The Economics of Tacit Collusion

Marc Ivaldi, Bruno Jullien, Patrick Rey, Paul Seabright, Jean Tirole

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I. Introduction

As mentioned in a companion report,[1] there are at least two ways in which competition may be threatened, other than by single dominant firms. A first situation is when market concentration is high enough for non-competitive outcomes to result from the individual profit-maximising responses of firms to market conditions (from what can be called "individual rivalry", in other words); in such a situation, firms may be able to exert some market power, even when none of the firms would be considered individually dominant. The second way in which competition may be threatened is when a number of firms engage in what economists refer to as tacit collusion,[2] as a result of which their behaviour may approximate that of a single dominant firm; tacit collusion has been dealt with under the notion of collective dominance in a number of important Court decisions and corresponds to the "coordinated effects" studied in the US. Our companion report proposes an overview of these two threats to competition and of their implications for merger control, as well as a detailed economic analysis of the impact of mergers on market power in oligopolistic industries (Section II) and of the quantitative approaches

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[1] See our report on "The Economics of Unilateral Effects."

[2] "Tacit collusion" need not involve any "collusion" in the legal sense, and in particular need involve no communication between the parties. It is referred to as tacit collusion only because the outcome (in terms of prices set or quantities produced, for example) may well resemble that of explicit collusion or even of an official cartel. A better term from a legal perspective might be "tacit coordination". In the rest of this paper we shall continue to refer to tacit collusion as this better reflects the terminology in the economic literature, but at no point does our analysis presuppose that the collusion is explicit.

that can be used to estimate these impacts empirically. The present report focuses instead on the economic analysis of the impact of mergers on tacit collusion.

II. The economics of tacit collusion

We now turn to the economics of collusion. Collusion can take many forms. It can be explicit, tacit, or any combination of the two. However, since explicit collusion is usually banned by antitrust law, we will focus here on the possibility of tacit collusion. As already mentioned, tacit collusion is a market conduct that enables firms to obtain supra-normal profits, where "normal" profits corresponds to the equilibrium situation described in the Section II above. Tacit collusion can arise when firms interact repeatedly. They may then be able to maintain higher prices by tacitly agreeing that any deviation from the collusive path would trigger some retaliation. For being sustainable, retaliation must be sufficiently likely and costly to outweigh the short-term benefits from "cheating" on the collusive path. These short-term benefits, as well as the magnitude and likelihood of retaliation, depend in turn on the characteristics of the industry.

Retaliation refers to the firms' reaction to a deviation from the collusive path. To be effective, retaliation must imply a significant profit loss for the deviating firm, compared with the profit that it would have obtained by sticking to the collusive path. As such it can take many forms, some being more effective than others.

A simple form of retaliation consists in the breakdown of collusion and the restoration of "normal" competition and profits. Firms then anticipate that collusive prices will be maintained as long as none of them deviates, but if one attempts to reap short-term profits by undercutting prices, they will be no more collusion in the future. Firms may then abide to the current collusive prices in order to keep the collusion going, in which case collusion is self-sustaining. This form of collusion has a simple interpretation: firms trust each other to maintain collusive prices; but if one of them deviates, trust vanishes and all firms start acting in their short-term interest. However, there may be more effective ways to support a collusive conduct. That is, more sophisticated forms of retaliation may inflict tougher punishments and thereby allow sustaining higher collusive prices. For example, retaliation may include temporary price wars, leading to profits below "normal" levels for some period of time.[3] It may also include actions that are specifically targeted at reducing the profits of the deviant firm. For example, in *Compagnie Maritime Belge* (case C-395/96P), it was argued that shipping companies chartered "fighting ships" that were specifically designed to compete head to head against the ships of a targeted company.

The multiplicity of retaliation and collusive mechanisms creates a potential for collusion in many industries. The main issue is how large is this potential, that is, how credible are the collusive mechanisms and to what extent is collusion likely to emerge. While economic theory provides many insights on the nature of tacitly collusive conducts, it says little on how a particular industry will or will not coordinate on a collusive equilibrium, and on which one.[4] The common feature of retaliation mechanisms is however that they must be effective in preventing firms from deviating, which implies two conditions:

i) The profit loss imposed on a deviant firm by retaliation must be sufficiently large to prevent deviations;

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[3] See for instance the work of Porter (1983) on the Joint Executive Committee for the rail-roads industry in the 1880s.

[4] Theory points to the possible equilibria of an industry, including collusive ones, but so far it does not predict which of these equilibria will emerge. See for example Fudenberg and Maskin (1986).

ii) It must be in the best interest of the firms to carry on the retaliation once a deviation has occurred.

The second condition can be difficult to assess, because retaliation is itself an equilibrium phenomenon. For example, the possibility always exists, as in the above self-sustaining scenario, to simply revert to "normal" competition; however, such retaliation may not be sufficiently effective, that is, the "punishment" it inflicts may not be sufficient to deter deviations. Effective retaliation must then involve actions that are costly for the firms, in the sense that they are not in the firms' short-term interest; there must however be a long-term rationale for these actions.

Economic analysis allows a better understanding of the basic nature of retaliation mechanisms and their common features. It so provides key insights about the structural characteristics that affect the effectiveness of collusive and retaliatory conducts. We shall concentrate on these aspects and discuss the various factors to be considered when evaluating the potential for collusion.

As already stressed, collusion arises from dynamic interaction. When deciding whether to stick to a collusive price or deviate, firms must conjecture the future conduct of their competitors. Collusion emerges when firms conjecture that any attempt to undercut the collusive price will be followed by tough retaliation from competitors. Since retaliation arises in the future while deviations generate immediate profits, the ability to collude depends in turn on the relative importance of current profits compared to future profits in the firms' objective, as reflected by their discount factor:[5]

[5] The discount factor δ represents the weight that the firms place on future profits: 1 € in the next period corresponds to δ € in the present period; firms thus weigh the

Collusion is sustainable if and only if firms put sufficient weight on future profits, i.e., if their discount factor is not too small.

To illustrate the effects and the factors affecting collusion, we will use as a base case the situation where firms sell a homogenous product with the same unit variable cost.

Homogeneous product Suppose for example that two firms produce the same good with the same unit variable cost c. Price competition would then lead these firms to price at cost ($p = c$) and dissipate any supra-competitive profits. Now, if these firms compete repeatedly they may be able to sustain a higher ("collusive") price $p^C > c$, sharing the market and earning half of $\pi^C = (p^C - c)D(p^C)$ each, by reaching a tacit understanding that any deviation from this price would trigger a price war, that is here, would lead the firms to revert to the competitive price $p = c$.[6] If the firms have the same discount factor δ, by sticking to the collusive price, each would earn

profits in T periods with a multiplicative factor δ^T. If firms face no risk and have free access to a credit market with interest rate R, 1 € today corresponds to $1+R$ € tomorrow and the discount factor is thus equal to $\delta = 1/(1+R)$.

[6] See Friedman (1971).

$$\frac{\pi^C}{2} + \delta\frac{\pi^C}{2} + \delta^2\frac{\pi^C}{2} + ... = \frac{\pi^C}{2}\left(1 + \delta + \delta^2 + ...\right).$$

If instead one firm slightly undercuts the other,[7] it captures the entire market and thus the entire collusive profit π^C, but the ensuing price war will eliminate any future profit. Each firm is thus willing to stick to the collusive price if

$$\frac{\pi^C}{2}\left(1 + \delta + \delta^2 + ...\right) \geq \pi^C + \delta \times 0 \tag{1}$$

that is, if [8]

$$\delta \geq \delta^* \equiv \frac{1}{2}. \tag{2}$$

In this base case, firms are able to sustain collusion when the weight they put on future profits, measured by their discount factor, is above a certain threshold. This critical threshold for the discount factor, δ^*, which is here equal to 1/2, thus summarizes the

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[7] It is easy to check that this is the best deviation as long as the collusive price does not exceed the monopoly price. Since any deviation will trigger a price war, the best deviation maximises the short-term profits; it thus consists in slightly undercutting the collusive price if it is lower than the monopoly price, and in simply charging the monopoly price otherwise.

[8] This uses the fact that $(1 - \delta)(1 + \delta + \delta^2 + ...) = 1 - \delta + \delta - \delta^2 + ... = 1$. Hence, multiplying by $1 - \delta$ and dividing by π^C, the above condition yields $1/2 \geq 1 - \delta$.

relevant industry characteristics for the sustainability of collusion. In this base case, if firms' discount factor lies above the threshold, any collusive price can be sustained, even the monopoly price. If instead the discount factor lies below this threshold, no collusion is sustainable: competition induces firms to price at cost in each and every period. The critical threshold δ* thus tells us how "easy" it is to sustain collusion.[9] Collusion is easier to sustain when this threshold is lower (then, even "impatient" firms with a lower discount factor could sustain collusion), and more difficult to sustain if this threshold is higher (in that case, even firms that place a substantial weight on future profits might not be able to sustain collusion). The determination of this critical threshold thus provides a natural way for assessing the scope for collusion. That is, in order to measure the influence of the industry characteristics on the likelihood of collusion, we can look at how these industry characteristics would affect this critical threshold. A facilitating factor will reduce this critical threshold, while an industry characteristic that makes collusion more difficult will raise it.

[9] This « knife-edge » configuration (no collusion or full collusion if the discount factor is lower or higher than the critical threshold) is specific to this particularly simple example. What is robust is that "no collusion" is sustainable if firms are highly impatient (very small discount factor, δ close to zero) and that "full collusion" (i.e., monopoly outcome) is sustainable when firms are very patient (large discount factor, δ close to 1). There would thus exist two thresholds, one below which no collusion is sustainable, and one above which full collusion is sustainable. Between these two thresholds, "more collusion" is achievable as the discount factor increases, that is, firms can sustain higher prices when they have a higher discount factor.

We review below the main relevant characteristics and discuss their impact on the sustainability of collusion, mainly by looking at how these factors affect the above threshold. We then draw some implications for merger policy.

III. Relevant factors for collusion

Many characteristics can affect the sustainability of collusion. First, there are some basic structural variables, such as the number of competitors, entry barriers, how frequently firms interact, and market transparency. Second, there are characteristics about the demand side: is the market growing, stagnating, or declining? Are there significant fluctuations or business cycles? Third, there are characteristics about the supply side: Is the market driven by technology and innovation, or is it a mature industry with stable technologies? Are firms in a symmetric situation, with similar costs and production capacities, or are there significant differences across firms? Do firms offer similar products, or is there substantial vertical or horizontal differentiation?

This section reviews the impact of these various industry characteristics. For expository purposes, we will use as much as possible the above duopoly base model, which we will extend to discuss each factor in turn.

1. *Number of competitors*

The number of competitors on the market is clearly an important factor. First, coordination is more difficult, the larger the number of parties involved, in particular when coordination is only based on a tacit common understanding of the market conducts underlying the sustainability of collusion. For example, identifying a "focal point", in terms of prices and market shares, may become less and less obvious, particularly when firms are not symmetric.[10]

Beyond the issue raised by the difficulty of reaching a consensus, there is another reason that makes it difficult to collude with too many competitors. Since firms must share the collusive profit, as the number of firms increases each firm gets a lower share of the pie. This has two implications. First, the gain from deviating increases for each firm since, by undercutting the collusive price, a firm can steal market shares from all its competitors; that is, having a smaller share each firm would gain more from capturing the entire market. Second, for each firm the long-term benefit of maintaining collusion is reduced, precisely because it gets a smaller share of the collusive profit. Thus the short-run gain from deviation increases, while at the same time the long-run benefit of maintaining collusion is reduced. It is thus more difficult to prevent firms from deviating.[11]

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[10] The idea that coordination is more difficult in larger groups is intuitive but there is little economic literature on this issue. See for example Compte and Jehiel (2001).

[11] This insight is valid when holding all other factors constant. The number of firms is however endogenous and reflects other structural factors such as barriers to entry and product differentiation.

For both of these reasons, it is easier to coordinate between the few:

Collusion is more difficult when there are more competitors.

Illustration

Consider the base case of a homogenous product with identical variable costs, but suppose now that there are n firms instead of only two. If they stick to a collusive price p^C, they each earn

$$\frac{\pi^C}{n} + \delta\frac{\pi^C}{n} + \delta^2\frac{\pi^C}{n} + ... = \frac{\pi^C}{n}\left(1 + \delta + \delta^2 + ...\right).$$

If instead one firm slightly undercuts the others, it will again obtain the entire collusive profit π^C but trigger a price war. Firms will thus be willing to stick to the collusive price if

$$\frac{\pi^C}{n}\left(1 + \delta + \delta^2 + ...\right) \geq \pi^C + \delta \times 0, \tag{3}$$

that is, if

$$\delta \geq \delta^*(n) \equiv 1 - \frac{1}{n}. \tag{4}$$

As before, collusion is sustainable if and only if firms put a sufficient weight on future profits. The critical threshold for the discount factor, δ^*, now depends on the number of firms: the more competitors there are, and the higher this threshold, meaning that collusion is less and less sustainable.[12] For example, the threshold increases from 1/2 = 0.50 to 1/3 = 0.67 when the number of competitors increases from 2 to 3. This means that if the firms' discount factor lies around 0.60, say, two "competitors" could in fact maintain the monopoly outcome but three or more competitors would have to price at cost.

When the discount factor simply reflects the interest rate (that is, $\delta = 1/(1+R)$), the above threshold can be expressed in terms of an equivalent threshold for the interest rate: collusion is sustainable when the interest rate is lower than

$$R \leq R^*(n) \equiv \frac{1}{n-1}. \tag{5}$$

Hence, raising the number of competitors from 2 to 3 would cut the interest rate threshold by half (from $R^*(2) = 1$ to $R^*(3) = 0.5$).

2. *Are market shares significant?*

It is often asserted that more symmetric market shares facilitate collusion. At first glance, this may seem justified since the firm with the lowest market share has more to gain from a deviation, and less to lose from retaliation.

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[12] Notice that the critical level does not depend on the market size, measured by π^C.

More specifically, suppose that there are two competitors with market shares $s \leq 1/2$ and $1 - s \geq 1/2$. The firm with the smaller market share s will then be willing to stick to the collusive price as long as

$$s\pi^C\left(1+\delta+\delta^2+\ldots\right) \geq \pi^C + \delta \times 0, \tag{6}$$

or, equivalently,

$$\left(1-s\right)\pi^C \leq \frac{\delta}{1-\delta}\left(s\pi^C - 0\right),$$

which in turn implies that

$$\delta \geq \delta^*\left(s\right) \equiv 1-s. \tag{7}$$

This threshold increases and collusion thus becomes more difficult when the smaller firm loses further market share, that is, when the two firms' market shares become more asymmetric.

However, market shares are largely endogenous. For example, in the hypothetical industry described above, where by assumption the firms produce the same good at the same constant marginal cost, there is no reason a priori for market shares to be symmetric. Put another way, when market shares are asymmetric in a given industry, one should suspect that firms have different (marginal) costs and/or provide differentiated goods or services. But then, the relevant question becomes the impact of these more profound asymmetries in cost or product range or quality. As we will see, these asymmetries tend indeed: (i) to hinder collusion; and (ii) to result in asymmetric market shares. Therefore:

While it may not constitute the main relevant factor for a correct analysis of an industry, market share asymmetry may reflect more profound and relevant asymmetries that tend to make collusion more difficult to sustain.

We will come back to this when discussing the underlying sources of asymmetry.

3. *Entry barriers facilitate collusion*

It should be clear that collusion is difficult to sustain if there are low barriers to entry. First, in the absence of entry barriers any attempt to maintain supra-competitive prices would trigger entry (e.g., short-term or "hit-and-run" entry strategies), which would erode the profitability of collusion. Second, the prospect of future entry tends to reduce the scope for retaliation, which in turns limits the sustainability of collusion. The basic idea is that firms have less to lose from future retaliation if entry occurs anyway. More precisely, the prospect of future entry does not affect the short-run benefit that a firm can obtain from a deviation, but it reduces the potential cost of deviation in terms of foregone future profits. Indeed, retaliation against a deviating firm is less significant if entry occurs, since entry dissipates profits irrespective of the past behaviour of incumbent firms. Firms are then more tempted to undercut collusive prices and the ability to collude thus declines when the likelihood of entry increases.

Illustration.

To see the latter effect in a simple way suppose that, in the above duopoly setup, with some probability μ a firm enters the market for one period and charges the competitive price, $p = c$; when entry does not occur (thus with probability $1 - \mu$), the two incumbents remain the sole competitors and can thus try to sustain some collusion.[13] To maximise the scope for collusion, the best scheme consists, when entry does not occur, in: (i) charging a collusive price p^C and dividing the corresponding profit π^C equally among the two incumbents, and (ii) reverting to the competitive price whenever an incumbent deviates from the monopoly price. Such collusion yields each incumbent a discounted profit equal to [14]

$$\frac{\pi^C}{2} + (1-\mu)\delta\frac{\pi^C}{2} + (1-\mu)\delta^2\frac{\pi^C}{2} + ... = \frac{\pi^C}{2} + (1-\mu)\frac{\delta}{1-\delta}\frac{\pi^C}{2}$$

and is thus sustainable if

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[13] This is a short-cut to reflect the competitive pressure exerted by entrants. Alternatively, suppose that when entry occurs, not one but two firms enter (again for one period) with the same cost than the incumbents. Then, when entry occurs, equilibrium prices are necessarily competitive (in particular, being short-term lived, the entrants cannot be included in a collusive scheme).

[14] This uses the fact that

$$\begin{aligned} 1 + (1-\mu)\delta + (1-\mu)\delta^2 + ... &= \mu + (1-\mu)\left(1 + \delta + \delta^2 + ...\right) \\ &= \mu + \frac{1-\mu}{1-\delta} = \frac{1-\mu\delta}{1-\delta}. \end{aligned}$$

$$\frac{\pi^C}{2} + (1-\mu)\frac{\delta}{1-\delta}\frac{\pi^C}{2} \geq \pi^C + \delta \times 0, \qquad (8)$$

that is, if

$$\delta \geq \delta^*(\mu) \equiv \frac{1}{2-\mu}. \qquad (9)$$

The critical threshold for the discount factor, δ^*, thus now increases with the probability μ of entry: the more likely entry is, the more difficult it is to sustain collusion.[15] This can be seen directly from condition (8): while each incumbent still has the same incentive to undercut the other when entry does not occur, a higher probability of entry reduces the collusive profits that the incumbents can expect to derive in the future and thus make the "cost" of a future price war (retaliation) less important. When the probability of entry becomes very high (that is, close to 1), the threshold δ^* approaches 1, meaning that it is almost impossible to sustain collusion.[16]

We have therefore:

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[15] The analysis assumed that entry could only occur in the future. If entry can also occur in the current period, collusion is sustainable if $\delta \geq \delta^* = (1+\mu)/2$, and the critical threshold (δ^*) thus still increases with the probability of entry (μ).

[16] When instead the probability of entry goes to zero, we are back to the benchmark case (see equation (2)) and the threshold δ^* reduces to $1/2$.

Collusion cannot be sustained in the absence of entry barriers and it is more difficult to sustain, the lower the entry barriers.

4. *Frequent interaction facilitates collusion*

As already mentioned, there is more scope for collusion when the same firms compete repeatedly. Relatedly, firms will find it easier to sustain collusion when they interact more frequently. The reason comes from the fact that firms can then react more quickly to a deviation by one of them. Therefore, retaliation can come sooner when firms interact more frequently.

To see this clearly, note first that firms could not tacitly collude if they did not anticipate interacting again in the future. Similarly, collusion is unlikely when firms interact only infrequently, since the short-term gains from undercutting a collusive price could then be "punished" only in a far future.[17]

This idea can be illustrated by the US government's practice[18] of buying vaccines in bulk in order to undo collusion. By buying in bulk, the government both increases the stakes of each procurement auction and makes these auctions less frequent, thereby limiting the interaction between the bidders. Therefore, increasing the stakes implies that

[17] Of course, other factors such as market transparency, which is discussed below, also affect the length of time before retaliation effectively occurs. But the point here is that retaliation will not even be feasible in the absence of frequent interaction.

[18] See Scherer (1980).

in each auction bidders have more to gain in the short-term from undercutting their rivals, and reducing the frequency of the auctions implies that retaliation can occur less rapidly. Both factors contribute indeed to hinder collusion.

Illustration.

To capture this simple idea, consider again our basic duopoly setup but assume now that firms compete only every *T* periods. That is, firms compete in periods 1, *T+1*, 2*T+1*, and so forth. A more frequent interaction means a smaller number of "waiting periods" *T*. Then, collusion is sustainable if

$$\frac{\pi^C}{2}\left(1+\delta^T+\delta^{2T}+\ldots\right)\geq\pi^C+\delta^T\times 0, \tag{10}$$

that is, if

$$\delta\geq\delta^*\left(T\right)\equiv\frac{1}{2^{1/T}}. \tag{11}$$

The critical threshold increases with *T*: when firms interact less often, the perceived cost of future retaliation is smaller, and thus collusion is more difficult to sustain.

A similar idea applies to the frequency of price adjustments. When prices adjust more frequently, retaliation will again come sooner; and in addition, a cheating firm will not be able to take advantage for as long a time as before of its cheating behaviour. Both factors contribute to hinder collusion. Thus, what matters most is not whether the firms are "selling" in each period or only every now and then, but how frequently they can adjust their prices. The more frequent price adjustments are, the easier it is to sustain collusion.

Illustration.

To see this, consider again the duopoly setup and assume now that firms "compete" in each period but fix their prices for T periods. That is, in period 1 firms set prices that remain valid in periods 1, 2, …, T; in period $T+1$ they set again prices valid for periods $T+1$, $T+2$,…, $2T$; and so forth. A more frequent interaction corresponds to less price rigidity, that is, to a smaller T. Collusion is then sustainable if

$$\frac{\pi^C}{2}\left(1+\delta+\delta^2+\ldots\right)\geq\pi^C\left(1+\delta+\delta^2+\ldots+\delta^{T-1}\right)+\delta^T\times 0, \qquad (12)$$

where the right-hand side reflects the fact that a cheating firm can benefit from undercutting its rivals for T periods before they react to its deviation. This condition yields the same threshold as above, namely

$$\delta\geq\delta^*\left(T\right)\equiv\frac{1}{2^{1/T}}. \qquad (13)$$

We thus have:

Frequent interaction and frequent price adjustments facilitate collusion.

5. *Market transparency facilitates collusion*

More frequent price adjustments give firms the physical possibility to quickly retaliate when one market participant undercuts the others. But such deviation must first be identified by the other participants. As a result, collusion can be difficult to sustain when individual prices are not readily observable and cannot be easily inferred from readily available market data. This, in turn, supposes that some uncertainty affects the market: otherwise any deviation would be detected by the rivals, who would perceive a reduction in their market share.

This observability problem has first been stressed by Stigler (1964)'s classic paper, and formally analysed by Green and Porter (1984) and Abreu, Pearce and Stachetti (1985):

The lack of transparency on prices and sales does not necessarily prevent collusion completely, but makes it both more difficult to sustain and more limited in scope.

We can illustrate with Tirole (1988)'s version of Green-Porter's model. Starting with the base duopoly model, suppose now that: (i) each firm only observes its own price and sales, but not the others'; and (ii) with some probability, demand vanishes (is equal to zero). Therefore, when a firm is unable to sell in a given period, it can either be because of “bad luck” (adverse shock on demand), or because another market participant has “cheated” (undercut the collusive price). As a consequence, perfect collusion is no longer possible. Perfect collusion would require firms to go on with the monopoly price, even after a shock on demand. But then, each firm would have an incentive to undercut the others – and blame the fact that the others did not sell on bad luck.

The best collusive scheme consists in: (i) start with the monopoly price, and maintain this price as long as each firm maintains its market share; (ii) whenever a firm is unable to sell, launch a price war for a limited number of time, namely, *T* periods, before reverting to the monopoly price. The price war is needed and must be sufficiently lengthy (and thus costly) to deter potential cheaters. But this price war can be triggered by pure bad luck, that is, simply because of an adverse shock on demand; firms have thus an incentive to limit the duration of the price wars to what is just sufficient to discipline the tacit conduct.

> More precisely, denoting by μ the probability of a demand shock, the expected discounted profit V generated by such a conduct is given by:
>
> $$V = (1-\mu)\left(\frac{\pi^C}{2} + \delta V\right) + \mu\delta^{T+1}V,$$
>
> where the two terms correspond respectively to what happens in without and with a shock on demand: in the absence of a shock, each firm gets half of the collusive profit and expects to maintain the collusive price in the next period; if the case of a shock, each firm is unable to sell and prices at cost for the following T periods, before returning to the monopoly price in period $T+2$. The above condition characterizes the expected discounted profit V, which is equal to

$$V = \frac{1-\mu}{1-\delta\left(1-\mu+\mu\delta^T\right)}\frac{\pi^C}{2}. \tag{14}$$

It is straightforward to check that this value V decreases with the probability of a bad shock (since it increases the likelihood of price wars) and with the duration T of the prices wars. Collusion is sustainable if

$$V = (1-\mu)\left(\frac{\pi^C}{2}+\delta V\right)+\mu\delta^{T+1}V \geq (1-\mu)\pi^C+\delta^{T+1}V, \tag{15}$$

where the right-hand side reflects the fact that undercutting the rival allows one firm to get the entire collusive profit in the current period (in the absence of a shock on demand) but triggers a price war with certainty. Condition (15) is equivalent to:

$$\delta\left(1-\delta^T\right)V \geq \frac{\pi^C}{2}, (16)$$

and thus (since the left-hand side decreases when T increases) requires price wars to be long enough.[19] An infinite price war (T infinite) would effectively "maintain" collusion (up to the first occurrence of a shock on demand) if (combining (15) and (16) for T infinite) if

$$\delta \geq \frac{1}{2(1-\mu)}, \tag{17}$$

[19] Longer price wars also reduce the value of the expected discounted profit (V). However, it can be checked, using the expression of V given by (14), that $(1-\delta^T)V$ indeed increases with T.

which requires the probability of demand shocks not to be too large.[20] If this condition is satisfied, the optimal collusive scheme consists in charging the monopoly price ($p^C = p^M$) and adjusting the duration of the necessary price wars to what is "just sufficient" to meet the no-cheating condition (16). In addition, when demand shocks are more likely (which can be interpreted as a further reduction of market transparency), the value V is reduced, implying that longer price wars are required to discipline potential cheaters.

With regard to transparency, we must stress that what matters is not what is directly observed by the firms, but what information firms can infer from available market data. When the market is stable, inferring deviations from collusive conduct is easier and requires less market data[21] than when the market is unstable.

Moreover the delay necessary to obtain reliable data on prices and quantities matters, as well as its nature. For example, professional associations sometimes publish information on prices, productions or capacity utilisation rates. It first matters whether this information is about aggregate or individual data, since in the latter case it is easier to identify a deviant firm.[22] The time lag elapsed between the pricing period and the

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[20] In particular, if this probability exceeds 50% the right-hand side in (17) exceeds 1.

[21] For example, in the above hypothetical industry, in the absence of any demand shock firms could perfectly detect any deviation by their rivals by simply looking at their own sales.

[22] See for example Kühn (2001).

publication period is also important. Even detailed information may not help to sustain collusion if it is available only after a long delay.

Finally, we should note that there is a link between the circumstances that make collusion difficult to enforce, and those that may make it difficult to coordinate on a collusive outcome in the first place. The harder it is to obtain data on prices and quantities, the harder it may be for the firms to work out, without explicit collusion, what would constitute a monopoly price. However, this equivalence is not precise. For instance, if the technology in the industry is fairly standard and the goods produced fairly homogeneous, the monopoly price may be fairly easy to work out even if there is no transparency about individual production levels. So collusion could be easy to coordinate upon but hard to enforce. Conversely, even in the presence of high transparency about individual production levels, when products are differentiated it may be difficult for the parties to be sure what counts as "not upsetting your competitors": does this just mean "avoiding price cuts" or also "avoiding quality improvements"? Does a Christmas promotion in a consumer goods industry fall within the spirit of tacit collusion? And so on. Thus collusion could be relatively easy to enforce once agreed but almost impossible to coordinate upon. Overall, these considerations suggest that, as with the number of firms in an industry, the lack of transparency that makes collusion hard to enforce *may* also make it hard to agree – but this is an intuitive conclusion on which there is little convincing scientific literature.

6. Demand growth

As stressed above, collusion is easier to sustain when short-term gains from a deviation are small compared with the cost of future retaliation. This implies that:

For a fixed number of market participants, collusion is easier to sustain in growing markets, where today's profits are small compared with tomorrow's ones.

Conversely, collusion is more difficult to sustain in declining markets, where tomorrow's profits (with or without retaliation) will be small anyway – in the limiting case where the market is on the verge of collapsing, there is almost no "future" and therefore no possibility to induce firms to stick to a collusive conduct.

Illustration.

To see this in a simple way suppose that, in our base duopoly model, demand "grows" steadily at a rate g; that is, in period $t = 0, 1, 2, \ldots$ demand is equal to $(1+g)^t D(p)$, where $D(p)$ represents the baseline demand function. The market is thus effectively growing when g is positive and declining when g is negative. By agreeing on a collusive price p^C, each firm gets in each period t a profit given by $(1+g)^t \pi^C/2$, with $\pi^C = (p^C - c)D(p^C)$. Collusion is therefore sustainable if

$$\frac{\pi^C}{2} + \delta(1+g)\frac{\pi^C}{2} + \delta^2(1+g)^2\frac{\pi^C}{2} + \ldots \geq \pi^C + \delta(1+g) \times 0, \qquad (18)$$

that is, if

$$\delta \geq \delta^*(g) = \frac{1}{2(1+g)}. \qquad (19)$$

Formally, this situation is equivalent to that of a stationary market, with a modified discount factor $\delta' = (1+g)\delta$ that accounts for market growth: future periods weigh more when the market grows (g positive) and weighs less when demand is vanishing (*g* negative). Thus, when the market is growing, collusion can be sustained even for lower values of the actual discount factor δ, provided that the adjusted factor $(1+g)\delta$ remains at a sufficient level.

The above analysis focuses on the specific impact of demand growth, assuming that the other characteristics of the industry (and in particular, the number of participants) are unaffected by the market growth. This conclusion appears somewhat at odds with some case courts and opinions expressed by the European Commission in guidelines.[23] Indeed demand growth is in practice often interpreted as a factor hindering collusion. One possible reason for this apparent discrepancy is that the above reasoning assumes that the number of market participants remains fixed despite market growth, while in practice, entry may be easier in growing markets.[24] As discussed above, the prospect of future entry then hinders the ability to collude. In this way, *market growth may be associated with market characteristics detrimental to collusion.* However, it may be useful to disentangle the intrinsic effect of market growth discussed above from the impact of entry and other factors, so as to assess their relative strengths. In markets with low entry barriers, market growth is indeed likely to generate entry, and the overall impact may well be detrimental to collusion. However, in those markets where entry barriers are high (e.g., because of needed patents), the intrinsic impact of market growth may prevail and facilitate collusion.

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[23] See for instance the recent guidelines for market definition in ...electronic communication markets.

[24] Market growth may also be the sign of a lack of maturity, or of a highly innovative market.

7. *Business cycles and demand fluctuations hinder collusion*

A corollary of the impact of growth and decline is that collusion is less sustainable in markets that are subject to demand fluctuations. The idea, formally captured by Rotenberg and Saloner (1986) and Haltiwanger and Harrington (1991), is that when the market is at a peak, short-term gains from a deviation are maximal while the potential cost of retaliation is at a minimum. Hence, collusion is more difficult to sustain in those times.

To see this, suppose that demand fluctuates from one period to another and, to fix ideas, assume for the moment that demand shocks are independent and identically distributed across periods. In this hypothetical scenario, firms know that they face an uncertain future, but in each period the prospects are the same; the probability of benefiting from a good shock is for example the same in each future period, and likewise for the probability of bad shocks. This in turn implies that the amount of future retaliation to which a firm exposes itself in each period, remains the same over time. However, in periods where demand is higher than average, the short-term benefits from a deviation are themselves higher than average. Therefore, in such a period, the firm must trade-off higher-than-average gains from deviation against a constant (and thus "average") level of punishment. Clearly, deviations are more tempting in such period and, by the same token, collusion is more difficult to sustain than in the absence of demand fluctuations, where both the short-term gains from deviations and retaliation possibility would always remain at an average level.

Illustration: demand fluctuations.

Suppose that, with equal probability, demand is either low and given by $(1-\varepsilon)D(p)$, or high and given by $(1+\varepsilon)D(p)$. On average, the expected demand is thus the same as in the previous base situation.[25] By sustaining a collusive price p^C, each firm thus gets an expected discounted profit

$$V = \frac{\pi^C}{2}\left(1+\delta+\ldots\right) = \frac{1}{1-\delta}\frac{\pi^C}{2}. \tag{20}$$

Collusion is sustainable when the short-term gains from stealing the rival's market share and profit is lower than the cost of future prices wars. Future price wars dissipate the expected rent δV, while the short-term gains from a deviation are clearly higher when demand is high (namely, $(1+\varepsilon)\pi^C/2$ instead of $(1-\varepsilon)\pi^C/2$); collusion is therefore sustainable if it is sustainable when demand is currently high:

$$\delta V = \frac{\delta}{1-\delta}\frac{\pi^C}{2} \geq \left(1+\varepsilon\right)\frac{\pi^C}{2}, \tag{21}$$

that is, if

$$\delta \geq \delta^*\left(\varepsilon\right) = \frac{1+\varepsilon}{2+\varepsilon}. \tag{22}$$

The threshold δ^* increases with the magnitude of demand fluctuations, measured here by ε.

As fluctuations gain in scale, collusion becomes more and more difficult to sustain, at least in those states where demand is especially high. Firms are then obliged to

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[25] The multiplicative form of demand shocks implies that the monopoly price remains the same over time: it maximises $(p-c)D(p)$.

collude “less” (by lowering the collusive price) or even abandon any collusion when demand is high. A similar analysis applies to more deterministic fluctuations, as for example in the case of seasonal or business cycles. There again, undercutting rivals is more tempting when demand is high. In addition, however, the perceived cost of future price wars is lower when the cycle is currently at its top, since retaliation will only occur later, thus in periods of lower demand.

Illustration: deterministic cycles.

Consider a highly simplified “cycle” where demand is alternatively low, given by $(1-\varepsilon)D(p)$, and high, given by $(1+\varepsilon)D(p)$. If firms sustain a collusive price p^C the expected discounted values of profits, evaluated when demand is high (V^+) and when it is low (V^-) are respectively characterized by

$$V^+ = (1+\varepsilon)\frac{\pi^C}{2} + \delta V^-, \quad V^- = (1-\varepsilon)\frac{\pi^C}{2} + \delta V^+, \tag{23}$$

which implies $V^+ \geq V \geq V^-$: the discounted value of the stream of profits is higher than average at the top of the cycle, and below than average at the bottom of the cycle. Collusion is again sustainable if it is so when demand is currently high, that is, at the top of the cycle; the sustainability condition (21) becomes:

$$\delta V^- \geq (1+\varepsilon)\frac{\pi^C}{2}. \tag{24}$$

This condition is more stringent than the condition (21) obtained in the previous example of random fluctuations: At the top this deterministic cycle, not only the short-term gains from a deviation are high ($(1+\varepsilon)\pi^C/2$ instead of $(1-\varepsilon)\pi^C/2$, since demand is currently high), but the cost of retaliation, which will start when demand is low, is itself lower (δV^- instead of δV^+). Conversely, of course, collusion is easier to sustain at the bottom of the cycle. However, overall, collusion remains more difficult to sustain than in the absence of any fluctuation. The threshold derived from condition (21) is higher than the one for random fluctuations, given by (22), and increases with ε. The same analysis applies to longer cycles. Then, collusion is most difficult at the beginning of recessions, when demand is still high but declining.

The lesson from this analysis is that *demand fluctuations hinder collusion, and more so when fluctuations are deterministic (as in the case of seasonal cycles) rather than random.*

8. *Collusion is more difficult in innovative markets*

Innovation makes collusion on prices less easy to sustain. The reason is that innovation, particularly drastic ones, may allow one firm to gain a significant advantage over its rivals. This prospect reduces both the value of future collusion and the amount of harm that rivals will be able to inflict if the need arises.

This idea is actually a particular variant than the more general point about cost asymmetry, but can already be captured here in a simple way. Consider an industry where, in the absence of any innovative activity, the incumbents would benefit from a secure, stable situation. They would then hesitate before cheating on a collusive conduct, which would trigger a price war and dissipate their future rents. Suppose now that, with some probability, one incumbent makes a drastic innovation, which drives its rival out of the market. If the probability of successful innovation is substantial, the incumbents then anticipate that their market position is short-lived (at least in expected terms); they thus put less emphasis on the cost of future retaliation and are more tempted to cheat on collusion.

Illustration.

Consider for example a duopoly where, with probability ρ, one of the incumbents (either one, with equal probability) can obtain the drastic innovation, and denote by V^I the corresponding expected rent. As long as no innovation arises, by sustaining a collusive price p^C each incumbent gets an expected rent given by[26]

$$\begin{aligned} V^C &= \frac{\pi^C}{2} + \delta\left[\frac{\rho}{2}V^I + \frac{\rho}{2}\times 0 + (1-\rho)\frac{\pi^C}{2}\right] + \delta^2(1-\rho)\left[\frac{\rho}{2}V^I + \frac{\rho}{2}\times 0 + (1-\rho)\frac{\pi^C}{2}\right] + \dots \\ &= \frac{\pi^C}{2}\left(\frac{1}{1-\delta(1-\rho)}\right) + \delta\frac{\rho}{2}V^I\left(\frac{1}{1-\delta(1-\rho)}\right). \end{aligned} \quad (25)$$

If, instead, one firm undercuts its rival, it gains the whole profit π^C in the short-term but triggers a price war in the future, which means it gets zero profits in the subsequent periods, unless it obtains a drastic innovation (which can happen with probability $\rho/2$ in each of the periods following its deviation). Hence, the deviant

[26] In the absence of innovation, the two incumbents share the collusive profit π^C. Then, in the next periods one innovator obtains a drastic innovation with probability $\rho/2$ and no innovation occurs with probability 1-ρ.

firm expected gains are as follows

$$V^D = \pi^C + \delta\left[\frac{\rho}{2}V^I + \frac{\rho}{2}\times 0 + (1-\rho)\times 0\right] + \delta^2(1-\rho)\left[\frac{\rho}{2}V^I + \frac{\rho}{2}\times 0 + (1-\rho)\times 0\right] + \ldots$$
$$= \pi^C + \delta\frac{\rho}{2}V^I\left(\frac{1}{1-\delta(1-\rho)}\right). \quad (26)$$

Collusion is thus sustainable if $V^C \geq V^D$, which boils down to

$$\delta \geq \delta^*(\rho) = \frac{1}{2(1-\rho)}, \quad (27)$$

and is thus more difficult to satisfy when the probability of innovation increases.

While we have considered here the case where innovation comes from the incumbents, a similar reasoning applies to the case when the innovation comes from an outsider: the reason is that retaliation is still less effective when an innovator arrives, whether the innovator is an incumbent or an outsider.

Illustration

Suppose now, in each period, with probability ρ an outside innovator can enter the market and "wipe out" the current incumbents. The incumbents thus survive in each period with probability *1-ρ*.[27] By sustaining a collusive price p^C, as long they survive the two incumbents get an expected rent given by

[27] The probability of surviving for *T* periods is thus $(1-\rho)^T$.

$$V = \frac{\pi^C}{2} + \delta(1-\rho)\frac{\pi^C}{2} + \delta^2(1-\rho)^2\frac{\pi^C}{2} + ... = \frac{1}{1-(1-\rho)\delta}\frac{\pi^C}{2}. \qquad (28)$$

Collusion is then sustainable when this rent exceeds the short-term profit from undercutting the rival, π^C. This sustainability condition amounts as before to[28]

$$\delta \geq \delta^*(\rho) = \frac{1}{2(1-\rho)}. \qquad (29)$$

Therefore, in both instances the same conclusion holds:

The more likely innovation is, the more difficult it is to sustain collusion.

Collusion is thus less of a concern for antitrust authorities in innovation-driven markets.

9. Cost asymmetries hinder collusion

Let us come back to our simplified duopoly model but assume that the two firms have different cost structures. The presence of such cost asymmetry has several

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[28] Formally, the situation is similar to the one where innovation never occurs, but incumbents' « effective » discount factor is reduced to $(1-\rho)\delta$.

implications.[29] First, firms may find it difficult to agree to a common pricing policy. Indeed, firms with a lower marginal cost will insist in lower prices than what the other firms would wish to sustain.[30] More generally, the diversity of cost structures may rule out any "focal point" in pricing policies and so exacerbate coordination problems. In addition, technical efficiency would require allocating market share to low-cost firms, but this would clearly be difficult to sustain in the absence of explicit agreements and side-transfers.[31]

Second, even if firms agree on a given collusive price, low-cost firms will again be more difficult to discipline, both because they might gain more from undercutting their rivals and because they have less to fear from a possible retaliation from high-cost firms.[32] To see this, let us come back to our simple duopoly model but assume that the

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[29] See Bain (1948) for an early discussion. Gertner (1994) validates this insight for environments with "immediate responses" where collusion is otherwise straightforward to achieve through simple price-matching strategies, even in the absence of repeated interaction.

[30] It is for example well-known that the monopoly price is an increasing function of the industry's marginal cost.

[31] Side-transfers need not be monetary, however. They may for example consist of in-kind compensations or, when the same firms are active in several markets, of concessions made in one of these other markets. Still, such collusion schemes are not very plausible in the absence of any explicit agreement, and thus go beyond the scope of this report. For a discussion of these issues, see Osborne and Pitchik (1983) and Schmalensee (1987).

[32] Mason, Phillips and Nowell (1992) note in experimental duopoly games that cooperation is more likely when players face symmetric production costs.

two firms have different unit costs, a low one c_L and a high one $c_H > c_L$; in addition, in order to simplify exposition, suppose that the demand is inelastic: firms can sell a total quantity D as long as the price does not exceed a reservation price r. This assumption implies that the monopoly price is equal to the customers' reservation price, r, whatever the firms' costs are. This eliminates the first issue mentioned above: the two firms would readily agree here that the best collusive price is $p^C = r$.

As just noted, the low-cost firm has less to fear from a price war, since it could serve the market at a price (slightly below) the other firm's cost. More generally, retaliation will be less effective when exerted by an inefficient firm against an efficient one, since the ability of the former to compete against the latter is limited. In particular, the inefficient firm will not be able to induce a substantial profit loss on the efficient one without imposing on itself an even larger burden. This means that the retaliations that the inefficient firm will be rationally willing to put in place will impose little discipline on the efficient firm. Thus the incentive to deviate from the collusive conduct of the low-cost firm will be larger than if it faced another low-cost firm.

Illustration.

Suppose for example that firms insist on equal market shares. The high-cost firm will be willing to sustain collusion if

$$\left(r-c_H\right)\frac{D}{2}\left(1+\delta+\ldots\right)\geq\left(r-c_H\right)D, \qquad (30)$$

that is,

$$\delta\geq\frac{1}{2}, \qquad (31)$$

while the low-cost firm will be willing to do so only if

$$\left(r-c_L\right)\frac{D}{2}\left(1+\delta+\ldots\right)\geq\left(r-c_L\right)D+\delta\left(c_H-c_L\right)D\left(1+\delta+\ldots\right). \qquad (32)$$

This condition is clearly more stringent, due to the fact that retaliation punishes less the low-cost firm. In particular, the low-cost firm would never agree to equal market sharing if c_H-c_L > $(r$-$c_L)/2$, since it would then gain more from a price war. We will thus focus on the case where the cost advantage is moderate, and index it by $\gamma = 2(c_H$-$c_L)/(r$-$c_L)$ (which we assume is lower than 1). The low-cost firm's no-cheating condition (33) then determines the threshold for the discount factor, below which collusion is not sustainable:

$$\delta\geq\delta^*\left(\gamma\right)=\frac{1}{2-\gamma} \qquad (33)$$

This threshold coincides with the standard one (1/2) when the two firms have the same cost, and increases with the magnitude of the cost difference, measured by γ. Cost asymmetry thus hinders collusion.

To better induce the low-cost firm to stick to the collusive conduct, firms can share the profits from collusion unevenly and grant larger profits for the low-cost firm. Since the incentives to deviate depend on the relative size of the collusive profits accruing to one firm, compared with the potential loss imposed by retaliation, firms that fear less retaliation must indeed have less short-run gains from deviations (by undercutting the others).

To achieve that, the two firms may tacitly grant a larger share of the market to the low-cost firm. However, while this helps sustaining collusion, it does not restore the same collusive possibilities as if the cost structure were symmetric. Indeed this helps providing incentives for the low-cost firms, but at the same time it affects the incentives of the high-cost firms. Thus there is a limit to the possible reallocation of market shares:

Compared to the case of symmetric cost structure, there is less scope for collusion with an asymmetric cost structure, and the most effective collusive conducts will involve asymmetric market shares, reflecting firms' costs.

Illustration.

When granting a market share $\alpha \geq 1/2$ to the low-cost firm, the incentive constraint of that firm becomes

$$(r-c_L)\alpha D(1+\delta+\ldots) \geq (r-c_L)D+\delta(c_H-c_L)D(1+\delta+\ldots) \qquad (34)$$

and is easier to satisfy, the larger the market share α. Of course, increasing the market share of the low-cost firm affects negatively the other firm's incentive constraint, which becomes

$$(r-c_H)(1-\alpha)D(1+\delta+\ldots) \geq (r-c_H)D. \qquad (35)$$

that is,

$$\delta \geq \alpha. \qquad (36)$$

The market sharing that maximises the scope for collusion thus consists in giving "as much as possible" to the low-cost firm while satisfying the other firm's incentive constraint, that is, $\alpha = \delta > 1/2$.[33]

This above example validates our previous claim that, while market shares are highly endogenous variables, market share asymmetry may still provide indirect evidence of more profound asymmetry that tends to hinder collusion.

The intuition that "it is easier to collude among equals" may also explain the informal discussions about the role of so-called "mavericks." A maverick firm can be interpreted as a firm with a drastically different cost structure, which is thus unwilling to participate to a collusive action.[34] Of course, this "asymmetry" can be along other dimensions (see below).

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[33] So doing reduces the critical discount factor threshold, from $\delta^* = 1/(2-\gamma)$ to $\delta^* = 1/(2-\gamma/2)$.

[34] A new entrant can also appear to destabilize a pre-entry collusive during a transition period, until a new collusive situation is reached. This is a rather different scenario, where the temporary absence of collusion simply reflects a tâtonnement process for reaching a new focal point.

10. Asymmetries in capacity constraints hinder collusion

The previous reasoning extends to other forms of differences in the cost structure, including differences in production capacities. Capacity constraints potentially affect the sustainability of collusion in two ways. First, a capacity-constrained firm has less to gain from undercutting its rivals. Second, capacity-constraints limit firms' retaliatory power. At first glance, capacity constraints thus appear to have an ambiguous effect on collusion, since they reduce both the incentives to deviate and the ability to punish such deviations. And indeed, studies that have focused on symmetric capacities[35] have confirmed this apparent ambiguity.[36]

What is less ambiguous, however, is the impact of an asymmetry in capacities. Compared with a situation where all firms face the same capacity constraints, increasing the capacity of one firm at the expense of the others both increases the first firm's incentive to undercut the others and limits these other firms' retaliatory power. Overall, therefore, introducing such asymmetry hinders collusion. This insight has been hinted at by several studies.[37] Lambson (1996) shows for example that introducing a slight

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[35] See e.g. Abreu (1986) for a symmetric Cournot context and Brock and Sheinkman (1985) for a first analysis of a symmetric Bertrand context, later extended by Lambson (1987).

[36] Brock and Scheinkman (1985) show for example in a linear model that, with exogenously given symmetric capacity constraints, the highest sustainable per capita profit varies non-monotonically with the number of firms.

[37] The first formal analysis of the impact of asymmetric capacity constraints on collusion is Lambson (1994), who provides some partial characterisations of optimal collusion schemes in this context.

asymmetry in capacities hinders tacit collusion; and Davidson and Deneckere (1984), (1990) and Pénard (1997) show that asymmetric capacities make collusion more difficult in duopolies, suing particular forms of collusive strategies.[38]

This insight has recently been explored in more detail by Compte *et al*. (2002), who show that the introduction of asymmetric capacities makes indeed collusion more difficult to sustain when the aggregate capacity is limited. To see this, consider a duopoly where the two firms face asymmetric capacity constraints: firm 1, say, benefits from a larger capacity (K_L) than firm 2 (K_S). Also, to simplify exposition, suppose that there are no variable costs and that demand is inelastic: in the absence of capacity constraints, the firms could sell a quantity D at any price lower than the customers' reservation price r. This assumption avoids here some intricacies about rationing schemes and residual demands.[39]

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[38] Davidson and Deneckere focus on grim-trigger strategies, while Pénard relies on maximal punishments (which can be sustained only if the asymmetry is small). See also Benoît and Krishna (1991), who show in a sequential duopoly that the second mover cannot enhance its gains from collusion by choosing a capacity different from the first mover's capacity.

[39] When a firm undercuts the other but has not enough capacity to serve the entire market, some customers cannot be served at the lower price. If customers' demands are heterogeneous, then who is served first at the lower price (e.g., the customers with the highest willingness to pay, or the ones with the lowest willingness to pay) affects the residual demand addressed to the high-price firm. Our demand assumption amounts to say that all customers have the same willingness to pay (the reservation price r) and thus bypasses this issue.

If the firms sustain the collusive price $p^C = r$ with market shares α_L and $\alpha_S = 1 - \alpha_L$,[40] each firm i gets a rent $\alpha_i D/(1-\delta)$. Instead, by undercutting its rival, a firm can sell at full capacity but is then exposed to retaliation. As already noted, the magnitude of this retaliation is itself affected by the capacity constraints. However, it can be expected that the smaller firm will be less able to harm the larger one, than the reverse.[41] Therefore, the larger firm is indeed more tempted to cheat on the collusive conduct: it gains more in the short-term, and has less to fear afterwards. As a consequence, to induce that firm to abide to collusion, it will be necessary to give it a higher market share.

> Suppose for example that, following a deviation, the two firms revert to standard price competition. The profits are then proportional to the production capacities. Since the short-term gains from undercutting the rival are also proportional to capacity, it implies that the overall discounted profit from a deviation is itself proportional to capacity. The best way to prevent both firms from deviating consists therefore in allocating market shares that are themselves proportional to production capacities: $\alpha_i = K_i/(K_L+K_S)$. The two firms' incentive conditions then coincide and determine the critical threshold for the discount factor:
>
> $$\delta \geq \delta^*(K_L, K_S) = \frac{K_L}{K_L + K_S} = \frac{1}{1+\lambda}, \tag{37}$$

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[40] We assume that the total capacity of the firms exceeds the market size; otherwise, there would be no effective competition (each firm could sell at full capacity at the monopoly price) and thus no need for collusion.

[41] This is for example the case under standard price competition, where profits are proportional to production capacities (see below).

where $\lambda = K_S/K_L$ represents the relative size of the small firm, compared with the larger one. This threshold coincides with the standard one (1/2) when the firms are symmetric (that is, $K_L = K_S$, and thus $\lambda = 1$) and increases with the asymmetry in production capacity: the smaller the relative size of the small firm, the higher the critical threshold δ^*.

Compte et al. (2002) generalise this result to an arbitrary number of firms: the above threshold remains relevant, interpreting K_S as the *aggregate* production capacity of all the smaller firms (that is, all the firms except the larger one), as long as this aggregate capacity does not exceed the market size.[42] Note that, in this situation, the total capacity of the market participants does not affect the scope for collusion.

When instead the small firms can altogether serve the entire market, the critical threshold only depends on the total capacity, and not on its distribution among the firms. This critical threshold actually increases with the total capacity. The reason is that, in this situation, retaliation possibilities are maximal – the "small firms" are together sufficiently large eliminate the largest firm if needs be. Therefore, any further increase in the production capacity of the firms only exacerbates their incentives to undercut their rivals, without any counterbalancing impact on retaliation power. In this situation, therefore, any

[42] The aggregate capacity of the small firms can however exceed the single capacity of the largest one.

additional extra capacity tends to make collusion more difficult (even in symmetric situations).[43]

11. Product differentiation

We have so far assumed that all firms were offering the same product (homogenous good market). In practice, firms often try to differentiate their offerings, and can do so in different ways.

One possibility is for a firm to develop a "better product"; this is what economists refer to as "vertical differentiation." In essence, firms are then in an asymmetric situation and the analysis is thus similar to that of asymmetric costs of production. A firm that has a better quality (possibly adjusted for the cost) is in a situation somewhat similar to that of a firm that would offer the same quality as the others, but at a lower cost. This firm would have more to gain from cheating on a collusive path (put another way, it may require setting a price that does not fully reflect the increase in quality), and it has less to fear from a possible retaliation from the other firms.

To see this more precisely, consider a duopoly with an inelastic demand where one firm offers a better quality (at the same cost c, for the sake of presentation), which translates into a monetary bonus b for its customers. That is, consumers are willing to pay r for the lower quality and $r+b$ for the higher quality. Collusive conducts must then

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[43] In these situations, excess capacities can thus make collusion more difficult to sustain. However, a merger that would merely redistribute this excess capacity may have little impact on the sustainability of collusion.

maintain a price differential of *b* between the two firms (otherwise, one firm would take over the entire market). For example, the firms could try to maintain a price of *r* for the low quality good and of *r+b* for the high quality good, whereas price competition would have the high-quality firm sell the entire market but at a lower price *c+b*.

This situation is formally equivalent to the one, already discussed, where the two firms offer the same quality but face different costs.[44] The conclusions of the previous discussion thus readily apply. The high quality firm is more tempted to cut prices, because it enjoys a higher margin and thus gains more from stealing any additional customer away from its rival. Therefore, to ease that firm's incentive constraint, collusive conducts will have to give a bigger market share to the high-quality firm. Still, the critical discount factor threshold will be higher, and thus:

When firms are differentiated by levels of quality, collusion is more difficult, the larger the competitive advantage of the high-quality firm.

Another and quite different form of product differentiation consists for the firms in offering different combinations of characteristics, possibly at comparable prices but targeted at different types of customers; this corresponds to the case of so-called horizontal differentiation. Such differentiation aims at segmenting customers, and to gain market power over specific customer segments by creating customer loyalty. Indeed, a customer may then be reluctant to switch away from its favourite brand, even it would

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[44] More precisely, the situation is formally the same as if consumers were willing to pay *r* for any of the products, but one firm faces a high cost $c_H = c$ whereas the other faces a low cost $c_L = c\text{-}b$.

benefit from a small price reduction by turning to an alternative brand. This segmentation strategy affects the scope for collusion in two ways. First, it limits the short-term gains from undercutting rivals, since it becomes more difficult to attract their customers. Second, it also limits the severity of price wars and thus the firms' ability to punish a potential deviation.

Overall, the impact of horizontal differentiation appears quite ambiguous.

And indeed, the economic work on this issue has shown that collusion may become easier or more difficult, depending on the exact nature of the competitive situation (e.g., competition in prices versus competition in quantity).[45] Raith (1996) notes however that *product differentiation may exacerbate informational problems in non-transparent markets*. That is, even if firms do not observe their rivals' prices or quantities, they may still be able to infer the relevant information from their own prices and quantities. But such inference may be easier to achieve when all firms offer the same goods than when they offer highly differentiated products. This may be one reason why antitrust authorities usually interpret product homogeneity as facilitating collusion.

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[45] See for example Ross (1992) and Martin (1993).

12. Multi-market contact

It is well recognised that firms can sustain collusion more easily when they are present on several markets.[46]

First, multi-market contact increases the frequency of the interaction between the firms.

Second, it may allow softening asymmetries that arise in individual markets. For example, one firm may have a competitive advantage in one market and its rival can have its own competitive advantage in another market. While a market-level analysis may then suggest that collusion is difficult to sustain, multi-market contact restores in such a case an overall symmetry that facilitates collusion.

Third, multi-market contact may allow the firms to sustain collusion in markets where the industry characteristics alone would not allow such collusion.

For example, suppose that two firms are in a duopoly situation in one market and face one more competitor in another market, and wish to sustain the same collusive profit π^C in these two markets. According to the above analysis, they could sustain collusion in the first market if their discount factor is higher than 1/2, but could not a priori collude in the second market if their discount factor is below 2/3. Yet, they can actually sustain collusion in both markets. The idea is that they can give a higher market share to the competitor in the second market, in order to induce it to collude, and rely on their interaction in the first market to discipline them.

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[46] The classic reference is Bernheim and Whinston (1990). See also Parker and Röller (1997) and Evans and Kessides (1994) for empirical evidence ;

Illustration.

Formally, they will need to leave a market share $\alpha = 1 - \delta$ to the competitor in the second market,[47] and will thus share the remaining fraction, δ, of that market. They will thus stick to the collusive path as long as

$$\left(\frac{1}{2}\pi^C + \frac{\delta}{2}\pi^C\right)\left(1+\delta+\delta^2+\ldots\right) \geq \pi^C + \pi^C + \delta \times 0, \qquad (38)$$

that is, if

$$\delta \geq \frac{3}{5} \qquad (39)$$

This threshold is higher than 1/2 but lower than 2/3; therefore, when firms have a discount factor between 5/12 and 2/3, they can sustain collusion in both markets even though they could not sustain collusion in the second market, if present only in that market. The intuition is that there is some slack in the sustainability of collusion in the first market, which the firms can use to facilitate collusion in the second market.

Therefore:

[47] That competitor will not deviate from collusion if $\alpha\pi^C(1+\delta+\delta^2+\ldots) = \alpha\pi^C/(1-\delta) \geq \pi^C$, that is, if $\alpha \geq 1 - \delta$.

Overall, multi-market contacts facilitates collusion.

13. Other factors

We have so far discussed the factors that have been identified in the economic literature as exercising a key influence on sustainability of collusion. In practice, other factors have often been mentioned or looked by competition authorities. These include the elasticity of the demand, the buying power of the customers, and so forth. We now briefly discuss each of these factors.

a) Demand elasticity

It is often perceived that low demand elasticity should exacerbate collusion concerns. While the above analysis stresses that the elasticity of the demand has no clear impact on the *sustainability* of collusive prices, it is however the case that collusion can be more profitable when demand elasticity is low.

To see this, let us come back to the basic duopoly model, where two firms producing the same good at the same cost *c* face a given demand *D(p)*. Standard competition would yield marginal cost pricing, that is, $p^c = c$, and thus zero profits. The two firms can however sustain *any collusive price* $p^C > c$ and thus share the corresponding profit $\pi^C = (p^C\text{-}c)D(p^C)$ if the short-term gains from a deviation are offset by the cost of a future price war, that is, if

$$\frac{\pi^C}{2}\left(1+\delta+\delta^2+...\right)\geq \pi^C+\delta\times 0, \tag{40}$$

or

$$\delta \geq \delta^* \equiv \frac{1}{2}. \tag{41}$$

We can see that the critical threshold for collusion does not depend on the characteristics of consumer demand – that is, the demand function *D(.)* does not contribute to determining this critical threshold. If the firms have a discount factor lower than ½, no collusion is sustainable and, whatever the shape of the demand, the only equilibrium yields the competitive price $p^c = c$. Conversely, if the discount factor of the firm exceeds ½, the firms can sustain any collusive price, even the monopoly price, whatever the shape of this demand function. Thus, demand elasticity has indeed no impact on the sustainability of collusion. This comes from the fact that demand elasticity (and more generally, the shape of consumer demand) affects in the same way both the short-term gains from undercutting rivals and the long-term cost of foregoing future collusion.

However, the shape of the demand does have an impact on *desired* collusive prices, as well as on the profitability of collusion. When picking a collusive price, the firms must trade-off the increased margins generated by higher prices with the reduction in sales that these higher prices would trigger. The industry's ideal collusive price is the monopoly price, p^M, which maximises the joint profit of the firms, $\pi^{joint} = (p\text{-}c)D(p)$. It is well-known that this price is higher when the demand elasticity is lower. More precisely, as shown in section II the monopoly price is such that the Lerner index is inversely proportional to the demand elasticity:

$$L = \frac{p^M - c}{p^M} = \frac{1}{\varepsilon\left(p^M\right)},$$

where the elasticity is given by *ε(p) = pD'(p)/D(p)*. This reflects the fact that, when demand is highly elastic, firms would lose too much sales if they tried to impose high prices. Conversely, if demand is low, then the firms can afford to maintain high prices without losing too many customers; the trade-off between sales and margins is then best solved for relatively high prices. *Therefore, for a given market size, the firms have more to gain from sustaining the monopoly price when demand elasticity is low.* In that sense, demand elasticity may constitute a relevant factor, although of a different nature than the factors listed above.[48] In addition, collusion is a larger concern for consumers when demand is inelastic than when it is elastic. This is both because the potential for a large profitable increase in prices above the "normal" level decreases when demand becomes less elastic, and because consumers are hurt more by a given price increase when they have little alternatives.[49]

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[48] The profitability of collusion can in turn influence the firms' willingness to design and implement practices that facilitate the implementation of a collusive action. It can also induce firms to engage in more explicit collusion, at the risk of being caught by antitrust enforcement. More generally, to the extent that "transactions costs" may affect the ease of identifying and coordinating upon tacitly collusive outcomes, as well as the ease of enforcing them, the profitability of the outcome is likely to increase the probability that the parties will find a way to reach it. Nevertheless, this remains an intuitive argument rather than one for which there exists any formal model.

[49] The potential harm to consumers is thus the larger, the less elastic is the demand. The impact on total welfare, however, is more ambiguous. The reason is that price increases generate less distortions when demand is inelastic (see e.g. Tirole (1988) for a discussion of this issue).

b) Buying power

A related factor concerns the countervailing buying power of the customers. If buyers are powerful, even a complete monopolist may find it difficult to impose high prices. The profitability of collusion is similarly reduced.

In addition, Snyder (1996) note that large buyers can successfully break collusion by concentrating their orders, in order to make firms' interaction less frequent and to increase the short-term gains from undercutting rivals; more generally, large buyers can design procurement schemes that reduce the scope for collusion.

c) Structural links

Structural links can facilitate collusion among firms. For example, cross-ownership reduces the gains derived from undercutting the other firm. Joint venture agreements can also enlarge the scope for retaliation – a firm can then for example punish a deviating partner by investing less in the venture.[50] For these reasons, collusion is more likely to appear in markets where competitors are tied through structural links.

[50] Martin (1995) provides a detailed analysis of this issue.

d) Cooperative and other contractual agreements

Even in the absence of structural links, simple cooperation agreements can contribute to foster collusion. As in the case of joint ventures, these cooperation agreements can for example enlarge the scope for retaliation, thereby enhancing the ability to punish deviating partners.

This may be particularly relevant for industries such as the telecommunications industry, where competitors need to reach interconnection agreements in order to offer good services. These agreements not only enlarge the scope for retaliation, they also have a direct impact on the operators' pricing strategies.[51] Competitors may then design these interconnection agreements so as to facilitate collusion.

More generally, firms may alter their contractual agreements, either between themselves or with third parties, so as to facilitate collusion. Marketing agreements can constitute good tools to that effect. Jullien and Rey (2002) show for example that producers of consumer goods can resort to Resale Price Maintenance to impose more uniform prices across local retail markets, thereby making it easier to detect deviations from a collusive price. Record companies have been accused to market their disks according to simple pricing grids (with only a few categories, instead of personalised prices for each author or composition) for a similar purpose.

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[51] For example, telecom operators that compete in linear prices could give each other incentives to maintain high prices, even in the absence of repeated interaction, by agreeing to a high reciprocal access charge – see e.g. Armstrong (1998) and Laffont *et al*. (1998).

e) The existence of a "maverick" firm

It is sometimes asserted that a particular firm acts as a "maverick" that discourages any attempt to sustain collusion. As already mentioned, this is in line with the economic intuition according to which "it is easier to collude among equals." The notion of maverick must however be defined properly. Consider for example a firm that has a drastically different cost structure, production capacity or product quality, or that is affected by different factors than the other market participants.[52] Very often such a firm will exhibit a market conduct that differs from others, reflecting its different supply conditions. This firm may then be unwilling to be part to a collusive conduct – put another way, it would do so only under terms that would not be acceptable or sustainable for the other firms. Alternatively, a firm may have a stronger preference for the short-term and be therefore more tempted to undercut the rivals.[53] The existence of such a "maverick" clearly tends to make collusion difficult if not impossible to sustain. It is however necessary to identify carefully the origin of the "maverick" character, in order to determine whether it is an inherent, long-lasting characteristic, or only reflects a transitory situation.

Example:

[52] A firm that use a different production technique than others will be affected by the price of different inputs, or the labour cost may fluctuate in a different manner.

[53] See Harrington (1989) for an analysis of collusion between firms that have different discount factors.

As for other types of asymmetry, the firms could grant a bigger share of the market to the firm with the lower discount factor; however, this has some limits since the other firms' incentives must be maintained as well.

Suppose there are three firms, the first two with a discount factor $\delta >$ 2/3 and the remaining one (the "maverick") with a discount factor $\delta' < 2/3$. Because of the maverick, a collusive path with equal market shares cannot be sustained: the maverick would deviate and undercut the others, since $\delta' < 2/3$ implies

$$\pi^C + \delta' \times 0 > \frac{1}{3}\frac{\pi^C}{1-\delta'}.$$

The minimal market share α that can be allocated to the first two firms must satisfy

$$\alpha \frac{\pi^C}{1-\delta} \geq \pi^C + \delta \times 0,$$

and is thus $\alpha = 1 - \delta$. The maximal market share that can be granted to the maverick is thus $1 - 2\alpha = 2\delta - 1$, which is higher than 1/3 but lower than 1. Therefore, collusion cannot be sustained if the maverick is sufficiently short-termist: this is the case when

$$\pi^C + \delta' \times 0 > (2\delta - 1)\frac{\pi^C}{1-\delta'},$$

that is, when the discount factor of the maverick is lower than $2(1-\delta)$.

f) Club and network effects

Some markets are subject to club or network effects, where consumers benefit from being in the same "club": using the same software, typing in the same keyboard pattern, subscribing to the same operator, and so forth.[54] Club effects have several relevant implications. They tilt the market in favour of a single participant, thereby creating a "winner-take-all" type of competition which is not prone to collusion. In addition, club effects create lock-ins effects that reinforce the position of the market leader and thus increase the benefits derived from such a position. Suppose then that firms try to maintain even market shares. Then, by undercutting its rivals a firm could trigger snow-balling effects that could easily tilt the market in its favour; the firm would thus secure a durable leadership position. Club effects therefore exacerbate the gains from undercutting the rivals and, at the same time, lock-in effects limit retaliation possibilities. Both factors contribute to make collusion less likely.

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[54] One important issue concerns the « compatibility » of rival clubs or networks. Club effects are fully internalised – and thus become irrelevant – when rival networks are fully compatible. This is for example the case in the telecommunications industry, where all operators are interconnected, so that subscribing to one or the other network does not affect who someone can communicate with. However, compatibility can be imperfect (e.g., some services can be proprietary) and pricing policies can also induce indirect club effects (for example, when it is cheaper to call subscribers of the same operator).

IV. Collusion in other dimensions than prices

1. Quantity competition

The conclusions derived above apply as well to situations where firms compete in quantity. In this case, a collusive conduct consists in reducing the levels of production below those that would constitute "normal" competitive levels, as discussed in Section II.1.2. Retaliation is triggered if one firm attempts increasing its market share by raising its production. A typical retaliation will have competitors react by raising their productions. This can again take the simple form of reverting to "normal" quantity competition, which involves a repeated equilibrium with higher production levels. But it can also correspond to a temporary large increase of the productions of competitors, above normal levels, that depresses prices and forces the deviating firm to reduce its own production by a large extent, thus selling little at a low price.

When discussing non-collusive oligopoly theory, we pointed out that the nature of competition is different under quantity competition than under price competition, and often less intense. Unfortunately, this has no simple and unambiguous implication for the scope of collusion, since quantity competition affects retaliation possibilities as well as the short-run gains of deviations from collusive conduct. Indeed, under quantity competition there is less temptation to increase one's production level to deviate from a tacitly collusive level, since prices will adjust to sell out the competitors' output. On its own this would make collusion easier to sustain. However, retaliation is somewhat more difficult under quantity competition since the firm that is the object of retaliation can always soften the blow (compared to a situation of price competition) by adapting its output level. Overall, since deviation is less tempting but the fear of retaliation less strong, it is not easy to compare the scope for collusion in the two forms of competition.

The mechanisms bear strong similarities, however, so that the factors discussed above affect the scope for collusion in the same manner.

2. Capacity, investment and prices

In some industries, capacity choices are determinant factors for the outcome of competition. This is the case for example in the chemical industry or in the paper industry.[55] In such industries, one may be concerned about the potential coordination of firm on collusive capacity choices. The role of excess capacities in supporting price collusion has been discussed above. Here, we focus instead on situations where firms produce close or up to full capacity utilisation. In this case, a reduction in capacity reduces supply and therefore implies higher prices. Collusion then consists in building less capacity, in order to constrain the subsequent prices. As stressed in section II, there is a close connection between this type of rivalry in capacity choices and competition in quantity. Thus, to a large extent the analysis of collusion under quantity competition applies to the analysis of collusion in capacities.

In particular, if capacities are short-lived, as for example in the *Airtour/FirstChoice* case, and if market conditions are indeed such that firms adjust their prices so as to sell up to capacity, capacity choices determine entirely output ones. In this case, a collusion in capacity is formally identical to a collusion on output levels, and thus to collusion with quantity competition.

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[55] The chemical industry is investigated by Gilbert and Lieberman (1987) and the newsprint industry is studied by Booth, Kanetkar and Whistler (1991), whereas Christensen and Caves (1997) investigate the pulp and paper industry.

In other cases, however, there exist some differences due to the nature of capacities and their interplay with price competition.

First, capacity choices are not final production decisions. Once capacities are in place, firms still interact through their pricing decisions. And they need not always reach a full capacity utilisation rate, in particular when demand is uncertain at the time capacity is built. This means that collusion on capacities will usually involve some form of collusion on prices as well. This is investigated in detail by Staiger and Wolak (1992). They characterize collusive conducts in the case where capacities are short lived and demand is fluctuating in an unpredictable manner. In this context they show that collusion can emerge, based on coordination on low capacity levels. Depending on the realized levels of demand, prices may then be collusive or not. In particular, when the realized demand is low and there is a large excess capacity, collusion on prices may be temporarily interrupted, without impeding collusion on capacities in future periods.

A second aspect is that often capacity choices are not a continuous phenomenon, but come in infrequent bursts, at points in times that may differ from one firm to another. Such choices then involve less frequent interactions than price decisions. As already pointed out, the infrequency of such interaction is a factor that impedes collusion. The "lumpiness" aspect of capacity building leads to pre-emption phenomena: when a market opportunity arises or simply when demand is growing, firms compete for being the first to build capacity. This is because if once a firm has already built a large capacity, its competitors have fewer incentives to add new capacities to the market, since this intensifies competition.

The last but not least aspect that differentiates capacity choices from production ones is that capacity choices often involve some irreversibility. When capacities stay in place for very long and demand is not growing too fast, the capacity choice of one firm affects the market for a very long time. In this context pre-emption phenomena may be particularly acute. Indeed, when capacity decisions are fully irreversible, a firm that deviates from a collusive conduct will impose a "fait accompli" on its competitors, who may have no choice left other than adapting themselves to this new situation. Investigating this aspect in the context of *UPM/Kymmene* (case COMP/M-2498), K.-U. Kuhn has shown that there is actually no scope for collusion when demand is constant over time and capacities do not depreciate.

Clearly, irreversibility may impede collusion. However irreversibility matters mostly when it is strong and when demand is constant or declining; in this context there is little or no prospect of building new capacities in the future, and thus little scope for repeated interaction. If instead demand is growing fast enough, or if capacities depreciate fast enough, irreversibility matters less because there will be frequent additions of capacities, even on a collusive capacity expansion path, which opens the scope for retaliation.[56]

For example, Jullien (2003) has shown (again in the context of *UPM/Kymmene*) that pre-emption has ambiguous consequences for collusion when demand grows or capacity depreciates. This comes from the fact that the possibility to pre-empt its rivals increases the potential gain of deviating and building extra capacity, but it also increases retaliation possibilities, since the deviating firm can itself be pre-empted in the future.

Therefore, overall:

While collusion in capacity expansion plans is similar in its nature to collusion under quantity competition, it is subject to more caveats. It is thus preferable to distinguish the two and to conduct a specific analysis accounting for the nature of the investment and the level of irreversibility.

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[56] They may limit retaliation to some extent, as a deviant firm cannot be forced to reduce its capacities below the irreversible level.

3. *Bidding markets*

The principles reviewed above apply to bidding markets as well. For example, collusion is easier when there are fewer bidders that repeatedly participate in the same bidding markets, when the frequency of these markets is high (e.g., daily markets), and so forth. In addition, however, bidding markets can be designed in ways that either hinder or facilitate collusion. For example, sealed bid auctions generate less information (that is, except if the auctioneer reveals the details of all the bids afterwards) than public descending procurement auctions, where sellers observe at each moment who is still bidding at the current price. Therefore, a close look at the organisation of the bidding markets may be necessary to assess the likelihood of collusion.[57]

4. *Research and Development*

Collusion on innovation strategies is subject to the observations made for the impact innovation and particularly complex to implement. It would suffer from substantial transparency problems, making it hard to monitor. The inherent uncertainty attached to R&D projects and the time lags usually involved would further contribute to

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[57] See e.g. Klemperer (2002).

make such collusion difficult. Collusion on R&D has thus to be considered as very unlikely.

V. Implications for merger control

The previous section has shown that many factors affect the sustainability of collusion. Most often, a given market will have some characteristics that facilitate collusion, and some that tend to hinder collusion. Predicting on this basis alone the likelihood of collusion can thus be complex.

In addition, a same market situation can give rise to many different equilibria. That is, the fact that firms *could* sustain collusion does not mean that they actually succeed in doing it. In particular, the firms may well compete in each period as if it were the last one, even if there exists another equilibrium in which they could maintain monopoly pricing in each and every period.[58] It is thus impossible to rely on a theoretical analysis alone to determine whether collusion is *actually* taking place. In an antitrust *ex post* context, the analysis of the past history of the industry can help answer that question. In a merger control context, the situation is different. The merger control office must

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[58] Technically speaking, repeated games tend to generate multiple of equilibria. In particular, the repetition of a static equilibrium of a one-shot game is also an equilibrium of the repeated game (it is even a « subgame-perfect » equilibrium, that is, an equilibrium that satisfies an additional credibility criterion). Therefore, any collusive pricing equilibrium comes *in addition* to the standard static equilibrium.

evaluate *ex ante* the future evolution of the industry; the past history may then only provide limited information to that effect (see the section on quantitative analyses).[59]

Short of determining whether collusion will indeed occur, a highly difficult if not impossible task, the merger control office can however address a different but still relevant question: will the merger create a situation where collusion becomes more likely, that is, will collusion significantly be easier to sustain in the post-merger situation?

A merger often affects many of the factors that are relevant for the sustainability of collusion and it can affect them in ways that tend to off-set each other. For example, a merger reduces the number of competitors, which tends to facilitate collusion, but it can make the remaining competitors more asymmetric, which tends to hinder collusion. The impact of the merger on collusion can thus involve a difficult assessment of possibly conflicting effects. Ideally, this could be done by building a "meta-model" encompassing all the relevant characteristics. However, the previous section makes clear that such a "global model" would probably not be tractable, and thus quite useless. It is therefore necessary to identify the characteristics that are most relevant in each particular industry, and also to prioritize these factors.

We first provide below the direct implications of the previous section, regarding the impact of a merger on each relevant characteristic of the industry. We then discuss a possible prioritisation of these effects.

[59] Past behaviour can however provide some information about specific characteristics of the market participants, which can for example be useful to identify whether firms are prone to collusion or of a "maverick" type.

1. *The impact of mergers on industry characteristics*

The previous section has outlined the importance of the following factors:

- Number of participants: a merger that eliminates one of the significant competitors contributes to make collusion more sustainable.
- Entry barriers: collusion is more of a concern in markets with high entry barriers. This has two implications. First, a merger that would raise entry barriers (e.g., by uniting two potentially competing technologies) would thus tend to facilitate collusion. Second, collusion should be a concern for merger control only in those markets where there are significant entry barriers in the post-merger situation.
- The frequency of interaction: collusion is easier when firms interact more frequently. This factor is less likely than others to be directly affected by a merger but is relevant to assess whether collusion is an important concern.
- Market transparency: collusion is easier when firms observe each other's prices and quantities. This factor thus contributes to determine whether collusion is an important concern; in addition, however, some mergers may have a direct impact on market transparency. For example, a vertical merger between a manufacturer and a distributor may allow the manufacturer to have better access to its rivals' marketing strategies.
- Demand characteristics: collusion is easier in growing markets (taking as given the number of competitors, that is, ignoring the possible positive effect of demand growth on entry) than in declining markets and in stable markets than in fluctuating markets. These factors are useful to assess the seriousness of the collusion concern but unlikely to be directly affected by a merger.

- Innovation: collusion is easier to sustain in mature markets where innovation plays little role than in innovation-driven markets. This is an important factor for assessing whether collusion is a serious concern. In addition, a merger that enhances the new entity's R&D potential may contribute to make collusion more difficult to sustain.
- Symmetry: it is easier to collude among equals, that is, among firms that have similar cost structures, similar production capacities, or offer similar ranges of products. This is a factor that is typically affected by a merger. Mergers that tend to restore symmetry can facilitate collusion, whereas those who create or exacerbate pre-existing asymmetry are more likely, ceteris paribus, to hinder collusion.
- Product homogeneity: we have noted that this factor has a more ambiguous impact on the likelihood of collusion, since it affects both the incentives to undercut the rivals and their ability to retaliate. Product differentiation can however have an impact when it contributes to introduce asymmetry between firms (e.g., when firms offer goods or services of different qualities); also, product homogeneity can make the market effectively more transparent. Overall, this factor, which is necessarily affected by mergers, can be useful to assess the plausibility of collusion.
- Multi-market contact: collusion is easier to achieve when the same competitors are present in several markets. Multi-market contact is thus relevant to assess the plausibility of collusion; in addition, a merger can increase significantly the number of markets on which the same firms are competing, in which case it may reinforce the possibility of collusion.
- Demand elasticity and buying power reduce the profitability of collusion; in addition, large buyers have more latitude to break collusion. This is mostly relevant to assess the potential relevance of collusion, although buyer mergers can also have a direct impact.
- Other factors are also relevant, such as the existence of structural links of cooperative agreements or of a "maverick" firm. Thus a merger – or a merger remedy – that would create such links or remove a maverick would

be more likely to facilitate collusion. The particular organisation of the markets (e.g., auction design for bidding markets) can be relevant to assess the plausibility of collusion.

2. Implications for merger control

While many factors appear relevant when evaluating the impact of a merger on collusion, the above overview highlights natural dividing lines among these factors.

First, some factors that may or may not be affected by the merger have a decisive impact on the firms' ability to sustain tacit collusion. These factors include *entry barriers*, the *frequency of interaction* and the role of *innovation*. Clearly, there is little scope of collusion in the absence of entry barriers, or if firms interact very infrequently, or else in innovation-driven markets. Therefore, whenever an industry presents one of these features, collusion is unlikely to constitute a significant concern.

Second, some factors are both relevant and likely to be directly affected by mergers. These factors include of course the number of market participants, but also the degree of symmetry among those participants. By eliminating a competitor, a merger reduces the number of participants and thereby tends to facilitate collusion. This effect is likely to be the higher, the smaller the number of participants already left in the market.

Example: The impact of a reduction in the number of competitors

Consider a simple oligopoly industry where *n* firms produce the same homogenous product with the same unit cost, and have the same discount factor δ. We have seen that the critical threshold for the discount factor is then given by

$$\delta^*(n) = 1 - 1/n.$$

This threshold is reduced by 25% (from 2/3 to 1/2) in the case of a 3-to-2 merger, whereas it is only reduced by 11% (from 3/4 to 2/3) in the case of a 4-to-3 merger and by 6% (from 4/5 to 3/4) in the case of a 5-to-4 merger.

In contrast, a merger that would create or reinforce asymmetry in costs, production capacities or product ranges would tend as such to make collusion more difficult. Of course, such a merger would *at the same time* both reduce the number of participants (which is good for collusion) and introduce additional asymmetry (which is bad for collusion). However, as long as the number of key variables remains limited, it is possible to evaluate a trade-off between these two conflicting effects.

Example: evaluating the net impact of an "asymmetric" merger

Suppose that, initially, 3 symmetric firms produce the same good at the same cost c, and sell it to consumers that are the same reservation price r. Consider now a merger between two firms, that would allow them to lower their cost to $c' < c$. Denoting by $\gamma = 2(c-c')/(r-c')$ the relative cost advantage of the new entity, the previous analysis has shown that the critical threshold for the discount factors would be

$$\delta^* = 2/3$$

in the pre-merger situation and

$$\delta^{**} = 2/(4-\gamma)$$

in the post-merger situation. This merger would thus overall facilitate (respectively, hinder) collusion if the cost advantage, as measured by γ, exceeds (respectively, is lower than) unity.

Other factors in this second group would be the removal of a maverick firm, as well as the existence of structural links or of cooperative agreements.

Third, there is series of factors that can have an influence on the sustainability of collusion, possibly to a lesser extent, and that may or may not be directly affected by mergers.

Among these, the degree of market transparency appears to be a key factor. Other factors include product differentiation, the characteristics of demand (demand trend and fluctuations, as well as demand elasticity and buying power), multi-market contact, or the organisation of particular markets such as bidding markets. These dimensions are relevant to assess the plausibility of collusion, particularly when the factors of the first two groups do not suffice to send a clear signal.

The above discussion thus provides some basis for prioritising the relevant factors. But this discussion also advocates for a structural analysis. Rather than a pure “check-list” of relevant factors, it seems indeed more appropriate to develop a clear understanding of why each dimension is relevant, as well as of how it affects collusion – and is affected by a merger. This not only helps prioritise these factors, but also facilitates an overall assessment when several factors have a role and push in different directions. For example, the above discussion provides an analytical framework for assessing how these conflicting factors affect the effectiveness of retaliation conducts, and thus how these retaliation possibilities are modified by a merger.

Moreover the interplay of the factors may be important; We have for instance pointed the effect of demand growth depends on entry barriers. If entry barriers are so large that entry is highly unlikely to occur, demand growth fosters collusion. If instead entry barriers are moderate, demand growth may be sufficient to outweigh them and stimulate entry, which would in turn impede collusion. Similarly, product differentiation may affect market transparency, by affecting what firms can infer from available data. In both instances, it becomes important to undertake a joint assessment of the factors.

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