Forthcoming in *Indian Growth and Development Review*

Cross ownership and merger under technology adoption*

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Submission: October 2023

First version: December 2023

Second revision: February 2024

Accepted: 13 February 2024

Abstract: We consider the effects of a merger on technology adoption and welfare in the presence of passive cross ownership. Merger increases investments in process technology and may increase welfare. Our results are important for antitrust policies and suggest that the antitrust authorities may not need to be too concerned about mergers in industries with cross ownership.

Key Words: Cross ownership; Merger; Technology adoption

JEL Classifications: D43; G34; L00; O30

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* I would like to thank two anonymous referees of this journal for helpful comments and suggestions. The usual disclaimer applies.

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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. Recently, 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 to Congress show that between 1990 and 1994, the agencies allege adverse innovation effects in about 3% of the merger challenges, while from 1995 to 1999, the concern about the adverse innovation effects has risen to 18% of the merger challenges, and between 2000 to 2003, the concern has increased to 38% of the merger challenges (Gilbert, 2006).

The "innovation theory of harm" revived the interest in recent years to examine the effects of mergers on innovation and welfare. Several recent papers are showing that mergers may increase innovation and welfare, thus questioning the robustness of the "innovation theory of harm".

Using the stochastic product innovation model of Federico et al. (2017), Denicolò and Polo (2018) show that mergers increase R&D investments if the probability of failure in innovation is log-concave in R&D investments, which induces the merged firm to operate one research lab to avoid duplication of R&D efforts. Bourreau and Jullien (2018) show that merger may increase R&D investment 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) considers a stochastic process innovation model to show that even if the probability of failure in innovation is log-convex in R&D investments, merger may increase R&D investments, expected consumer surplus and expected welfare under process innovation. Mukherjee (2023) shows that merger may increase product innovation in the presence of cross ownership[1] or cooperative R&D.

There is another set of papers, which show that merger or collusive behaviour in the product market increases R&D investments in the presence of knowledge spillover. See, e.g., Davidson and Ferrett (2007), Kleer (2012), Mukherjee and Roy Chowdhury (2013), Federico et al. (2018), López and Vives (2019) and Motta and Tarantino (2021), for this strand of the literature.

The purpose of this paper is to examine the effects of a merger on the investment in process technology and welfare in the presence of cross ownership. To show the effects of cross ownerships, we abstract our analysis from the other factors, such as stochastic innovation, demand expansion, convex cost and knowledge spillover, that created positive effects of mergers on innovation, as mentioned above.

Shapiro (2012) argued 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 showed that merger decreases the total R&D investments in the industry if the number of firms is low. Hence, to get sharper results, like Denicolò and Polo (2018) and Mukherjee (2022, 2023), we consider a duopoly model with no knowledge spillover and no R&D synergy in merger.

[1] Cross ownership, which refers to a situation where a firm holds non-controlling shares in rival firms, has grown significantly in recent decades. For example, it can be found in the automobile (Alley, 1997),

We show that merger increases investment in new process technology and might also increase welfare in the presence of cross ownership. These results are in contrast to Federico et al. (2017), and suggest that the antitrust authorities may not need to be too concerned about mergers in industries with cross ownership.

It is worth contrasting our paper with Mukherjee (2022, 2023). Mukherjee (2022) considered stochastic process innovation and examined the effects of a merger on R&D investment and expected welfare. He did not consider cross ownership and showed that if the products are homogeneous (as considered in this paper), merger may increase or decrease the R&D investment and does not increase welfare. In contrast, merger in our analysis does not decrease the R&D investment and increases welfare under significant cross ownership. Hence, in the absence of cross ownership, a stochastic process innovation and a deterministic process innovation may create similar welfare implications but their effects on the R&D investments can be different. Further, unlike that paper, we show that if the products are homogeneous, merger may increase welfare in the presence of cross ownership.

Mukherjee (2023) considers *stochastic product innovation* and shows the effects of merger on the R&D investment and welfare in the presence of cross ownership and cooperative research under non-cooperation. He shows that if there is either cross ownership or cooperative research under non-cooperation, merger may increase R&D investment and welfare under Bertrand competition but not under Cournot competition. In contrast, we consider investment in new process technology and show that merger may increase investment and welfare under Cournot

IT (Gilo et al., 2006), telecommunications (Brito et al. 2014), and banking industries (Azar et al., 2022).

competition in the presence of cross ownership. Thus, this paper complements Mukherjee (2022, 2023).

Although Shelegia and Spiegel (2022) compare merger and non-cooperation with cross ownership, we differ from their paper in some important ways. They consider a stochastic R&D process, homogenous Bertrand duopoly and drastic R&D, to compare merger and non-cooperation with cross ownership. They show that merger reduces expected consumer surplus and may reduce R&D investment compared to non-cooperation with cross ownership. They do not look at the welfare implications. In contrast, we consider deterministic investment, Cournot duopoly and non-drastic innovation, and show that merger increases investment in new technology adoption, reduces consumer surplus and may increase welfare compared to non-cooperation with cross ownership.

The remainder of the paper is organised as follows. Section 2 describes the model and derives the results. Section 3 concludes.

2. The model and the results

Consider two firms, firm 1 and firm 2, which compete in the product market with homogeneous products. Assume that the firms face the same constant marginal cost of production, c. However, the ith firm can invest r_i^2 amount in R&D to reduce its marginal cost of production to $(c - r_i)$.

We assume that each firm holds α fraction of shares in the other firm. For our analysis we will consider $\alpha \in [0, 0.33)$ and $c \in (\frac{1}{4}, 1)$. This will help us to convey our point in the easiest way by ensuring the second order conditions for profit maximisation and positive marginal costs ex-post R&D. Although $\alpha \in (0.33, 0.5]$ is

consistent with cross ownership, the second order conditions for maximisation in our analysis do not hold for these values of α. Hence, we ignore $\alpha \in (0.33, 0.5]$ to avoid complications in our analysis, since they will not add much to our main purpose.

We consider a two-stage game. At stage 1, the R&D investments are determined and the outcomes of R&D are realised. At stage 2, the outputs are determined and the profits are realised. We solve the game through backward induction.

We consider two different market scenarios.

Non-cooperation: Where the ith firm maximises $\pi_i = (1-\alpha)[(P-c+r_i)q_i - r_i^2] + \alpha[(P-c+r_j)q_j - r_j^2]$ by choosing its R&D investment and output non-cooperatively.

Merger: Where the firms merge and the merged firm chooses the R&D investment and output to maximise $\pi_m = (P-c+r_m)q_m - r_m^2$. Like Denicolò and Polo (2021), we consider that the research is completely duplicative and therefore, under merger, only one research lab will operate.

We consider the inverse market demand function $P = 1 - q$ for our analysis, where P is price and q is the total output.

2.1. Non-cooperation

As the firms are symmetric in nature, without any loss of generality, we look at the problem of firm 1 only.

In stage 2, given the R&D investments, firm 1 determines q_1 to maximise effectively

$$(1-\alpha)(P-c+r_1)q_1 + \alpha(P-c+r_2)q_2 . \quad (1)$$

The equilibrium outputs can be found as

$$q_1^* = \frac{(1-\alpha)\left(1-c-r_2+2r_1(1-\alpha)-2\alpha+2c\alpha\right)}{3-4(2-\alpha)\alpha} \tag{2}$$

$$q_2^* = \frac{(1-\alpha)\left(1-c-r_1+2r_2+2c\alpha-2(1+r_2)\alpha\right)}{3-4(2-\alpha)\alpha}. \tag{3}$$

The second order conditions for maximising outputs are satisfied.

Given the equilibrium outputs in (2) and (3), firm 1 determines the R&D investment in stage 1 to maximise the following expression:

$$\pi_1 = (1-\alpha)[(P^* - c + r_1)q_1^* - r_1^2] + \alpha[(P^* - c + r_2)q_2^* - r_2^2]. \tag{4}$$

Solving the maximisation problems of the firms, we get the symmetric equilibrium in R&D investments. The symmetric equilibrium R&D investments are

$$r_1^* = r_2^* = r^* = \frac{(1-c)\left(4-\alpha(5-2\alpha)\right)}{(2-\alpha)(7-6\alpha)}. \tag{5}$$

The second order conditions for maximising R&D investments are satisfied for $\alpha < 0.33$. Further, we find $(c - r^*) > 0$ for $\alpha \in [0, 0.33]$ and $c \in (\frac{1}{4}, 1)$. As mentioned before, we will concentrate on $\alpha \in [0, 0.33]$ and $c \in (\frac{1}{4}, 1)$.

The total equilibrium profits of firms 1 and 2 are

$$\pi^* = \pi_1^* + \pi_2^* = \frac{2(1-c)^2\left(20-\alpha\left(44-\alpha\left(23+4(1-\alpha)\alpha\right)\right)\right)}{(2-\alpha)^2(7-6\alpha)^2}. \tag{6}$$

It can be found that $\frac{\partial \pi^*}{\partial \alpha} > 0$ for $\alpha \in [0, 0.33]$ and $c \in (\frac{1}{4}, 1)$. Hence, cross ownership is profitable for firms 1 and 2.

The equilibrium consumer surplus is

$$CS^* = \frac{8(1-c)^2\left(3-5\alpha+2\alpha^2\right)^2}{(2-\alpha)^2(7-6\alpha)^2}. \tag{7}$$

The equilibrium welfare under non-cooperation, which is the sum of the total net profits of firms 1 and 2 (π^*) and consumer surplus (CS^*), is

$$W^* = \frac{2(1-c)^2\left(56-\alpha\left(164-\alpha\left(171-4\alpha(19-3\alpha)\right)\right)\right)}{(2-\alpha)^2(7-6\alpha)^2}. \tag{8}$$

2.2. Merger

In stage 2, given the R&D investment, the merged firm, firm M, determines its output, q_m, to maximise effectively

$$(P-c+r_m)q_m, \tag{9}$$

where r_m is the R&D investment of the merged firm.

The equilibrium output can be found as

$$q_m^* = \frac{1}{2}(1-c+r_m). \tag{10}$$

The second order condition for maximising output is satisfied.

Given the equilibrium output in (10), firm M determines the R&D investment in stage 1 to maximise the following expression:

$$\pi_m = (P^*-c+r_m)q_m^* - {r_m}^2. \tag{11}$$

The equilibrium R&D investment can be found as

$$r_m^* = \frac{1-c}{3}. \tag{12}$$

The second order condition for maximising R&D investment is satisfied. Further, we find $(c-r_m^*)>0$ for $c\in(\frac{1}{4},1)$.

The equilibrium profit of firm M is

$$\pi_m^* = \frac{1}{3}(1-c)^2 . \tag{13}$$

The equilibrium consumer surplus is

$$CS_m^* = \frac{2}{9}(1-c)^2 . \tag{14}$$

The equilibrium welfare under merger, which is the sum of the net profit of the merged firm (π_m^*) and consumer surplus (CS^*), is

$$W_m^* = \frac{5}{9}(1-c)^2 . \tag{15}$$

2.3. Comparison of R&D investments and profits

Given the symmetric R&D investments, both firms use the same technologies under non-cooperation. Hence, comparison of the R&D investment of each firm under non-cooperation to that of the merged firm shows whether better technologies are used under non-cooperation or under merger.

Proposition 1: *The equilibrium R&D investment of the merged firm is higher than the equilibrium R&D investment of each firm under non-cooperation, implying that better technologies are used under merger compared to non-cooperation.*

Proof: We get $r^* - r_m^* = -\frac{2(1-c)(1-2\alpha)}{3(2-\alpha)(7-6\alpha)} < 0$. ■

Higher market concentration under merger compared to non-cooperation helps to increase the equilibrium R&D investment under merger.[2]

Although it is intuitive that better production technology and higher concentration in the product market help to create higher profits under merger compared to non-cooperation, we show merger profitability in the following result for the sake of completeness.

Proposition 2: *Merger increases the profits compared to non-cooperation.*

Proof: We get $\pi^* - \pi_m^* = -\dfrac{(1-c)^2\left(76-268\alpha+391\alpha^2-252\alpha^3+60\alpha^4\right)}{3(2-\alpha)^2(7-6\alpha)^2} < 0$. ■

2.4. The implications on consumer surplus and welfare

Proposition 3: *The equilibrium consumer surplus is lower under merger compared to non-cooperation.*

Proof: We get $CS^* - CS_m^* = \dfrac{2(1-c)^2(1-2\alpha)(4-3\alpha)\left(32-49\alpha+18\alpha^2\right)}{9(2-\alpha)^2(7-6\alpha)^2} > 0$. ■

Although the merged firm produces with a better technology compared to firms 1 and 2 under non-cooperation, higher market concentration under merger compared to non-cooperation creates lower consumer surplus under the former than the latter.

[2] Comparison between the total R&D investments shows that the total R&D investments are lower under merger compared to non-cooperation, since $r_m^* - 2r^* = -\dfrac{(1-c)(10-\alpha(11-6\alpha))}{3(2-\alpha)(7-6\alpha)} < 0$.

However, this comparison is not relevant for comparing the technologies used under non-cooperation and under merger, since the technology used under non-cooperation depends on the R&D investment of each firm and not on their total R&D investments.

Proposition 4: *The equilibrium welfare is higher under merger compared to non-cooperation if cross ownership is sufficiently high.*

Proof: We get $W^* - W_m^* = \frac{(1-c)^2\left(28+\alpha\left(-292+\alpha\left(433+12\alpha\left(-19+3\alpha\right)\right)\right)\right)}{9\left(2-\alpha\right)^2\left(7-6\alpha\right)^2} < (>)0$

for $\alpha \in (\alpha^*, 0.33)(\alpha \in (0, \alpha^*))$, where $\alpha^* = 0.114\,(approx.)$. ■

On the one hand, production with a better technology and higher market concentration under merger compared to non-cooperation tends to increase welfare under merger compared to non-cooperation by increasing the total profits under merger. On the other hand, higher market concentration under merger compared to non-cooperation tends to reduce welfare under merger by reducing consumer surplus. We get that if cross ownership is higher than 11.4%, it creates enough market concentration under non-cooperation so that merger does not create significant adverse effect on consumer surplus compared to non-cooperation. In this situation, the positive effect of merger on the profits dominates the negative effect of merger on consumer surplus to create higher welfare under merger.

3. Conclusion

Antitrust authorities often use the "innovation theory of harm" to challenge merger decisions in many countries, such as the USA, UK and Europe. For example, it 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.

However, several recent papers started to question the robustness of the innovation theory of harm.

We contribute to this literature by providing a new reason for the innovation and welfare raising merger. We show that merger increases the R&D investment and may increase welfare in the presence of cross ownership. Hence, it contradicts the innovation theory of harm, and suggests that the antitrust authorities may not need to be too concerned about mergers in industries with cross ownership. Thus, our paper complements the recently growing literature showing the innovation and welfare raising merger.

Previous papers showed that merger may increase innovation and welfare if the merged firm does not find it profitable to run all the research labs, the production costs are convex, firms invest in stochastic process innovation, firms invest in stochastic product innovation in industries with cross ownership or cooperative research under non-cooperation. In this paper, we show that merger may increase innovation and welfare if the firms invest in deterministic process innovation in industries with cross ownership. While cross ownership is not required for the innovation and welfare raising merger under a stochastic process innovation (Mukherjee, 2022), we show that cross ownership is required for the innovation and welfare raising merger when the process innovation is deterministic. Thus, our analysis provides new insights for competition policies.

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