UNIVERSITY OF HOHENHEIM

Hohenheim Discussion Papers in Business, Economics and Social Sciences

MERGERS AND PARTIAL TACIT COLLUSION

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15-2019

Discussion Paper 15-2019

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ISSN 2364-2084

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23rd December 2019

Abstract

This paper studies whether mergers may lead to partial tacit collusion, thereby having the potential to induce simultaneous coordinated and non-coordinated effects. We use a Bertrand-Edgeworth model with heterogeneous discount factors to derive conditions for profitable and stable collusion and provide a numerical example. Mergers that change the market structure in a way such that maverick firms are eliminated or colluding firms reach a critical share in total capacity can lead to partial collusion.
Keywords: Partial Collusion, Tacit Collusion, Mergers, Coordinated Effects, Non-coordinated Effects, Umbrella Effects

1 Introduction

A merger can induce anti-competitive effects by lowering the intensity of competition in a market such that firms may charge higher prices even if they do not coordinate their behaviour. This effect is known as the non-coordinated effect of a merger. However, a merger may also cause coordinated effects where firms tacitly collude post-merger and behave similarly to an explicit cartel.

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In this paper, we study whether a merger in an oligopolistic market – that is, where no collusion either tacit or explicit is possible – may induce some firms in the market to tacitly collude post-merger. Stated otherwise, we analyse mergers that cause only some firms to coordinate their behaviour while, simultaneously, other firms behave competitively. Hence, coordinated and non-coordinated effects would occur at the same time *without* prior collusion. This finding stands in contrast to the literature, which has treated coordinated and non-coordinated effects either as separate effects or with the assumption that collusion already exists prior to the merger.

The analysis is related to studies of partial cartels, which are characterised by only some firms entering an explicit cartel agreement while the outsiders react to the increased prices charged by the cartel members by raising their prices as well, causing so-called umbrella effects. The main difference between the analysis carried out here and studies of partial cartels is that in our model the merger of two firms induces collusion in a market that was competitive before the firms merged.

To analyse the simultaneous occurrence of coordinated and non-coordinated effects of a merger, it is expedient to distinguish between unilateral effects of a merger, where only the merging firms are considered, and non-coordinated effects. While the former is an out-of-equilibrium effect, the latter considers the change in the Nash equilibrium of the oligopoly game caused by the merger. Coordinated and *unilateral effects* are assumed to be mutually exclusive in general (Fabra and Motta 2013, p. 12; implicitly in Gore et al. 2015, p. 320) because the merged firm either charges the price resulting from coordinated behaviour or it charges the optimal price in the new Nash equilibrium.

If coordinated and *non-coordinated effects* are considered, exclusiveness is not necessarily given anymore. Coordinated effects have been studied in several papers with *all-inclusive* collusion (Compte et al. 2002; Vasconcelos 2005) or *partial cartels* (Escrihuela-Villar 2008; Bos and Harrington 2010). The first strand of the literature studies the change in the smallest discount factor that is needed to sustain collusion. Because the collusion is all-inclusive, non-coordinated effects cannot emerge. The second strand shows indeed that coordinated and non-coordinated effects occur simultaneously. The effects of a merger are, however, analysed under the assumption that a cartel exists already prior to the merger (see for example Bos and Harrington 2010, p. 104).

The literature on the connection between partial cartels and umbrella effects discusses the circumstances under which umbrella effects may arise (Inderst et al. 2014) and the legal context of umbrella effects (Hansberry et al. 2014; R. Blair et al. 2016; R. D. Blair and Durrance 2018). An experiment, which is based on the model used in Bos and Harrington (2010), confirms that partial cartels charge prices above the competitive level and that outside firms react to this behaviour by raising prices as well. Mergers are reported to have no significant effects on prices, however (Gomez Martinez 2017).

Partial tacit collusion caused by a merger might be present in the German cement market. After the German cement cartel broke down in 2002, a period of intense competition characterised by low prices followed. On 27.09.2004, the German cement company *Cemex* took over *Readymix*, a producer of ready-mixed concrete in Düsseldorf-Wersten in Germany. *Readymix* was part of the *RMC Group plc*, a public limited company located in the United Kingdom. Following the takeover, the price index for cement increased drastically. In a sector inquiry, the German Federal Cartel Office (FCO) showed that this industry is indeed susceptible to collusion (Bundeskartellamt 2017, p. 129). The FCO announced that 12 of 15 firms could be persuaded to stop communicating price increases to competitors (Bundeskartellamt 2018). Not all firms took part in this practice, however. It has been reported that those firms which announced prices covered 93% of the German cement market. This outcome can be seen as a form of partial collusion.

The paper is organised as follows: In section 2, we introduce a modified version of the Bertrand-Edgeworth model of endogenous cartel formation (Bos and Harrington 2010) where firms are characterised by heterogeneous discount factors. We derive conditions for partial tacit collusion in section 3. In section 4, conditions for the existence of stable collusion are derived. The link to mergers is drawn in section 5. A numerical example that illustrates the point is given in section 6. The last section concludes.

2 Model

We consider an oligopolistic market and a homogeneous product where capacity-constrained firms compete with prices. This Bertrand-Edgeworth setting in Bos and Harrington (ibid.) is modified by allowing for heterogeneous discount factors.

Consider a set of firms $I := \{1, ..., n\}$. Each firm $i \in I$ seeks to maximise its profit. The market demand for the homogeneous good depends on the price $p \in \mathbb{R}_+$ and is given by $D(p) := a - bp$, where $a, b > 0$. Each firm i simultaneously chooses a price p_i from the set $P_i := \{0, \epsilon, \ldots, c-\epsilon, c, c+\epsilon, \ldots\}$, where $\epsilon > 0$. Furthermore, each firm i faces the individual demand function $D_i(p_i, p_{-i})$, where p_i denotes the price of firm i and p_{-i} denotes the prices of all other firms.

All firms produce using the same technology characterised by marginal costs of $c \geq 0$. There are no fixed costs. Each firm i has a capacity $k_i \in (0, D(c)/2)$ which gives the maximum possible output and is characterised by a discount factor $\delta_i := 2k_i/D(c)$. As pointed out in Harrington (1989, p. 292), possible explanations for differences in discount factors may be capital market imperfections, conglomerates internally allocating funds to subsidiary enterprises or principal-agent problems with regards to the design of contracts for managers. The link between discount factors and capacities, in particular, is drawn to take into account the so-called *small stock* effect according to which smaller firms have higher rates of total returns on average compared to larger firms (Banz 1981; Fama and French 1993). This implies that investors use higher capitalisation rates for smaller firms. Though some studies challenged the effect (Dijk 2011), recent studies support the existence of the small stock effect (Asness et al. 2018; Ciliberti et al. 2019).

The sum of all capacities is called $K := \sum_i^n k_i$ and is assumed to be fixed. The capacities and discount factors of individual firms are assumed to change only in the case of a merger. Firms maximise their profits given by $\pi_i(p_i, p_{-i}) := (p_i - c)D_i(p_i, p_{-i})$. The stage game can thus be described by $\Gamma := (I, (P_i)_{i\in I}, (\pi_i)_{i\in I})$.

For the following assumptions with respect to demand, $\Omega(p) := \{j : p_j = p\}$ is the set of firms that charge a price of p. Additionally, $p_{-i}^{\min} := \min\{p_1, \ldots, p_{i-1}, p_{i+1}, \ldots, p_n\}$ is the minimum of all prices except that of firm i. 2.1 describes the behaviour of the individual demand if the price of firm i approaches the lowest price among its competitors from above. In this case, its individual demand is equal to market demand at price $p_{-i}^{\min}$ net of the capacities of all firms that price at $p_{-i}^{\min}$.

Assumption 2.1.

$$\lim_{\eta \to 0^+} D_i(p_{-i}^{\min} + \eta, p_{-i}) = \max\left\{ D(p_{-i}^{\min}) - \sum_{j \in \Omega(p_{-i}^{\min})} k_j, 0 \right\}.$$

2.2 describes that if some firms price at p and if these firms have excess capacity in sum, then each of these firms individually must face excess capacity.

Secondly, it describes that if demand for some firms is non-negative, then the individual demand of each of these firms is non-negative. This ensures that, among firms charging the same price, demand is distributed equally to at least some extent.

Assumption 2.2.

$$0 < \sum_{i \in \Omega(p)} D_i(p_i, p_{-i}) < \sum_{i \in \Omega(p)} k_i, \text{ then } 0 < D_i(p_i, p_{-i}) < k_i, \forall i \in \Omega(p).$$

2.3 describes that no firm i has enough capacity to meet the demand at the monopoly price $p^m := (a + bc)/2b$.

Assumption 2.3. $k_i < D(p^m)$.

2.4 assures that every combination of $n - 1$ firms has enough capacity to meet the demand at the competitive price $p = c$.

Assumption 2.4. $\sum_{j \neq i} k_j \geq D(c)$, $\forall i$.

The stage game Γ is repeated infinitely. Now, it is possible that a subgame perfect Nash equilibrium exists that consists of a set of firms that tacitly collude. Firms are assumed to use a *grim trigger strategy* (Friedman 1971), where defection is punished by infinite Nash reversion. Such a set of colluding firms can be described by a combination of at least two firms, as in 2.1.

Definition 2.1. A set $\kappa \in \mathcal{K}$, where $\mathcal{K} := \{S \in \mathcal{P}(I) \mid |S| \geq 2\}$ is called a *collusive set*.

The sum of the capacities of the members of a collusive set is referred to as $K_\kappa(\kappa) := \sum_{i \in \kappa} k_i$ and the sum of capacity of firms that are not part of the collusive set is referred to as $K_o(\kappa) := \sum_{j \in I \setminus \kappa} k_j$ to simplify the notation.

3 Collusive Price

Consider first the stage game Γ. There are two Nash equilibria. The first consists of $p_i = c \quad \forall i \in I$ with $\pi_i = 0 \quad \forall i \in I$. The second consists of $p_i = c + \epsilon \quad \forall i \in I$. As $\epsilon \to 0$, $p_i \to c \quad \forall i \in I$ and $\pi_i \to 0 \quad \forall i \in I$. Any other price leaves the profits unchanged at best.

If the game is repeated infinitely often, it may be profitable for firms to tacitly collude. We start with the optimal response of firms that are not part of the collusive set. An outside firm will not find it optimal to charge a price above that of the collusive set as no demand exists. A price that is significantly lower than the collusive price may not be optimal as well. If the outside firm is capacity constrained, it can achieve a higher profit by raising its price, ultimately charging a price just below the collusive price. This result is depicted in 3.1.

Lemma 3.1. *Assume a collusive set κ charging the price $p_\kappa > c + \epsilon$. If $\sum_{j \notin \kappa} k_j \leq D(p_\kappa)$, then the equilibrium price for a non-colluding firm is $p_j := p_\kappa - \epsilon \; \forall j \notin \kappa$.*

All proofs are contained in Appendix A. A collusive firm $i \in \kappa$ is assumed to earn a share of the collusive profit proportional to its share in the capacity of the collusive set.[1] The net present value of its share is

$$V_i(p, \kappa) := \left(\frac{1}{1 - \delta_i}\right)(p - c)\left[D(p) - K_o(\kappa)\right]\frac{k_i}{K_\kappa(\kappa)}.$$

It is assumed that the collusive set maximises the sum of net present values under the constraint that no firm in this set has an incentive to defect from the collusive price. A firm profitably deviates from the collusive price by undercutting it. As all firms will charge prices equal to marginal cost (or ϵ above it) after a defection occurs, the defecting firm obtains a positive profit only in the period in which defection occurs (and, of course, before it defects). Optimally, the defecting firm undercuts the collusive price by ϵ if it is capacity constrained at this price or otherwise undercuts the collusive price by 2ϵ and so forth. These prices are approximately equal to the collusive price. With the knowledge on the profit of a collusive set member that is defecting, we are able to determine the incentive compatibility constraint. A firm has no incentive to deviate from the collusive price if the stream of profits it obtains by adhering to the collusive price is higher or equal to that obtained by defection. Taking this into account, the maximisation problem of the collusive set is given by

$$\max_p V(p, \kappa) := \sum_{i \in \kappa} V_i(p, \kappa)$$

[1] Bos and Harrington (2010, p. 97) mention Röller and Steen (2006, p. 322) among others to support this assumption.

subject to the incentive compatibility constraint

$$V_i(p,\kappa) \geq (p-c)k_i \quad \forall i \in \kappa.$$

The solution of the unconstrained maximisation problem is

$$\hat{p}(\kappa) = \frac{a+bc-K_o}{2b}.$$

Solving the constraint for p gives

$$\bar{p}(\kappa) = \frac{-K + K_\kappa(\kappa)\delta_i + a}{b} \quad \forall i \in \kappa. \tag{1}$$

There are several important aspects to notice here. First, if the constraint is binding, the collusive profit is maximised by charging the highest price that satisfies the incentive compatibility constraint. Therefore, Equation 1 is written as equality. Second, the lowest value of the constrained price is equal to marginal cost. This price satisfies the incentive compatibility constraint. The colluding firms would, of course, not make positive profits in this case. The third feature refers to the discount factors of the collusive firms. As the incentive compatibility constraint could be different for all firms, it is sufficient to look at the firm with the smallest discount factor (or – as it defines the size of the discount factor – the smallest capacity) in order to find the lowest value the condition on the right side in Equation 1 can take. To this end, let $\delta_{\min}(\kappa) := \min(\delta_i)_{i\in\kappa}$ be the smallest discount factor among the members of the collusive set κ and $k_{\min}(\kappa) := \min(k_i)_{i\in\kappa}$ the smallest capacity among the members of κ. If Equation 1 holds for $\delta_{\min}(\kappa)$ (or $k_{\min}(\kappa)$), then it holds for all other members of κ as well.

The profit maximising price $p^*(\kappa)$ given the constraint is then the minimum of $\hat{p}(\kappa)$ and $\bar{p}(\kappa)$, so $p^*(\kappa) := \min\{\hat{p}(\kappa), \bar{p}(\kappa)\}$.

Given the optimal prices, the net present values may be restated as

$$V(\kappa) = \begin{cases} \frac{(D(c)-K_o)^2 \sum_{i\in\kappa} \frac{1}{1-\delta_i}}{4b} & \bar{p}(\kappa) \geq \hat{p}(\kappa) \\ \sum_{i\in\kappa} -\frac{(\delta_{\min}(\kappa)-1)(-K_\kappa(\kappa)\delta_{\min}(\kappa)+K-D(c))k_i}{b(\delta_i-1)} & \hat{p}(\kappa) > \bar{p}(\kappa) \end{cases} \tag{2}$$

Before continuing with the analysis of the two cases in Equation 2, we define a profitable collusive set in 3.1. The term requires the net present value of a collusive set to be positive.

Definition 3.1. A collusive set κ is called *profitable* if $V(\kappa) > 0$.

It is easy to see in Equation 2 that if the constraint is not binding, the profit of collusion is always positive. Whether the unconstrained profit is positive or not ultimately depends, via the discount factors, on the capacities of the collusion as described in 3.2.

Lemma 3.2. *If $k_{\min}(\kappa) > \bar{k}_{\min}(\kappa) := \frac{D(c)}{2}\left(1 - \frac{D(c)-K_o(\kappa)}{K_\kappa(\kappa)}\right)$ holds, the profit of a collusive set κ, for which the incentive compatibility constraint is binding, is positive.*

The criterion described in 3.2 shows a familiar expression with $D(c)/2$ being the demand at the monopoly price. This value is reduced by the term that follows. One part of that term is the ratio of the residual demand of the collusive set at the competitive price per unit of collusive capacity. In analysing changes of the condition, we should keep in mind that a change in κ has an impact on the capacity of collusive members *and* on the capacity of collusive outsiders. Separating these two effects would violate the assumption that the total capacity is fixed. We can state, however, that an additional member in the collusive set leads to a larger ratio as long as the residual demand at competitive prices is lower than the collusive capacity. A larger ratio in turn leads to a lower $\bar{k}_{\min}(\kappa)$. While it is true that the threshold for the profitability of collusion decreases if it controls more capacity, this additional member in the collusive set perhaps has a capacity that is below the condition and renders the collusion unprofitable.

The next step is to determine whether the constraint is binding or not. Consider, therefore, the difference between the unconstrained price $\hat{p}(\kappa)$ and the price resulting from the constraint $\bar{p}(\kappa)$. If this difference is negative, the constraint is not binding because $\bar{p}(\kappa) > \hat{p}(\kappa)$. 3.3 describes the condition that determines whether the constraint is binding or not.

Lemma 3.3. *If $k_{\min}(\kappa) \geq \hat{k}_{\min}(\kappa) := \frac{D(c)}{2}\left(1 - \frac{D(c)-K_o(\kappa)}{2K_k}\right)$ holds, the incentive compatibility constraint for a collusive set κ is not binding.*

3.1 provides a condition for the case where the constraint is always binding. The condition may be derived by using the upper limit of the capacity of a firm described in 2.4.

Corollary 3.1. *If $K_o(\kappa) > D(c)$ holds, the constraint for collusive set κ is always binding.*

A collusive set κ with $K_o(\kappa) > D(c)$ will, however, never be formed as any collusive price above $c+\epsilon$ would be profitably undercut by outside firms, leaving the collusive set without any demand because outsiders would control enough capacity to satisfy any demand at a price $p \geq c$. It can be concluded, however, that if $K_o(\kappa) \leq D(c)$, then the constraint is *not always* binding. After all, the smallest capacity among collusion members ultimately defines whether the constraint is binding or not; a result that holds even when all firms participate in the collusion.

The previous results are now used to determine the lowest value of $k_{\min}(\kappa)$ that defines whether collusion is profitable or not. We already know when the collusive profit is positive, either from 3.2 or from the fact that the unconstrained collusive profit cannot become negative. By using 3.3, we can identify the situation where the constraint is not binding for a collusive set. Comparing the two conditions leads to 3.4.

Lemma 3.4. *If $D(c) > K_o(\kappa)$ holds, $\hat{k}_{\min}(\kappa) > \bar{k}_{\min}(\kappa)$.*

This result states that the condition for profitable collusion where the incentive compatibility constraint is binding is always lower than the condition that identifies a situation where the constraint is not binding for a collusive set. We use this to state properties of collusive sets that do not operate profitably in the sense that their profit would be negative.

Lemma 3.5. *If $k_{\min}(\kappa) \leq \bar{k}_{\min}(\kappa)$ holds, $\hat{p}(\kappa) > \bar{p}(\kappa) \leq c$.*

So far, we know when a collusive set is bound by the incentive compatibility constraint and when it operates profitably. Profitability, however, is just one aspect we need to analyse in order to determine whether collusion will emerge or not. Stability also plays a crucial role and will be addressed in the next section.

4 Collusive Stability

Following D'Aspremont et al. (1983), a cartel or, in the context considered here, collusion is considered stable if it is internally and externally stable. Internal stability is given if no cartel member firm has an incentive to deviate. External stability prevails if no firm that is not a member of a cartel has an incentive to join the cartel. Formally, the set of all stable collusive sets can be described by 4.1.

Definition 4.1. A collusive set is called *stable* if it is an element of the set

$$S := \{\kappa \in \mathcal{K} \mid (1-\delta_i)V_i\,(p(\kappa)) > k_i\,(p(\kappa \setminus \{i\}) - c) \quad \forall i \in \kappa \quad \wedge \\ k_j\,(p(\kappa) - c) > (1-\delta_i)V_j\,(p(\kappa \cup \{i\})) \quad \forall j \in N \setminus \kappa\}.$$

A critical relation between profitable collusive sets and stable collusive sets may be established using the algorithm developed in D'Aspremont et al. (1983, p. 22) and apply it to collusive sets.[2] The algorithm starts with the smallest cartel (in our case, a profitable collusive set consisting of two firms). This cartel is internally stable. If it is externally stable, then there is a stable cartel. If it is not externally stable, then at least one of the next larger cartels must be internally stable and so on up to the point where, in the last case, the monopoly cartel is stable. In 4.1, this algorithm is used to find at least one stable collusive set among profitable collusive sets.

Lemma 4.1. *If there is at least one profitable collusive set κ, then $S \neq \emptyset$.*

With the knowledge on the profitability and stability of collusive sets, the influence of a merger may be analysed. We turn to this topic in the next section.

5 Effects of a Merger

A merger is assumed to take place between exactly two firms. Several effects follow. First, the number of firms is reduced by one. Second, the capacity of the new firm is calculated as the sum of the capacities of the merging firms. As the merged firm now has a larger capacity than the any of the firms which merged, the discount factor of this firm is updated accordingly, again reflecting the already mentioned small stock effect. Mergers are formally described in 5.1.

Definition 5.1. Assume two firms $m, a \in I$. A *merger* between firm m and a to firm ma has three effects:

1. $I' := \{ma\} \cup I \setminus \{m, a\}$
2. $k_{ma} := k_m + k_a$

[2] The authors use a model of symmetrical firms.

3. $\delta_{ma} := \frac{2(k_m+k_a)}{D(c)}$

Whether a collusive set may operate profitably depends on the smallest capacity among its members and the capacity that the collusive set controls. Contrary to Bos and Harrington (2010, p. 104), where a merger without a prior cartel never leads to a cartel, in this model, a merger may lead to partial collusion. The reason for this is that, in this model, a merger changes not only the capacities of firms but also the discount factors. The discount factors, in turn, have an influence on profit and, therefore, on the profitability of a collusive set. As discount factors and capacities are linked, a merger either may raise the smallest capacity among a collusive set or raise the capacity that a collusive set controls. This process is summarised in 5.1.

Proposition 5.1. *If $k_{\min}(\kappa)$ is sufficiently close to $\bar{k}_{\min}(\kappa)$, then a merger may lead to (partial) collusion.*

The link for the first type of merger is rather straightforward. In the sense of Baker (2002), a merger may serve the goal of eliminating a maverick firm, which, in this case, is the firm with the smallest capacity among potential colluding firms. Through the takeover of such a maverick firm, some collusive sets may become profitable. More problematic are mergers where some firms merge, and this affects a *third* maverick firm because the condition for profitability of collusion changes. As the maverick firm is not involved in the merger, it is harder to draw a connection between a merger and collusion.

The next section provides a numerical example, demonstrating the effects of a merger that we just analysed and showing the implications for prices, profits and welfare.

6 Numerical Example

This example shows that if firms have heterogeneous capacities and heterogeneous discount factors, a merger can lead to partial collusion. Consider the market demand function

$$D(p) = 1 - p. \tag{3}$$

Assume that there are seven firms in the market all competing with prices and producing with marginal cost $c = 0$ and without fixed costs. To simplify

2.2, in this example, we assume that the excess capacity or demand that each firm faces is proportional to its capacity and that market share is based on capacity. Capacity, discount factors, market share and profits of firms for this situation are given in Table 1.[3]

Firm	k_i	δ_i	**Market share**	π_i
0	0.47	0.94	0.2017	0
1	0.41	0.82	0.1760	0
2	0.39	0.78	0.1674	0
3	0.39	0.78	0.1674	0
4	0.25	0.50	0.1073	0
5	0.22	0.44	0.944	0
6	0.20	0.40	0.858	0

Table 1: Pre-merger market

Using 3.4 and 3.3, the respective conditions for collusion are depicted in Figure 1.[4] The bars represent the minimal capacities of a collusive set $k_{\min}(\kappa)$. The solid line represents the profitability condition $\bar{k}_{\min}(\kappa)$, and the dashed line represents the condition concerning the constraint for a collusive set $\hat{k}_{\min}(\kappa)$. Colluding firms operate profitably as soon as the smallest capacity meets the profitability condition. Visually, this would be the case if a bar and the solid line intersect. As can be seen, there are no profitable collusive sets pre-merger. Therefore, the pre-merger Nash equilibrium consists of all firms pricing at marginal cost and profits of zero.

Consider now a merger between the firms with $k_5 = 0.22$ and $k_6 = 0.20$. The capacities and discount factors of all other firms remain unchanged. Table 2 shows the distribution of capacities, discount factors, market shares and profits after the merger. Pre-merger, the Herfindahl-Hirschman Index may vary between $1/7 \approx .0.143$ and 1, taking the value of $H = 0.155$. After the merger, the index may vary between $1/6 \approx .0.167$ and takes on the value of $H' = 0.172$. One could argue that the change in market shares and in the Herfindahl-Hirschman Index do not raise serious concerns about anti-competitive effects of this merger.

However, exactly one set of firms could profitably raise the price above

[3] Note that the index which is used to address firms starts with 0.

[4] Only collusive sets for which $D(c) - K_o(\kappa) \geq 0$ holds true are depicted, as otherwise collusion can never be profitable.

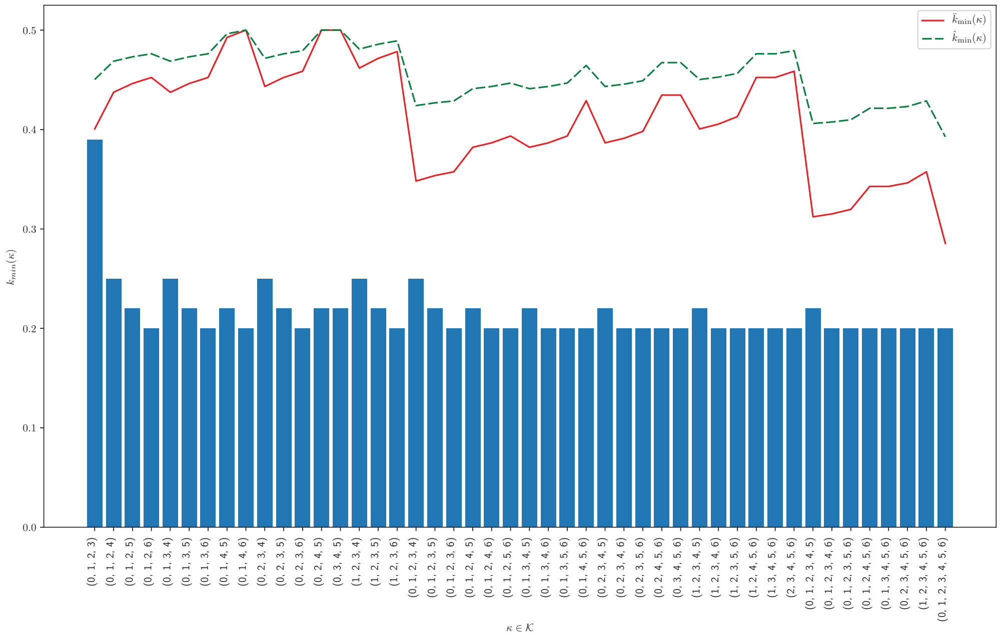

Figure 1: Pre-merger $k_{\min}(\kappa)$ and conditions

Firm	k_i'	δ_i'	Market share	π_i'
0	0.47	0.94	0.2017	0.0302
1	0.42	0.84	0.1803	0.0270
2	0.41	0.82	0.1760	0.0264
3	0.39	0.78	0.1674	0.0251
4	0.39	0.78	0.1674	0.0251
5	0.25	0.50	0.1073	0.0731

Table 2: Post-merger market

the competitive level. That set is called $\kappa^* = \{0, 1, 2, 3, 4\}$. The respective collusive price is $p^*(\kappa^*) = 0.29$. As it is the only profitable collusive set, it is stable according to 4.1. This is depicted in Figure 2.[5] Whenever κ^* is reduced by any one firm, the resulting collusive price is zero. Therefore, κ^* is internally stable. Analogously, the only proper *superset* of κ^* is not able to operate profitably. With external stability given as well, κ^* is the only

[5]Again, only collusive sets for which $D(c) - K_o(\kappa) \geq 0$ are considered.

stable collusive set and therefore is *unique*.

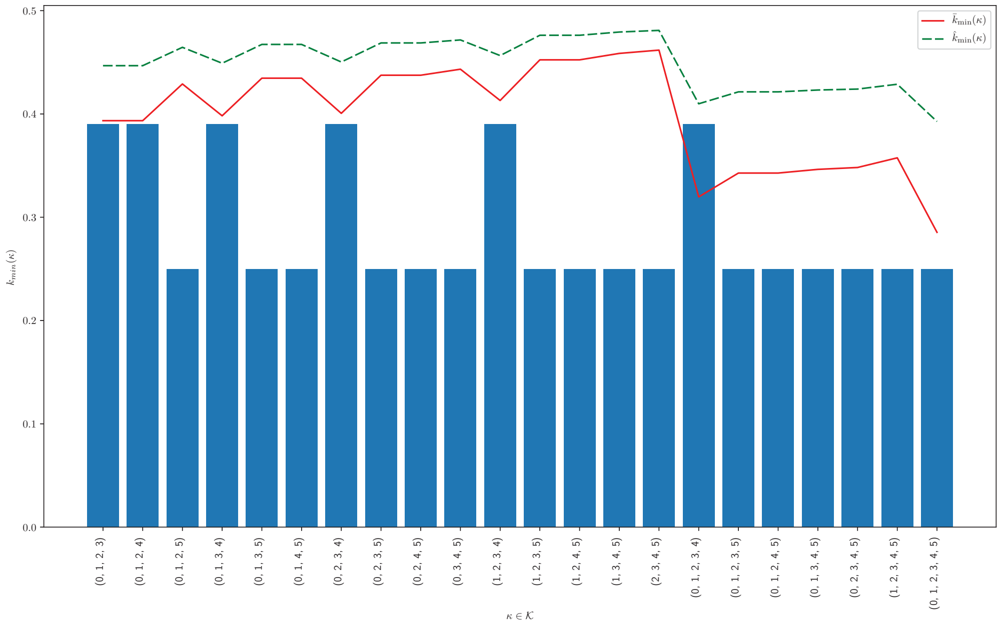

Figure 2: Post-merger $k_{\min}(\kappa)$ and conditions

Pre-merger, total welfare stemmed solely from the consumer surplus amounting to $CS = 0.5$. Post-merger, the collusive set obtained a per-period profit of $PS'_\kappa = 0.1338$ while the profit of the outside firms was $PS'_o = 0.0731$. The consumer surplus was $CS' = 0.2503$. Overall welfare decreased such that $\Delta W = -0.0428$ which corresponds to 8.6 %.

An additional interesting feature arises if the profits of all firms are compared. Though all firms earned a positive profit after the merger, the firm which was not part of the collusive set had the highest profit. This could be interpreted as another variant of the merger paradox that, in this model, applies to partial tacit collusion as well.

7 Conclusion

Mergers can lead to partial collusion where some firms coordinate their behaviour, and some firms merely react to the new situation, as was shown in an infinitely repeated Bertrand-Edgeworth game with heterogeneous discount factors. A merger potentially affects capacities and discount factors of firms in a competetive market such that collusion becomes profitable. It is clear that coordinated effects and non-coordinated effects may occur simultaneously if a merger allows an already existing cartel to raise prices further. This paper shows, however, that an existing cartel is not a precondition for a merger to lead to partial simultaneous coordinated and non-coordinated effects.

A numerical example was provided, showing that a merger could lead to partial collusion. Simply comparing market shares or the Herfindahl-Hirschman Index would not raise any serious concerns about the merger, while the partial collusion that emerged indeed had a negative effect on total welfare.

Some implications may be drawn. Though collusion is treated in both the European and U.S. Merger Guidelines, it may be worth considering partial collusion as a follow-up phenomenon of a merger more explicitly. The economic environment, especially regarding market share, may be unsuitable for a cartel or collusion involving all firms. It may, however, be just suitable for partial collusion, which could cause considerable economic damage. Mergers in which maverick firms are eliminated from the market are equally suitable to promote partial collusion as mergers between two firms that seem to be unrelated. A practical example of the former can be found in the developments of the German cement market. After the takeover of what can be seen as the maverick firm *Readymix* which deviated from the prior cartel agreement, partial tacit collusion emerged.

The analysis showed that, in addition to heterogeneous capacities, heterogeneous discount factors are necessary for a merger in a copmetetive market to lead to partial collusion. Lessening the assumptions on demand, costs and discount factors would further increase the applicability of the model. After all, a model which may theoretically predict the actual outcome of a merger would be very useful. With such a model, the process of accepting or rejecting a merger would be greatly improved.

A Proofs

3.1. Outside firms may earn positive profits by charging the collusive price p_κ as well. Assume now that a single firm charges a price $p_\jmath > p(\kappa)$. This approach is not profitable as, according to 2.4, firm i would see no demand. Assume next that a set of at least two outside firms $\Omega(p_o)$ charge a price $p_o > p(\kappa)$. Each firm in $\Omega(p_o)$ may now raise its profit by undercutting p_o by ϵ. When $\epsilon \to 0$, the profit margin virtually stays the same while the demand increases substantially. As p_o is the highest price, the firms in $\Omega(p_o)$ must have excess capacity and would profit from undercutting the price p_o. Charging a price $p_o > p(\kappa)$ therefore cannot result in an equilibrium. Assume now that all outside firms charge a price of $p_o = p(\kappa) - \epsilon$. If $\sum_{j \notin \kappa} k_j \leq D(p(\kappa))$, then no single outside firm and no group of outside firms has an incentive to undercut the price p_o. While the profit margin would decrease, no additional demand could be attracted as the outside firms already produce up to capacity. Undercutting the price of $p_o = p(\kappa) - \epsilon$ cannot result in an equilibrium. If outside firms charge the collusive price $p(\kappa)$, they would share demand with the collusive set, and profits would thereby decrease. If $\sum_{j \notin \kappa} k_j \leq D(p(\kappa))$, the equilibrium price of outsiders, therefore, is $p_o = p(\kappa) - \epsilon$. □

3.1. It is assumed that $k_i \in (0, D(c))$. If $k_{\min}(\kappa) \geq \frac{D(c)}{2}$, then no capacity satisfies the condition for an unconstrained optimisation of the collusive profit. This is the case if

$$\begin{aligned}\hat{k}_{\min}(\kappa) = \frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{2K_\kappa(\kappa)}\right) > \frac{D(c)}{2}\\ K_o(\kappa) > D(c).\end{aligned}$$

□

3.2.

$$V\left(\bar{p}(\kappa)\right) = \sum_{i=1}^{m} -\frac{\left(\delta_{\min}(\kappa) - 1\right)\left(-K_\kappa(\kappa)\delta_{\min}(\kappa) + K - D(c)\right)k_i}{b\left(\delta_i - 1\right)}$$

is positive if the second parenthesis in the numerator is negative, so

$$\begin{aligned}-K_\kappa(\kappa)\delta_{\min}(\kappa) + K - D(c) < 0\\ \delta_{\min}(\kappa)K_\kappa(\kappa) > K - D(c).\end{aligned}$$

Substituting the smallest discount factor with the respective capacity yields

$$
\begin{aligned}
\frac{2k_{\min}(\kappa)}{D(c)}K_\kappa(\kappa) &> K - D(c) \\
k_{\min}(\kappa) &> \frac{D(c)(K - D(c))}{2K_\kappa(\kappa)} \\
k_{\min}(\kappa) &> \frac{D(c)}{2}\frac{K_\kappa(\kappa) + K_o(\kappa) - D(c)}{K_\kappa(\kappa)} \\
k_{\min}(\kappa) &> \bar{k}_{\min}(\kappa) := \frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{K_\kappa(\kappa)}\right)
\end{aligned}
$$

which is the condition stated in 3.2. □

3.3. The difference between the two prices is non-positive if

$$
\begin{aligned}
0 &\geq \hat{p} - \bar{p} \\
0 &\geq \frac{a + bc - K_o(\kappa)}{2b} - \frac{-K + K_\kappa(\kappa)\delta_{\min}(\kappa) + a}{b} \\
\delta_{\min}(\kappa) &\geq \frac{K + K_\kappa(\kappa) - D(c)}{2K_\kappa(\kappa)} \\
k_{\min}(\kappa) &\geq \hat{k}_{\min}(\kappa) := \frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{2K_\kappa(\kappa)}\right).
\end{aligned}
$$

□

3.4. The condition for profitable collusion that is bound by the constraint (stated in 3.2) is lower than the condition that identifies if the collusive set is not bound by the constraint (stated in 3.3) if

$$
\begin{aligned}
\bar{k}_{\min}(\kappa) &< \hat{k}_{\min}(\kappa) \\
\frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{K_\kappa(\kappa)}\right) &< \frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{2K_\kappa(\kappa)}\right) \\
\frac{D(c) - K_o(\kappa)}{K_\kappa(\kappa)} &> \frac{D(c) - K_o(\kappa)}{2K_\kappa(\kappa)} \\
1 &> \frac{1}{2}
\end{aligned}
$$

which is true as long as $D(c) - K_o(\kappa) \geq 0$. □

3.5. It is clear that for any unprofitable collusive set, that is a collusive set for which $k_{\min}(\kappa) \leq \bar{k}_{\min}(\kappa)$, the constraint is always binding. Substituting the discount factor for the capacity yields

$$
\begin{aligned}
c \geq \bar{p} &\leq \frac{-K + K_\kappa(\kappa)\delta_{\min}(\kappa) + a}{b} \\
c &\geq \frac{a-K}{b} + \frac{K_\kappa(\kappa)}{b}\frac{2k_{\min}(\kappa)}{D(c)}.
\end{aligned}
$$

We know that if $k_{\min}(\kappa)$ decreases, then $\bar{p}(\kappa)$ decreases because $\frac{\partial \bar{p}(\kappa)}{\partial k_{\min}(\kappa)} > 0$. The highest value that $k_{\min}(\kappa)$ can take is just the condition for a profitable collusive set itself. If $k_{\min}(\kappa)$ would be higher, then the collusion would not be unprofitable. Substituting in the condition yields

$$
\begin{aligned}
c &\geq \frac{a-K}{b} + \frac{2K_\kappa(\kappa)}{bD(c)}\left[\frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{K_\kappa(\kappa)}\right)\right] \\
c &\geq \frac{a-K}{b} + \frac{K - D(c)}{b} = c
\end{aligned}
$$

which is always true. □

4.1. Assume that at least one collusive set κ operates profitably. If it is the only profitable collusive set, then it is internally and externally stable as members of the collusive set have no incentive to deviate from the collusive price and outside firms have no incentive to join in the collusion. If there are several profitable collusive sets, then the algorithm in D'Aspremont et al. (1983, p. 22) assures the existence of a stable collusive set. We know that all profitable collusive sets, which consist of exactly two firms, are internally stable as deviating from the collusive price would lead to the reversion to the static Nash equilibrium with profits of zero. If at least one of those sets is externally stable, then a stable collusive set is found. If none of these sets are externally stable, then all profitable collusive sets of size three are internally stable. Again, if at least one of those sets is also externally stable, then we have found a stable collusive set. This procedure is repeated until we reach the point where all firms collude – internally stable because of the use of the algorithm and externally stable as no outside firm can join in the collusion. Therefore, at least one stable collusive set must exist if there is to be at least one profitable collusive set. □

5.1. $\bar{k}_{\min}(\kappa)$ in 3.4 describes the condition for which a collusive set operates profitably. Consider a merger between the firms m and a with $m, a \in I$ to firm $ma \in ma \cup I \setminus \{m, a\}$. There are two ways in which a merger may change the condition for a profitable collusive set. First, let $a, o \in \kappa$ with $k_a > k_o = k_{\min}(\kappa)$ and $m \notin \kappa$ and o is another non-merging firm. The critical capacity that is necessary for a profitable collusive set lowers through this merger if

$$\begin{aligned}
\frac{D(c)}{2}\left(1 - \frac{D(c) - K_o(\kappa)}{K_\kappa(\kappa)}\right) &\geq \frac{D(c)}{2}\left(1 - \frac{D(c) - (K_o(\kappa) - k_m)}{K_\kappa(\kappa) + k_m}\right) \\
K_\kappa(\kappa)(D(c) - (K_o(\kappa) - k_m)) &\geq (K_\kappa(\kappa) + k_m)(D(c) - K_o(\kappa)) \\
K &\geq D(c)
\end{aligned}$$

which is true by 2.4. If k_o is sufficiently close to the condition, then post-merger collusion will be profitable. For the second possibility let firms $a, m, o \in \kappa$ with $k_m > k_{\min}(\kappa \setminus a) = k_o > k_{\min}(\kappa) = k_a$. As $k_{ma} > k_a < k_o$, $k_{\min}(\kappa)$ will increase post-merger either way. If k_a is sufficiently close to the condition, then post-merger collusion will be profitable.

□

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