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“Horizontal Mergers and Innovation"

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Horizontal Mergers and Innovation*

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Abstract

This paper discusses the effects of horizontal mergers on innovation. We rely on the existing academic literature and our own research work to present the various positive and negative effects of mergers on innovation. Our analysis shows that the overall impact of a merger on innovation may be either positive or negative and sheds light on the circumstances under which each of these scenarios is likely to arise. We derive a number of policy implications regarding the way innovation effects should be handled by competition authorities in merger control and highlight the differences with the analysis of price effects.
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1 Introduction

The debate about the impact of mergers on innovation is not a recent one. First, it is tightly related to the long-standing debate about the effect of competition on innovation initiated by Schumpeter (1942) and Arrow (1962). Second, the effects of mergers on innovation have been discussed, sometimes heatedly, in a large number of cases over the last decade both in the U.S.[1] and the EU.[2]

While not being new, the debate on the effect of mergers on innovation has been particularly lively in Europe since the European Commission's use of a broader innovation theory of harm in the recent *Dow/DuPont* case. In previous merger cases, the Commission's innovation concerns were about the development and commercialization of well-defined pipeline products for which a substantial part of the R&D process has been completed. In contrast, in the merger between Dow and DuPont, the Commission considered the effects of the merger on *overall* R&D investments, including those for products and technologies for which the "research" part of the R&D process will be performed after the merger takes place. Furthermore, the statement of the Commission in its press release that "only five players are globally active throughout the entire research & development (R&D) process" has been interpreted by some commentators as meaning that five-to-four mergers may be considered in the future as particularly problematic by the European Commission if they happen in industries in which R&D is a key element of competition.

The reasons behind this debate lie in the opposite effects that mergers can have on firms' incentives to invest in R&D. These effects will be discussed extensively throughout the paper but let us provide here a simple example that illustrates this point. Consider two firms that produce similar products and engage in R&D in order to develop the "next-generation" product. Assume that if only one firm manages to do so, it becomes a monopolist, while if both of them innovate, they compete against each other. This implies that a firm's R&D investment may have a negative impact on its rival, independently of whether the latter also invests in R&D or not. If the two firms merge they will maximize their joint profits and, consequently, they will "internalize" any negative impact of each one's R&D investment on the other's profit. This may tend to lower the merged entity's incentives to invest in R&D. However, this is not the only effect at work. The merger also relaxes product market competition, which implies that a firm succeeding in developing the next-generation product will be able to sell it at a higher price. This tends to increase the returns to R&D investment and, thereby, may increase the merged entity's incentives to innovate. The overall impact of the merger on innovation is *a priori* ambiguous because of the existence of these two opposite effects.

[1] See e.g., Gilbert and Greene (2015).

[2] In particular, several merger cases have been cleared by the European Commission subject to the divestiture of R&D assets. See e.g., *Metronic/Coviden*, *Novartis/GSK*, *Pfizer/Hospira*, and *General Electric/Alstom.*

This paper relies on the existing academic literature and our own research work to present the potential effects of mergers on innovation. In line with the current assessment of mergers in practice, we make a distinction between the effects of mergers on the merging firms' (and, to a lesser extent, their rivals') *incentives* to innovate for given innovation capabilities, and their impact on the merging partners' *ability* to innovate. We also distinguish between the effects of mergers on R&D investments in *product* innovation and in *process* innovation because some of the effects we highlight are relevant only (or particularly) for one of these two types of innovation.

Considering first the effects of mergers on product innovation, we start with a description of what we call the *innovation diversion effect*. This effect stems from the impact that a firm's innovation has on its rivals' sales. A key point of our analysis is that this impact can be either positive or negative. In the latter scenario, the internalization of this "externality" affects negatively the merged entity's incentives to invest in R&D, while it affects them positively in the former scenario.

Next, we turn to two effects of mergers on innovation that follow from the standard market power effect of mergers on prices. We call the first one the *demand expansion effect*. This effect is positive and captures the idea that the margin increase induced by a merger provides the merging firms with higher incentives to innovate in order to increase their demand. The second effect we identify is a *margin expansion effect*: in the absence of efficiency gains, a merger leads to a decrease in the merging firms' output, which lowers the firms' incentives to innovate in order to increase their margins (by setting higher prices).

Finally, we consider the *spillover effect*. As has been emphasized in the literature, a given firm's investment in R&D may not only benefit the firm itself but also its rivals through technological spillovers. When such a positive innovation externality exists, it creates another channel through which a merger can lead to more innovation.

We pay special attention to the recent theoretical papers by Federico, Langus and Valletti (2017a, 2017b) as they formalize the arguments that the Commission used in the *Dow/DuPont* case. In particular, we argue that these two papers provide only a partial picture of the impact of mergers on innovation and do not justify the authors' claim that "a merger between two out of a limited number of innovators is likely to lead to a reduction of innovation in a market characterized by limited knowledge spillovers and in the absence of other possible countervailing efficiencies". In contrast, Bourreau, Lefouili and Jullien (2018) show that the overall impact of a merger may be positive even in the "worst-case" scenario in which the merger leads to monopoly and there are neither spillovers nor efficiencies.

Turning to the effect of mergers on process innovation, we discuss the in-depth theoretical study of this issue by Motta and Tarantino (2017). Their analysis is grounded on the existence of a variant of our *margin expansion effect*: a firm's benefit from investing in a cost-reducing technology is lower if its output is smaller. In the absence of efficiency gains in production, a horizontal merger leads to higher prices and smaller output. This creates a channel through which a merger may decrease the merging firms' incentives to invest in process innovation. However, they show that this need not be the only effect. First, knowledge spillovers generate a countervailing effect that could lead to a positive overall effect on innovation. Second, when investments are observable by rivals, a new "strategic" effect appears, which makes the impact of a merger generally ambiguous.

We then analyze the R&D complementarities that a merger may induce and show how they may boost innovation. We also argue that non-R&D related cost reductions induced by a merger should be taken into account not only to assess the effect of a merger on prices but also to analyze its impact on innovation.

We derive the implications of our analysis on the way innovation effects should be handled in merger cases. We argue that a presumption of a negative impact of mergers on innovation in R&D-intensive industries is not supported by our knowledge of how a merger impacts innovation. We contend instead that competition authorities should perform a thorough balancing exercise of the opposite effects altering firms' incentives to innovate. We also claim that all the effects of a merger on the incentives to innovate should be part of the main competitive assessment carried out by competition authorities. In particular, it should include the analysis of spillover effects.

The remainder of the paper is structured as follows. Section 2 presents preliminary discussions that are useful for our analysis and conclusions. Section 3 examines the impact of a merger on firms' incentives to innovate, holding fixed their ability to innovate. Section 4 analyzes the effect of complementarities between R&D assets and non-R&D-related cost reductions induced by a merger on innovation. Section 5 concludes and derives the policy implications of our analysis on the assessment of innovation effects in merger control.

2 Competition, mergers and innovation: preliminaries

This section presents preliminary discussions of issues that are relevant to our core analysis in Sections 3 and 4 and the conclusions we draw in Section 5. We first briefly summarize a few key contributions to the literature on the relationship between competition and innovation, and discuss the relevance of this literature for the debate on the impact of mergers on innovation. Second, we point out some fundamental differences between the unilateral price effects of a merger and its unilateral innovation effects. Third, we illustrate the lack of consensus among economists about a presumed (negative or positive) sign of the impact of mergers on innovation.

2.1 The literature on market structure, competition and innovation

The two seminal positions on the relationship between innovation, market power and competition can be summarized as follows. The Schumpeterian view contends that market power and size can promote innovation. In particular, Schumpeter (1942) considered that the short-run benefits from competitive pricing can be outweighed by the long-run benefits of market power on firms' incentives to innovate. In contrast, Arrow (1962) showed that market power is detrimental to innovation in certain circumstances. More precisely, he argued that a monopolist has less incentives to invest in R&D than a firm in a perfectly competitive industry. Key to his finding is the so-called "replacement effect" (Tirole, 1988): contrary to a firm facing strong competition, a monopolist is making substantial profits even if it does not innovate. Therefore, the difference between post-innovation profits and pre-innovation profits - which drives the incentives to invest in R&D - is higher under competition than under monopoly. A crucial assumption for Arrow's conclusion to hold is that the monopolist is not facing any threat of entry. If this condition is not satisfied then the current monopolist may lose profits if it does not innovate while a potential entrant does. In this case, the monopolist may have stronger incentives to invest in R&D than a potential entrant: through innovation, the monopolist may preempt investment by a potential entrant and maintain its monopoly rent (Gilbert and Newberry, 1982). Tirole (1988) calls this the "efficiency effect" as it relies on the fact that entry by a competitor usually lowers industry profits, which makes the monopolist's gain from deterring entry greater than the potential entrant's gain from entering the market.

A number of authors have tried to reconcile or combine the contrasting conclusions reached by Schumpeter and Arrow. A particularly influential work in this area is the paper by Aghion et al. (2005). These authors develop a duopoly model where, at each point in time, the industry can be either in a "neck-and-neck" state or in a "leader-laggard" state. In the former state, both firms have the same marginal costs, while in the latter, one of them (the leader) is more efficient than the other (the laggard). Focusing on cost-reducing innovation, Aghion et al. (2005) show that in the "neck-and-neck" scenario firms have stronger incentives to innovate if competition is more intense. This is what they call the "escape the competition effect", which Shapiro (2012) considers as the "flip slide of the Arrow replacement effect". By contrast, an increase in competition gives a laggard firm less incentives to innovate.[3] This is a Schumpeterian effect. By combining these two effects, Aghion et al. (2005) obtain an inverted U-shaped relationship between competition and innovation.[4] In a similar vein, Shapiro (2012) argues that there is no fundamental conflict between the insights offered

[3] In Aghion et al. (2005), the assumptions of the model are such that a leader does not have incentives to innovate.

[4] Gilbert, Riis and Riis (2017) extend the stepwise models in Aghion et al. (2001) and Aghion et al. (2005) to (symmetric) oligopolies and show that that the predictions of the effects of competition on innovation from the duopoly models do not generalize to oligopolies.

by Schumpeter and Arrow. He interprets the former's thesis as saying that stronger *post-innovation* competition lowers firms' incentives to innovate, while the latter's view contends that stronger *pre-innovation* competition leads to higher incentives to innovate.[5] Finally, Gilbert and Greene (2015) emphasize that a firm's ability to appropriate the benefits of its investment in R&D is key to understand the difference between Arrow's and Schumpeter's conclusions. They argue that "weak appropriation supports the Schumpeterian view that size, and, indirectly, market share promotes innovation. In contrast, if firms can appropriate the benefits from their innovations, Arrow's conclusion applies, as profits from existing operations reduce the net returns to innovation and the incentive to invest in R&D."

Several authors have pointed out that the literature on competition and innovation building on Schumpeter's and Arrow's seminal contributions is not directly applicable to merger analysis (see e.g., Shapiro, 2012; Motta and Tarantino, 2017; Federico, Langus and Valletti, 2017a, 2017b). The main reason for this is that a merger not only leads to a decrease in the number of firms (which has been used as a measure of competition intensity in a number of papers[6]) but also allows the merging firms to coordinate their decisions, in particular at the R&D stage. In other words, the merging firms can internalize the externalities they were exerting on each other before the merger. However, the fact that policy prescriptions regarding the treatment of innovation effects in merger control should not rely solely on the (ambiguous) results put forward by the literature on competition and innovation does not mean that this literature is not useful at all for merger analysis. On the contrary, as will become apparent in our analysis, the key effects identified in that literature are still relevant when assessing the effects of a merger on innovation. For instance, the replacement effect put forward by Arrow is very similar in nature to the "innovation externality" effect driving (partly) the results in Federico, Langus and Valletti (2017a, 2017b).

2.2 Unilateral price effects vs. unilateral innovation effects

Some recent studies have suggested that the analysis of unilateral innovation effects in merger cases bears resemblance with the analysis of unilateral price effects (see e.g., Federico, 2017; Federico, Langus and Valletti, 2017a, 2017b). In contrast, we claim that there are three key differences between competition in prices and competition in innovation that advocate for a clear distinction between the assessment of innovation effects and that of price effects.

First, while the substitutability between competing products is sufficient to justify a presumption that the merged entity will raise prices absent efficiency gains, the existence of a potential negative innovation externality is *not* sufficient to make the claim that the merged

[5] More precisely, Shapiro (2012) interprets the Schumpeterian thesis as saying that "the prospect of obtaining market power is a necessary reward to innovation" and Arrow's view as meaning that "a firm with a vested interest in the status quo has a smaller incentive than a new entrant to develop or introduce new technology that disrupts the status quo".

[6] See e.g., Vives (2008).

entity will decrease its innovation in the absence of efficiency gains. The reason for this is that a merger may provide firms with higher incentives to innovate even if the merging firms' investments in R&D exert negative effects on each other. For instance, if the merger leads to an increase in the merging firms' price-cost margins, it may generate higher incentives to engage in demand-enhancing innovation that may outweigh the effect stemming from the negative externalities between the merging firms (if such externalities exist).[7]

Second, a fundamental difference between competition in R&D and competition in prices is the potential existence of spillover effects in R&D (Salinger, 2016). Those effects capture the idea that the output of a firm's investment in R&D may benefit its rivals, through e.g., the information disclosed in its patents.[8] When this positive externality exists, it may compensate partly, or even outweigh other negative externalities, thus altering substantially the very nature of the strategic interaction between firms.

Finally, while a static analysis of prices, such as the one performed in a unilateral price effects exercise, is meaningful, a static analysis of innovation is necessarily reductionist because of the fundamentally dynamic nature of the innovation process (see e.g., Marshall and Parra, 2018). This process is cumulative both at the firm level and the industry level (Scotchmer, 2004), which implies that a structural change, such as a merger, may have a long-lasting effect on innovation.

Petit (2018) also questions the transposition of the (standard) unilateral price effects exercise to innovation effects. He notes in particular that R&D cannot be adjusted as quickly as prices, which might undermine merging firms' ability to discontinue R&D (even when they have incentives to do so). He also argues that coordination in innovation can dominate competition in innovation from a welfare perspective and highlights the fact that standard unilateral effects analysis ignores the organisation of R&D within the merged entity.

2.3 The lack of consensus regarding a presumed effect of mergers on innovation

There is no consensus among economists about a presumed (negative or positive) sign of a horizontal merger's impact on innovation. The literature shows that the impact of a merger is generally a combination of positive and negative effects (see, e.g., Katz and Shelanski, 2007; Shapiro, 2012; Gilbert and Greene, 2015). Leading economists do not agree about how to balance these effects in merger analysis, and whether there should be a presumption that mergers harm innovation absent efficiency gains. The comparison of the views expressed by Katz and Shelanski (2007) and Shapiro (2012) illustrates this point. Katz and Shelanski (2007)

[7] This effect will be discussed in detail later.

[8] Note that patent protection does not preclude spillovers as rivals can work around patents to develop non-infringing alternatives, or build on the knowledge diffused by patents to invent next-generation products/technologies.

recommend that "merger review proceed on a more fact-intensive, case-by-case basis where innovation is at stake, with a presumption that a merger's effects on innovation are neutral except in the case of merger to monopoly, where there would be a rebuttable presumption of harm", while Shapiro (2012) argues that "we *do* know enough to warrant a presumption that a merger between the only two firms pursuing a specific line of research to serve a particular need is likely to diminish innovation rivalry, absent a showing that the merger will increase appropriability or generate R&D synergies that will enhance the incentive or ability of the merged firm to innovate."

The literature, however, does provide guidance regarding the potential effects of a merger on innovation, which we discuss in detail in the next section.

3 The effects of horizontal mergers on the incentives to innovate

3.1 Key concepts

Prior to analyzing the effects of mergers on innovation, it is worth discussing the nature of the exercise conducted by competition authorities in merger control and how our analysis relates to it. As has been emphasized by many authors,[9] a merger can be viewed as a combination of several economic operations that affect market outcomes.

3.1.1 Incentives vs. ability

The first consequence of a merger is that, holding the organization and technologies fixed, common ownership of two economic entities leads to the coordination of all these entities' actions, with the aim of achieving a common goal, namely the maximization of joint profits. Coordination implies that any action of one entity is taken by considering the implications for this entity but also considering the effect on the other merging entity. Thus, each entity, when determining its pricing, production or innovation strategy, internalizes the effects on its merging partner. In economic terms, a merger changes the incentives of each merging firm. In "standard" merger analysis (i.e., when innovation effects are not incorporated), the assessment of the consequences of a change in incentives brought about by a merger is done by analyzing the unilateral price effects of the merger. Consider for instance a merger between two car producers. The first step of the analysis is to evaluate how prices will change, holding fixed the product lines and the organization of production. The presumption regarding the unilateral effects of a merger on prices is that the changes in firms' incentives will result in higher prices for each product sold when firms compete in prices.

[9] See the discussion in Shapiro (2012) for instance.

However, a merger entails more than just a coordination of the merging firms' actions. It also affects the merged entity's *ability* to produce. The new firm controlling all the merging firms' assets can re-optimize the organization of production. The reallocation of assets and/or reorganization of production allows the merged entity to reduce marginal costs of production compared to the pre-merger situation. In the example of car producers, the merging firms can rationalize production, say by producing all engines in the same factory, or can re-optimize the product lines of each brand. The assessment of the effect of a merger on the merged entity's ability to produce is difficult because of its prospective nature. In particular, the quantification of the effects on final prices makes an efficiency defense very complicated.

Although somewhat artificial,[10] the distinction between incentives and ability has proved useful and provides an operational framework for merger analysis that is consistent with the legal standards for merger control.

When innovation is to be factored, the analysis becomes significantly more complex because innovation affects by nature products and production processes. Since innovation alters technologies, it is no longer possible to analyze the effect of new incentives resulting from the merger holding fixed production technologies and product lines. However, and precisely because of the complexity of these effects, the assessment of a merger gains in clarity when the same methodological approach - focusing first on incentives and then considering any merger-induced increase in ability - is adopted. The analysis of incentives should determine the outcome of the coordination of the merging firms' behaviors, now holding fixed the organization and technology in terms of R&D and production. In this context, the effect of the merger on ability relates to the reallocation of resources within the merged entity and the exploitation of complementarities at two levels: R&D and production.

Where innovation is at stake, the analysis of incentives is complicated by the need to account for firms' pricing behavior when analyzing innovation effects. It is therefore necessary to understand how a merger affects incentives along two dimensions - prices and investments in R&D - that are related. Moreover, as already pointed out, the analysis of innovation is by nature dynamic while in most cases an analysis of unilateral effects involving only price coordination (within the merged entity) can be conducted in a static framework.

We will focus to a large extent on the effect of mergers on firms' incentives to innovate but we will also discuss their effect on the merging firms' ability to innovate.

[10] For instance, along the lines that we will develop for the analysis of innovation effects, a question arises in our car manufacturer example as to whether coordinated optimization of product lines by each brand should be treated as part of the analysis of the merging firms' incentives to innovate or as part of the analysis of their ability to do so.

3.1.2 Initial impetus vs. equilibrium analysis

A second distinction that has proved useful for understanding the effect of mergers is between *initial impetus*[11] and equilibrium behavior. A source of complexity in the analysis of unilateral effects is that a merger also affects the behavior of non-merging firms, who will change prices, quantities and, in the context of innovation, their investment in R&D. The initial impetus refers to the effect of the merger under the assumption that the behavior of non-merging firms is not affected by the merger. In the case of product market competition, the initial impetus leads the merging firms to charge higher prices and sell less than what they would have done if they had set their prices independently (in the absence of efficiency gains). The importance of the initial impetus stems from the idea that, while the equilibrium effects resulting from rivals' responses to a merger may exacerbate the initial impetus or mitigate it, they are unlikely to reverse it (see e.g., Whinston, 2012). Therefore, the initial impetus informs about the likely sign of the effect of a merger. Moreover, a measure of the initial impetus provides useful insights into the likely magnitude of the effect of a merger. A small initial impetus should lead to little reaction to the merger by non-merging firms and hence to a small overall effect. This is for instance the logic behind the "upward pricing pressure" (UPP) analysis (Farrell and Shapiro, 2010).

Most of the debate regarding the effect of mergers on innovation is about the initial impetus: will the merged entity innovate more or less than would the merging firms in the absence of a merger? As far as innovation is concerned, there are two ways of thinking about the initial impetus. One can analyze innovation incentives fixing the R&D investments of rivals but allowing all prices to adjust post-merger, as in Federico, Langus and Valletti (2017b). Alternatively, one could analyze innovation incentives holding constant both the prices and R&D investments of all rivals.

3.2 Product innovation

3.2.1 The innovation diversion effect

Imagine a situation involving an incumbent firm that is the sole seller of a product and a new innovative firm that is investing to develop a rival product. If the latter succeeds, it will enter the market and "divert" some of the incumbent's sales: some consumers will prefer to buy the new product instead of the incumbent's. Consider now the innovative firm's decision to invest in R&D. This decision depends on R&D costs, the likelihood of success, and the profit the innovator obtains if its investment is successful. However, the innovator will not factor in its decision the loss of sales suffered by the incumbent in case of success. Suppose now that the incumbent acquires the innovator before R&D takes place. Endowed with the

[11] We use the same terminology as Farrell and Shapiro (2010) and Federico, Langus and Valletti (2017b).

innovating firm's R&D technology, the incumbent will account not only for the sales of the new product but also for the lost sales on the old product when evaluating the gain from a successful investment. Hence, the incumbent would invest less when owning the innovating firm than an independent innovator.

This effect has been well understood at least since Arrow (1962) as it underlies Arrow's view that established incumbents have less incentives to innovate than new entrants. In the economic literature, the fact that a firm does not internalize in its strategy the negative impact on its rivals' sales is often referred to as the "business-stealing effect". In particular, this effect has been discussed at length in the literature on entry in a market (see e.g., Mankiw and Whinston, 1986).

Note that the direct diversion of sales due to an innovation is amplified by firms' reactions in terms of pricing. As firms losing demand react by reducing their prices, price competition between an innovator and its rivals may magnify the diversion of sales. For instance, an innovator that invents a superior product can either divert all or part of its rivals' sales depending on its choice of price.

We will refer to the impact of a merging firm's innovation on another merging firm's sales as the *sales externality*. Further, we will call the *innovation diversion effect* the effect of a merger on the merging firms' incentives to innovate stemming from the internalization of the sales externality by the merged entity. A recent and prominent illustration of this effect in merger analysis is provided by Federico, Langus and Valletti (2017a).

In this paper, the authors consider N (identical) research labs that compete to invent a product to serve a new market. One may think for instance of pharmaceutical labs trying to develop a treatment for a disease. As research is an uncertain activity, the number of labs that succeed in finding a treatment is random. When several products are discovered, they are marketed and competition erodes profits. In the above terms, firms' innovations divert each other's sales. To simplify, Federico, Langus and Valletti (2017a) assume that competition between three or more products erodes all profits. Therefore, an investor can expect positive profits only if it is the sole successful inventor or there is only one other successful inventor. They then consider what happens if two research labs merge. They assume that in this scenario the two research units remain separate but the research efforts exerted in each of them are coordinated by the merged entity.

Focusing on the case where the merged entity continues to invest (the same amount) in R&D in both research units, they conclude that a merged entity controlling two research labs would invest less in R&D than two independent labs. The main idea behind their argument is that, when deciding its investment in one research lab, the merged entity discounts the fact that a success would divert ("cannibalize", in their terms) sales from the product discovered by the other research lab if both succeed simultaneously. The merged entity would then invest less because it internalizes the sales externality. They also argue that for concentrated industries, the reaction of non-merging firms will not be sufficient to offset the reduction of innovation by the merging firms.

While a nice illustration of the innovation diversion effect in a simple model of mergers, Federico, Langus and Valletti's paper should be viewed as providing *one* factor that should be considered, along with other factors, when evaluating innovation effects in merger assessment. For reasons that we now develop, concluding that mergers are always likely to impede incentives to innovate (in the absence of efficiency gains) because of the innovation diversion effect would be misleading.

Merging firms may reduce the number of research projects but invest more in the remaining ones. A crucial assumption in the model by Federico, Langus and Valletti (2017) is that the merged entity will choose to maintain both research units active. As shown by Denicolò and Polo (2018a, 2018b), this assumption holds only under certain conditions. Denicolò and Polo establish that the merged entity may find it optimal to shut down one research lab and focus on the other one. In this case, reduced rivalry at the research level (due to the removal of one competitor) would induce firms to invest individually more than without the merger. Through this effect the merger may boost total investment and benefit consumers. More precisely, the logic behind their finding is the following. A merged entity investing in two research paths internalizes potential cannibalization of sales in case of innovation duplication, that is, if both research investigations succeed in bringing new (substitutable) products to the market. This provides the merged entity with incentives to reduce its effort in one research path. But this reduction raises the value of investing in the other research path as it is more likely now that it will lead to a single innovation. A consequence is that the merged entity may be tempted to reduce drastically its effort in one research path and increase substantially its effort in the other one. Whether it will do so or will instead reduce uniformly its efforts on both research paths depends on the extent of decreasing returns in R&D. In particular, when the R&D technology involves little decreasing returns at the research unit level, the merged entity will focus all its effort on one research path. The resulting likelihood that an innovation will occur may be larger than in the no-merger scenario where both research paths are followed but with little effort (due to the risk of duplication).

The innovation diversion effect may be either positive or negative depending on the sign of the sales externality. An important feature of the setup considered by Federico, Langus and Valletti (2017a) is that innovation by one firm always diverts sales from its rivals.[12] However, this need not always be the case. Unlike a price reduction in a price competition game, an increase in R&D activity by one firm does not always hurt its competitors. The reason is that there are several ways through which R&D allows a firm to

[12] The same applies for Federico, Langus and Valletti (2017b).

make additional profits. In order to escape intense competition, a firm may invest in R&D to offer a product that is better than its rivals', but it can also invest to propose a product that is different from its competitors'. Most rivalry in innovation combines both dimensions. For instance, smartphone producers clearly invest to improve the quality of their products, but they do so in part by introducing features that make these products different from those offered by their rivals. While innovation leading to vertical differentiation (i.e., resulting in a product of higher quality) would induce a diversion of rivals' sales, innovation leading to horizontal differentiation (i.e., allowing the innovator to appeal to different customers than its competitors') may be beneficial to rivals. This is illustrated in Bourreau, Lefouili and Jullien (2018) in a simple variant of the Hotelling duopoly model. In that setting, R&D allows to modify product characteristics so that the new product becomes relatively more attractive for consumers who are less interested in the competitor's product. A consequence is that R&D investment by one firm relaxes price competition and allows its competitor to sell more (potentially at higher prices). As a firm's innovation *raises* rival's demand, the innovation diversion effect is positive: it leads to an *increase* in the merging firms' incentives to invest in R&D aimed at increasing horizontal differentiation (as compared to the case where they would have remained independent).

The differentiation effect described above is related to the analysis underlying the statement in the U.S. Horizontal Merger Guidelines that "a merger is not likely to lead to unilateral elevation of prices of differentiated products if, in response to such an effect, rival sellers likely would replace any localized competition lost through the merger by repositioning their product lines". The fact that firms may innovate to "reposition" themselves away from competitors is well-documented in the literature and emphasized for instance by Gandhi et al. (2008). These authors adapt a standard model from the empirical literature (commonly used in merger analysis) to allow firms to choose product positioning as well as prices. Focusing on price competition, they conclude that, along the lines of the U.S. Horizontal Merger Guidelines, "combining close substitute products creates a strong incentive for the merged firm to separate those products", and that "this repositioning substantially mitigates the merged firm's price increases and thereby also reduces the extent to which the merged firm's price increases" (see, also, the EU Horizontal Merger Guidelines, paragraphs 28-30 to like effect). In the context of incentives to innovate, the same logic suggests that a merged firm will reposition innovations toward more differentiation, which mitigates sales diversion.

Of course, most innovation processes involve both vertical and horizontal differentiation. Firms benefit from introducing the best and most differentiated products, as they will generate the highest margins. Thus, we expect both dimensions to be present in most mergers. One illustration, though not in the context of mergers, is the analysis of product and process innovation by Lin and Saggi (2002). In their paper, product innovation by one firm raises its demand but also its rival's demand, due to lower substitutability between products after innovation than before.[13]

Let us finally notice that introducing a "horizontal" dimension in the innovation strategy is a way for independent firms to guard themselves against the risk of having their sales diverted by another innovation. If two innovations occur simultaneously, product differentiation allows firms to relax competition and reduces the negative externality that each innovator exerts on the other one. Relaxing *ex post* competition is more important when it is likely that several innovations coexist, which is precisely when the innovation diversion matters more for firms. Thus, when the innovation diversion effect is relevant, we expect firms to try to differentiate their innovations.

The innovation diversion effect may be either positive or negative depending on whether the sales externality is greater or smaller after the merger. There is a complex and subtle relationship between price competition and sales diversion. Indeed, when products are substitutes, firms will compete in prices and, therefore, the total value of sales diverted by an innovation will depend on the nature of competition. An important aspect of this issue can be illustrated as follows. Consider two firms competing on the market by selling goods that are substitutes and suppose that a single firm innovates and improves the quality of its product, making it more attractive to more consumers. There are several ways through which the firm can monetize its innovation. For instance, the firm could maintain its price despite the better quality of its product, which would induce a strong diversion of sales of the non-innovating firm. Alternatively, the innovator could raise its price at a level such that its volume of sales remains the same as before the innovation. In this case, the innovator does not attract new buyers, implying that the sales of the non-innovating competitor remain unchanged (as consumers who do not buy from the innovator have no reason to change their behavior). This shows that the volume of diverted sales depends on how firms choose to adjust prices. Moreover, when facing sales diversion, the non-innovating competitor will react by changing its prices. The resulting price competition will affect both the returns from innovation and the value of diverted sales.

In this context, the merged entity will adapt its whole strategy to internalize the sales externality. In particular, it will coordinate post-innovation prices accounting for the price externality (Greenstein and Ramey, 1998; Chen and Schwartz, 2013) and may also reposition its products and research lines. In other words, the merged firm will shape its strategy in order to raise appropriability and reduce cannibalization between the two merging firms. The implications of this for the merged firm's investment in R&D is in general complex.

In the Appendix, we present a simple extension of the model developed by Federico, Langus

[13] Another illustration is the pharmaceutical industry where an innovation may be "drastic" (creating a new therapeutic class) or differentiated within an existing therapeutic class (see e.g., Bardey, Bommier and Jullien, 2010, and González, Macho-Stadler and Pérez-Castrillo, 2016).

and Valletti (2017a) where innovators' products are differentiated, and show that in this context, a merger may raise the level of investment in R&D (see Conclusion 3) and may benefit consumers. We maintain the assumption that non-integrated firms obtain positive duopoly profits if they both innovate. However, a difference with Federico, Langus and Valletti (2017a) is that we do not assume that the merged entity's profit is the same with one innovation and with two innovations. Instead, when both research labs innovate, the merged entity obtains two differentiated products and brings both products to the market, adjusting prices to mitigate cannibalization between them. Therefore, it obtains a higher profit with two innovations than with a single innovation. We show that in this context, a merger fosters innovation if the incremental profit that a second innovation generates for the merged entity is larger than the duopoly profit that each non-integrated innovator obtains when both firms innovate. We present a simple and standard setup (the Hotelling model with quadratic transportation costs) where the merged entity eliminates cannibalization by raising prices. As a result, the merger entity invests more in R&D than independent firms.

In a second paper, Federico, Langus and Valletti (2017b) consider a richer model in order to allow explicitly for the interaction between the internalization of the sales externality and price competition. They consider a symmetric oligopoly where firms invest in improving the quality of their products and assume that an innovation replaces the old product with a new, better product. Thus, innovation in their model is purely vertical. They then study the effect of a merger between two firms on the incentives to innovate, assuming away any spillovers or efficiencies. For this purpose, they decompose the impact of a merger into two terms: one term summing up the consequences of unilateral effects in prices on innovation, and another one measuring the innovation diversion effect. The authors do not solve analytically the model but, instead, discuss the effects at work and perform numerical simulations. They obtain two results:

- Their simulations find that there are conflicting effects in the models they consider: the effect of the merger on the pre- and post-innovation price equilibrium raises the incentives to innovate, while the innovation diversion effect reduces these incentives.
- In the simulations they perform, the latter effect dominates so that overall impact of a merger on the merging firms' innovation efforts is negative, and so is the effect of the merger on consumers.

It is difficult to draw lessons from this paper as the simulation exercise remains limited in terms of demand formulation and parameters. Given the existence of conflicting effects, whether other model specifications may reverse the second conclusion is an open question. The authors emphasize the fact that the parametric models they use are standard models. However, one should keep in mind that "standard" models have special features that make them tractable at the cost of structural restrictions that may shape the relative weight of conflicting effects. This is illustrated by the model provided in the Appendix and discussed above. Moreover, the most common and simpler model specifications tend to capture only some types of innovation. For instance, a common modeling approach in the literature is to require all consumers to attach the same value to an increase in product quality. Another standard model assumes that consumers care only about the product of the quantity they buy and the quality of the good. Consequently, a conclusion grounded on these models may not apply in alternative settings.

For new products, the impact of a merger on innovation is small if the sales externality is large and merged firms maintain all research projects. A key, yet under-discussed, result in Federico, Langus and Valletti (2017a) is that when the sales externality is maximal (i.e., when competition erodes all profits if two labs succeed in developing a new product), a merger has *no impact* on innovation.[14] We illustrate this result in the Appendix where we show in a simple two-firm setting that the merged entity has the same incentives to innovate as two independent firms when the sales externality is maximal (see Conclusion 2). The reason is that the value of a second innovation is zero in both cases. In the absence of a merger, a second innovator obtains no profit because product market competition dissipates both innovators' profits. In case a merger occurs, the second innovation does not bring any additional value to the merged entity since the first innovation exhausts monopoly profit. When the merged entity chooses to invest in both projects, it cares only about the success of *one* of the projects. Moreover, the gain in case of a single success is the same for the merged entity and an independent firm; it is equal to the monopoly profit. Because of this, it turns out that the merged entity invests the same amount than two independent firms.[15]

This is not to say that there is no effect in general as full diversion (which occurs under price competition if all labs develop the same homogeneous product) is an extreme case. Moreover, the conclusion that the merger has no impact on innovation when the sales externality is maximal holds only in a setting where an innovator comes up with a new product that does not affect the sales of its own old products if any.[16] That said, this conclusion implies that, when it comes to the invention of new products, the impact of a merger on innovation may be small when the sales externality is large.[17] This is the case for instance for winner-takes-all competition (Sah and Stiglitz, 1987), which sometimes occurs for goods with network effects. Further, it is obvious that when the sales externality is small, the associated effect is also

[14] The same point has been made in a more general setting by Sah and Stiglitz (1987).

[15] As a consequence, the merger does not affect the non-merging firms' investment in R&D either.

[16] Otherwise, the standard Arrow effect combined with the market power effect of a merger would imply that a merger reduces innovation.

[17] In Federico, Langus and Valletti (2017a), the negative effect of a merger on consumer surplus is mostly due to the standard price coordination induced by the merger rather than to innovation effects.

small. Therefore, it is only for intermediate levels of sales externality that the innovation diversion effect plays a significant role.

3.2.2 Demand expansion effect and margin expansion effect

There has been a debate over recent years about the potential effect of mergers on the adoption of new technologies by telecommunication operators. Contrasting views have been expressed. One view is that a merger, by reducing rivalry, would reduce incentives to gain a competitive advantage through the deployment of fiber landscape networks, or 4G antennas in the case of mobile telephony. The other view is that, due to higher margins and efficiency gains, a merger would enhance investment in the deployment of the most advanced technology.

Bourreau and Jullien (2017) contribute to this debate by considering the effect of a merger on the incentives of firms to invest in "coverage" for a new technology, where coverage determines which part of the population can access the service offered by a firm. In their two-firm setup, different levels of coverage are chosen by the firms. The one with the larger coverage serves both a "contestable" demand served by the other firm as well as a "captive" demand for which it is a monopolist. Prices are the same for the contestable demand and the captive demand, and reflect the differences in coverage: the firm with the larger coverage chooses a higher price than its competitor (because some of its demand is captive). Bourreau and Jullien (2017) then compare the outcome under competition with the outcome when the two firms merge, and conclude that the merged entity will expand total coverage and reduce the contestable demand. The effect of market expansion can be so strong that under some parameter values it can outweigh the effect of the merger on prices, leading to a positive effect of the merger on total welfare and consumer surplus.

The intuition behind this result is as follows. If, in the duopoly situation, the contestable demand (determined by the coverage of the smaller firm) is a relatively large share of the total demand (determined by the larger coverage), then competition is intense and margins are constrained. The incentive to spend resources to expand coverage depends on the return to investment and, therefore, on the equilibrium margin. It follows that a larger contestable demand reduces the larger firm's incentive to expand the non-contestable demand (because it reduces margins) and, therefore, total coverage. When the two firms merge, the merged entity raises margins on the two services offered to consumers. This raises the return on investment in coverage expansion and, therefore, leads to a higher total coverage.

The paper by Bourreau and Jullien (2017) is admittedly specific to technology adoption, but it brings two key insights. First, it shows that for some types of innovation, a merger may indeed lead to an increase in the level of investment even in the absence of spillovers and efficiencies. Second, it highlights when and why this may occur.

Consider now an innovator replacing an old product with a new one. The new product is of better quality and thus generates more sales. As already discussed, an innovator introducing a new product needs to decide on how to balance its margin and sales so as to maximize profits. The key element in this trade-off is the own price-elasticity of demand:[18] if the post-innovation demand faced by the innovator is significantly less elastic than the pre-innovation demand, then the innovator will set the price of the new product above the price of the old product. However, if the post-innovation demand is as elastic as the pre-innovation demand, the innovator will prefer to maintain the price at its pre-innovation level, and sell higher quantities. When the firm competes in the market with sellers of substitutable products, this trade-off is also affected by the behavior of competitors, but a similar logic applies.

Let us now consider the case in which innovation does not affect significantly the innovator's margin (because innovation increases the level of demand but does not have a significant effect on the price-elasticity of demand). For the sake of argument, assume that innovation does not affect the innovator's margin at all. In this case, innovation is solely motivated by the willingness to expand demand and the profit from innovation can be written as

$$M_0 * (Q_1(X) - Q_0) - X,$$

where M_0 is the pre-innovation margin, Q_0 is the pre-innovation quantity and $Q_1(X)$ is the post-innovation quantity sold for an investment X in R&D. The key driver of innovation in this setting is the margin M_0, whose level is affected in particular by the intensity of competition. Suppose now that an innovative firm merges with the seller of a competing good (for conciseness, suppose this seller cannot innovate). As a consequence of less intense competition, the margins will increase on all products and, in particular, M_0 will increase. It follows that the innovator will have higher benefits from expanding demand and thus will invest more to do so. We call this the *demand expansion* effect.

While this effect is quite transparent in the above example, we argue below that it is actually present in all mergers involving product innovation. We summarize it as follows:

Higher post-merger margins raise incentives to invest in demand-enhancing innovation.

In contrast, let us now consider the case in which innovation affects mostly the margin, both in the merger scenario and in the absence of a merger. Innovation is then mostly motivated by the willingness to increase the margin rather than sales. Assume that the volume of sales is not affected by innovation. Then, we can write the innovation profit as

$$(M_1(X) - M_0) * Q_0 - X,$$

where $M_1(X)$ is the post-innovation margin. In this case, the key driver of innovation is

[18] The own-price-elasticity of demand measures the sensitivity of demand to the price of a firm's own product. In contrast, the cross-price-elasticity measures the sensitivity of demand to the price of a rival's product.

the pre-innovation volume of sales Q_0. This quantity depends on market structure. If the innovative firm merges with a competitor, standard merger analysis shows that, absent efficiency gains, the new entity is expected to produce less than in the no-merger scenario. As a consequence of the reduction in the volume of sales Q_0, the new entity will invest less in margin-enhancing innovation. We call this the *margin expansion* effect.

Again, this effect will be present to a variable extent in all merger situations involving product innovation. We summarize it as follows:

Lower post-merger output reduces incentives to invest in margin-enhancing innovation.

The demand expansion effect and the margin expansion effect are essential effects that need to be considered, along with the innovation diversion effect, when evaluating the likely impact of a merger on the incentives to innovate. In general, the innovative firm will increase both margins and quantity so that both effects will coexist. We then expect these two effects to be conflicting as the demand expansion effect is associated with a positive impact of a merger on innovation, while the margin expansion effect is associated with a negative impact on innovation. Which effect dominates depends on how innovation affects the level and elasticity of demand.

The scenario analyzed by Bourreau and Jullien (2017) is one where the demand expansion effect dominates. In contrast, Bourreau, Lefouili and Jullien (2018) show that the analysis by Motta and Tarantino (2017) of the effect of mergers on product innovation[19] and the analysis by Federico, Langus and Valletti (2017b) rely on classes of demand functions for which the main effect at work is the margin expansion effect. This explains why they get a negative impact of mergers on innovation.

More precisely, Bourreau, Lefouili and Jullien (2018) present a theoretical framework that allows to disentangle the various effects of a merger on innovation. They focus on a symmetric duopoly model where the innovation efforts exerted by a firm affects its demand in a predictable way. Their analysis shows that the impact of a merger on innovation can be decomposed into four terms corresponding to the three effects discussed above and an interaction term. More precisely,

- the margin expansion effect is proportional to the reduction in demand due to price coordination within the merged entity;
- the demand expansion effect is related to the price diversion ratio which measures what share of sales corresponds to sales diverted from the competitor when the price decreases, and is used in UPP analysis (Farrell and Shapiro, 2010);

[19] Motta and Tarantino (2017) focus on process innovation in their baseline model but they analyze the effect of a merger on quality-improving innovation in an extension.

- the innovation diversion effect is related to the innovation diversion ratio - discussed by Salinger (2016)[20]- which measures what share of sales corresponds to sales diverted from the competitor when investment in innovation increases;

- the fourth term is an interaction term that cannot be signed *a priori* and that relates to the change in the relative effect of innovation and price on the demand when the price increases.

The decomposition provided by Bourreau, Lefouili and Jullien (2018) allows us to identify the key effects at work and to discuss the likely impact of a merger on the merged entity's investment in R&D under various model specifications. In particular, the authors perform this exercise for the models used in the analysis of product innovation by Motta and Tarantino (2017) and by Federico, Langus and Valletti (2017b).[21] A first class of models considered by both papers is one in which all consumers attach the same value to a unit increase in quality, which implies that increasing quality has the same effect on demand as decreasing prices. Bourreau, Lefouili and Jullien (2018) show that for this particular class of models - sometimes referred to as models with *hedonic prices* - the demand expansion effect and the innovation diversion effect exactly cancel each other, while the interaction term is zero. The only remaining effect is the margin expansion effect which is always negative. Hence, a merger always impedes innovation in this type of models.

Motta and Tarantino (2017) also consider the class of models with *quality-adjusted demand*. These models assume that consumers care about the "total quality" of the good, defined as the product of the quantity bought and the quality of the good.[22] Further, Federico, Langus and Valletti (2017b) consider a class of models with CES demand. For these two classes of models, Bourreau, Lefouili and Jullien (2018) show that the sum of all the effects is always negative.

Thus, in the classes of models discussed above, the margin expansion effect, somewhat artificially, dominates the other effects. Bourreau, Lefouili and Jullien (2018) show formally that in the framework they consider, i.e., demand-enhancing innovation in an industry which is symmetric before the merger, most demand specifications considered by Federico, Langus and Valletti (2017b) and Motta and Tarantino (2017) can only lead to the conclusion that a merger will impede innovation.

To illustrate the fact that other demand specifications may reverse the conclusion that these two papers reach regarding the impact of mergers on product innovation, Bourreau,

[20] This paper is discussed in Section 3.2.3.

[21] Federico et al. (2017b) model an uncertain innovation technology and assume a sequential choice of innovations and prices. While our results do not apply directly to their setting, the properties of the demand functions that we demonstrate below should help explain their conclusions.

[22] In this case the demand for total quality depends on the price per unit of quality. Innovation increases the quality of the product, reducing the effective per unit price of quality for a given price of the product.

Lefouili and Jullien (2018) use the same decomposition in a model where innovation allows two firms to differentiate their products. The setting they consider is a standard extension of the Hotelling model. In that setting, innovation raises a firm's demand and relaxes price competition because it increases product differentiation. Therefore, both the innovation diversion effect and the demand expansion effect are positive. The sum of these two effects dominates the margin expansion effect, which implies that a merger raises the level of investment in R&D.[23]

3.2.3 Technological spillovers

Technological spillovers refer to the "phenomenon that technological improvement by one company may help other companies improve their technology as well" (Salinger, 2016). Spillovers are pervasive in the context of R&D (see e.g., Bloom et al., 2013) and are highly relevant for the analysis of incentives in merger assessment.

In this section, we first present spillovers that may exist *regardless* of whether the merger occurs or not (d'Aspremont et Jacquemin, 1986; Lopez and Vives, 2016), and analyze the way they affect the impact of a merger on innovation. We then explain why a merger can increase spillovers between the merging firms. Finally, we discuss how spillovers can be taken into account in merger control.

A first example of technological spillovers, that has received much attention in the literature, is the fact that a firm's innovation may be imitated (to some extent) by its rivals due to weak (enforcement of) intellectual property rights. This type of spillovers is likely to be more prevalent for product innovations rather than process innovations as the latter can often be effectively protected by means of a trade secret, while the former typically cannot. Since the magnitude of this type of spillovers is strongly related to the strength of intellectual property rights, they can often be assessed without a thorough understanding of the merging partner's R&D processes.

However, there are other types of technological spillovers. In particular, spillovers may happen when researchers present their work in conferences and publications. They may also result from the mobility of researchers across companies. Finally, spillovers need not be contemporaneous; they can be inter-temporal. An example is that of sequential innovations by rivals who build upon the knowledge diffused in patents to develop new products or processes that do not infringe the first innovator's patent rights.[24] Note that such spillovers may exist even in the presence of relatively strong intellectual property rights.

A common feature of the spillovers discussed above is that they are positive innovation

[23] The interaction term is zero in this model.

[24] Relatedly, Whinston (2012) recalls that "in a quality ladder model there is an important positive externality across generations (each innovation enables later ones)". Furthermore, Denicolò and Polo (2018b) consider the effect of mergers on the sharing of fundamental knowledge.

externalities and, therefore, their internalization by the merged entity has a positive effect on its incentives to invest in R&D. This effect should be combined with other potential positive effects and weighted against other potential negative effects of a merger on firms' incentives to innovate in the assessment of individual merger cases (Katz and Shelanski, 2007). D'Aspremont and Jacquemin (1988) have been the first to investigate theoretically the effect of cooperation between rivals at the R&D stage and/or the product market stage on the level of R&D investment in the presence of technological spillovers. They consider a two-stage game in which two firms decide first to invest in a cost-reducing technology and then set the level of their output in the product market. In their setting, a merger has two opposite effects on firms' incentives to innovate: a positive effect stemming from the internalization of spillovers by the merging firms, and a negative effect resulting from the merged entity's incentives to reduce its output which lowers the marginal benefit from cost-reducing innovation.[25] They find that the overall effect of a merger on innovation is negative if spillovers are low, but is positive if they are high.[26]

A merger between two innovative firms not only leads to the internalization of existing spillovers by the merged entity but is also likely to increase the level of spillovers between the merging firms. This follows from the very nature of the knowledge used during, or produced by, the R&D process: it can be either transferred at no or little cost, or protected through intellectual property rights or secrecy. In economic terms, this type of knowledge is a *public good with exclusion*. By removing a motive for exclusion, a merger increases each merging firm's use of the knowledge produced by the other merging firm (Davidson and Ferret, 2007; Denicolò and Polo, 2018b).[27] For instance, in the case of process innovation, a merged entity may be able to use the same cost-reducing technology developed by one of the merging partners to reduce the cost of production of the other partner. The same gains arise for product innovation when the same component (e.g., software) may be embedded in several final products. This implies that a merger creates economies of scale and scope in R&D as the same innovation can be exploited across multiple business units of the merged entity.

Finally, let us discuss the way spillovers can be taken into account by competition authorities in merger control. Since spillovers affect firms' *incentives* to innovate, they should be treated as part of the main competitive assessment conducted by competition authorities. Salinger (2016)'s analysis of the change in incentives following a merger in the presence of spillovers shows that the logic of the upward pricing pressure (UPP) methodology can be adapted to competition in innovation, and derives a simple formula for the "net innovation pressure" (NIP) that accounts for spillovers. In his setting, consumers only care about some

[25] This effect is discussed further in Section 3.3.

[26] Lopez and Vives (2016) extend d'Aspremont and Jacquemin's analysis to the case of minority shareholdings and consider more general demand functions.

[27] Relatedly, a merger also removes the concern that innovation by one of the merging firms may infringe intellectual property rights held by the other merging firm.

product characteristics that can be improved with R&D. In other words there is competition in innovation but not in prices.[28] In such a framework, a merger has only two effects on the merging firms' incentives to invest: the innovation diversion effect (see Section 3.2.1) and the spillover effect described above. When the diversion effect is negative, the NIP methodology shows that the overall effect of the merger on innovation is determined by the comparison of the diversion ratio and the spillover ratio: the merger fosters innovation if the spillover ratio exceeds the diversion ratio and reduces it otherwise. Relatedly, Bourreau, Jullien and Lefouili (2018) show that spillover effects can be accounted for in their methodology by replacing the innovation diversion ratio with a "spillover-adjusted innovation diversion ratio" whose sign is given by the difference between the spillover ratio and the diversion ratio.

3.3 Process innovation

Motta and Tarantino (2017) provide a thorough theoretical analysis of the impact of horizontal mergers on firms' incentives to invest in process innovation. More precisely, they analyze a model in which firms producing differentiated products choose the level of their investment in cost-reducing innovation (in addition to setting prices).[29] They first investigate the effect of a merger to monopoly on firms' incentives to invest in R&D. This is akin to examining the effect of a merger on the merging firms' incentives to innovate holding fixed the non-merging firms' behavior. They find that, absent involuntary spillovers and merger-induced efficiency gains, such a merger leads to a decrease in the merged entity's investment. The key intuition behind this finding is related to the standard market power effect of mergers. The merged entity internalizes pricing externalities, which leads to higher prices relative to the benchmark scenario in which firms set their prices independently. This implies that the quantity produced by the merging partners is lower than in the benchmark case. Since the benefit from lowering the unit cost of production is greater the larger the quantity produced, the merging firms benefit less from this as compared to the case where they would act independently. This implies that the merger has a negative impact on their incentives to invest in cost-reducing technologies.

Motta and Tarantino also consider the scenario in which only two firms (the "insiders") merge in an industry comprised of at least three firms. They conduct an equilibrium analysis that takes account of the non-merging firms' (the "outsiders") response to the merger, both in terms of prices and cost-reducing investments. The outsiders' incentives to engage in cost-reducing R&D are also driven by the effects of the merger on the quantities they produce, which is related to their prices and those of their rivals. Because the merger reduces the competitive pressure on the outsiders, it leads to an increase of their prices, albeit at a

[28] Such setting may be relevant for instance for ad-supported websites offering free services to users.

[29] See also Matsushima, Sato and Yamamoto (2013) who investigate the effect of horizontal mergers when firms can undertake process innovation in a model of quantity competition with linear demand.

lower extent than for insiders. Since outsiders offer better relative prices after the merger, their demand may increase, which would affect positively their incentives to invest in cost-reducing innovation. While this shows that a merger may have opposite effects on insiders' and outsiders' incentives to innovate, Motta and Tarantino find that there are cases, in which the impact on total investments in R&D decreases. Perhaps more importantly, they argue that, absent spillovers and efficiency gains, a merger in an industry in which firms compete both in prices and cost-reducing investments will typically lead to lower consumer surplus.

Motta and Tarantino focus in their baseline setting on the scenario in which investment decisions are unobservable by rivals. They then extend their analysis to the case where these decisions are observable by rivals before they set prices. This alters the analysis because firms now know that their cost-reducing investments will make them appear more aggressive (because a lower cost gives them incentives to decrease their prices), which may make the rivals also more aggressive. Because of this "strategic" effect, all firms may end up spending less on R&D as compared to the case of unobservable investments. More importantly, this new effect makes the predictions of their model regarding the impact of the merger on both investments and prices generally ambiguous. To cope with this, Motta and Tarantino use two specific models to suggest that their results extend qualitatively to the case where investments are observable.

Finally, the authors find that a merger may have a positive overall impact on investments and consumer surplus if involuntary spillovers are strong enough. While this finding is in line with our previous discussion on the importance of taking spillovers into account in merger control, Motta and Tarantino ignore this effect (or considers it to be second order with respect to the margin expansion effect) in their conclusion, where they state that they "have showed that, absent cost savings from the merger, both in the general model and in all the (standard) parametric models analyzed, the merging firms will always reduce their investments."[30]

Motta and Tarantino's analysis of the effect of mergers on process innovation when investments are unobservable to rivals differs fundamuntally from the analysis of product innovation for two reasons. First, unlike the diversion effect, the margin expansion effect driving their results has a clear-cut, negative sign. Second, there is no countervailing demand expansion effect in the case of process innovation. Their analysis of the case in which investments are observable shows that the effect of mergers is generally ambiguous, and only establishes that their main result still holds in this scenario in two specific models. This, combined with the fact that technological spillovers seem to be relegated by the authors to a second-order status makes us disagree with their claim that "absent efficiency gains, the well-known detrimental

[30] In their extension on spillovers, Motta and Tarantino note that "there is a close parallel between the model with involuntary spillovers and the model with economies of scale in the investment function: in both cases, the merger will allow to internalize an externality." They seem to conclude from this that spillovers should be treated the same was as efficiencies affecting the merging firms' *ability* to innovate, even though spillovers only affect their *incentives* to innovate.

effects of the merger are confirmed in an environment where firms set not only prices but also investments."[31]

4 R&D complementarities

Perhaps more than in any other activity, talent is both a key factor for R&D and a scarce resource. A merger fosters the interactions between researchers with different experiences. By pooling talents from two research entities, it may induce creative emulation and foster new innovative ideas. Moreover, by reallocating talents towards the most promising research projects, a merged entity may raise its research productivity.

The existence of complementarities between merging firms' R&D assets has been emphasized in particular by Davidson and Ferret (2007) and Motta and Tarantino (2017). Commenting on the clearance by the Federal Trade Commission of the merger between BP Amoco and Atlantic Richfield, Davidson and Ferret argue that "horizontal mergers are often driven by the opportunities they create (via knowledge transfers between plants) for the exploitation of R&D complementarities". Davidson and Ferret refers to the effect of R&D complementarities as the *R&D pooling effect.*

Pooling of R&D assets *de facto* reduces production costs or raises the quality of the products offered to consumers. It occurs, for instance, when a process innovation by one merging partner reduces the production cost of the other partner. Moreover, it fosters the merged entity's returns to R&D spending and, therefore, the merged firm's investment in R&D. Just as production complementarities raise the merged firm's incentives to expand output, complementarities in R&D raise the merged firm's incentives to expand R&D. In Davidson and Ferret's analysis of mergers with cost-reducing R&D, the final outcome of the merger results from the interaction of the R&D pooling effect and the standard market power effect of mergers. Analyzing merger profitability, they conclude that "for technically close brands, bilateral mergers in multidimensional competition benefit the insiders but harm outsiders independently of the strategic variable".[32] The condition in this statement that brands should be technically close is needed to ensure that R&D complementarities in process innovation will be large. Motta and Tarantino (2017) also examine the effect of R&D complementarities in the case of process innovation, by assuming that a merger generates positive cost externalities in the R&D process. They confirm that when there are sufficient R&D complementarities, a merger would result in lower costs, lower prices and higher consumer surplus.

We must also emphasize that efficiency gains in *production* matter for the impact of

[31] Note that in Motta and Tarantino's setting, even in the absence of efficiency gains in R&D, the impact of a merger on innovation can be positive if there are significant efficiency gains in *production*. This will be discussed further in Section 4.

[32] The notion of strategic variable refers to the distinction between competition in prices and competition in quantities.

mergers on *innovation*. This is particularly clear in the case of process innovation. Consider the margin expansion effect identified by Motta and Tarantino (2017). If there are significant efficiency gains in production then the merger will tend to decrease prices. Therefore, the merging firms's total output may be higher than their pre-merger total output. In this case, the same margin expansion effect highlighted by Motta and Tarantino will lead to an *increase* in the merged entity's investment in process innovation. One implication is that efficiency gains that would be sufficient to offset the negative effect of the merger on prices would also remove any concern regarding a potential negative effect of the merger on process innovation.

A shown by Bourreau, Jullien and Lefouili (2018), efficiency gains in the production stage also matter for the impact of mergers on product innovation. The demand expansion effect relies on the fact that the marginal benefit from engaging in demand-enhancing innovation is greater the larger the firm's price-cost margin. An increase in the margin can be generated by an increase of prices but it can also result from a decrease in (marginal) production costs due to efficiency gains in production. In the presence of such gains, we expect the price-cost margin to be greater than in their absence,[33] which would magnify the demand expansion effect. Moreover, the same argument as above shows that the margin expansion effect may become positive. This would mitigate concerns about the impact of a merger on R&D investment.

5 Conclusions and policy implications

We argue that the academic literature on mergers and innovation does not support a presumption of a negative impact of mergers on innovation. This conclusion follows from the existence of potential positive effects of mergers on innovation, even in the absence of spillovers and R&D complementarities. Leaving aside spillovers in the first part of our analysis, we identified three main effects of mergers on the incentives to innovate: the innovation diversion effect, the demand expansion effect and the margin expansion effect. While the last one provides the merged entity with lower incentives to innovate, the second one provides it with higher incentives to innovate, and the sign of the first one depends on the nature of innovation. We show that the combination of these effects can result in either a positive or negative impact of a merger on innovation.

Our analysis strongly suggests that competition authorities should take a neutral perspective when assessing the impact of a merger on innovation, and should balance the various effects at work. Competition authorities should take account of both theories of harm *and* benefits. All the effects of a merger on the *incentives* to innovate identified in this paper, including spillover effects, should be part of the *main* competitive assessment carried out by competition authorities. Insofar as the demand expansion and margin expansion effects are

[33] This is because a decrease in cost is usually passed on only partially to consumers (i.e., the so-called pass-through rate is less than 100%).

part of the appropriability dimension of a merger, appropriability must be a key element in merger analysis, at par with other dimensions. In particular, there should not be a hierarchical bias towards the diversion/cannibalization aspect when analyzing the effects of mergers on innovation. Such bias could result from the main message of Federico, Langus and Valletti (2017a) that "the internalization of the innovation externality remains the dominant driver of the impact of the merger on innovation incentives". Introducing an unjustified leaning towards the diversion effect in merger policy would be detrimental to innovation both in the short run (by blocking innovation-friendly mergers) and in the long run (by reducing the profitability of innovative activities). Relatedly, note that the potential positive effects of a merger on innovation are not of a fundamentally different nature from its potential negative effects: on the one hand, both the innovation diversion effect and the spillover effect capture externalities exerted by an innovative firm on its rivals and, on the other hand, the demand expansion effect and the margin expansion effect are the two sides of the same coin.

Finally, we view the analysis of technological spillovers as an important part of the discussion about innovation externalities in merger analysis, at par with the diversion effect. Indeed, both spillovers and sales diversion affect incentives for similar reasons, although possibly in different directions. We also want to emphasize that spillovers should not be related exclusively to imitation and, therefore, to the strength of intellectual property rights. As we argued, there are direct spillovers in R&D activities as well as inter-temporal spillovers that enhance other firms' ability to innovate in the future.

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Appendix

In this Appendix, we adapt the analysis of Federico, Langus and Valletti (2017a) to a setup in which innovators' products are potentially differentiated. We show that their main result, i.e., that a merger reduces the merging firms' incentives to innovate, hinges on the following assumption: the merged entity's incremental gain from a second innovation is smaller than the profit of an innovator when both firms innovate in the no-merger scenario. When this assumption does not hold, as is the case in the standard Hotelling model with quadratic transportation costs, a merger can lead to more innovation by the merging firms and can benefit consumers.

For the sake of simplicity, let us consider a situation involving two firms only, denoted firm 1 and firm 2. This implies that the merger will be a merger to monopoly. 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 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.

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., $\Pi_2>\Pi_1$.

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 (2017a) 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.[34] 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 for the duopoly leads to the following result:

Conclusion 1 *The merged entity invests less in innovation than the duopoly 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 smaller than the profit of an innovator when both firms innovate in the no-merger scenario.*

A second immediate implication of the analysis is that when $\Pi_2-\Pi_1=\pi_2=0$, the optimality conditions and, therefore, the levels of innovation in the two scenarios coincide. The case $\Pi_2-\Pi_1=\pi_2=0$ corresponds to the case where the sales externality is so large that the value of a second innovation is nil (e.g., Bertrand competition with homogenous products). By continuity, we get the following result:

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

Conclusion 2 *The investment in innovation of the merged entity is equal (resp. close) to the level of investment of duopoly firms if* $\Pi_2 - \Pi_1$ *and* π_2 *are equal (resp. close) to zero, i.e. if the sales externality is maximal (resp., very large).*

An implicit assumption in the analysis of Federico, Langus and Valletti (2017a) is that $\Pi_2 - \Pi_1 = 0 < \pi_2$.[35] This property holds for instance under Cournot competition if the two innovative products are identical. However, when there is some product differentiation between the two innovations, 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 a standard Hotelling model.

Illustration of an innovation-friendly merger 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 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 $U \geq 3t$.[36] 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 $p \leq U - t/4$ (as long as the consumer located at an equal distance from both firms is willing to buy), and it is $2\sqrt{(U-p)/t}$ for larger p. Under our assumptions, 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

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

[35] Feredico, Langus and Valletti (2017b) relax this assumption.

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

Conclusion 3 *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

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

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

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

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

$$2\hat{\lambda}\left(1 - \hat{\lambda}\right) CS_{M1} + \left(\hat{\lambda}\right)^2 CS_D = \max_{\lambda \leq 0.5} 2\lambda(1-\lambda) CS_{M1} + \lambda^2 CS_D = \frac{CS_{M1}}{2} + \frac{CS_D}{4}.$$

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

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

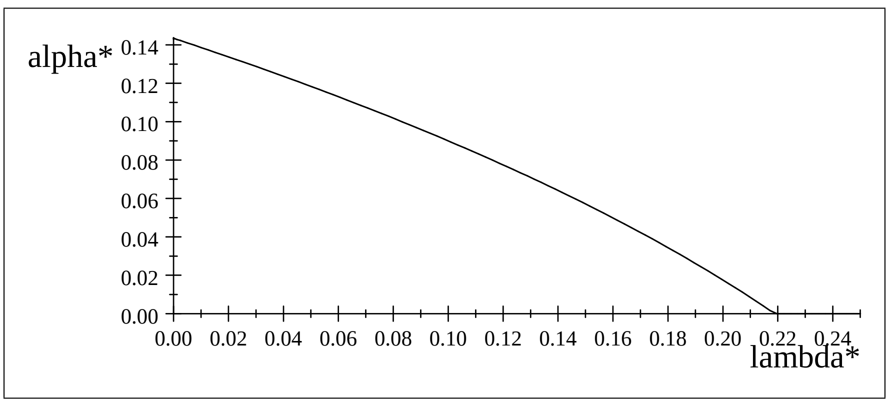
Assume now that $C(\lambda) = \frac{\beta}{1+\alpha}\lambda^{1+\alpha}$ where $\alpha > 0$ and β is chosen so that the monopoly maximization program has a symmetric solution (this implies that λ^* is small). Then, a merger to monopoly benefits consumers if

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

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 large. The graph shows that this is the case for $\lambda^* < 0.22$ and α small. *Therefore, when the likelihood of innovation* λ^* *is small and the innovation technology does not involve strong decreasing returns to scale, a merger raises consumer surplus despite the induced increase in prices.*