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Losses from horizontal merger and collusion

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Abstract
We show that the implications of a merger on collusion sustainability change significantly from the extant literature if merger is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game. Merger either does not affect collusion sustainability or it may decrease or increase collusion sustainability, depending on the output allocation for the merged firm. Our paper has the following implication for antitrust policies. If merger is observed, the authority will expect an industry-wide collusion, since merger will occur in our analysis provided it increases collusion sustainability.

Keywords Collusion · Cournot–Nash · Merger

JEL Classification D21 · D43 · D45 · L13

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1 Introduction

Horizontal merger and collusion help firms to gain market power but create concerns for the antitrust authorities. Merger induced collusion creates further concern for merger control policies, which generated a literature analysing the effects of mergers on collusive behaviour.[1]

In an earlier paper, Oliner (1982) shows that whether a horizontal merger helps to sustain an industry-wide tacit collusion among the competing firms depends on the way outputs are allocated among firms. Considering a merger of m firms in an industry with n symmetric firms competing like Cournot oligopolists, Oliner (1982) considers two types of output allocations. In one allocation, called allocation C, each independent firm produces $\frac{1}{n}$ of the collusive output while the merged firm produces $\frac{m}{n}$ of the collusive output. In another allocation, called allocation I, the merged firm behaves like one of the $(n - m + 1)$ firms in the industry, and each of the $(n - m + 1)$ firms produces $\frac{1}{n-m+1}$ of the collusive output. It is shown that merger reduces collusion sustainability under allocation C, while it fosters collusion under allocation I. Hence, the incentive for collusion may encourage (discourage) merger under allocation $I(C)$. The section on Cournot competition in Davidson and Deneckere (1984) considers an allocation like allocation C in Oliner (1982) and shows that merger reduces collusion sustainability.

A common feature of Oliner (1982) and Davidson and Deneckere (1984) is that they assume that a merger forms irrespective of collusion sustainability. In other words, *they ignore the issue of merger profitability in the punishment subgame where firms play non-cooperative Cournot–Nash game*. Since it is immediate from Salant et al. (1983) that a merger among a subset of Cournot oligopolists is not profitable always, it is important to internalise the optimal behaviour of the merged entities in the punishment subgame where they will decide whether to continue as a merged firm or to demerge. They will prefer to demerge in the punishment subgame if merger is not profitable there.

We internalise merger profitability under Cournot–Nash game to see the effects of a merger on the industry-wide (i.e., including merged and non-merged firms) collusion sustainability.[2] More particularly, we show how merger (in comparison to no merger) affects collusion sustainability under allocation C and allocation I if a merger is not profitable in Cournot–Nash game, which happens in the punishment subgame.

We show that if a merger is not profitable under Cournot–Nash game, the presence of a merger does not affect the industry-wide collusion sustainability under allocation C, but it decreases (increases) the industry-wide collusion sustainability under allocation I if the number of merger participants is small (not small). Hence,

[1] The Horizontal Merger Guidelines of the Federal Trade Commission and the Department of Justice pay attention to this aspect.

[2] Although we consider it as the effects of a merger on collusion sustainability, our paper will be applicable to other types of horizontal alliance, such as horizontal joint venture, where multiple firms run a project jointly rather than running their individual projects separately.

if a merger is not profitable under Cournot–Nash game, the results of Oliner (1982) and Davidson and Deneckere (1984) mentioned above may not hold.

The reasons for our results are as follows. Under allocation *C*, if there is no merger under Cournot–Nash game, the output shares of the non-merged firms are the same under no merger and merger for collusion, deviation and Cournot–Nash game. Hence, the incentive for collusion is the same for the non-merged firms under merger and no merger, implying that merger does not affect collusion sustainability compared to no merger.

Under the output allocation *I*, we have two effects. One effect is like Oliner (1982) where, as the number of merger participants increases, it reduces the number of effective firms in the market, which tends to increase collusion sustainability under merger compared to no merger. Since we are considering that merger is not profitable under Cournot–Nash game, there is another effect in our analysis. Under Cournot–Nash game, all firms behave non-cooperatively. However, when considering collusion sustainability under merger, the merger participants consider their total profits, whereas each firm considers its own profit only when considering collusion sustainability under no merger. Hence, the respective profits under Cournot–Nash game are higher when considering collusion sustainability under merger than when considering collusion sustainability under no merger, which tends to reduce collusion sustainability under merger compared to no merger. If a few firms (not few firms) merge, the first effect is weak (strong) and the second (first) effect plays the dominant role to decrease (increase) collusion sustainability under merger compared to no merger.

In our analysis, the possibility of a merger does not affect collusion sustainability under allocation *C* and decreases (increases) collusion sustainability under allocation *I* when the number of merger participants is small (not small). Thus, our results suggest that even if a merger is not profitable under Cournot–Nash game, it occurs under allocation *I* when it increases collusion sustainability. Hence, even if a merger is not profitable under Cournot–Nash game, there is an incentive for proposing a merger to achieve collusion with allocation *I*, which creates important implications for antitrust policies.

Collusive practices create important challenges for the authorities and leniency programs are designed to prohibit those practices. As mentioned by Aubert et al. (2006), "Leniency programs reduce the fines for cartel members that bring evidence to the antitrust authority, and their impact can be seen in the recent increase in successfully prosecuted cartels." However, our results suggest that leniency programs may not be required to detect collusive practices if a merger is observed when it is not profitable under Cournot–Nash game, since the incentive for merger in this situation may come from sustaining collusion with allocation *I*. Hence, if a merger is observed when it is not profitable under Cournot–Nash game, the authority may expect an industry-wide collusion with allocation *I*, since merger increases industry-wide collusion sustainability in this situation.

Since our paper is based on Oliner (1982) and the section on Cournot competition in Davidson and Deneckere (1984), it is worth comparing our structure with those papers. Like both Oliner (1982) and Davidson and Deneckere (1984), we consider an industry with *n* symmetric Cournot firms competing with homogeneous goods, facing a linear market demand function,[3] and m of these firms can merge. Like Oliner (1982), we consider two possible output allocations—C and I—as mentioned above, while Davidson and Deneckere (1984) considered only the C type output allocation. Oliner (1982) considers a fixed cost of production. However, like Davidson and Deneckere (1984), we normalised the fixed cost to zero, since the results of Oliner (1982) didn't depend on the fixed cost. The main difference between our paper and those papers, which is responsible for the difference in our result from those papers, is in the market structure when collusion is not sustained. Under merger, those papers assume that whether or not the collusion is sustained, merger will continue. In contrast, we assume that if the collusion is not sustained, merger will not continue if it is not profitable in Cournot–Nash game.

Although the literature didn't pay much attention earlier to uncover the relationship between merger and collusion following Oliner (1982) and Davidson and Deneckere (1984), a literature is growing in recent decades. Under Bertrand competition, Davis (2006) uses simulation to show that mergers help collusion unless they create highly asymmetric market structure. Considering Bertrand competition, Kovacic et al. (2009) and Ivaldi and Lagos (2017) also show that mergers increase the incentive for collusion. Considering Bertrand competition and an indivisible cost associated with cartel, Ganslandt et al. (2012) show that the incentive for collusion may be highest if a merger creates moderately asymmetric market structure. Considering Cournot competition and allowing mergers in every period, thus considering merger waves, Garcia et al. (2018) show that mergers foster collusion.

There are some papers examining this issue for capacity constrained firms. Using Bertrand and Cournot competition respectively, Compte et al. (2002) and Vasconcelos (2005) show how mergers affect the incentive for collusion in the presence of asymmetric capacity constraints. They find that a merger encourages (discourages) collusion if it decreases (increases) inequality in asset holdings post-merger. Considering Bertrand competition, capacity constrained firms and endogenous cartel formation, Bos and Harrington (2010) show that the incentive for collusion may be highest if a merger creates moderately asymmetric market structure.[4]

Like Oliner (1982) and Davidson and Deneckere (1984), other papers mentioned above didn't internalise merger profitability, which is the focus of our paper. This would not be an issue if there is Bertrand competition in the product market, since it follows from Deneckere and Davidson (1985) that a merger is always profitable under Bertrand competition. Hence, merger profitability is an important issue to consider if there is Cournot competition in the product market, since, as mentioned above, it follows from Salant et al. (1983) that a merger may not be profitable under Cournot competition. Hence, our paper shows that merger control policies might need a careful look when examining the relationship between merger and collusion under Cournot competition, since merger decisions might be contingent on collusion sustainability.

[3] For simplicity, we assumed the slope of the demand function as 1.

[4] There is another literature comparing the incentives for explicit and tacit collusions (Garrod and Olczak 2018).

Correia-da-Silva et al. (2016) examine collusion sustainability in an industry with market growth and entry where firms maximise their own profits. In contrast, we focus on the effects of a merger on collusion sustainability and with no market growth. Since we consider merger, different output allocations occur in our analysis, which is not in their paper.

In a recent paper, von Auer and Pham (2023) consider a Stackelberg leader–follower framework with free entry of firms to examine collusion sustainability. They consider the "coefficient of cooperation" used by Cyert and DeGroot (1973) to capture the level of collusion. By determining the equilibrium number of firms in the market and the number of colluding firms, they focus on the interplay of four important issues of cartel theory: output sustainability, status stability, market stability, and antitrust policy. In contrast, in a given market structure with Cournot–Nash game under no collusion, we show the effects of a merger on the industry-wide collusion sustainability. We use a supergame with grim trigger strategy to model collusion. In this respect, we show the implications of different types of output allocation under merger.

In our analysis, demerger is a possibility in the punishment game but it will not occur in equilibrium, since firms will either merge or not merge. However, it may still be important to mention that the possibility of demerger or separation of the collaborative partners is actually a real life phenomenon in the business world. For example, Porter (1987), and Shimizu and Hitt (2005) show that many mergers and acquisitions are divested. 44% of the acquisitions studied by Kaplan and Weisbach (1992) were divested. Deloitte (2018) found that 70% of 123 global organizations had undertaken demerger.[5] Schweizera and Lagerström (2020) use the demerger between Ford Motor Company and Volvo Cars Corporation to examine how the demerger process of previously merged or acquired firms unfold. They provide a process description for the reversal of a previous merger and acquisition between two firms, where the pre-merger and acquisition status is re-established completely or partially.

Evidences for the instability of collaborative ventures can be found from the joint venture (JV) literature also. For example, 36 out of the 37 international JVs studied in Killing (1982) were prone to breakdown. The average lifespan of a JV studied in Harrigan (1988) was only 3.5 years. About half of the 92 JVs studied in Kogut (1988) had broken up by the sixth year. See Yan and Zeng (1999) for a survey on JV instability in different industries and in different countries.

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

[5] As explained in Schweizera and Lagerström (2020), demerger and divestiture are often used synonymously; while some researchers "understand a demerger as … spin off a division of an existing entity into a separate entity without any change in the ownership, others use the term demerger as an umbrella term for all firm divestitures". Among other factors, competitive positions of firms may be a reason for merger and demerger (Hopkins 1991).

2 The model and the results

Consider an industry with $n(\geq 3)$ symmetric Cournot oligopolists producing homogeneous products. Assume that the marginal cost of each firm is c, which is normalised to *0* for simplicity. We assume that the inverse market demand function is $P = 1 - q$, where P is price and q is the total output.

Assume that the firms play an infinitely repeated game and want to collude. We will consider two situations: (1) where each firm behaves like a single firm, i.e., there is no merger, and the firms want to collude, and (2) where m number of firms, $2 \leq m \leq n$, want to merge, and the merged and non-merged firms want to collude.

2.1 No merger

Consider that each firm behaves like a single firm, i.e., there is no merger. Given the symmetry of the firms, assume that the firms make the tacit agreement that, in each period, each firm will produce $\frac{q^m}{n}$, where q^m is the monopoly output corresponding to the demand and the marginal cost mentioned above.

We consider the following grim trigger strategy under collusion adopted by each firm. If every firm produces $\frac{q^m}{n}$, no firm deviates from this output level. However, if a firm deviates from $\frac{q^m}{n}$ in one period, all firms play non-cooperative Cournot–Nash game from next period.

If a firm deviates in period t from the collusive output, its gain from deviation is $(\pi^{de} - \pi^{co})$, where π^{co} is each firm's equilibrium profit under collusion and π^{de} is the deviating firm's equilibrium profit from deviation.

Since all firms will play non-cooperative Cournot–Nash game from period $t+1$ following deviation by a firm in period t, the deviating firm's loss from deviation is $\frac{(\pi^{co}-\pi^{nc})\delta}{1-\delta}$, where $\delta(=\frac{1}{1+r})$ is the common discount factor and r is the common discount rate faced by the firms, and π^{nc} is the equilibrium Cournot–Nash profit of each firm.

Each firm will prefer to collude, i.e., no firm will want to deviate from collusion in any period, if $\frac{(\pi^{co}-\pi^{nc})\delta}{1-\delta} \geq (\pi^{de} - \pi^{co})$ or $\delta \geq \frac{\pi^{de}-\pi^{co}}{\pi^{de}-\pi^{nc}} \equiv \delta_1$. Given the demand and cost functions, we find $\delta_1 = \frac{(1+n)^2}{1+n(6+n)} \in [0, 1]$.[6]

2.2 A merger of m firms

Now consider a merger among m firms, where the merged firm and the non-merged firms want to collude.

Our purpose is to show the implications of a merger on collusion sustainability when the *merger is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game*. Hence, appealing to Salant et al. (1983), we consider that m is sufficiently small for a given n so that a merger among m firms is not

[6] Since this critical value of δ and the following critical values of δ are greater than *0*, as usual in the literature, collusion will not be sustainable if the game is finite.

profitable in the punishment subgame. In our analysis, merger is not profitable if $m < \frac{1}{2}\left(3 + 2n - \sqrt{5 + 4n}\right) = \overline{m}$.[7] Hence, we will do our analysis under the following assumption:

Assumption $2 \leq m < \overline{m}$.

If m is sufficiently large for a given n so that a merger among m firms in an industry with n firms is profitable in the punishment subgame where firms play Cournot–Nash game, i.e., $m > \overline{m}$, the results will be similar to Oliner (1982). We skip this case.

It may worth clarifying that formation and dissolve of a merger depends on the merged entities, while collusion sustainability depends on the merged and non-merged firms. Further, if the game does not reach the punishment stage, meaning that the collusion is sustained under merger, the merger participants will continue to produce as the merged firm.

2.2.1 Allocation *C*

Under the output allocation C of Oliner (1982), each independent firm produces $\frac{1}{n}$ of the collusive output while the merged firm produces $\frac{m}{n}$ of the collusive output.

If a merger among m firms is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game, the merged entities will not continue to merge there. When all firms play non-cooperative Cournot–Nash game, the per-period total profits of the merged entities (i.e., of m firms) will be $m\pi^{nc}$, and the per-period profit of each non-merged firm will be π^{nc}.

Denote the merged firm's per-period collusive profit and its deviation profit by $\pi^{co,C}$ and $\pi^{de,C}$ respectively. Following the procedure mentioned in the previous subsection, it is easy to find that the merged entities will prefer to collude if $\frac{(\pi^{co,C} - m\pi^{nc})\delta}{1-\delta} \geq (\pi^{de,C} - \pi^{co,C})$ or $\delta \geq \frac{\pi^{de,C} - \pi^{co,C}}{\pi^{de,C} - m\pi^{nc}} \equiv \delta_2$. Note that we need to consider $m\pi^{nc}$ instead of π^{nc} as the non-cooperative Cournot–Nash profits for the merged entities while considering the cost of deviation for the merged firm, as it is the total profits of m firms if collusion is not sustained. Given the demand and cost functions, we find $\delta_2 = \frac{(m-n)^2(1+n)^2}{m^2(1+n)^2 + n^2(1+n)^2 + 2mn(1+(-6+n)n)} \in [0, 1]$.

Comparing the critical discount factors under no merger and merger, we get $\delta_1 - \delta_2 = \frac{4(-1+m)n(1+n)^2\left(-m+n^2\right)}{\left(1+6n+n^2\right)\left(m^2+2mn+2m^2n+n^2+mn^2(m-2)+2mn^2(n-3)+2n^2(n-m)+n^2(n^2-2m)\right)} > 0$, for $3 \leq n$ and $m \in [2, n]$, and therefore, for $m \in [2, \overline{m}]$. Hence, the merger participants' incentive for collusion is higher under merger compared to no merger. Merger increases the merger participants' profits under deviation, collusion and non-cooperation compared to no merger. However, due to fewer firms in the industry under merger compared to no merger, the merger participants' gain from deviation compared to

[7] This upper bound on m is equal to the upper bound in Salant et al. (1983).

collusion reduces and their gain from deviation compared to non-cooperation increases under merger compared to no merger. As a result, like the standard result in supergames, merger increases the merger participants' incentive for collusion by reducing the number of firms in the industry.

Now denote each of the non-merged firm's per-period collusive profit and its deviation profit under merger by $\pi^{co,C,NM}$ and $\pi^{de,C,NM}$ respectively. Each non-merged firm will prefer to collude if $\frac{(\pi^{co,C,NM}-\pi^{nc})\delta}{1-\delta} \geq (\pi^{de,C,NM} - \pi^{co,C,NM})$ or $\delta \geq \frac{\pi^{de,C,NM}-\pi^{co,C,NM}}{\pi^{de,C,NM}-\pi^{nc}} \equiv \delta_3$. Given the demand and cost functions, we find $\delta_3 = \frac{(1+n)^2}{1+n(6+n)} = \delta_1 \in [0, 1]$. Hence, each non-merged firm's incentive for collusion is the same under merger and no merger.

If a merger is not profitable under Cournot–Nash game, all firms play non-cooperative Cournot–Nash game if collusion does not occur. Hence, the non-merged firms' profits under non-cooperative Cournot–Nash game are the same under no merger and merger. Further, under the output allocation *C*, each non-merged firm and the merged entities get the same share of the collusive output under no merger and merger. Therefore, if there is a merger of *m* firms, the profits of the non-merged firms under sustained collusion and under deviation remain the same under no merger and merger. Thus, the non-merged firms' incentive for collusion remain the same under no merger and merger.

Collusion under merger will be sustainable if the merged firm and the non-merged firms prefer collusion compared to no collusion. The merged entities prefer collusion compared to no collusion (i.e., non-cooperation) if $\delta > \delta_2$. Under merger, each non-merged firm prefers collusion compared to no collusion if $\delta > \delta_3 = \delta_1$. Hence, collusion is sustainable (not sustainable) under merger for $\delta > (<) \max\{\delta_2, \delta_3 = \delta_1\} = \delta_3 = \delta_1$, since we have seen $\delta_1 > \delta_2$. Hence, here collusion sustainability is determined by the non-merged firms' incentive for collusion. Since merger does not change the non-merged firms' incentive for collusion, as their output allocations remain the same under merger and no merger, merger will not affect the incentive for collusion even if it increases the merged firms' incentive for collusion.

Hence, the following proposition is immediate.

Proposition 1 *If a merger among m firms in an industry with n symmetric firms is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game, a merger among m firms does not affect collusion sustainability compared to no merger under the output allocation C.*

The above result contrasts with Oliner (1982) and Davidson and Deneckere (1984). The reason for this difference is as follows. In our case, merger is not profitable under Cournot–Nash game. Hence, if collusion does not occur, all firms play non-cooperative Cournot–Nash game. This contrasts with Oliner (1982) and Davidson and Deneckere (1984), where even if collusion does not occur, a merger is formed irrespective of merger profitability under Cournot–Nash game. Hence, in our analysis, the non-merged firms' profits under Cournot–Nash game remain the same under no merger and merger, while they are different in Oliner (1982) and Davidson and Deneckere (1984). Other profits are the same in our analysis and in those papers.

The issue of "merger paradox", where the merged entities earn less than the non-merged firms, occurs in Oliner (1982) and Davidson and Deneckere (1984). However, that may not happen in our case. Since collusion sustainability in our analysis is not affected under allocation *C*, the profits of the merger participants are equal to the profits of the non-merged firms under merger. This happens since, in each period, they either earn $\frac{1}{n}$ fraction of the monopoly profits under collusion or earn the non-cooperative Cournot profits when collusion is not sustainable.

Proposition 1 holds for $2 \leq m < \overline{m}$. Hence, it implies that a two-firm merger, which the authorities may need to confront with more often, does not change collusion sustainability under allocation *C* compared to no merger.

2.2.2 Output allocation I

Under the output allocation *I* of Oliner (1982), the merged firm's output allocation under collusion is the same to that of each non-merged firm.

Like subSect. 2.2.1, if merger among *m* firms is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game, the merged entities will not continue to merge there. In this situation, all firms play Cournot–Nash game if collusion does not occur, and the per-period total profits of the merged entities (i.e., of *m* firms) are $m\pi^{nc}$ and the per-period profit of each non-merged firm is π^{nc}.

If *m* firms merge, denote the merged firm's per-period collusive profit and the deviation profit by $\pi^{co,I}$ and $\pi^{de,I}$ respectively. The merged entities will prefer to collude if $\frac{(\pi^{co,I}-m\pi^{nc})\delta}{1-\delta} \geq (\pi^{de,I} - \pi^{co,I})$ or $\delta \geq \frac{\pi^{de,I}-\pi^{co,I}}{\pi^{de,I}-m\pi^{nc}} \equiv \delta_4$. Given the demand and cost functions, we find $\delta_4 = -\frac{(m-n)^2(1+n)^2}{16m^3-(1+n)^2(2+n)^2+2m(1+n)^2(10+n)-m^2(1+n)(33+n)} \in [0,1]$.

We get $\delta_1 - \delta_4 = -\frac{\left(4(-1+m)(1+n)^2\left(1-4m+4m^2+3n-7mn+3n^2\right)\right)}{\left((1+6n+n^2)\left(\begin{array}{l}4-20m+33m^2-16m^3+12n-42mn+34m^2n\\+13n^2-24mn^2+m^2n^2+6n^3-2mn^3+n^4\end{array}\right)\right)}$.

Each non-merged firm will prefer to collude if $\frac{(\pi^{co,I,NM}-\pi^{nc})\delta}{1-\delta} \geq (\pi^{de,I,NM} - \pi^{co,I,NM})$ or $\delta \geq \frac{\pi^{de,I,NM}-\pi^{co,I,NM}}{\pi^{de,I,NM}-\pi^{nc},} \equiv \delta_5$. Given the demand and cost functions, we find $\delta_5 = \frac{(m-n)^2(1+n)^2}{\left(2+m(-3+n)+n-n^2\right)\left(m(5+n)-(1+n)(6+n)\right)} \in [0,1]$.

We get $\delta_1 - \delta_5 = \frac{4(-1+m)(1+n)^2\left(3-4m+5n-mn+n^2\right)}{\left(1+6n+n^2\right)\left(-2+3m-n-mn+n^2\right)\left(6-5m+7n-mn+n^2\right)}$.

If $3 \leq n$, we get $(\delta_1 - \delta_4) < 0$ for $2 \leq m < \frac{1}{8}(4+7n) - \frac{1}{8}\sqrt{8n+n^2} = \overline{\overline{m}}$, where $2 < \overline{\overline{m}} < \overline{m}$, and $(\delta_1 - \delta_5) > 0$ for $m \in [2, \overline{m}]$. Hence, if $m < \overline{\overline{m}}$, we get $\delta_5 < \delta_1 < \delta_4$, implying that collusion is sustained under no merger but not sustained under merger for $\delta_1 < \delta < \delta_4$.

If $\overline{\overline{m}} < m < \overline{m}$, we get $(\delta_1 - \delta_4) > 0$ and $(\delta_1 - \delta_5) > 0$. Since $\delta_5 < \delta_4$, we get $\delta_5 < \delta_4 < \delta_1$. Hence, if $\overline{\overline{m}} < m < \overline{m}$ and $\delta_4 < \delta < \delta_1$, collusion is sustained under

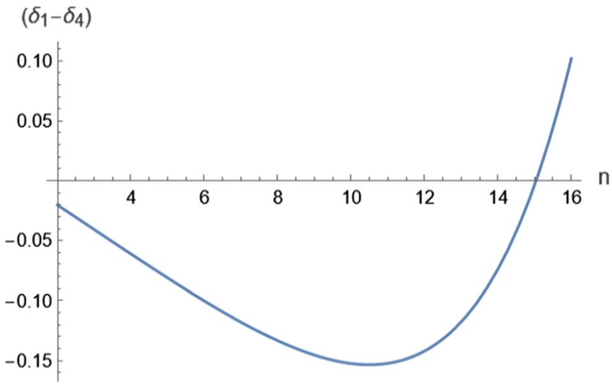

Fig. 1 $(\delta_1 - \delta_4)$ for $n = 20$ and $m \in [2, 16]$

merger but not sustained under no merger. In this situation, merger (in comparison to no merger) increases collusion sustainability under allocation *I*, implying that merger occurs in this situation provided collusion occurs.

We get the following proposition from the above discussion.

Proposition 2 *If* $m < \overline{m}$ *so that a merger among m firms in an industry with n symmetric firms is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game, a merger among m firms decreases (increases) the incentive for collusion compared to no merger under the output allocation I if* $2 \leq m < \overline{\overline{m}}$ $(\overline{\overline{m}} < m < \overline{m})$.

As an example for Proposition 2, consider $n = 20$ and $m \in [2, 16]$, since $\overline{m} = 16.89$, i.e., merger is not profitable under non-cooperative Cournot–Nash game if the number of firms in the industry is less than *16*.

We plot $(\delta_1 - \delta_4)$ in Fig. 1 for $n = 20$ and $m \in [2, 16]$. It follows from the figure that $(\delta_1 - \delta_4) < (>)0$, and therefore, merger decreases (increases) collusion sustainability for $m < (>)15$.

The above result contrasts with Oliner (1982) and the reason for it is as follows. On the one hand, more merger participants tend to increase collusion sustainability under merger compared to no merger by reducing the number of effective firms in the market. On the other hand, the merger participants consider higher Cournot–Nash profits under merger compared to no merger, which tends to reduce collusion sustainability for the merger participants under merger compared to no merger. If a few firms (not few firms) merge, the first effect is dominated by (dominates) the second effect, and merger decreases (increases) collusion sustainability for the merger participants and the industry compared to no merger.

Like Proposition 1, the reason for the above result and the reason for the difference between our result and that of Oliner (1982) is attributable to the fact that a merger in our analysis is not profitable under non-cooperative Cournot–Nash game. In our analysis, all firms play Cournot–Nash game if collusion does not occur, while

Oliner (1982) considered that a merger forms regardless of merger profitability under Cournot–Nash game.

If collusion is sustainable in our analysis under merger and no merger, the total profits of the merger participants are $\frac{1}{4(n-m+1)}$ and $\frac{m}{4n}$ under merger and no merger respectively. Since $\frac{1}{4(n-m+1)} < \frac{m}{4n}$, merger reduces the total profits of the merger participants. This problem is also in Oliner (1982). However, in our analysis, the incentive for collusion may reduce with the possibility of merger. Hence, if the discount factors are such that collusion occurs only under no merger, the total profits of the potential merger participants are $\frac{m}{(n+1)^2}$ and $\frac{m}{4n}$ under the possibility of merger and no merger respectively, where $\frac{m}{(n+1)^2} < \frac{m}{4n}$. Hence, there is no incentive for proposing a merger under allocation I if collusion is sustained either under both merger and no merger or only under no merger.

But if collusion is sustained in our analysis only under merger, which can happen for $\overline{\overline{m}} < m < \overline{m}$, the total profits of the potential merger participants are $\frac{1}{4(n-m+1)}$ and $\frac{m}{(n+1)^2}$ under the possibility of merger and no merger respectively, where $\frac{m}{(n+1)^2} < \frac{1}{4(n-m+1)}$ for $n > 3$.[8] In this situation, there is an incentive for proposing a merger under allocation I even if merger is not profitable under Cournot–Nash game.

Comparing our results under allocation C and allocation I, we can say the following. Since the possibility of a merger does not affect collusion sustainability under allocation C, there is no incentive for proposing a merger under allocation C. However, there is an incentive for proposing a merger under allocation I if $\overline{\overline{m}} < m < \overline{m}$ and $\delta_4 < \delta < \delta_1$, since merger helps to sustain collusion, although it is not profitable under Cournot–Nash game. It suggests that if a merger is observed in our analysis, the antitrust authorities may expect an industry-wide collusion with output allocation I.

Since $2 < \overline{\overline{m}}$, Proposition 2 implies that if we consider a two-firm merger, the possibility of merger decreases collusion sustainability under allocation I compared to no merger.

3 Conclusion

Merger and collusion are two important ways through which competing firms can increase their profits. The extant literature shows that merger may increase or decrease collusion sustainability depending on the way outputs are allocated among firms. It is shown that merger reduces collusion sustainability under allocation C, while it fosters collusion under allocation I. Hence, the incentive for collusion may encourage (discourage) merger under allocation I (C). However, this result did not internalise merger profitability under Cournot–Nash game. In other words, it assumed that merger will continue whether or not collusion is sustained.

[8] $\frac{m}{(n+1)^2} = \frac{1}{4(n-m+1)}$ for $m=2$ and $n = 3$.

We show that if the number of merger participants is lower than a threshold level so that a merger is not profitable in the punishment subgame where firms play non-cooperative Cournot–Nash game, the presence of a merger either does not affect collusion sustainability (under the output allocation C) or decreases (increases) collusion sustainability if the number of merger participants is small (not small) (under the output allocation *I*). However, if the number of merger participants is higher than the threshold level so that merger is profitable in the punishment game, collusion sustainability will follow the results of the extant literature mentioned above.

There is an incentive for proposing a merger in our analysis under allocation *I* provided it increases collusion sustainability. Hence, even if a merger is not profitable under Cournot–Nash game, it is proposed under allocation *I* for sustaining collusion, which creates the following implication for antitrust policies. If a merger is observed, the authority may expect an industry-wide collusion with allocation *I*, since merger increases collusion sustainability in this situation.

Modelling repeated game with grim trigger strategy equilibrium makes our analysis comparable to Oliner (1982) and Davidson and Deneckere (1984). However, there are other ways to model an infinitely repeated game; e.g., with a limited period of punishment, which is different from the grim trigger strategy, or as in Abreu (1988), which considers punishment not only for deviating from the agreed output choice but also for deviating from an previously prescribed punishment. Different ways of modelling will affect the critical discount factors derived in this paper. However, we conjecture that our results showing collusion sustainability under merger and no merger, i.e., the relationship between different critical discount factors shown in our analysis, will go through. This is because the driving force behind our results is the output shares of the merged and non-merged firms in the punishment subgame under merger and no merger. However, we leave a thorough analysis with different trigger strategies for future research.

Declarations

Conflict of interest The authors have no relevant or material financial interests that relate to the research described in this paper.

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