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"Mergers and Investments in New Products"

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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 invest in R&D that generates 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 greater than the individual profit of a firm when both firms innovate in the no-merger scenario. Applying this result to the Hotelling model, we find that a merger spurs innovation if the degree of product differentiation is not too high, and show that a merger can be beneficial to consumers.

Keywords: Horizontal Mergers, 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 not too high.[2] We also show that the merger can be beneficial to consumers under that condition.

Our note is related to the recent theoretical literature on the impact of mergers on innovation[3] and, more generally, to the vast literature on the effect of competition on innovation building on Schumpeter (1942) and Arrow (1962).[4] The closest papers to ours are Federico, Langus and Valletti (2017) and Denicolò and Polo (2018a). Both papers also consider the effect of a horizontal merger on the incentives to develop a new product in a model where investments in R&D affect the probability of success but not the value of the innovation. A key difference, however, is that they assume that products are homogeneous while we allow for horizontal product differentiation. This implies that, in our model, the merged entity's profit when both merging firms innovate can be higher than its profit when a single firm innovates.[5] This explains why a merger between two duopolists can spur innovation in our setting while this cannot happen in the environment considered by Federico, Langus and Valletti (2017). Denicolò and Polo (2018a) also show that a merger can lead to more innovation but the mechanism

[1]See e.g. Katz and Shelanski (2007), Shapiro (2012), Motta and Tarantino (2018), Denicolò and Polo (2018c), Jullien and Lefouili (2018), and Régibeau and Rockett (2019).

[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 e.g. Letina (2016), Motta and Tarantino (2018), Federico, Langus and Valletti (2017, 2018), Denicolò and Polo (2018a, 2018b), Gilbert (2019), Moraga-González, Motchenkova and Nevrekar (2019), and Letina et al. (2020).

[4]See Vives (2008) and Schmutzler (2013) for recent contributions to that literature.

[5]Another important difference is that Federico, Langus and Valletti (2017) assume that, when (only) two independent firms are successful in developing a new product, they are able to coordinate their pricing (i.e. collude), which ensures that they make non-zero profits. In the Hotelling model we consider in our application, the firms also make non-zero profits when they both succeed but this is due to product differentitation.

they rely on is fundamentally different from ours. Specifically, they show that this can happen when the returns to R&D decrease moderately, so that the merged entity's investment levels in the merging firms' research labs are different, while we consider a setting in which post-merger investment levels in the two labs are symmetric.

Our work is also related to Chen and Schwartz (2013) who show in a setting with deterministic R&D 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.[6] However, their result relies on the idea that an incumbent monopolist can coordinate the prices of the new product and the old one, while ours hinges on the fact that the merged entity can coordinate the prices of two new products.

2 Reduced-form model

Consider two firms – firm 1 and firm 2 – that invest in a product innovation that creates a new market. More precisely, suppose that each firm owns a research lab aiming at developing a new product and that firms compete in the product market if they both succeed in innovating. Assume that firms set simultaneously their R&D investments and that a firm's probability of success depends on its investments. Formally, firm $i \in \{1, 2\}$ needs to invest $C(\lambda_i)$ to achieve a probability λ_i to innovate, where $C(0) = 0$, $C'(\lambda_i) > 0$, and $C''(\lambda_i) > 0$. A firm's success (or lack thereof) does not depend on the other firm's investment in R&D or the other firm's success.

When a firm succeeds in innovating while the other does not, the sole innovator obtains the single-product monopoly profit Π_1 from marketing the new product. When both firms succeed in innovating, each of them obtains 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.[7]

Consider a firm $i \in \{1, 2\}$, and suppose that the other firm, denoted j, chooses an investment $C(\lambda_j)$ leading to a probability of innovation λ_j. When firm i succeeds (which happens with probability λ_i), there is a probability $1 - \lambda_j$ that the other firm fails to innovate, in which case firm i makes a profit Π_1, and a probability λ_j that the

[6] See Greenstein and Ramey (1998) for a related analysis in a model where products are vertically differentiated.

[7] 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).

other firm succeeds, in which case firm i obtains only the duopoly profit π_2. Therefore, the expected profit of firm i is given by

$$\lambda_i \left[(1 - \lambda_j) \Pi_1 + \lambda_j \pi_2 \right] - C(\lambda_i).$$

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:

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

Let us now consider what happens if the two firms merge, thus becoming a monopolist.[8] We assume that there are no synergies in R&D, so that the merged entity can only coordinate the R&D investments in the labs of the two merging partners and the prices in the product market. The merged entity chooses the probabilities 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 single-product monopoly profit Π_1. However, when both labs are successful, the merged entity coordinates the marketing of the two innovations, which allows it to obtain the two-product monopoly profit Π_2, that is larger than or equal to Π_1. For example, if the two new products are identical, the profits 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., $\Pi_2 > \Pi_1$.

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 it is optimal for the merged entity to invest the same amount in both research labs.[9] In this case, the profit is

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

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

maximized at $\lambda_1 = \lambda_2 = \lambda^m$ which solves

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

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

$$\left(1-\lambda^m\right)\Pi_1 + \lambda^m\left(\Pi_2 - \Pi_1\right) = C'\left(\lambda^m\right). \tag{2}$$

A straightforward comparison of conditions (1) and (2) leads to the following result.

Proposition 1 *The merged entity invests more in R&D 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 conditions (1) and (2) and, therefore, the levels of innovation in the two corresponding 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 $\Pi_2 - \Pi_1 = 0 < \pi_2$.[10] 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 represented by the interval $[0, 1]$. We assume that firm 1 is located at $x_1 = 0$ and firm 2 is located at $x_2 = 1$. An innovation by firm $i \in \{1, 2\}$ brings to the market a new 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

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

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 a 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 single-product monopoly profit $\Pi_1 = \sqrt{\frac{U}{3t}}\frac{2U}{3}$ if $U < 3t$ and $\Pi_1 = U - t$ if $U \geq 3t$.[11] In the duopoly case, if both firms innovate they compete by setting prices and consumers decide which firm to patronize. It is well known that in equilibrium, each firm serves half of the market at price $p = t$ (see e.g., Tirole, 1988). 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 values of 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[12]

$$\Pi_2 - \Pi_1 > \pi_2,$$

which, combined with Proposition 1, yields the following result.

Corollary 1 *In the Hotelling model with quadratic transportation costs, a merger raises R&D investments if product differentiation is not too high (i.e. if $t < U/1.362$).*

The intuition behind this result is that the merged entity's benefit from coordinating prices decreases with the level of product differentiation. If this price coordination effect is sufficiently strong or, equivalently, if the product differentitaion is not too high, 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. This implies that a merger leads to more R&D investments in this scenario.

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

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

Given that in most jurisdictions, competition authorities clear a merger if and only if they expect it to have no adverse effects on consumers, it is important to examine the impact of a merger on consumer surplus.[13] In particular, can it be the case that a merger raises consumer surplus in the Hotelling model?

Let us denote CS_{M1}, CS_{M2}, and CS_D consumer surplus for the single-product monopoly case, the two-product monopoly case and the duopoly case, respectively. Therefore, the expected consumer surplus is

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

when firms are independent, and

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

when firms merge. A natural assumption is that $CS_D > CS_{M2}$. This, combined with the observation that the functions $2\lambda (1 - \lambda) CS_{M1} + (\lambda)^2 CS_D$ and $2\lambda (1 - \lambda) CS_{M1} + (\lambda)^2 CS_{M2}$ are both increasing in λ over $[0, 1/2]$, imply that in this range a merger raises consumer surplus if and only 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 to

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

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

$$2\hat{\lambda} \left(1 - \hat{\lambda}\right) CS_{M1} + \left(\hat{\lambda}\right)^2 CS_D = \max_{\lambda \leq 1/2} 2\lambda (1 - \lambda) CS_{M1} + \lambda^2 CS_{M2} = \frac{CS_{M1}}{2} + \frac{CS_{M2}}{4}.$$

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

$$\frac{C' \left(\lambda^S (\lambda^*)\right)}{C' (\lambda^*)} < \frac{\Pi_1 + \lambda^S (\lambda^*) (\Pi_2 - 2\Pi_1)}{\Pi_1 + \lambda^* (\pi_2 - \Pi_1)}. \tag{3}$$

Proposition 2 *Suppose that* $C (\lambda) = \frac{\beta}{1+\alpha} \lambda^{1+\alpha}$, *with* $\alpha > 0$. *Then a merger increases both R&D investments and consumer surplus if* $\alpha < \frac{(\Pi_2 - \Pi_1 - \pi_2)}{CS_D - CS_{M2}} \frac{2CS_{M1}}{\Pi_1}$ *and* β *is small.*

[13] In our model, a necessary condition for a merger to rasie consumer surplus is that it raises R&D investments. However, this is not a sufficient condition.

Proof. Solving for λ^S in this special case yields $\frac{\lambda^S(\lambda^*)}{\lambda^*} = 1 + \Delta\lambda^* + o(\lambda^*)$, where $\Delta \equiv \frac{CS_D - CS_{M2}}{2CS_{M1}}$. Condition (3) can be written as

$$(1 + \Delta\lambda^* + o(\lambda^*))^\alpha < 1 + \frac{\lambda^* (\Pi_2 - \Pi_1 - \pi_2) + \Delta (\lambda^*)^2 (\Pi_2 - 2\Pi_1)}{\Pi_1 + \lambda^* (\pi_2 - \Pi_1)} + o(\lambda^2).$$

Moreover, λ^* goes to zero when β goes to zero. Therefore, the condition above holds for sufficiently small β if

$$\alpha < \lim_{\lambda \to 0} \frac{\ln\left(1 + \frac{\lambda(\Pi_2 - \Pi_1 - \pi_2)}{\Pi_1}\right)}{\ln(1 + \Delta\lambda)} = \frac{\Pi_2 - \Pi_1 - \pi_2}{\Delta\Pi_1}.$$

■

In our Hotelling illustration, consumer surplus is given by

$$CS_{M1} = \min\left\{\sqrt{\frac{U}{3t}}\frac{2U}{9}, \frac{2t}{3}\right\}, \quad CS_{M2} = \frac{t}{6}, \quad CS_D = U - \frac{13t}{12},$$

in the single-product monopoly scenario, the two-product monopoly scenario, and the duopoly scenario, respectively. Therefore, a merger leads to more R&D investments if

$$\alpha < \frac{\frac{U}{t} - 3/4 - \min\left\{\sqrt{\frac{U}{3t}}\frac{2U}{3t}, \frac{U}{t} - 1\right\}}{\frac{U}{t} - \frac{15}{12}} \frac{\min\left\{\sqrt{\frac{U}{3t}}\frac{2U}{9t}, \frac{2}{3}\right\}}{\min\left\{\sqrt{\frac{U}{3t}}\frac{2U}{3}, U - t\right\}}$$

and β is sufficiently small.

4 Conclusion

This note derives a necessary and sufficient condition for a horizontal merger between two duopolists to spur innovation when firms invest to bring new products to the market and investments affect the probability that R&D is successful. This condition is shown to hold in the Hotelling model with quadratic costs when 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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