists* from the second period onward.

Another possibility is that independent firms may choose to develop the same product initially, referred to as "clustering" hereafter[2]. We assume that, if both firms develop the same product, then each firm has a 50% chance to register a patent on the product and start to sell it as a *mo-*

---

[1]The pre-existed literature, represented by Bhattacharya and Mookherjee (1986) and Dasgupta and Maskin (1987), also discusses product portfolios, but not explicitly in the context of cooperative product development.

[2]The clustering behavior is described in Cardon and Sasaki (1998) under a different set of assumptions. Clustering in our context should be expressly distinguished from so-called "herd behavior" in a context with incomplete information, as in Scharfstein and Stein (1990), Banerjee (1992), Bikhchandani, Hirshleifer and Welch (1992).

nopolist in the second period, earning profit Π_{M1} per period. The losing firm must develop the other product in the second period. At the same time, the winning firm also continues to develop the second product, hence the two firms compete for the second product again. If the previous winner wins again, which we assume to occur with probability ρ, then it will hold monopoly on both products from the third period onward forever, earning Π_{M2} per period, while the loser earns nil. If the former loser wins in the second product, which occurs with probability $1-\rho$, then the firms become duopolists from the third period onward.

The purpose of this model is an equilibrium comparative statics analysis of the following two ownership structures:

1. A common owner[1], who controls both firms to maximize their *joint* expected discounted profits.
2. Two separate owners[2], each of whom independently controls his/her own firm to maximize its expected discounted profits.

As for the product market, in order to maintain as much generality as possible, we avoid assuming specific demand and cost functions, and simply introduce the following notation instead.

- When the two firms are owned commonly, and if they supply two products, then their *joint* profit is denoted by Π_{M2}, consumers' surplus is Σ_{M2}, and the welfare is $W_{M2} = \Pi_{M2} + \Sigma_{M2}$, all per period (the subscript $M2$ stands for monopoly with two products). The same occurs if one firm monopolizes both products at a time, except that the entire monopoly profit Π_{M2} is raised by the single firm.
- When the two firms are owned separately, and if they are supplying two different products, then the profit *for each firm* is denoted by Π_D, consumers' surplus is Σ_D, and the welfare is $W_D = 2\Pi_D + \Sigma_D$ per period (D for duopoly).
- When there is only one product supplied by one firm, (irrespective of the ownership of the firms) the profit is Π_{M1}, consumers' surplus is Σ_{M1}, and the welfare is $W_{M1} = \Pi_{M1} + \Sigma_{M1}$ per period ($M1$ for monopoly with one product).
- Note that, in general:
  if the two products are substitutes,

$$\Pi_{M2} \geq \Pi_{M1} > \Pi_D, \qquad \Sigma_D > \Sigma_{M2} \geq \Sigma_{M1}, \qquad W_D > W_{M2} \geq W_{M1} , \tag{1}$$

where the equalities would hold if and only if the two products were perfect substitutes, while in this paper we assume product differentiation and thus these inequalities are always strict;

if the two products are complements,

$$\Pi_{M2} > \Pi_D > \Pi_{M1}, \qquad \Sigma_{M2} > \Sigma_D > \Sigma_{M1}, \qquad W_{M2} > W_D > W_{M1}. \tag{2}$$

Throughout this paper we assume that both monopoly and duopoly profits are sufficiently large relatively to C, so that firms' participation constraints are always satisfied and non-binding. That is, firms continue development as long as there still exists a product not yet patented.

Next we characterize the dependence of possible pure-strategy equilibria upon the ownership structure.

---

[1]Or a common set of owners.

[2]Or two disjoint sets of shareholders.

2.2. The equilibrium under separate ownership

Two separately owned firms may or may not *cluster* (develop the same product in the first period), depending on parameters (Lemma i below). If they do not cluster, i.e., develop two different products in the first period, each earns the discounted profit

$$-C+\sum_{t=1}^{\infty}\delta^{t}\Pi_{D}=-C+\frac{\delta}{1-\delta}\Pi_{D}, \tag{3}$$

which leads to the discounted social welfare

$$-2C+\sum_{t=1}^{\infty}\delta^{t}W_{D}=-2C+\frac{\delta}{1-\delta}W_{D}. \tag{4}$$

Otherwise, if they cluster, each firm's profit stream is as illustrated in Figure 1.

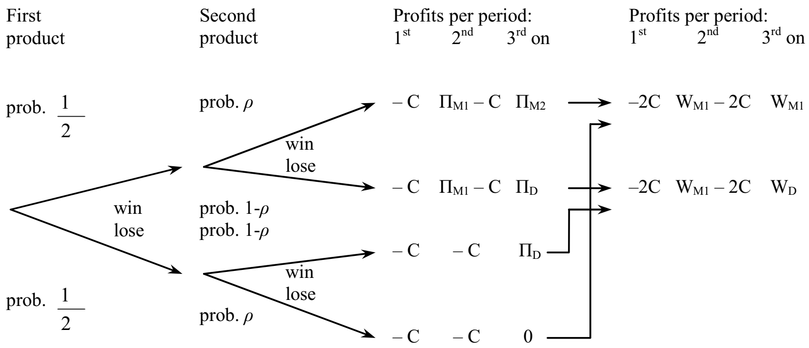


Fig. 1. Profits for each clustering firm

Hence, the expected discounted profit for each of the clustering firms is

$$-(1+\delta)C+\frac{\delta}{2}\Pi_{M1}+\frac{\delta^{2}}{1-\delta}\left(\frac{\rho}{2}\Pi_{M2}+(1-\rho)\Pi_{D}\right) \tag{5}$$

and the expected discounted welfare is

$$-2(1+\delta)C+\delta W_{M1}+\frac{\delta^{2}}{1-\delta}\left(\rho W_{M2}+(1-\rho)W_{D}\right). \tag{6}$$

These observations can be summarized into the following statements.

Lemma i : When separately owned, the two firms cluster on the same product if

$$C\le\left(\frac{\Pi_{M1}}{2}-\Pi_{D}\right)+\frac{\rho\delta}{1-\delta}\left(\frac{\Pi_{M2}}{2}-\Pi_{D}\right), \tag{7}$$

or diversify over two different products if

$$C \geq \left(\frac{\Pi_{M1}}{2} - \Pi_D \right) + \frac{\rho\delta}{1-\delta} \left(\frac{\Pi_{M2}}{2} - \Pi_D \right). \tag{8}$$

Proof : Inequality (7) is derived from (5) $\geq$ (3), and inequality (8) is from (5) $\leq$ (3).

Intuition : Clustering softens product market competition on two fronts. One is a short-term effect: clustering always delays the entry of the second firm by one period. This effect is embodied in the term $\frac{\Pi_{M1}}{2} - \Pi_D$, which is positive only if (but not always if) the two potential products are substitutes (would be unambiguously positive if the products were perfect substitutes). The other is a longer-term effect: clustering can *permanently* deter the entry of the second firm with probability ρ. This effect is incorporated in the term $\frac{\rho\delta}{1-\delta}\left(\frac{\Pi_{M2}}{2} - \Pi_D \right)$, which is unambiguously positive.

Meanwhile, clustering intensifies the R&D race, costing an extra C per firm. The balance between the benefit of softened market competition and the cost of intensified R&D competition entails firms' decisions as in Lemma i.

2.3. The equilibrium under common ownership

A common owner will never let the two firms cluster. Under common ownership, each firm develops a different product in the first period, and the two firms maximize joint profits thereafter[1]. Their joint profit discounted to the beginning of the first period is therefore

$$-2C + \sum_{t=1}^{\infty} \delta^t \Pi_{M2} = -2C + \frac{\delta}{1-\delta} \Pi_{M2}, \tag{9}$$

with the associated discounted social welfare

$$-2C + \sum_{t=1}^{\infty} \delta^t W_{M2} = -2C + \frac{\delta}{1-\delta} W_{M2}. \tag{10}$$

2.4. Welfare comparative statics

Proposition I :

- When the two products are (imperfect) substitutes, common ownership welfare-dominates separate ownership if and only if

$$\frac{(1-\rho)\delta}{1-\delta}(W_D - W_{M2}) - (W_{M2} - W_{M1}) \leq 2C \leq \Pi_{M1} - 2\Pi_D + \frac{\rho\delta}{1-\delta}(\Pi_{M2} - 2\Pi_D); \tag{11}$$

- When the two products are complements, common ownership always welfare-dominates separate ownership.

Proof : When the products are substitutes, the expected discounted welfare is higher under common ownership than under separate ownership if and only if either:

1) inequality (7) holds and (10) $\geq$ (6), or
2) inequality (8) holds and (10) $\geq$ (4).

[1] Note that if the two potential products were perfect substitutes, a common owner would never invest to develop both. Abandoning one product completely and concentrating on developing the other would be unambiguously more profitable than developing both. This is implicitly assumed away in our product differentiation setting.

The latter is never satisfied insofar as the two products are substitutes (see (2)). Therefore the former is the only remaining possibility. The second inequality in (11) is equivalent to (7). On the other hand, the first inequality in (11) is derived from (10) $\geq$ (6).

When the products are complements, the proposition is obvious by (2).

Economic interpretation : In the case of substitute products, the welfare effects of separate ownership with clustering versus common ownership (without clustering) consist of a short-term effect and a long-term effect, analogous to Lemma i. Clustering delays the arrival of the second product to the market, incurring the welfare loss $W_{M2} - W_{M1}$ in the second period. From the third period, however, clustering can lead to duopoly with probability $1-\rho$, entailing the expected discounted welfare increment $\frac{(1-\rho)\delta}{1-\delta}(W_D - W_{M2})$ which is positive if and only if the two products are substitutes. The sum of these two effects should be evaluated against the extra R&D costs $2C$ resulting from clustering. Hence the first inequality of (11).

Therefore the overall interpretation of inequalities (11) is that, when the two potential products are substitutes, common ownership is socially desirable if and only if the R&D costs are high enough to make the protracted effort duplication detrimental to the social welfare (the first inequality), yet these costs are still low enough to make clustering profitable from firms' point of view (the second inequality, which is identical to (7) in Lemma i).

Corollaries: When the two potential products are substitutes, the welfare superiority relation between the two ownership structures is:

- *non-monotone* in the R&D cost C ;
- *non-monotone* in the time discount factor δ ;
- *monotone* in the probability parameter ρ .

Intuitive interpretation : The first two corollaries are straightforward from Proposition I. Note that (11) can be rewritten as

$$\frac{2C-(\Pi_{M1}-2\Pi_D)}{2C-(\Pi_{M1}-2\Pi_D)+\rho(\Pi_{M2}-2\Pi_D)} \leq \delta \leq \frac{2C+W_{M2}-W_{M1}}{2C+W_{M2}-W_{M1}+(1-\rho)(W_D-W_{M2})}, \quad (12)$$

The left-hand side of (12) reflects the monopoly-duopoly *profit* differential. It becomes small when Π_{M2} is substantially larger than $2\Pi_D$. The right-hand side of (12) reflects the monopoly-duopoly *welfare* differential. It becomes large when W_{M2} is not much less than W_D .

This implies that, when the profit differential between monopoly and duopoly is large while the welfare differential is not overwhelming, the range (12) broadens, making common ownership favorable. Conversely, the widely held belief that common ownership is (as long as the products are substitutes) harmfully "anti-competitive" tends to gain grounds when the monopoly-duopoly profit differential is relatively minor while there is a major welfare differential between monopoly and duopoly, and therefore the range (12) is narrow.

Finally, the third corollary reflects the fact that the clustering equilibrium becomes increasingly monopolistic as ρ increases. This makes the competitive benefit of separate ownership less relevant, and thus comparatively enhances the benefit of common ownership.

To enhance intuition, a graphic illustration of Proposition I and Corollaries is provided in Figure 2. To the right of the thickened loci, where inequality (8) in Lemma i holds, two separately owned firms would have incentives *against* clustering. This means that the two firms will never cluster irrespective of their ownership, and separate ownership unambiguously outperforms common ownership by enhancing competition in the product market.

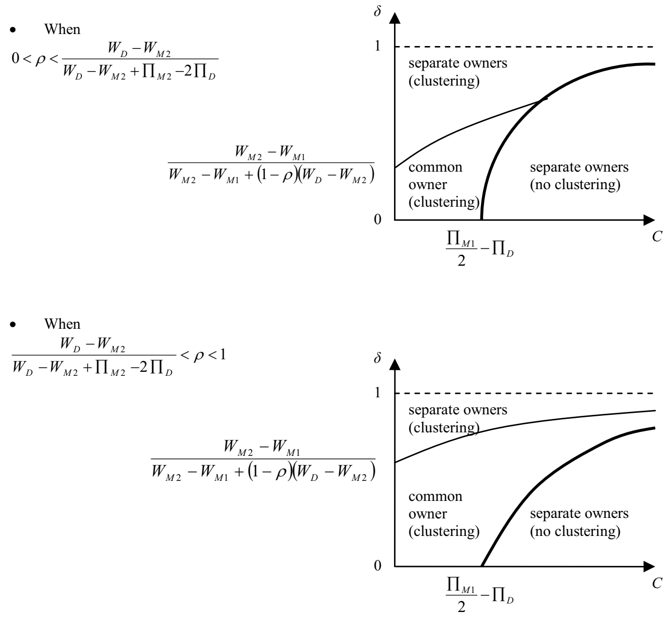


Fig. 2. Welfare-optimal ownership

To the left of the thickened loci, where inequality (7) in Lemma i holds, two separately owned firms would cluster. Note that clustering can be avoided if the two firms are commonly owned, but that common ownership reduces welfare in the other front by eliminating competition in the product market. The welfare inefficiency created by clustering outweighs the anticompetitive effect of common ownership over the regions below the thin curves. It is only in these parametric areas where common ownership enhances welfare. This is the source of our non-monotonicity results (see Corollary).

As ρ increases, the thickened loci become flatter while the thin loci shift upward, enlarging the area in which common ownership is desirable for the society. A high ρ implies that it is likely for one firm to win both products if firms are owned separately, which increases the stakes of the R&D competition and at the same time, reduces the expected welfare resulting from separate ownership.

3. Merger with economies of R&D cooperation

We now allow for the economies of R&D cooperation. We keep intact the assumption that each firm can develop no more than one product at a time. This means that economies of R&D cooperation can be attained when and only when the two firms are owned commonly.

Let ΔC ($0 < \Delta C < C$) denotes the saving in R&D investment (per firm) made possible under common ownership. Therefore the innovation costs per product stay C when firms are owned separately, and become $C - \Delta C$ when they are merged.

3.1. The equilibria

Once this cost-saving effect is taken into consideration, profit (9) and welfare (10) under *common* ownership are modified as

$$-2(C - \Delta C) + \frac{\delta}{1-\delta}\Pi_{M2} \tag{13}$$

and

$$-2(C - \Delta C) + \frac{\delta}{1-\delta}W_{M2} \tag{14}$$

respectively. This modification does not affect profits and welfare under *separate* ownership.

3.2. Welfare comparative statics

According to (13) and (14), Proposition I should now be modified as follows.

Proposition II :

- When the two products are substitutes, common ownership welfare-dominates separate ownership if and only if either

$$\frac{(1-\rho)\delta}{1-\delta}(W_D - W_{M2}) - (W_{M2} - W_{M1}) - \frac{2}{\delta}\Delta C \le 2C \le \Pi_{M1} - 2\Pi_D + \frac{\rho\delta}{1-\delta}(\Pi_{M2} - 2\Pi_D); \quad (15)$$

or

$$2\Delta C \ge \frac{\delta}{1-\delta}(W_D - W_{M2}) \quad \text{and} \quad 2C \ge \Pi_{M1} - 2\Pi_D + \frac{\rho\delta}{1-\delta}(\Pi_{M2} - 2\Pi_D). \quad (16)$$

- When the two products are complements, common ownership always welfare-dominates separate ownership.

Proof : When the products are substitutes, the expected discounted welfare is higher under common ownership than under separate ownership if and only if either:

a) inequality (7) holds and (14) $\ge$ (6), or

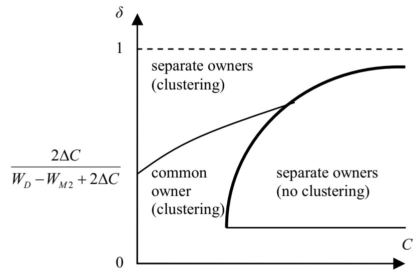
b) inequality (8) holds and (14) $\ge$ (4).

The former implies (15), while the latter (16).

Intuition: Inequality (15) is similar to (11) in Proposition I except that the economy of R&D cooperation ΔC is now serving to enlarge the range (15) by lowering the lower bound (the left-hand side). At the same time, the cost-saving effect ΔC also creates a new range (16) where common ownership outperforms separate ownership, which did not exist in Proposition I.

Accordingly, the comparative statics diagrams in Figure 2 are now modified as in Figure 3.

- ρ and/or ΔC small



- ρ and/or ΔC large

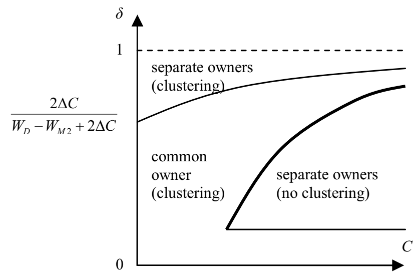


Fig. 2. Welfare-optimal ownership

The cost-reducing effect of R&D cooperation does not affect separately owned firms, hence Lemma i stays intact. In Figure 3, the thick loci do not shift as ΔC varies. However, the influence of ΔC can be found on both sides of these loci. To the left, where inequality (7) in

Lemma i applies, ΔC shifts the thin curve upward as the cost reduction by R&D cooperation is favorable for common ownership. Note that (15) can be rearranged as

$$\frac{2C-(\Pi_{M1}-2\Pi_D)}{2C-(\Pi_{M1}-2\Pi_D)+\rho(\Pi_{M2}-2\Pi_D)}\le\delta$$
$$\le\frac{2(C-\Delta C)+W_{M2}-W_{M1}+\sqrt{(2(C+\Delta C)+W_{M2}-W_{M1})^2+8\Delta C(1-\rho)(W_D-W_{M2})}}{2(2C+W_{M2}-W_{M1}+(1-\rho)(W_D-W_{M2}))}, \quad (17)$$

where the upper bound of δ increases in ΔC.

To the right of the thick loci, where inequality (8) in Lemma i applies, ΔC shifts the horizontal boundary upward for a similar reason. Inequality (16) can be rearranged as

$$\delta\le\min\left\{\frac{2\Delta C}{W_D-W_{M2}+2\Delta C},\frac{2C-(\Pi_{M1}-2\Pi_D)}{2C-(\Pi_{M1}-2\Pi_D)+\rho(\Pi_{M2}-2\Pi_D)}\right\}. \quad (18)$$

Hence, the parametric region where common ownership outperforms separate ownership *monotonically increases* in ΔC.

3.3. Effect of clustering

Now we take a closer look at the effect of clustering. When the two firms are to develop two separate products irrespective of their ownership structure (inequality (8) in Lemma i, to the right of thick loci in Figure 3), common ownership will be preferred if discounted welfare (14) dominates discounted welfare (4), i.e., if and only if:

$$2\Delta C\ge\frac{\delta}{1-\delta}(W_D-W_{M2}) \quad (19)$$

(see the first inequality of (16) in Proposition II). In words, a merger between the two firms should be encouraged if and only if it brings significant R&D cost savings that outweigh its possibly negative welfare effects in the product market.

On the other hand, when separately owned two firms are to cluster, i.e., to start developing the same product (inequality (7) in Lemma i, to the left of thick loci in Figure 3), common ownership welfare-dominates separate ownership if (14) outperforms (6) (recall that the two firms never cluster under common ownership), i.e.

$$2\Delta C\ge\frac{\delta}{1-\delta}(W_D-W_{M2})-\delta(W_{M2}-W_{M1})-\frac{\delta-(1-\rho)\delta^2}{1-\delta}(W_D-W_{M2})-2\delta C \quad (20)$$

(equivalent to the first inequality of (15) in Proposition II). Inequality (20) is simply inequality (19) plus the clustering effect. By inequality (1), the clustering effect is unambiguously negative insofar as the two firms' products are substitute, even if imperfect. Hence clustering reduces the amount of cost saving required in order to justify the welfare superiority of common ownership. (This is why the thin boundaries in Figure 3 are higher on the left side of the thickened loci than on the right side.)

4. Conclusion

R&D which leads to patentable products creates special problems for merger analysis in industries where it is important. The broadly shared belief that concentrated ownership is "anti-competitive" turns out to be apt in two ways. First, firms controlled by the same owner avoid competing against each other in the *product market*. This effect unambiguously reduces welfare insofar as these firms are substitute producers. This is the central concern when antitrust authorities and regulations prohibit mergers in highly-concentrated industries.

At the same time, firms controlled by the same owner also avoid competition in *product development*. Namely, they do not race on the same R&D path. Their not developing the same product eliminates socially wasteful effort duplication, and therefore enhances welfare.

In this paper we have shown that when firms are separately owned they may have an incentive to cluster on the same R&D path in an attempt to pre-empt each other in the presence of exclusive patent protection[1]. In such a case, the beneficial cost-saving effect of merger at the R&D stage becomes relevant and may indeed outweigh its negative effect at the marketing stage.

Traditional static oligopoly models usually ignore the strategic aspects of prior R&D investment decisions. Yet, foresighted firms will understand that they are playing a dynamic game, and will choose strategies that circumvent product market competition as much as possible. It is therefore inappropriate to consider R&D and the ensuing product market separately. In addition, strategic path choices in R&D races have been studied far less extensively than other strategic aspects of R&D. Our paper is an attempt to shed light on positive and negative effects of anti-competitive mergers, by focusing on firms' R&D path decisions[2].

References

1. Banerjee, A.V., "A Simple Model of Herd Behavior", Quarterly Journal of Economics, Vol. 107 (1992), pp. 797 - 817.
2. Bhattacharya, S. and Mookherjee, D., "Portfolio Choice in Research and Development", RAND Journal of Economics, Vol. 17 (1986), pp. 594 - 605.
3. Bikhchandani, S., Hirshleifer, D. and Welch, I., "A Theory of Fads, Fashion, Custom and Cultural Change as Informational Cascades", Journal of Political Economy, Vol. 100 (1992), pp. 992 - 1026.
4. Cabral, L.M.B., "R&D Alliances as Non-Cooperative Supergames", CEPR Discussion Paper (1996) No. 1439.
5. Cardon, H. and Sasaki, D., "Preemptive Search and R&D Clustering", RAND Journal of Economics, Vol. 29 (1998), pp. 324 - 38.
6. Dasgupta, P. and Maskin, E., "The Simple Economics of Research Portfolios", Economic Journal, Vol. 97 (1987), pp. 581 - 95.
7. d'Aspremont, C. and Jacquemin, A., "Cooperative and Noncooperative R&D in Duopoly with Spillovers", American Economic Review, Vol. 78 (1988), pp. 1133 - 37.
8. d'Aspremont, C. and Jacquemin, A., "Cooperative and Noncooperative R&D in Duopoly with Spillovers: Erratum", American Economic Review, Vol. 80 (1990), pp. 641 - 42.
9. Gilbert R. and Newbery, D., "Preemptive Patenting and the Persistence of Monopoly", American Economic Review, Vol. 74 (1982), pp. 238 - 42.
10. Goto, A. and Wakasugi, R., "Technology Policy", in Komiya, R., Okuno, M., and Suzumura, K. (eds.), Industrial Policy of Japan (1988), Academic Press, New York.
11. Kamien, M., Muller, E., and Zang, I., "Cooperative Joint Ventures and R&D Cartels", American Economic Review, Vol. 82 (1992), pp. 1293-1306.
12. Katz, M.L., "An Analysis of Cooperative Research and Development", RAND Journal of Economics, Vol. 17 (1986), pp. 527 - 43.
13. Martin, S., "R&D Joint Ventures and Tacit Product Market Collusion", European Journal of Political Economy, Vol. 11 (1995), pp. 733 - 41.
14. Motta, M., "Cooperative R&D and Vertical Product Differentiation", International Journal of Industrial Organization, Vol. 10 (1992), pp. 643 - 61.
15. Scharfstein. D.S. and Stein, J.C., "Herd Behavior and Investment", American Economic Review, Vol. 80, (1990), pp. 465 - 79.
16. Shapiro, C. and Willig, R., "On the Antitrust Treatment of Production Joint Ventures", Journal of Economic Perspectives, Vol. 4 (1990), pp. 113 - 29.
17. Suzumura, K., "Cooperative and Noncooperative R&D in an Oligopoly with Spillovers", American Economic Review, Vol. 82 (1992), pp. 307 - 20.

[1] The concept of pre-emptive patenting has been presented previously by Gilbert and Newbery (1990).

[2] Diversified R&D portfolios can enhance welfare not only by product differentiation and by eliminating effort duplication but also, when the success of product development is stochastic, by hedging the risk. Namely, by developing different products, firms can minimize the probability that none of them succeeds by the end of the first period. Therefore the arrival of the first product is made faster, which can enhance welfare.