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Mergers and Investments in New Products*

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Abstract

We investigate the impact of a horizontal merger between two competitors on their incentives to develop new products. We show that a merger raises the incentives to innovate if and only if the merged entity's incremental gain from a second innovation is larger than the individual profit of an innovator when both firms innovate in the no-merger scenario. Applying this result to the Hotelling model, we find that a merger spurs innovation and can be beneficial to consumers if the degree of product differentiation is positive but not too high.

Keywords: Merger Policy, Product Innovation, R&D Investments.

JEL Classification: K21, L13, L40.

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1 Introduction

This note contributes to the debate on the impact of mergers on innovation[1] by investigating the effect of a horizontal merger between duopolists investing in the development of new products on their incentives to innovate.

We first consider a setup where competition is modeled in reduced form and an increase in R&D investment raises the probability that a product innovation is achieved. We establish that a merger raises firms' incentives to innovate if and only if the merged entity's incremental gain from a second innovation is larger than the profit of an innovator when both firms innovate in the no-merger scenario. We then apply this result to the standard Hotelling model with quadratic transportation costs and find that a horizontal merger spurs innovation if product differentiation is positive but not too high.[2] We also show that the merger can be beneficial to consumers under that condition.

Our model is closely related to the one developed by Federico, Langus and Valletti (2017). A key difference between the two models is that we consider differentiated products instead of homogeneous products, which implies in particular that the merged entity's profit when both firms innovate is higher than its profit when a single firm innovates. We show that relaxing the homogeneity assumption can overturn the central result in Federico, Langus and Valletti (2017), i.e. that a merger stifles innovation. Our work is also related to Chen and Schwartz (2013) who show that the gain from bringing a new product to the market can be larger for a monopolist than to a firm that would face competition from independent sellers of the old product.[3] However, their result relies on the idea that the monopolist can coordinate the prices of the new and the old products, while ours hinges on the fact that the merged entity can coordinate the prices of two new products.

2 Reduced-form model

Consider an industry with two competitors, firm 1 and firm 2. Thus, a merger between these two firms is a merger to monopoly.[4] Suppose that each firm is a research lab searching for an innovation that will create a new market. Initially, each firm is inactive in the product market but actively conducts research. Firm $i \in \{1, 2\}$ may succeed in innovating with a probability λ_i that depends on the level of investment in R&D. It costs a firm $C(\lambda_i)$ to

[1] See e.g. Katz and Shelanski (2007), Shapiro (2012), Motta and Tarantino (2018), and Denicolò and Polo (2018b).

[2] In the limiting case of homogeneous products, we find that a merger does not affect the firms' incentives to innovate, which in line with the central result of Sah and Stiglitz (1987).

[3] See Greenstein and Ramey (1998) for a related analysis in the context of vertical product differentiation.

[4] Focusing on a merger to monopoly allows to abstract away from the response of rivals and the equilibrium effects generated by their existence. In other words, this allows to focus on what Shapiro (2010) and Federico, Langus and Valletti (2018) call the *initial impetus*.

achieve a probability λ_i to innovate. Success is independent between firms, meaning that whether a firm innovates or not is affected by neither the other firm's investment in R&D nor the other firm's success.

When a firm is the sole innovator on the market it obtains a value Π_1 from marketing the product, equal to the monopoly profit. When both firms innovate, they obtain each a duopoly profit π_2 that is less than Π_1. For example, if the product is the same for both firms and firms compete in prices, the value of π_2 is zero. If they compete "à la Cournot" or if there is some differentiation between the firms' products, then π_2 will be positive.[5]

Consider a firm $i \in \{1, 2\}$, and suppose that the other firm, denoted j, chooses an investment $C(\lambda_j)$ leading to a likelihood of innovation λ_j. Then, the profit of firm i is

$$\lambda_i \{(1 - \lambda_j) \Pi_1 + \lambda_j \pi_2\} - C(\lambda_i).$$

When firm i succeeds (which happens with probability λ_i), there is a chance $1 - \lambda_j$ that the other firm fails to innovate, in which case firm i is a monopoly, and a chance λ_j that the other firm succeeds, in which case firm i obtains only the duopoly profit.

Assuming that $C(.)$ is a convex function, the "best-reply" of firm i is to invest at a level that results in a probability of success λ_i which solves the following first-order condition:

$$(1 - \lambda_j) \Pi_1 + \lambda_j \pi_2 = C'(\lambda_i).$$

In a symmetric equilibrium of the innovation game, both firms choose the same probability λ^* of success, which must be the unique solution of the following equation:

$$(1 - \lambda^*) \Pi_1 + \lambda^* \pi_2 = C'(\lambda^*).$$

Let us now consider what happens if the two firms merge. We assume that there are no complementarities in R&D, so that the merged entity can only coordinate the research programs and the prices on the product market. The merged entity chooses the likelihood of success λ_1 and λ_2 for the lab of firm 1 and that of firm 2, respectively. When only one lab is successful, the merged entity obtains the monopoly profit Π_1. But when both labs are successful, the merged entity coordinates the marketing of the two innovations which allows it to obtain the total monopoly profit Π_2, which is larger than or equal to Π_1. For example, if the two innovative products are identical, the profit Π_1 and Π_2 will be equal. By contrast, if the products are differentiated, the profit with two products is larger than with one product, i.e., $\Pi_2 > \Pi_1$.

[5] The profit π_2 can be positive in a homogeneous product setting if firms are able to collude (as assumed by Federico, Langus and Valletti, 2017).

The merged entity's profit can then be written as

$$\lambda_1 (1 - \lambda_2) \Pi_1 + \lambda_2 (1 - \lambda_1) \Pi_1 + \lambda_1 \lambda_2 \Pi_2 - C(\lambda_1) - C(\lambda_2).$$

We assume in what follows - as Federico, Langus and Valletti (2017) implicitly do - that the cost function C is convex enough to ensure that the profit function above is concave and that it is optimal for the merged entity to invest the same amount in both research labs.[6] In this case, the profit is maximized at $\lambda_1 = \lambda_2 = \lambda^m$, the solution of

$$\max_{\lambda} 2\lambda (1 - \lambda) \Pi_1 + \lambda^2 \Pi_2 - 2C(\lambda).$$

The likelihood of success of each research project is then the solution of the optimality condition:

$$(1 - \lambda^m) \Pi_1 + \lambda^m (\Pi_2 - \Pi_1) = C' (\lambda^m).$$

The comparison of the optimality condition for the merged entity and the equilibrium condition with two independent firms leads to the following result:

Proposition 1 *The merged entity invests more in innovation than independent duopolistic firms if and only if* $\Pi_2 - \Pi_1 > \pi_2$, *i.e., if the merged entity's incremental gain from a second innovation is larger than the profit of an innovator when both firms innovate in the no-merger scenario.*

Another (immediate) implication of our analysis is that in the limiting case $\Pi_2 - \Pi_1 = \pi_2 = 0$, the optimality first-order conditions and, therefore, the levels of innovation in the two scenarios coincide. The case $\Pi_2 - \Pi_1 = \pi_2 = 0$ corresponds to a situation in which the cannibalization between the two products is so large that the value of a second innovation is zero for both an independent firm and the merged entity. This requires that products are homogeneous and that firms compete à la Bertrand.

Federico, Langus and Valletti (2017) assume that products are identical but that firms are able to collude if there are two successful innovators, which implies that $\Pi_2 - \Pi_1 = 0 < \pi_2$.[7] However, when there is some differentiation between the two innovative products, it is possible that $\Pi_2 - \Pi_1 > \pi_2$, in which case the merged entity will invest *more* in innovation. We now illustrate this in the Hotelling model.

3 Application to the Hotelling model

Consider the Hotelling model with quadratic transportation costs. Consumers are located uniformly on a segment of size 1. Each firm is located at one extreme of the segment. Indexing

[6] Denicolò and Polo (2017) show that this property may not hold if C is only slightly convex.

[7] Feredico, Langus and Valletti (2018) relax this assumption.

location from 0 to 1, we assume that firm 1 is located at $x_1 = 0$ and firm 2 is located at $x_2 = 1$. An innovation by firm $i \in \{1, 2\}$ leads to a product whose consumption by a consumer generates a gross utility U (if firm i does not innovate, it is not active in the market). To purchase from firm $i \in \{1, 2\}$, a consumer located at x incurs a transportation cost td^2 where $d = |x_i - x|$ is the distance to firm i. Thus, a consumer buying at price p from a firm at distance d obtains utility $U - td^2 - p$. We assume in what follows that $U \geq 3t/4$.

If a single firm innovates, it charges the monopoly price $p = \frac{2U}{3}$ and serves a share $\sqrt{\frac{U}{3t}}$ of the market if $U < 3t$, while it charges the price $U - t$ and covers the market if $U \geq 3t$. The firm then obtains the monopoly profit $\Pi_1 = \sqrt{\frac{U}{3t}}\frac{2U}{3}$ if $U < 3t$ and $\Pi_1 = U - t$ if $U \geq 3t$.[8] In the duopoly case, if both firms innovate they compete by setting prices and consumers decide where to buy. It is well known (see e.g., Tirole, 1988) that in equilibrium, each firm serves half of the market at price $p = t$. It follows that the duopoly profit is $\pi_2 = t/2$.

Suppose now that the two firms merge. If only one research lab succeeds in innovating, the profit of the merged entity is Π_1. When both labs succeed, the merged entity can sell the two products. When the firm sets a price p (for both products), the total demand is 1 as long as $p \leq U - t/4$ (i.e. as long as the consumer located at an equal distance from both firms is willing to buy), and is equal to $2\sqrt{(U-p)/t}$ for larger p. It is straightforward to show that, if $U \geq 3t/4$, the merged entity chooses the price $p = U - t/4$, serves all the market and obtains a profit $\Pi_2 = U - t/4$.

The comparison of the incremental monopoly profit from a second innovation and a single firm duopoly profit shows that for $U/t > 1.362$, we have[9]

$$\Pi_2 - \Pi_1 > \pi_2.$$

Proposition 2 *In the Hotelling model with quadratic transportation costs and $U/t > 1.362$, a merger leads to more innovation by the merging firms.*

It is important to emphasize that the merger not only leads to more innovation but may also benefit consumers. More precisely, consumer surplus is given by:

$$CS_{M1} = \begin{cases} \sqrt{\frac{U}{3t}}\frac{2U}{9} & \text{if} \quad U < 3t \\ \frac{2t}{3} & \text{if} \quad U \geq 3t \end{cases}, \quad CS_{M2} = \frac{t}{6}, \quad CS_D = U - \frac{13t}{12},$$

for the single-product monopoly case, the multi-product monopoly case and the duopoly case, respectively. Therefore, the expected consumer surplus in the absence of a merger is

$$CS^* = 2\lambda^*(1-\lambda^*)\,CS_{M1} + (\lambda^*)^2\,CS_D,$$

[8] We assume, for the sake of exposition, that marginal costs of production are equal to zero.

[9] In the limiting case $t = 0$, this inequality becomes an equality.

while in the case of a merger it is given by

$$CS^M = 2\lambda^M \left(1-\lambda^M\right) CS_{M1} + \left(\lambda^M\right)^2 CS_{M2}.$$

Both functions are increasing in the range $\lambda \in [0, 1/2]$ from 0 to some upper bound, and $CS^* > CS^M$. Hence, in this range, a merger raises consumer surplus if λ^M is sufficiently larger than λ^*. More precisely, $CS^M > CS^*$ if and only if $\lambda^M > \lambda^S(\lambda^*)$, where $\lambda^S(\lambda^*)$ is the solution of

$$2\lambda^S \left(1-\lambda^S\right) CS_{M1} + \left(\lambda^S\right)^2 CS_{M2} = 2\lambda^* \left(1-\lambda^*\right) CS_{M1} + \left(\lambda^*\right)^2 CS_D.$$

Note that $\lambda^S(\lambda^*)$ exists only for λ^* below a threshold $\hat{\lambda}$ which is such that:

$$2\hat{\lambda}\left(1-\hat{\lambda}\right) CS_{M1} + \left(\hat{\lambda}\right)^2 CS_D = \max_{\lambda \leq 1/2} 2\lambda(1-\lambda) CS_{M1} + \lambda^2 CS_D = \frac{CS_{M1}}{2} + \frac{CS_D}{4}.$$

We conclude that $\lambda^* < \lambda^M$ if and only if the marginal gain of innovation at $\lambda^S(\lambda^*)$ is strictly positive, which can be written as (using $C'(\lambda^*) = \Pi_1 + \lambda^*(\pi_2 - \Pi_1)$):

$$\frac{C'\left(\lambda^S(\lambda^*)\right)}{C'(\lambda^*)} < \frac{\Pi_1 + \lambda^S(\lambda^*)(\Pi_2 - 2\Pi_1)}{\Pi_1 + \lambda^*(\pi_2 - \Pi_1)}.$$

As an illustration, we normalize the transport cost to $t = 1$ and consider the case in which $U = 2$. Then $\hat{\lambda} = 0.286$ and

$$\lambda^S(\lambda^*) = \frac{1}{16\sqrt{2}\sqrt{3} - 9}\left(-27\sqrt{\left(\frac{2}{3} - \frac{32}{27}\sqrt{2}\sqrt{3}\right)\left(2\lambda^*(1-\lambda^*)\sqrt{\frac{2}{3}\frac{4}{9}} + (\lambda^*)^2\frac{11}{12}\right) + \frac{128}{243}} + 8\sqrt{2}\sqrt{3}\right)$$

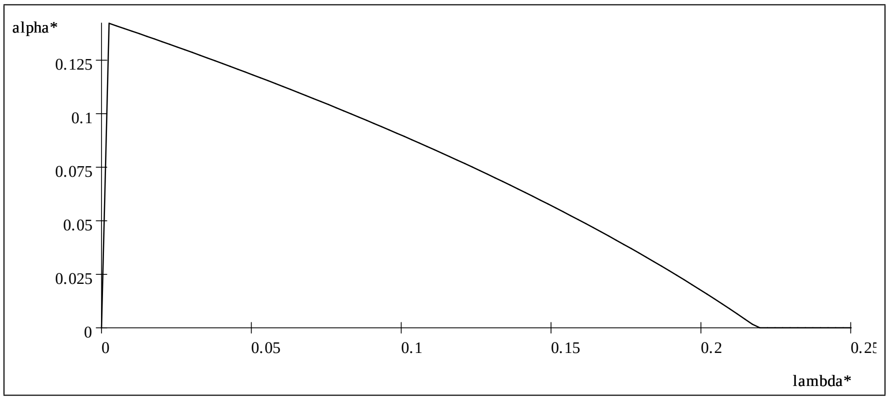
Assume now that $C(\lambda) = \frac{\beta}{1+\alpha}\lambda^{1+\alpha}$ where $\alpha > 0$ and β is chosen so that the monopoly maximization program has a symmetric solution (this implies that λ^* is small). Then, a merger to monopoly benefits consumers if

$$\left(\frac{\lambda^S(\lambda^*)}{\lambda^*}\right)^\alpha < \frac{\sqrt{\frac{2}{3}\frac{4}{3}} + \lambda^S(\lambda^*)\left(\frac{7}{4} - 2\sqrt{\frac{2}{3}\frac{4}{3}}\right)}{\sqrt{\frac{2}{3}\frac{4}{3}} + \lambda^*\left(\frac{1}{2} - \sqrt{\frac{2}{3}\frac{4}{3}}\right)}$$

which is equivalent to

$$\alpha < \alpha^* \equiv \frac{\ln\left(\frac{\sqrt{\frac{2}{3}\frac{4}{3}} + \lambda^S(\lambda^*)\left(\frac{7}{4} - 2\sqrt{\frac{2}{3}\frac{4}{3}}\right)}{\sqrt{\frac{2}{3}\frac{4}{3}} + \lambda^*\left(\frac{1}{2} - \sqrt{\frac{2}{3}\frac{4}{3}}\right)}\right)}{\ln\left(\frac{\lambda^S(\lambda^*)}{\lambda^*}\right)}$$

We plot below the value of α^*:



Maximal curvature α^* as a function of λ^*

A merger raises expected consumer surplus if α is not too large and β is sufficiently large. The graph above shows that this is the case for $\lambda^* < 0.22$ and α small. *Therefore, when the likelihood of innovation λ^* in the no-merger scenario is relatively small and the innovation technology does not involve strong decreasing returns to scale, a merger raises consumer surplus despite the induced increase in prices.*

4 Conclusion

This note derives a necessary and sufficient condition for a merger between two competitors to spur innovation when firms invest to bring new products to the market and the outcome of R&D is stochastic. This condition is shown to hold in the Hotelling model with quadratic costs whenever products are not too differentiated. In this case, a merger not only increases firms' incentives to invest in R&D but may also benefit consumers.

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