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Published Version:
Denicolo V., Polo M. (2021). Mergers and innovation sharing. ECONOMICS LETTERS, 202, 1-4 [10.1016/j.econlet.2021.109841].

Availability:
This version is available at: https://hdl.handle.net/11585/842921 since: 2021-12-23

Published:
DOI: http://doi.org/10.1016/j.econlet.2021.109841

Mergers and innovation sharing*

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March 2021

Abstract

We extend the classic model of Perry and Porter (1985) to allow for cost-reducing innovations and in this setting we analyze the competitive effects of horizontal mergers. The analysis focuses on the innovation-sharing mechanism, whereby the merging firms share the results of their research, enlarging the base of application of inventions and hence the incentive to innovate. We show that if marginal costs are increasing, the innovation-sharing mechanism may more than offset the contractionary output effect that operates for any given state of the technology, making horizontal mergers pro-competitive even in the absence of synergies in production and research.

Keywords: Mergers, Innovation; Sharing of technological knowledge

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1 Introduction

In the lively debate on the impact of horizontal mergers on innovative activity,[1] *innovation sharing* has been pointed to as an important mechanism whereby mergers may spur innovation.[2] The innovation-sharing mechanism rests on the existence of limits to the sharing of technological knowledge among competitors. These limits are clearly evidenced by the large and persistent differences in productivity across firms (Syverson, 2011). By removing many of the obstacles to the sharing of innovative knowledge among the merging firms, mergers enlarge the base of application of innovations and thus increase the incentive to invest in R&D.

It is well known that innovation sharing can increase the incentive to innovate (Atallah, 2016) and the profitability of mergers (Kleer, 2012). But less is known on whether the innovation-sharing mechanism in itself can make horizontal mergers pro-competitive, more than offsetting the well-known contractionary output effect that operates for any given state of the technology. In this respect, existing results are sparse and tend to suggest a negative answer.[3]

In this paper, we re-consider the issue, taking as our starting point the classic model of mergers with Cournot competition and homogeneous products of Salant, Switzer and Reynolds (1983), extended by Perry and Porter (1985) and Farrell and Shapiro (1989) to allow for diminishing returns. We further extend the model by including cost-reducing innovations into the picture. To focus on the innovation-sharing mechanism, we rule out any other form of synergy or technological spillover. Even so, our analysis shows that even mergers that would be regarded as anti-competitive for a given state of the technology may actually become pro-competitive if antitrust authorities consider their beneficial effect on innovation.

2 The model

We extend Perry and Porter's classic model of Cournot oligopoly with homogeneous products and increasing marginal costs (Perry and Porter, 1985) by including endogenous, cost-reducing innovations. We stick to Perry and Porter's simple specification with linear demand and quadratic production costs and assume that the R&D cost function is quadratic as well.[4]

[1]Recent contributions include, among others, Federico, Langus and Valletti (2017), Motta and Tarantino (2017), Jullien and Lefouli (2018), Denicolò and Polo (2019) and Regibeau and Rockett (2019).

[2]See for instance Cabral (2018). The innovation sharing mechanism is also sometimes called "learning" or "information sharing."

[3]After presenting our results, we discuss the related literature in greater detail in the concluding section.

[4]The analysis could be extended to more general functional forms, but focusing on the linear-quadratic specification is without loss of insights.

2.1 Demand, cost and timing

Consider a homogeneous product industry with n firms, indexed by $i = 1, 2, ...n$, that compete in quantities. *Ex ante*, firms are symmetric. Asymmetries may however arise *ex post*, when firms merge.

Demand is taken to be linear; with no further loss of generality, it may be specified as

$$p = 1 - Q \tag{1}$$

where q_i is firm i's output and $Q = \sum_{i=1}^{n} q_i$ is aggregate output.

Firm i's total cost function is:

$$C(q_i, x_i) = (c - x_i)q_i + \frac{\nu}{2}q_i^2 + \frac{\beta}{2}x_i^2. \tag{2}$$

Parameter $\nu \geq 0$ is the slope of the marginal cost function $C'_{q_i}(q_i) = c + \nu q_i$ and thus measures the degree of diminishing returns at the firm level. The variable x_i, which is bounded above by c, denotes firm i's cost-reducing innovation.[5] The last term of (2) is the R&D cost, with parameter $\beta \geq 0$ measuring the costliness of innovation.

Equation (2) implicitly assumes that each firm can freely use its invention, without infringing any intellectual property right that may be owned by its competitors.[6] It also assumes that each firm benefits only from its own research, so there is no innovation sharing among competitors. Abstracting from inadvertent technological spillovers, copying, imitation, and licensing allows us to better highlight the innovation-sharing effect of mergers.

To avoid proliferation of cases, we assume that

$$c < \frac{2 + \nu}{4 + \nu}. \tag{3}$$

This condition guarantees that all firms produce a positive output, both in the pre- and post-merger equilibrium.

Finally, we assume that firms choose output and R&D investment simultaneously, or, equivalently, that a firm's investment is not observable by its competitors. In this way, we abstract from strategic commitment effects.

2.2 Mergers

When two firms, say k and j, merge, they can freely reallocate their aggregate output $q_j + q_k = q_M$ across the two plants. Plainly, with decreasing returns and symmetric cost functions it is efficient to set $q_j = q_k = \frac{q_M}{2}$.

[5] Note that innovation is assumed to affect the constant component of the marginal cost c, but not the slope v. The analysis of the case where R&D investment reduces ν is more involved, but results are similar.

[6] In other words, technological progress is non-tournament. This assumption is appropriate, for instance, if inventions are protected by trade secrets, or by patents so narrow that they are not infringed when rivals use their own inventions.

In contrast to independent firms, we assume that merged firms fully share their innovative technological knowledge. That is, the merged entity applies the more advanced technology (the lower cost) developed in its research units to both of its plants. We assume that research is entirely duplicative – an assumption that minimizes the beneficial technological effects of a merger and thus provides the most conservative setting to assess the impact of the innovation-sharing mechanism.[7] Thus, the cost reduction obtained by the merged entity is

$$x_M = \max[x_k, x_j]. \tag{4}$$

Since innovation is deterministic, it follows immediately that after the merger it is pointless to conduct the research in two separate units. One of them will therefore be shut down, and all the research will be conducted in the sole laboratory that remains active. This is efficient as it avoids wasteful duplication of R&D efforts.[8]

In light of these efficient choices, the cost function of the merged entity is:

$$\begin{aligned} C^M(q_M, x_M) &= \left[(c - x_M)q_j + \frac{\nu}{2}q_j^2\right] + \left[(c - x_M)q_k + \frac{\nu}{2}q_k^2\right] + \frac{\beta}{2}x_M^2 \\ &= (c - x_M)q_M + \frac{\nu}{4}q_M^2 + \frac{\beta}{2}x_M^2. \end{aligned} \tag{5}$$

The slope of the marginal cost curve for the merged entity falls from ν to $\frac{\nu}{2}$. Note that this downward shift in the marginal cost curve is not due to sub-additivity,[9] i.e. synergies in production, but simply reflects the efficient allocation of output across the merged entity's plants.

3 Results

In this section, we compare the equilibrium before and after the merger, focusing on the effect of the merger on total output. The output effect determines also the impact of the merger on consumer surplus, which we use as our welfare criterion. Thus, a merger is said to be pro-competitive if it increases total output, decreases the price and increases consumer surplus, anti-competitive if these effects are reversed.

[7] A more general assumption would be that the reduction in the marginal cost on plant j is

$$\left(x_k^\sigma + x_j^\sigma\right)^{\frac{1}{\sigma}}.$$

Our assumption of duplicative research is obtained for $\sigma \to -\infty$. The opposite case of perfectly non-duplicative research is instead obtained for $\sigma = 1$. As σ increases, it becomes more likely that the merger may have pro-competitive effects. Thus, the case $\sigma \to -\infty$ represents the worst-case scenario for our purposes.

[8] If research were not duplicative, in contrast, it would be profitable to continue to invest in both research units. The same could be true with duplicative research but uncertain innovation. In this case, whether the optimal strategy involves shutting down one research unit depends on the risk of duplication: see Denicolò and Polo (2018).

[9] The first line of (5) clarifies that the cost function is actually additive.

Proposition 1 *A merger between two firms is pro-competitive if and only if*

$$\nu > \frac{2 - c(n+2)}{c} \tag{6}$$

and

$$\frac{1}{c(n+2+\nu) - 1} < \beta < 1. \tag{7}$$

Proof. When β is very small, profit maximization will entail a corner solution with $x_i = c$ for all firms, both with and without the merger. In this case, we are effectively back to the original Perry and Porter model with no innovation, where mergers are always anti-competitive. Thus, in what follows we focus on the case where β is sufficiently large that the pre-merger equilibrium entails an interior solution with $x_i < c$.[10]

In the pre-merger equilibrium, each firm i chooses q_i and x_i so as to maximize $\pi_i = pq_i - C(q_i, x_i)$. The first-order conditions are

$$1 - 2q_i - Q_{-i} - (c - x_i) - \nu q_i = 0$$

where Q_{-i} denoted the aggregate output of firm i's competitors, and

$$q_i - \beta x_i = 0.$$

The latter condition immediately implies that the optimal level of innovation

$$x_i = \frac{q_i}{\beta} \tag{8}$$

is proportional to the firm's output. Combining the two first-order conditions one obtains firm i's "inclusive" best response function

$$\tilde{q}_i(Q) = \frac{1 - c - Q}{1 + \nu - \frac{1}{\beta}}.$$

Total output in the pre-merger equilibrium is then given by the solution to $n\tilde{q}_i(Q) = Q$ and is

$$Q^{\mathrm{pre}} = \frac{n(1-c)}{n + 1 + \nu - \frac{1}{\beta}}.$$

When firm j and k merge, the first-order conditions for the merged entity (assuming again an interior solution) are

$$1 - 2q_M - Q_{-M} - (c - x_M) - \frac{\nu}{2} q_M = 0$$

[10] To be precise, the condition is

$$\beta > \frac{1}{c(1 + n + v)}.$$

This condition also guarantees that the second-order conditions for the profit maximization problem hold.

and

$$q_M - \beta x_M = 0,$$

whence we get

$$\tilde{q}_M(Q) = \frac{1 - c - Q}{1 + \frac{\nu}{2} - \frac{1}{\beta}}.$$

Inspection of the above expressions immediately reveals that $\tilde{q}_M(Q) > \tilde{q}_i(Q)$, so the merged entity has a greater incentive to invest in R&D than the outsiders. This inequality is due to the innovation-sharing effect and implies that the merged entity's maximization problem may have a corner solution $x_M = c$ even if the outsiders' solution is interior.[11] When $x_M = c$, proceeding as before one finds that the merged entity's inclusive best-response function is:

$$\hat{q}_M(Q) = \frac{1 - Q}{1 + \frac{\nu}{2}}.$$

The merger will expand aggregate output if

$$\tilde{q}_M(Q^{\text{pre}}) > 2\tilde{q}_i(Q^{\text{pre}})$$

when $x_M < c$, or if

$$\hat{q}_M(Q^{\text{pre}}) > 2\tilde{q}_i(Q^{\text{pre}})$$

when $x_M = c$. Simple algebra shows that the former condition reduces to

$$\beta < 1,$$

the latter to

$$\beta > \frac{1}{c(n + 2 + \nu) - 1}.$$

Since at $\beta = \frac{1}{c(n+2+\nu)-1}$ the corner solution $x_M = c$ holds as long as $\nu > \frac{2-c(n+2)}{c}$, and, similarly, at $\beta = 1$ the interior solution $x_M < c$ holds as long as $\nu > \frac{2-c(n+2)}{c}$, the region where mergers are pro-competitive is when both conditions (6) and (7) hold. ■

Figure 1 illustrates. A merger is pro-competitive to the right of the vertical line $\nu = \frac{2-c(n+2)}{c}$, in the region below the horizontal line $\beta = 1$ and above the decreasing curve $\beta = \frac{1}{c(n+2+\nu)-1}$.

The intuition for this result follows from the following remarks. First, the optimal level of innovation x is an increasing function of the firm's output, which is the base of application of a cost-reducing innovation (see condition (8)). Second, with increasing marginal costs, a merger shifts the marginal cost curve downward, creating

[11] The merged entity's problem has a corner solution when

$$\beta \leq \frac{4}{2 + 2v + c(2n + v) - \sqrt{4(1 + v)^2 + c^2(2n + v)^2 - 4c\,[2n + v(5 + v)]}}.$$

an incentive for the merged entity to expand production. As a result, for any given level of the technology, the merged firm's total output would be greater than the pre-merger individual outputs of the merging firms. This implies that the merged firm can now apply the innovation to a greater output, and therefore has a greater incentive to invest in R&D than each merging firm had before the merger. As a result, the merged firm will obtain a bigger cost reduction. In turn, this further increases its incentive to expand production in a self-reinforcing, cumulative process.[12] This output-expanding effect counteracts the standard contractionary effect of horizontal merger and explains why the overall effect may be pro-competitive.

Figure 1 about here: The region where mergers are pro-competitive. Condition (6) holds to the right of the dashed vertical line, and condition (7) holds in the grey area. The dashed curve separates the regions where the post-merger equilibrium is interior (above the curve) or involves a corner solution xM = c (below the curve). The figure has been drawn for c = 0.3 and n = 4.

In particular, the overall effect is pro-competitive, when ν is sufficiently large, for intermediate values of β. The reason for this is simple. When β is small, firms have a strong incentive to innovate irrespective of the merger, so x_i will be equal or close to c in any case. On the other hand, if β is large x_i will be close to 0 both before and after the merger. In both cases, mergers have little impact on innovation and thus the innovation sharing effect is weak or non-existent. But for intermediate values of β, mergers have a significant impact on innovation, and the innovation-sharing effect can be strong enough to reverse the static negative impact of the merger on output.

The reason why mergers are pro-competitive when ν is sufficiently large, and the pro-competitive region enlarges as ν increases, is that the more strongly diminishing are the returns at the firm level, the greater is the merged firm's incentive to expand its output beyond the individual pre-merger level, and hence the stronger is the cumulative process described above. As a result, it is more likely that this process can overcome the negative static effects of the merger.

The region where mergers are pro-competitive also gets larger as c increases (for the simple, mechanical reason that when c is small there is little scope for innovating) and as n increases (because the traditional output-contracting effect of a merger is weaker when the number of competitors is large).

Note that even accounting for the innovation-sharing effect, the pro-competitive region vanishes when $\nu = 0$ (so marginal costs are constant, as in Salant, Switzer and Reynolds (1983)) and $n = 2$. With $\nu = 0$ and $n \geq 3$, the pro-competitive region is non-empty provided that c is large enough, but it is small. However, with constant marginal costs mergers are unlikely to be profitable. The more strongly decreasing are the returns at the firm level, the higher is the profitability of mergers, and the greater is also the possibility that mergers are pro-competitive accounting for their effect on innovation.

[12] This process is not explosive when the condition that guarantees interior solutions holds.

4 Conclusion

In this paper, we have demonstrated that the innovation-sharing mechanism may make horizontal mergers pro-competitive. Thus, even mergers that would be anti-competitive for a given state of the technology may increase consumer surplus thanks to their positive impact on innovation. In the literature, this possibility is typically associated with the presence of technological spillovers or other forms of synergy, as for instance in Motta and Tarantino (2017). Our analysis shows that the result may be driven by the innovation-sharing effect in itself.

The possibility that the innovation-sharing mechanism may make mergers pro-competitive has been demonstrated in the classic model of Perry and Porter (1985), augmented to allow for cost-reducing innovations. Previous literature on innovation sharing has largely overlooked this possibility because it has focused mainly on the case of constant marginal costs, where the possibility is, indeed, limited.[13] But with constant marginal costs it is also unlikely that horizontal mergers are profitable. Diminishing returns, which make mergers more likely to be profitable, also make them more likely to be pro-competitive in our setting.

In a different theoretical framework, Davidson and Ferrett (2007) have demonstrated the possibility of pro-competitive mergers with differentiated products. In their model, however, pro-competitive effects can arise only when the products are poor substitutes but are sufficiently similar from a technological point of view that much of the innovative knowledge developed for one can be transferred to the others – a combination that may sound implausible. Davidson and Ferrett assume also that the research conducted by different firms is entirely non-duplicative. But in fact the possibility of pro-competitive mergers does not rest on such strong assumptions and arises also in more standard models of merger and innovation.

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[13] For example, Mukherjee and Chowdury (2013) find that in the absence of technological spillovers, mergers are always anti-competitive with two firms, which is consistent with our findings. Kleer (2012) obtains the same conclusion with 3 firms – a case where in our model pro-competitive effects are possible even with constant marginal costs. However, Kleer assumes that firms can observe rivals' R&D investment before choosing their output levels. This attenuates the innovation sharing effect, explaining the difference with our result.

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