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Merger and product innovation under cross ownership and cooperative R&D

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ABSTRACT

We show that merger may increase investments in product innovation, and expected welfare if there is either passive cross ownership or cooperative research. Hence, the antitrust authorities may not need to be too concerned about mergers in these situations.

1. Introduction

Merger decisions are often challenged due to their adverse effects on innovation. Federico et al. (2017) articulated the "innovation theory of harm" that played a major role in the European Commission's decision on the *Dow-DuPont* case. The Competition and Markets Authority in the UK blocked the proposed merger between Microsoft and Activision Blizzard due to its possible adverse effects on innovation (https://www.gov.uk/government/news/microsoft-activision-deal-prevented-to-protect-innovation-and-choice-in-cloud-gaming). The DOJ/FTC annual reports show concerns about the adverse innovation effects of mergers (Gilbert, 2007). However, several studies questioned the robustness of the "innovation theory of harm".

Denicolò and Polo (2018) show that mergers increase the R&D investments, expected consumer surplus and expected welfare if the probability of failure in innovation is log-concave in R&D investments. Bourreau and Jullien (2018) show that mergers may increase R&D investments if demand expands due to increased market coverage. Denicolò and Polo (2021) show that mergers can be pro-competitive under convex production costs. Mukherjee (2022) shows that mergers may increase process innovation, expected consumer surplus and expected welfare.

We provide *two new reasons* for the innovation and welfare raising merger. Using the *product innovation* model of Federico et al. (2017), we show that mergers may increase R&D investments and expected welfare if there is either passive cross ownership among firms or firms cooperate to determine the joint profit maximising R&D investments under non-cooperation.[1] In this respect, the type of product market competition plays important roles. Hence, the antitrust authorities may not need to be too concerned about mergers in industries with passive cross ownership or cooperative research.

Federico et al. (2017) mentioned that mergers affect innovation in two ways compared to non-cooperation. First, innovation by a firm creates a negative externality on the rival firm under non-cooperation. Merger tends to reduce the R&D investments compared to non-cooperation by internalising the externality. Second, merger tends to increase the R&D investments compared to non-cooperation by increasing the profits ex-post R&D. In their analysis, the first effect

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[1] Passive cross ownership refers to a situation where a firm holds non-controlling shares in rival firms, and can be found in many industries (Alley, 1997; Gilo et al., 2006; Brito et al., 2014). See Becker (2015) for the evidences and a review of the literature on cooperative R&D.

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dominates the second effect and merger reduces R&D investments.

Cross ownership and cooperative R&D reduce the above-mentioned negative externality by creating collusive behaviour among firms under non-cooperation. Hence, they reduce the R&D investments under non-cooperation, and merger may increase R&D investments and expected welfare under cross ownership and cooperative R&D.

Shelegia and Spiegel (2022) also compare merger and non-cooperation with cross ownership. However, we differ from them in some important ways. First, they consider *process innovation*, while we consider *product innovation*. Hence, unlike their paper, innovation does not cannibalise any pre-existing profit in our analysis. Second, they consider Bertrand competition with homogeneous products, whereas we show the implications of different types of competition. Third, the R&D investments in their analysis are higher under non-cooperation for small cross ownership, while the R&D investments in our analysis are lower under non-cooperation for any amount of cross ownership under Bertrand competition with homogeneous products. Fourth, they neither consider welfare implications nor compare merger and non-cooperation with cooperative R&D.

2. The basic model

Consider the duopoly version of Federico et al. (2017). To get sharper results, like Denicolò and Polo (2018), we consider a duopoly model with no knowledge spillover and no R&D synergy in merger, as Shapiro (2012) argues that a merger is most likely to diminish innovative activity when only two firms pursue a specific line of research to serve a particular need in the absence of appropriability or R&D synergy in the merger. Federico et al. (2017) also show that merger decreases the total R&D investments in the industry if the number of firms is low.

Consider two risk-neutral firms, firm 1 and firm 2, which invest to invent a new product. The R&D process is uncertain. If firm i invests τz_i^2 in R&D, it succeeds in R&D with probability z_i, $i = 1, 2$.

Consider two situations:

Non-cooperation: Each firm maximises its total expected profit by choosing its R&D investment and the product market strategy.

Merger: The firms merge and the merged firm chooses R&D investment and the product market strategy to maximise the expected profit of the merged firm.

Consider the following game. Conditional on non-cooperation or merger, the R&D investments are determined in stage 1. The product market strategies are determined in stage 2 and the profits are realised. We solve the game through backward induction.

Consider the following profits ex-post R&D under non-cooperation. If both firms succeed in R&D, each firm gets D. If only one firm succeeds in R&D, the successful firm gets M and the unsuccessful firm gets 0. If neither firm succeeds in R&D, both firms get 0. We consider $2D < M$.

Assume $M < 2\tau$, i.e., the decreasing returns to innovation are high compared with monopoly profit.

To avoid the demand expansion effect of Bourreau and Jullien (2018), assume that the profit of the merged firm under successful R&D in at least one research lab and the profit of the successful innovator under non-cooperation with a unilateral success in R&D are the same.

3. Cross ownership

3.1. Non-cooperation

Under non-cooperation, the ith firm holds $\alpha \in [0, 0.5]$ fraction of shares in the jth firm, $i,j = 1,2$, $i \neq j$. Hence, the expected profit of the ith firm at the R&D stage is

$$\Pi_i^{NCO} = z_i z_j D + z_i(1 - z_j)(1 - \alpha)M + (1 - z_i)z_j \alpha M - (1 - \alpha)\tau z_i^2 - \alpha \tau z_j^2 \quad (1)$$

where, D is a function of α. It is well-known that a higher α increases D (Reynolds and Snapp, 1986) or may not affect D (Shelegia and Spiegel, 2022, considering Bertrand competition with homogeneous products).

The symmetric equilibrium probability of success in R&D is:

$$z_1^{NCO*} = z_2^{NCO*} = z^{NCO*} = \frac{M(1 - \alpha)}{M - D + 2(1 - \alpha)\tau} > 0 \quad (2)$$

The second order condition for maximisation holds. We get $z^{NCO*} < 1$ for $M < 2\tau$.

3.2. Merger

Under merger, the ith lab determines x_i, $i,j = 1,2$, $i \neq j$, to maximise

$$\Pi^{ME} = z_i z_j M + z_i(1 - z_j)M + (1 - z_i)z_j M - \tau\left(z_i^2 + z_j^2\right) \quad (3)$$

The symmetric equilibrium probability of success in R&D for each lab is

$$z_1^{ME*} = z_2^{ME*} = z^{ME*} = \frac{M}{M + 2\tau} \in (0, 1) \quad (4)$$

The second order condition for maximisation holds for $M < 2\tau$. Hence, in equilibrium, it is optimal for the merged firm to use both research labs. This eliminates the reason for the innovation raising merger in Denicolò and Polo (2018).

3.3. Comparison of R&D investments

Proposition 1. The R&D investments are higher under merger compared to non-cooperation for $D < \alpha M$.

Proof: Since the probability of success is positively related to the R&D investment, compare the equilibrium probabilities of success in R&D. From (2) and (4), $z^{NCO*} - z^{ME*} = \frac{M(-M\alpha + D)}{(M+2\tau)(M-D+2(1-\alpha)\tau)} < (>)0$ for $D < (>)\alpha M$. ■

Federico et al. (2017) is a special case of Proposition 1 with $\alpha = 0$.

Now see the effects of the type of product market competition on the result in Proposition 1.

If there is Bertrand competition with homogeneous products, $D = 0$ under cross ownership (Shelegia and Spiegel, 2022). In this situation, Proposition 1 shows that merger increases the R&D investments compared to non-cooperation for positive cross ownership.

If there is Cournot competition with homogeneous products, merger may not increase the R&D investments. To see this, consider the inverse demand function $P = 1 - q$, where q is the total output. For simplicity, normalise the marginal cost of production for both firms to 0. In this situation, we get $D(\alpha) = \frac{1-\alpha}{(3-2\alpha)^2}$ and $M = \frac{1}{4}$. Hence, $D - \alpha M = \frac{(1-2\alpha)(4-5\alpha+2\alpha^2)}{(3-2\alpha)^2} > 0$, implying that the R&D investments are higher under non-cooperation compared to merger.

Hence, we get:

Corollary 1. The R&D investments are higher under merger compared to non-cooperation if there is Bertrand competition with homogeneous products, but that may not be the case under Cournot competition with homogeneous products.

3.4. Consumer surplus and welfare

For the implications on consumer surplus and welfare, assume that the demand function is $P = 1 - q$, and the marginal cost to production is 0 for both firms. Given Corollary 1, consider Bertrand competition with homogeneous products.

The equilibrium probability of success in R&D, the equilibrium expected consumer surplus and the equilibrium expected welfare under non-cooperation are respectively $z^{NCO*} = \frac{1-\alpha}{1+8(1-\alpha)\tau}$, $ECS^{NCO*} = \frac{(1-\alpha)(2-\alpha+8(1-\alpha)\tau)}{4(1+8(1-\alpha)\tau)^2}$, and $EW^{NCO*} = \frac{(1-\alpha)(2+\alpha+16(1-\alpha)\tau)}{4(1+8(1-\alpha)\tau)^2}$ under Bertrand

competition, and they are, respectively $z^{ME*} = \frac{1}{1+8\tau}$, $ECS^{ME*} = \frac{1+16\tau}{8(1+8\tau)^2}$, and $EW^{ME*} = \frac{3+32\tau}{8(1+8\tau)^2}$ under merger.

We get $ECS^{NCO*} - ECS^{ME*} = 3(1-2\alpha) + 2\alpha^2 + \frac{\tau(48+48\alpha^2-112\alpha)+\tau^2(192+320\alpha^2-512\alpha)}{8(1+8\tau)^2(1+8\tau-8\alpha\tau)^2} > 0$, and $EW^{NCO*} - EW^{ME*} = \frac{(1-2\alpha-2\alpha^2)+\tau(16-48\alpha)+\tau^2(64-256\alpha+192\alpha^2)}{8(1+8\tau)^2(1+8\tau-8\alpha\tau)^2} < (>)0$ for $\alpha \in (\alpha^*(\tau), 0.5]$ ($\alpha \in [0, \alpha^*(\tau))$), where $\alpha^*(\tau) = \frac{1+8\tau}{1+16\tau+\sqrt{(1+8\tau)(3+8\tau)}} \in [0, 0.5]$.

Proposition 2. If there is Bertrand competition with homogeneous products under non-cooperation, the expected welfare is higher under merger compared to non-cooperation if cross ownership is high, i.e., $\alpha \in (\alpha^*(\tau), 0.5]$.

4. Cooperative research

Consider cooperative research under non-cooperation and no cross ownership.

Under cooperative research, the ith firm maximises the following expression:

$$\Pi_i^{COR} = \left[z_i z_j D + z_i(1-z_j)M - \tau z_i^2\right] + \left[z_i z_j D + z_j(1-z_i)M - \tau z_j^2\right] \quad (5)$$

The symmetric equilibrium probability of success in R&D is

$$z_1^{COR*} = z_2^{COR*} = z^{COR*} = \frac{M}{2(M-D+\tau)} > 0 \quad (6)$$

The second order condition for maximisation holds. We get $z^{COR*} < 1$ for $M < 2\tau$.

We assumed under cooperative research that the firms choose R&D investments to maximise joint profits but do not share the R&D outcomes under unilateral success in R&D. As we show now, the firms are better off by not sharing the R&D outcomes than sharing the R&D outcomes under cooperative research if $2D < M$.

Maximizing (5), we get $z_1^{COR*} = z_2^{COR*} = z^{COR*} = \frac{M}{2(M-D+\tau)}$. The corresponding total equilibrium profits of firms 1 and 2 are $\pi^{COR*} = \frac{M^2}{2(M+\tau-D)}$.

If the firms choose R&D investments to maximise joint profits and also share the R&D outcomes under cooperative research, the ith firm maximizes $\Pi_i^{CORS} = 2D(z_i + z_j - z_i z_j) - (z_i^2 + z_j^2)\tau$, and the equilibrium probability of success is $z_1^{CORS*} = z_2^{CORS*} = z^{CORS*} = \frac{D}{D+\tau}$. The corresponding total equilibrium profits of firms 1 and 2 are $\pi^{CORS*} = \frac{2D^2}{D+\tau}$. We get $\pi^{COR*} - \pi^{CORS*} = \frac{(M-2D)(D(M-2D)+2D\tau+M\tau)}{2(M+\tau-D)(D+\tau)} > 0$ for $2D < M$.

The analysis under merger is similar to that of in Section 3.2.

Proposition 3. The R&D investments are higher under merger compared to non-cooperation with cooperative research.

Proof: From (4) and (6) $z^{COR*} - z^{ME*} = -\frac{M(M-2D)}{2(M-D+\tau)(M+2\tau)} < 0$. ■

4.1. Consumer surplus and welfare

Assume that the demand function is $P = 1 - q$, the marginal cost to production is 0 for both firms.

Under Bertrand competition, the equilibrium probability of success in R&D, the equilibrium expected consumer surplus and the equilibrium expected welfare under cooperative research are, respectively $z^{COR*} = \frac{1}{2(1+4\tau)}$, $ECS^{COR*} = \frac{3+8\tau}{16(1+4\tau)^2}$, and $EW^{COR*} = \frac{5+16\tau}{16(1+4\tau)^2}$.

We get $ECS^{COR*} - ECS^{ME*} = \frac{1+8\tau(1+4\tau)}{16(1+4\tau)^2(1+8\tau)^2} > 0$ and $EW^{COR*} - EW^{ME*} = -\frac{1+16\tau(1+2\tau)}{16(1+4\tau)^2(1+8\tau)^2} < 0$.

Under Cournot competition, the equilibrium probability of success in R&D, the equilibrium expected consumer surplus and the equilibrium expected welfare under cooperative research are, respectively $z^{COR*} = \frac{9}{10+72\tau}$, $ECS^{COR*} = \frac{81(1+8\tau)}{16(5+36\tau)^2}$, and $EW^{COR*} = \frac{9(19+144\tau)}{16(5+36\tau)^2}$.

We get $ECS^{COR*} - ECS^{ME*} = \frac{31+8\tau(53+180\tau)}{16(1+8\tau)^2(5+36\tau)^2} > 0$ and $EW^{COR*} - EW^{ME*} = \frac{21+16\tau(17+54\tau)}{16(1+8\tau)^2(5+36\tau)^2} > 0$.

Proposition 3. The expected welfare is higher (lower) under merger compared to non-cooperation with cooperative research when there is Bertrand (Cournot) competition with homogeneous products under non-cooperation.

5. Conclusion

We show that mergers may increase R&D investments and expected welfare in industries with passive cross ownership or cooperative R&D, thus, questioning the "innovation theory of harm". Hence, the antitrust authorities may not need to be too concerned about mergers in industries with passive cross ownership or cooperative R&D.

As a final remark, it can be found that cross ownership, merger and cooperative research are profitable in our analysis.

Data availability

No data was used for the research described in the article.

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