The Economics of Horizontal Mergers:
Unilateral and Coordinated Effects

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

March / November 2003

Report for DG Competition, European Commission

This document builds on two reports commissioned by the European Commission on the economic analysis of horizontal mergers, dealing respectively with unilateral effects and tacit collusion. The document comprises four parts: Part A provides a general introduction and overview of the main issues. Part B focuses on the economics of unilateral effects, while Part C studies coordinated effects through the economics of tacit collusion. Part D reviews a number of quantitative procedures that can be used for the analysis of unilateral effects and tacit collusion.

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2006

ISBN 92-79-00409-3

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

Table of content

Part A: Introduction

There are at least two ways in which competition may be threatened, other than by single dominant firms. These two ways are conceptually distinct even if sometimes hard to distinguish in practice. The first is when a number of firms engage in what economists refer to as tacit collusion,[1] 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. The second 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) even when none of these firms would be considered individually dominant. Situations of the second kind are captured by the legal concepts of many jurisdictions. Indeed, one interpretation of the use of the Herfindahl-Hirschman index in the Merger Guidelines of the US Department of Justice is as reflecting the impact of concentration on the exercise of single-firm market power[2].

What exactly is the difference between these two concepts? Both are instances of oligopolistic behaviour, contrasting with monopoly on the one hand and perfect competition on the other. Both imply strategic interaction between a small number of firms, each of which is sufficiently large to influence the market but which cannot act without taking the actions of

---

[1] We should stress at once that "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.

[2] For example, if the price-cost margin of firms in a given market is proportional to their market share, then the average price-cost margin in the market as a whole (weighted by the share of firms) is proportional to the Herfindahl-Hirschman index. That is, $m_i = k.s_i$ implies that $\sum_i s_i.m_i = k.\ \sum_i (s_i)^2 = k.HHI$. However, it should be stressed that the proportionality of the price-cost margin to market share, although doubtless consistent with the use of market shares as a measure of single-firm dominance, is not a general property of models of oligopolistic competition. As we will see, the relationship between the HHI index and price-cost margins, profits or welfare can be extended to particular forms of oligopolistic interaction.

competitors into account. Where they differ, however, is in the precise way in which they suppose firms take into account their competitors' behaviour. Under individual rivalry firms take their competitors' behaviour as in some sense given, and not open to influence by the firm's own actions (what that means in practice will be discussed more fully below). Market power may nevertheless result from their behaviour, since some or all firms in such a market may be able to raise prices profitably above competitive levels. This might be due to a firm's technological advantage over its rivals or from significant product differentiation and entry barriers.

Tacit collusion also supposes significant entry barriers (otherwise the collusion would be pointless since it would rapidly be undermined by new entry to the industry). But it could occur even in the absence of significant individual market power - for instance, when the firms present in the industry produce exactly the same good with the same technology. Instead, a necessary condition of tacit collusion is that firms should be acting with the intention of influencing the future actions of their competitors. If firms are acting in a way that takes their competitors' future actions entirely as given, and not as open to influence by the firm's own actions in the present, then the situation is not one of tacit collusion, even if (as a result of the high concentration in the market) prices are significantly above marginal cost, or if other symptoms of non-competitive behaviour are present

Note that even if firms are not expecting to influence their competitors, this does not imply that they are unresponsive to market conditions. On the contrary, each firm will be taking its decisions regarding prices, output or other choice variables in a way that responds to market conditions (which themselves are the results of the decisions of other firms). To see this most clearly, suppose that in each relevant time period, firms' decisions only involve the setting of prices or outputs for that period. We can abstract for the moment from other dimensions, such as investments, innovation, and so on, that may have a lasting impact on the industry. In each period *t* the choice of each firm is likely to be a function of the decisions it expects to be made by all others in that period. Provided firms are not expecting to influence their competitors, each firm will choose its own prices or outputs on the assumption that neither in period *t* nor in any future period will the actions of other firms be influenced by its own decisions in period *t*. Tacit collusion, in contrast, requires that a firm make a choice which would not be in its interest if it assumed that other firms would be uninfluenced by its choice. For instance, under tacit collusion a firm can choose to set an output which, when added to the output produced by other firms, yields the monopoly output in the market as a whole. This could not be a short-term profit-maximising choice for all firms in the market if

each were able to increase output without other firms' reacting, since in the absence of such reactions at least one firm and possibly all firms would find it profitable to deviate from the monopoly level.[3] For the monopoly output to be consistent with profit-maximisation would require each firm to anticipate that deviations from this level would trigger responses by other firms that outweighed the short run gains from the deviation. Consequently the anticipation of a response to one's own action is at the heart of tacit collusion, and passive adaptation to market conditions is incompatible with tacit collusion under any circumstances.

This distinction still applies when some of the firms' decisions, such as investments in capacity or R&D projects, have a lasting impact on the industry. In particular, these additional dimensions do not alter the above distinction between the mere exercise of market power and tacit collusion on prices or outputs. But we can also apply the same distinction to the investment decisions. In each period t the investment choice of each firm will again be a function of all the investments it expects to be made by the other firms in that period. It can furthermore be affected by all firms' past investments, and will take into account the lasting impact of other firms' current investments on their likely future decisions. For tacit collusion on investments to take place, however, each firm must choose its own investment plans on the assumption that the future investments of other firms will be influenced by its own current decisions, *beyond* the direct lasting impact of these decisions. Specifically, each firm hopes that by choosing investments in a way that softens competition (typically, by limiting its investments), it can induce others to do the same.

Nevertheless, if the distinction between these two kinds of situation is clear in principle, can they be distinguished in practice? Consider a situation in which one firm changes its behaviour, say by making an investment in capacity. Shortly afterwards, one or more of its competitors adds to capacity as well. What could possibly lead us to decide whether the firms were reacting passively to market conditions or acting strategically to influence each other? Here it might be helpful to bear in mind the distinction between actions that are strategic complements and those that are strategic substitutes – these are, respectively, actions that

[3] One way to see this is to note that each firm is a monopolist on its *residual demand*, that is the demand for its own products given the other firms' outputs or prices. This residual demand is typically more sensitive than the aggregate demand to changes in the firm's price or output, leading the firm to favour a lower price or a higher output than the true monopoly level. In economic terms, when one firm considers increasing its output or reducing its price, it considers its own margin-output trade-off (i.e., increasing output leads to a lower market price and thus to a lower margin), but ignores the impact of lower prices on the other firms; it therefore has a unilateral incentive to charge a lower price or expand output beyond the monopoly level.

normally induce a similar response from rivals and actions that normally induce an opposite response, holding constant other features of the market environment such as the level of demand. Capacity choices are typically strategic substitutes: if the other firms expand their overall capacity, then the optimal choice of a remaining firm is often to reduce the amount of capacity it holds, or at least not to increase it. Strictly speaking, in fact, the comparison is simultaneous: capacity choices are substitutes because, the higher the level of capacity a firm expects its rivals to choose, the lower the level it will choose itself. Increasing capacity in response to a higher expected level of capacity on the part of rivals makes sense only as part of a co-ordinated response. Consequently when actions that are strategic substitutes move in a similar direction it may make sense to diagnose the presence of a coordinated set of actions. Of tacit collusion, in short.

However, things are not quite as simple, since even firms that are responding passively to market conditions may act in ways that appear coordinated. This can for example be the case when the actions of one firm send information that changes the expectations of another. Thus, even though a rise in capacity by firm A means that, for a given anticipated level of demand, firm B should cut its capacity, the rise in capacity may convey information about a likely increase in future demand that makes it optimal for B to increase capacity as well. This may even trigger a "rush to be next" where all remaining firms react at once by expanding their own capacity. More generally, things tend to be more complicated when accounting for market dynamics. For example, if firms invest at the same time because they try to pre-empt each other, what may look like positive correlation with strategic substitutes may in fact result from healthy competition.[4]

Box 1: Capacity choices: the case of airlines

Airline A announces a doubling of its number of weekly flights on a key intra-European route along with price cuts on that route. Airline B, two weeks later, announces price cuts and an increase of 50% in the number of its weekly flights on that route (without making changes on any other routes). How can the competition authorities tell whether this is individual rivalry or tacit collusion? This depends on whether B was taking A's capacity increase as given or was hoping to influence A into reversing it. Some indicators:

[4] In contrast, tacit collusion would rather involve no investment (each firm understanding that the other would resume investing if it does).

- B's price cut does not constitute evidence either way. Cutting prices in response to A's capacity increase would be a profit-maximising response in either case.

- B's capacity increase *does* constitute *prima facie* evidence in favour of tacit collusion, since the profit-maximising response to capacity increase by a competitor that is expected to persist is to *cut* capacity. However, this depends on B's not having increased its expectations about likely future demand since the time of A's announcement.

- In principle 2 weeks seems a short time lag so it is likely that B has not changed its expectations (unless significant news events have intervened). However, it could be that A's announcement itself convinced B of the existence of significant additional price-sensitive demand which could be satisfied even if A's capacity increase persists). If internal documents to that effect exist, could be used to counter the *prima facie* evidence of tacit collusion

In the context of merger control, the primary task is not to distinguish between individual rivalry and tacit collusion when they occur but, rather, to assess the competitive impact of a proposed merger, and therefore the likelihood that they will occur in the future. Since both types of situation may create competitive concerns, we should therefore assess the impact of a merger on both the exercise of individual market power and on the risk of tacit collusion. To assess the first type of effect, it is necessary to evaluate the impact of the merger on the behaviour of the new entity, and also to account for the extent to which other firms could be expected to react to the modification of the new entity's expected actions.

Assessing the second type of effect requires the diagnosis of conditions that make tacit collusion more likely in the future. This amounts to looking for circumstances under which it would be rational for firms to seek to coordinate their strategies. For this to happen it is necessary for there to be significant gains to firms from using strategies that explicitly seek to influence their competitors into acting more anti-competitively than their short-run profit maximising incentives would prescribe.

For the purposes of merger control, therefore, it makes sense to distinguish two tasks. The first is the task of assessing how a given concentration affects what would happen to prices, outputs and other important features of a market if firms responded in an individually rivalrous way to market conditions, without any increased likelihood of engaging in tacit collusion. The second is to assess what the impact of the concentration may be on the

incentives for tacit collusion.[5] These two tasks involve quite different analyses and could be undertaken at distinct stages of merger analysis. The first effect is typically unambiguous even if of uncertain importance. As we show below, a concentration will of itself tend to increase the price-cost margin charged by the merging parties (albeit sometimes by a very small amount); whether this tends to harm consumers will depend on whether costs are reduced or other benefits are obtained in the process. By contrast, the effect of a concentration on the incentives for tacit collusion is more complex: for instance, by reducing the number of firms in the market it might make tacit collusion easier to plan, but by making them more asymmetric it might make it harder for firms to reach a consensus on the type of behaviour required, as well as to discipline one another for deviations from such behaviour. It might therefore make tacit collusion harder to implement.

The rest of this introduction is organised as follows. Section I focuses on models of imperfect competition where firms have some individual market power but do not try to influence each others' decisions. It discusses in particular the circumstances under which outcomes that do not involve tacit coordination may nevertheless depart significantly from competitive prices and outputs. Section II turns to models of tacit collusion and identifies circumstances under which such collusion may occur. Section III discusses how these models can be used for the purposes of merger control.

[5] The distinction between these two effects corresponds to the distinction in the US merger guidelines between "unilateral effects" and "coordinated effects". Note however that "unilateral effects" clearly include here not only the impact of the merger on the behaviour of the merging firms, but also the "equilibrium effect" resulting from the other firms' adjustment to the merging firms' new decisions.

I. Competition in Oligopolistic Markets

In this section, we consider what could be expected to result from competition between firms when each firm is reacting to market conditions but is not expecting to influence the future behaviour of other firms. If firms are producing the same good with the same technology then, if many firms are effectively active[6] in the market, and absent tight capacity constraints, one would expect to see competitive prices and outputs (specifically with output priced at or close to marginal cost). Conversely, when there are a limited number of firms, non-competitive outcomes may arise, particularly if the goods (or services) produced by different firms are not in fact identical, but are imperfect substitutes for each other, even while belonging to the same market.

We shall focus on the determination of prices and outputs, since these are the decisions that are most likely to be affected in the timeframe usually considered by merger control procedures. However, it should be clear that the analysis has also implications for firms' longer-term decisions (investment, product choices, R&D, …). Note also that the "market power" analysed below may simply derive from the existence of large fixed or sunk costs, which implies that only a limited number of competitors can be effectively active in the industry. In that case, the impact of the merger on these costs should also be accounted for.

1. The role of product differentiation

The goods (or services) produced by different firms are often not identical, but are imperfect substitutes for each other, even while belonging to the same market. What does this mean in practice? It means that the market price of each good will depend on the amount of the good that is produced, but will also be influenced – although usually to a lesser degree – by the amount of the imperfect substitutes produced by other producers. The relationship between the price of a particular type of lemonade and the quantity sold will depend, for instance, on the amounts sold of rival brands of lemonade, as well as on the amounts of cola and other soft drinks. Suppose that there are n competitors in the market, each producing one

[6] This is unlikely in the presence of significant economies of scale or scope; such economies give rise to a "natural monopoly" or oligopoly type of industry, in which only a small number of firms can be effectively active.

good. The demand for the goods then induces relationships between quantities and prices, of the form

$$q_i = D_i(p_1, p_2, ..., p_n), \qquad (1)$$

where p_i and q_i respectively denote the price and the quantity for product i. In practice, the nature of these relationships could be verified by econometric analysis provided data on prices and sales of the products are available.

Given the prices of the other firms, each firm i faces a "residual demand" which slopes downwards: the higher its own price p_i, the lower the quantity q_i it can sell. To measure the sensitivity of this residual demand, it is convenient to define product i's *own-price elasticity of demand*, ε_i, as the proportionate reduction in demand for the product of firm i generated by a *1%* increase in its own price, *if all other firms' prices remain unchanged*.[7]

These elasticities determine firms' optimal pricing strategies. That is, if firm i considers the prices of the other firms as given, maximising its profit

$$p_i q_i - C_i(q_i),$$

where $C_i(q_i)$ denotes its cost of production, will lead firm i to choose a mark-up that is inversely proportional to the own-price elasticity of its demand:

$$\frac{p_i - C_i'}{p_i} = \frac{1}{\varepsilon_i},$$

That is, the more sensitive to price changes the demand is, the closer to marginal cost the price will be. This expression corresponds to the standard "monopoly pricing" formula, but the relevant "elasticity" is the one of *residual* demand for firm i. It thus depends not only on the overall sensitivity of customers' demand for the products in question, but also on the availability of competing products that are reasonably good substitutes: when firm i raises its own price p_i, some consumers may be discouraged from buying the product, but others may simply buy instead the product offered by one of the competitors.

For instance, suppose a firm sells a particular brand of whisky. Its ability to raise its price above the cost of producing the whisky (including taxes and marketing and distribution costs) depends not just on the extent to which, if it did so, some of its customers would give up drinking whisky altogether. It depends also on the extent to which its customers would

---

[7] That is, $\varepsilon_i = \frac{-p_i \partial D_i / \partial p_i}{D_i}$. With this sign convention, ε_i is positive when, as expected, the residual demand is downward sloping.

consider other brands of whisky an acceptable substitute. The more other brands of whisky there are, and the closer substitutes they are considered to be, the less the firm can afford to raise its price above cost.

To see this, denote by η_{ji} the cross-price elasticity of demand between product *j* and product *i*, measured as the proportionate increase in demand for the product of firm *j* generated by a *1%* increase in the price of firm *i* if all other prices remain unchanged.[8] This cross elasticity η_{ji} will be the higher, the closer substitutes the goods *i* and *j* are. We can also denote by E_i the elasticity of the *aggregate demand* for the goods in the same relevant market as *i*. Then the elasticity of the aggregate demand is equal to the elasticity of *i*'s residual demand *less* the sum of all the relevant cross-price elasticities, and can be written as follows:

$$E_i = \varepsilon_i - \sum_{j \neq i} \eta_{ji},$$

This way of expressing the relationship between the aggregate demand and the residual demand helps us to see why monopolists can charge higher prices than firms facing some (albeit imperfect) substitutes for their product. Indeed, when demand and cost conditions are symmetric, the monopoly mark-up for the price p_i is inversely proportional to the elasticity of the *aggregate demand* for the goods:

$$\frac{p_i - C_i'}{p_i} = \frac{1}{E_i},$$

and since the aggregate demand elasticity is smaller than the residual demand elasticity this mark up will be larger than that determined by the residual demand.

In summary, therefore, the own-price elasticity ε_i that each firm *i* faces on its residual demand is much higher than the overall elasticity E_i when there are many substitutes and/or when these other goods are close substitutes. This, in turn, implies that equilibrium prices will be much closer to the competitive level (which corresponds to marginal costs) when there are many and/or close substitutes. In contrast, a firm that offers a highly differentiated product will charge a price close to the monopoly level.

---

[8] That is, $\eta_i = \frac{p_i \partial D_j / \partial p_i}{D_j}$. With this sign convention, η_i is positive when goods are (possibly imperfect) substitutes, since increasing the price of one good encourages consumers to move to the other goods.

We provide in section *c* below an illustration of these issues in a simple example with symmetric firms and linear demands.

2. *Competition in prices or quantities*

The degree of substitutability between products in the same market thus affects the way in which competition occurs. However, the exercise of competition also depends on how firms are reacting to each other – which aspects of each other's behaviour are they looking out for, and taking as a given part of their market environment. We have assumed so far that firms were "competing in prices", in other words that firms were taking their decisions, *taking as given the other firms' prices*; this corresponds to a model of oligopolistic interaction known as the Bertrand model. An alternative possibility, particularly in industries where production capacity is relatively fixed in the short term and prices are set so as to sell capacity (glass, cement and package holidays have all been suggested as fitting this description), is that firms make conjectures instead about the quantities of output sold by their competitors. It is then convenient to express the demand relationship (1) between prices and quantities as

$$p_i = P_i(q_1, q_2, ..., q_n). \qquad (2)$$

If each firm *i* considers the other firms' quantities as relatively fixed and not open to influence, then it will choose to put on the market a quantity which maximises

$$P_i(q_1, ..., q_i, ..., q_n)\, q_i - C_i(q_i).$$

There again, profit maximisation will imply a mark-up over marginal cost that is close to the monopoly level if the products are highly differentiated. If instead the firm has a reasonable number of close competitors, then it will set prices close to the competitive level, since any attempt to raise prices will result in a loss of business to these competitors.

As mentioned, this model is particularly relevant when capacity choices are the key variables in the industry. When choosing their capacity levels, firms anticipate how they will compete in prices thereafter; capacity choices affect their market positions for this price competition and determine in this way the prices that will eventually prevail. Typically, an increase in one firm's capacity will exert downward pressure both on its own prices and, through market interaction, on those of its competitors; this "two-stage" competition (first, capacities and second, prices) thus generates a positive correlation between prices, with

higher capacity by each firm being associated with lower prices for all firms.[9] In such industries, firms often charge different prices as time goes by. For example, tour-operators book flights and hotels one and half year before each "season," and then set their prices when first publishing their catalogues. However, they often offer "last-minute discounts" when they still have vacancies close to the opening of the season. Even in such industries, however, the initial choice of capacities (that is here, the number of plane seats and hotel nights booked in advance) still contribute to determine the overall distribution of prices. An increase in the capacity of one firm is likely to result in an effective reduction in most prices (e.g., a reduction in that firm's catalogue prices, followed by larger discounts granted by the competing tour-operators). Indeed, such induced price reduction may well not even be conscious on the part of the competitors; they may simply discover (as a consequence of the first firm's capacity increase) that it takes larger discounts than expected to sell their own capacity.

Thus the nature of capacity competition resembles that of quantity competition, referred to as the Cournot model of oligopolistic interaction. Interpreting quantity variables as capacities instead of actual outputs, the Cournot analysis can provide a good representation of such industries, where firms react to each other's capacity choices rather than to each other's prices (which they may not even directly observe).[10]

Note that in this mode of competition in quantities, the firm acts again as a monopolist on its residual demand. However, the relevant "residual demand" is not the same as before. In the Bertrand mode of competition, firms take as given the other firms' prices; in other words, when considering a change in its own price or quantity, each firm assumes that the other firms will maintain the same prices, implying that their quantities will adjust to the change in its own behaviour. For example, if the goods are close substitutes, then each firm will anticipate that, by undercutting its rivals even only slightly, it will be able to steal most consumers away from its competitors; this, in turn, will imply intense competition and very low mark-ups. In contrast, in the Cournot mode of competition, firms take as given the other firms' outputs. This means that, when considering alternative choices of quantity, each firm assumes that the

[9] As we further explain below, this is why the result is less competitive when firms respond to each other's capacity choices (or quantities) than when they respond to prices.

[10] The formal analogy between the Cournot model of quantity competition and the "two-stage" competitive game, in which firms first choose capacities and then compete in prices, requires technical conditions on costs and demand; in addition, capacity must be irreversible to a sufficient extent.

other firms will adjust their prices so as to maintain their quantities – even if the goods are close substitutes[11].

This fundamental difference in the modes of competition implies that competition typically results in lower prices in the Bertrand mode of price competition than in the Cournot mode of quantity competition. To see why, note that, in the latter case, rivals' prices must match at least partially any change in each firm's price. Therefore, when considering a change in its own price, the relevant elasticity is lower than in the case of Bertrand competition, and is now given by

$$\varepsilon_i - \sum_{j \neq i} \lambda_{ij} \eta_{ij},$$

where as before η_{ij} denotes the cross-price elasticity of demand between products *i* and *j*, whereas λ_{ij} denotes the proportionate change in the prices of the product of firm *j* that is implied by maintaining the other's quantities in response to a *1%* modification of firm *i*'s price.[12] When goods are substitutes, the cross-price elasticity η_{ij} and the price response λ_{ij} are both positive, implying that the relevant elasticity is lower than the own-price elasticity ε_{ij}. If firm *i* chooses to lower its price, and expects its rivals to maintain their output, this implies that their prices will also weaken, which in turn attenuates the impact of its own price change on firm *i*'s output. Consider, for example, a package holiday company contemplating an increase in the number of holidays it will offer in the coming season. Not only is it likely to have to reduce the price of its own holidays to induce consumers to buy more holidays in total, but its rivals will also feel the tougher competition and will find themselves lowering list prices and increasing discounts as well (possibly without realising why). The perceived elasticity of demand for the firm's holidays will therefore be lower than if its rivals could be expected to maintain exactly the same prices as before, so it will set a higher mark-up over marginal cost. As this example shows, firms that expect rivals to maintain their quantities tend to set higher mark-ups than firms that expect their rivals to maintain their prices.

---

[11] Note that this does not mean the rivals consciously adjust their prices; more probably, they continue to produce the same output (or make the same capacity choices) as before, and simply discover that to sell this output now requires lower prices than it did before.

[12] That is, $\lambda_i = \dfrac{p_i \partial p_j / \partial p_i}{p_j}$, where $\partial p_j / \partial p_i$ is the price response of each other good *j* to the price change of good *i*, that is needed to keep selling the same amounts of output for all the rival firms.

Overall, two main factors thus determine how closely the unilateral adaptation to market conditions practised by firms in an oligopoly approximates to a competitive outcome: first, the degree to which their products are substitutes for each other, and secondly, the extent to which they adapt to each others' prices as opposed to each others' output decisions. The upshot is that, even when firms are just engaging in individual rivalry rather than seeking actively to influence each others' behaviour, the effect of this behaviour on market outcomes depends not just on the objective parameters of the goods concerned, but also on whether firms observe and adapt to prices or to quantities. Adapting to prices tends to produce more competitive outcomes, because it means firms perceive an incentive to undercut one another – whereas adapting to quantities means that aggressive behaviour by one firm can be expected to lead to lower prices for all.

Different market circumstances will make a big difference to which of these two modes of competition is more likely to be relevant. When mail-order firms compete, for example, it makes sense to think that reductions in price by one firm lead its competitors to sell lower quantities at the same prices they were charging before, rather than to react immediately with lower prices, because of the cost of printing new catalogues or price lists. By contrast, when one tour operator increases its capacity (in terms of hotel rooms aircraft seats available for the coming season), it is likely that other operators' capacity will be unaffected in the short term, so that the effect of the first operator's capacity increase is to lower the prices at which holidays can be sold by all operators.

3. A simple illustration

Suppose that the demand relationship (2) between prices and quantities is symmetric and take the simple linear form:

$$p_i = P_i\left(q_1,...,q_n\right) = \alpha - \beta q_i - \gamma \sum_{j \neq i} q_j ,$$

where α is a constant, q_i is the output of good i, β is the sensitivity of the price of one good to the output of that good, and γ is the sensitivity of the price of one good to the total output of all other goods.

The symmetry assumption amounts to suppose that all goods are equally close substitutes for each other. We can then use the relative sensitivity of the price of one good to the output of the same and the other goods as a simple indicator of how differentiated are the products. Consider the ratio

$$\sigma = \frac{\gamma}{\beta}.$$

When this ratio is zero the products are not substitutes at all (and should therefore not even be considered in the same market); when it is equal to one the products are perfect substitutes, because each one's price reacts just as sensitively to the output of all its competitors as it does to its own output. For most interesting competition cases the ratio will be reasonably close to, but not exactly equal to one.

When firms compete in quantities, an increase in the degree of substitution σ lowers prices to some degree, but never all the way to the competitive level. If for example the firms have the same unit cost $c < \alpha$,[13] the Cournot equilibrium price is given by

$$p^C = \frac{\alpha + \left[1 + (n-1)\sigma\right]c}{2 + (n-1)\sigma}.$$

Therefore, as the degree of substitution σ increases from *0* (no substitution) to *1* (perfect substitution), the equilibrium price decreases from the monopoly level to a lower level, which itself depends on (and decreases with) the number of competitors.

When instead firms compete in prices, the Bertrand equilibrium price is given by

$$p^B = \frac{(1-\sigma)\alpha + \left[1 + (n-2)\sigma\right]c}{2 + (n-3)\sigma},$$

and is thus lower than the Cournot price.[14] In addition this price, which coincides again with the monopoly price when there is no substitution between the products ($\sigma = 0$), approaches

[13] The industry would not be viable if $c > \alpha$, since in that case there would be no demand even at the competitive price $p = c$.

the competitive level when products are close substitutes (σ close to *1*). If σ is large enough, then even one competitor (i.e., $n = 2$) may be enough to push prices close to the competitive level.

Whether firms react to each others' prices or to each other's quantities thus makes a substantial difference to market outcomes. In particular, when firms are principally reacting to each others' prices, it is the presence of *some* reasonably close substitutes that is crucial for establishing competitive conditions – it matters more that there be some close competitor, not how many close competitors there are. By contrast, when firms are mainly reacting to each other's quantities, the numbers of competitors will matter as well as the extent to which their goods are substitutes for each other. It matters not just that there be some competition but that there be enough of it.

II. Tacit collusion

We have focused so far on firms' uncoordinated exercise of individual market power. We now address the possibility of coordination between competing firms. Such coordination may arise when, as it is often the case, the same firms repeatedly compete in the same markets. We thus briefly review in this section how dynamic considerations can lead to the joint exercise of collective market power, resulting in prices above those predicted by the uncoordinated effects. This corresponds to what economists refer to as tacit collusion.

The key to tacit collusion is that when firms interact repeatedly, they may react not only to fundamental market conditions but also to each other's past behaviour. The fundamental idea behind all models of tacit collusion is that firms may have an incentive to set a price higher than the price they would otherwise wish, because of the fear that if they do not do so, other firms will react by setting lower prices in the future. Whether they do in fact have such an incentive will depend on four main factors:

- How much each firm has to gain from undercutting its rivals instead of sticking to the collusive price

[14] In both cases the equilibrium prices are a weighted average of the competitive price c and the demand intercept $\alpha > c$, and it is easily checked that the relative weight on the competitive price is higher in the case of Bertrand competition: $[1 + (n-1)\sigma]/(1 - \sigma) > 1 + (n-2)\sigma$.

- How much such a firm would lose in the future if its rivals cut their prices in response

- How likely is undercutting by the firm to lead to a price cut in response

- How much the firm cares about lost profits in the future compared to profit gains today – otherwise known as its "discount rate", since this reflects how much it discounts future profits relative to today's.[15]

Suppose, for example, that a firm believes a price cut today would lead to the permanent collapse of a tacit collusive agreement (and zero future profits) with some probability *p*. We can write the short-run profits it would gain by such a price cut today as π_U (where U stands for "undercutting"). We can write the profits it gains from tacit collusion as π_C (where C stands for "collusion").

To be sustainable, tacit collusion requires that no firm find it profitable to undercut. In other words, getting an extra current profit $(\pi_U - \pi_C)$ must not be worth taking the risk of losing the benefit of collusion in the future. If *R* denotes the rate at which future profits are discounted, tacit collusion is possible only if the following condition is satisfied:

$$R(\pi_U - \pi_C) < p.\pi_C,$$

This condition has several implications. Tacit collusion will be easier to sustain if:

a) The individual gains from undercutting rivals ($\pi_U - \pi_C$) are low

Obviously tacit collusion is easier to sustain when the gains from undercutting are low. Typically this puts limits on the level of prices that can be sustained with tacit collusion. The gains that a firm derives from undercutting depend on several factors. Important determinants are the price-cost margin and the own-price elasticity ε_i of the firm demand discussed above[16]. Thus the degree of product differentiation matters. A consequence of the discussion of the

[15] A discount rate *R* means that the firm weights the profits in period T with a multiplicative factor $1/(1+R)^T$. If the firm faces no risk and can freely access to the credit market, the discount rate corresponds to the market interest rate.

[16] At a given demand level, the benefits from a small price cut increase as the price-cost margin or the own-price elasticity of demand increase.

previous section is that the nature of competition also matters. In particular the benefits from undercutting will be smaller when firms compete in quantities than when they compete in prices.

b) The gains from collusion (π_C) are high

Given that undercutting generates profits in the short-run, preventing firms from doing so requires that it is associated with some losses in future profits. This requires that one firm's competitors react to observed undercutting by cutting prices in the future. The long-term profit loss is the difference between the long-run collusive profit that the firm obtains if it sticks to the collusive price and output, and the long-run profit it obtains under the new market conditions that may prevail if undercutting occurs. The reaction of firms to perceived undercutting of the collusive price is usually referred to as "retaliation", although it needs not always take the form of aggressive actions against the firm; it may just involve abandoning any effort at maintaining high prices

Indeed the simplest deterrent to undercutting is the fear that it may lead to a "breakdown of coordination". This would bring the market to the situation studied in the previous section, where prices and profits are smaller than their collusive levels. This breakdown of coordination might last for a limited time or for the foreseeable future.

The consequence for a firm of undercutting its rivals may of course be more severe than a simple breakdown of coordination. For instance, competitors may engage in a temporary phase of intense price war, cutting prices to very low levels, or they may coordinate on commercial actions targeted at the firm's clientele. Alternatively, they may refuse to cooperate on other joint policies (such as joint ventures or joint distribution arrangements) in standard setting process. The retaliatory power of rivals thus depends on market specificity, and determines to a large extent the ability of all parties to maintain tacit collusion.

However, in all instances retaliation mechanisms must satisfy two conditions. First, they must be "effective" (they must impose a sufficiently heavy cost on the undercutting firm). Secondly, they must be "credible", in that they must depend on reactions that retaliating firms would actually be prepared to carry out if the undercutting occurs.

c) The probability that undercutting will lead to retaliation (p) is high

Clearly, if there is little chance that undercutting will be followed by some form of retaliation, the fear of losing the collusive profit will be an ineffective deterrent. The probability that undercutting by one firm triggers retaliation depends mostly on firms' ability to monitor each other's behaviour, and thus on market transparency.[17] Obviously it will be helpful if there is reliable publicly available information on prices and quantities, but other dimensions such as market stability (demand and cost volatility, frequency of innovation and so forth) matter as well. For example, when the market is unstable, firms will have difficulty using market data to diagnose undercutting behaviour on the part of their rivals, as opposed to changes in the underlying market conditions.

Firms' ability to guess how their rivals are behaving (for instance whether they are secretly offering discounts to customers) will also depend on how similar are the cost and demand conditions the different firms face. So it is likely that tacit collusion will be easier to sustain between firms of a similar size producing similar types of product under similar technological constraints; by contrast, tacit collusion between firms of very different size and type may be much harder to sustain.

d) The weight attached to future profits is high (R is low)

If firms care mostly about current profits, they will focus on the short-term and tend to "ignore" the consequences of retaliation. They will thus have a strong incentive to undercut and collusion will not be easy to sustain. The relative weight of current and future profits in the firm's objectives depends among other things on the market real interest rate. With low interest rates, future profits matter more, which facilitates collusion. Another key determinant is the delay before competitors react. Long delays may be due simply to the time necessary to monitor rivals' behaviour. They may also be due to structural factors. For instance if competitors must adjust their capacities before they cut prices and capacity building is lengthy, retaliation may require long delays. Similarly, the reaction delay may be shorter on spot markets than in markets where firms are engaged in long contractual agreements, as in the latter case it may take time before these agreements can be renegotiated.

Overall, therefore, the sustainability of tacit collusion depends on four types of factor. Only some of them can be quantified with any degree of precision. The main reason why it is

[17] The exact meaning of market transparency in the analysis of tacit collusion is a delicate issue that will have to be discussed in detail.

often so difficult to assess the effect of a concentration on the ease with which tacit collusion can be sustained is that a concentration may affect all of these four factors, sometimes in countervailing directions.

Tacit collusion relies moreover to a large extent on firms' conjectures about the future reactions of competitors to their pricing or production decisions. For this reason there is not one but many potential forms that it may take for a given market structure, defined in terms of firms, products, costs and demand. Whether a particular form of coordination occurs or not depends on factors that affect managers' perception of the industry and that can be to some extent subjective or manipulated by specific participants. We should point here that while there is a good understanding of the mechanisms underlying tacit collusion in general, as well as of many factors that hinder or enhance the ability to coordinate, this is not so for the conditions under which a particular form of tacit collusion emerges at a specific point in time.

A final point worth emphasising is that while the same structural factors may enter in the analysis of the uncoordinated exercise of individual market power and in the analysis of tacit collusion, they will usually not be considered in the same manner. For instance, asymmetries between firms may lead to more individual market power, while at the same time making tacit collusion more difficult. To give a trivial example, if two firms constituting a duopoly decide to merge, this creates de facto a dominant monopoly, but at the same time this removes any meaning to the notion of tacit collusion.[18] More subtly, if two firms in an industry merge to create a firm that is significantly larger than its rivals (without being individually dominant), this may increase its potential market power, but make tacit collusion with its rivals more difficult than before.

III. Implications for merger control

Both the mere exercise of market power and the possibility of tacit collusion yield outcomes that differ from the competitive ones. The implications for merger control are substantially different in the two cases, though.

[18] Reversing the argument, a monopoly that sells some of its assets to a new entrant creates the possibility of tacit collusion where they were none before.

A merger between competitors is likely to increase firms' individual market power, both for the merging firms and for the other competitors. The main issue there is to assess the implications of this increase in market power for equilibrium prices, and possibly for barriers or invitations to entry. One needs then to compare the increase in market power against any benefit the merger may bring in terms of efficiency gains, improved quality and so forth.

The impact of the same merger on the scope for collusion is more delicate to evaluate; some mergers may facilitate collusion, but other mergers may well make it more difficult to achieve. Thus an increase in concentration need not always be associated with an increase in collective market power, defined as the ability to achieve high prices through tacit collusion.

We briefly discuss these two issues below. For the sake of exposition, and keeping in line with the above discussion, we focus on mergers between firms producing goods that are substitutes. We should however point out that the case of complementary goods would involve a drastically different analysis; the strategic effects of a merger are indeed often opposite in this case (see the remark at the end of section *a*).

1. The impact of mergers on market power

Whether firms compete in prices or quantities (or capacities), a merger between competitors increases the remaining firms' market power (both for the merged firm and its competitors), thereby leading (absent any offsetting efficiency gain) to higher prices and lower output. This is so because the merged entity is acting in a less competitive way than the two uncoordinated firms would have done. The exact nature of this increase in market power does depend, however, on the type of competition (in prices or quantities, for instance). To understand the overall effect in various contexts, it is useful to distinguish the impact of the merger on the merging firms and on the remaining ones.

The impact on the merging firms is qualitatively the same in the two types of competition. Consider for example a merger between two firms that produce two imperfect substitutes. In both cases, the new firm gains a monopoly position on the residual demand for these two products, given the others' decisions, whereas before they were not only reacting to the others' decisions but also competing among themselves.

Put differently, a merger between two firms allows them to coordinate the prices of their goods perfectly. But if the two goods are (even imperfect) substitutes, raising the price for one

product induces some consumers to buy more of the other product. Similarly, reducing the supply for one product increases the price of the other product. Prior to the merger, each party would have considered the potential loss of business to its rival a cost of raising its price. But the merger removes this cost. As a result, the merging firms will have an incentive to raise their price-cost margins and/or reduce their output of each product.

The extent to which the merging firms will increase their prices or reduce outputs will however depend both on the degree of substitution between their products and the remaining ones, and on the nature of competition (prices versus quantities). First, a merger between firms that produce close substitutes is more likely to raise prices than a merger between firms that produce imperfect substitutes. Similarly, a merged firm should raise prices to a lesser extent if other competitors produce close substitutes than if they produce imperfect substitutes. And this latter effect is likely to be more important in the case of price competition, since the elimination of competition between substitutes will matter more in that case.

The impact on the remaining firms depends considerably on the type of competition. While in both cases an increase in the merging firms' prices or a reduction in their output limits the competitive pressure on the other firms, and thus allows them to achieve higher profits, how these firms are likely to react to such a change of behaviour differs in the two types of situation.

When firms compete in prices, these prices are often *strategic complements*: an increase in the price of one good will typically lead competing firms to increase their own prices, although probably to a lesser extent. Then, an increase in the merging firms' prices triggers a positive response from the other firms – thereby further encouraging the merging firms to raise their own prices. Thus, because of the strategic complementarity of the prices, the direct impact of the merger on the behaviour of the new firm is exacerbated by the firms' adaptation to the new industry structure.

When instead firms compete in quantities, these quantities are often *strategic substitutes*: a reduction in the output of one firm typically leads competing firms to expand their own outputs, although not to the extent of fully compensating the initial output reduction. Then, a reduction in the merging firms' outputs triggers an opposite response from the other firms – which contributes to discourage the merging firms from reducing their

output.[19] Thus, because of the strategic substitutability of the quantities, the direct impact of the merger on the behaviour of the new firm is somewhat attenuated by the firms' adaptation to the new industry structure.

Any merger analysis, therefore, that considers only the impact of the merger on the merging parties and ignores the incentives of competitors to react will tend to produce a biased assessment of the likely impact on prices. For an industry where price competition is important, such as mail-order retailing, this bias will lead to an under-estimate of price rises. For an industry where quantity competition is important because of relatively irreversible capacity choices, such as cement or semi-conductors, the bias will lead to an over-estimate of likely price rises.

The impact of a merger on prices, for the linear model presented in section 2c, is illustrated in Annex A. There it is assumed that all goods are equally substitutes. The graphs in the annex show that in this case, the impact of a merger between two firms on prices is higher the more concentrated the industry is, with a stronger sensitivity to the number of firms in the case of price competition than in the case of quantity competition. Moreover, it appears that the effect of the merger on prices is much more sensitive to the substitutability of the products in the case of price competition than in the case of quantity competition.

The strategic nature (complementarity or substitutability) of prices and quantities has also some bearing on the firms' incentives to merge. In the case of price competition, strategic complementarity implies that a merger is likely to be profitable, even in the absence of any efficiency gain: this is because the merging firms both eliminate competition between them and induce their competitors to raise their own prices.[20]In contrast, in the case of quantity competition, strategic substitutability implies that a merger may well be unprofitable in the absence of significant efficiency gain. While the merging firms eliminate competition between them, the merger triggers a more aggressive response from the rival firms, which may suffice to reduce the profits of the merging firms (even if it does not lower the equilibrium prices).

---

[19] A key issue is the extent to which the capacities will be reduced post mergers. In a stable market, the Cournot model is likely to overestimate the reduction of capacity post merger, since a good share of the cost of capacities is sunk. The prediction of the Cournot model is probably more accurate in expanding markets.

[20] Put differently, a merger allows the firms to gain a monopoly position over the residual demand for their products, and this residual demand benefits from (is shifted upwards by) the induced increase in competitors' prices.

Remark on complement goods. We have focussed so far on the case where the merging firms are producing goods that are (possibly imperfect) substitutes. It should be stressed here that most of the analysis is reversed in the case of complement goods. Then, increasing the price of one good *reduces* the demand for the other goods. A merger would allow firms to internalise this effect, leading the merging firms to *lower* their prices or expand their output. In the case of price competition, suppliers of competing goods (i.e., suppliers of components that are substitutes for the components produced by the merging firms) would in turn typically lower their own prices; such a merger would thus have a desirable impact on all prices. In the case of quantity competition, suppliers of competing goods may react to the merging firms' expanded output by reducing their own output, but typically not up to the point of fully compensating the merging firms' increased output. There again, therefore, such a merger is likely to have a desirable impact on prices and outputs, and on customers' surplus.

Evaluating the impact of the merger thus requires a detailed assessment of the nature of competition (in prices, quantities, capacities, …) and of the degree of substitution between the competing products. In practice, evaluations can be based on calibrated models of oligopolistic competition. If data are available, econometric techniques can be used to estimate the relevant structural variables, both on the demand and on the supply side; such an econometric model can then be used to simulate the impact of the merger on each firm's prices and outputs, as well as on customers' surplus. It is also possible to incorporate in the prediction exercise alternative assumptions about the expected efficiency gains generated by the merger.

2. The impact on tacit collusion

Evaluating the impact of a merger on the scope for tacit collusion is more difficult both in theory and in practice. As we have seen, many different dimensions may affect the sustainability of collusion; and typically, a merger will alter several of these dimensions, in ways that may partially off-set each other. Evaluating the impact of the merger on collusion thus often involves a delicate assessment of the net result of possibly conflicting effects. In particular, while the impact of the merger on the sustainability of collusion can be studied, it will not be possible to reach a definite conclusion from available market data on whether tacit collusion will actually occur as a consequence of the merger or not.

The exercise is made all the more difficult in that we do not have good models that incorporate the various effects; the main problem is that models incorporating all the relevant dimensions would in most cases be unmanageable and unlikely to yield clear-cut predictions. While some guidelines can be derived, as we will see later, we should keep in mind that this exercise is by nature more difficult than the evaluation of a same merger on the uncoordinated firms' market power.

This increased difficulty is also reflected in the more limited help offered by quantitative or econometric approaches. In particular, while some successful efforts have been made to evaluate *ex post* the likelihood of collusion in a particular industry, predicting the impact of a merger on the *future* likelihood of collusion appears substantially more challenging.

One main difficulty is that, as was emphasized before, tacit collusion may take many forms. Thus any attempt to evaluate the likelihood of collusion must first be grounded on an a priori judgement of the particular form it can take in the specific case at stake. If the case is build on the premise that firms were not tacitly colluding in the pre-merger phase, past market data and econometric studies can help in assessing key structural parameters but will not provide direct information on potential collusive behaviour. Even if there is some evidence on past collusive conducts, one has to account for the fact that firms will adapt their conduct to accommodate the new environment created by the merger, which again requires some prospective analysis.

While the evaluation of both situations (uncoordinated behaviour and tacit collusion) calls for a structural quantitative approach, establishing the link between structure and conduct thus requires much more prospective and qualitative analysis for tacit collusion.

The last point is that because the same market situation may have very distinct implications for the uncoordinated exercise of individual market power and for the joint exercise of collective market power, it is important that the two analyses be conducted separately. Moreover, as the former provides information that is relevant for the latter, it would be natural to conduct it prior to the evaluation of collective dominance.

Part B: Unilateral effects

I. Competition in Oligopolistic Markets

1. The effect of mergers on prices and quantities

In this section, we consider the short-run effect of a merger in an oligopolistic industry. For this purpose, we assume that the range of products offered and the technologies for producing them are not affected by the merger. The effect of the merger is thus to bring the activities of two firms under the same ownership and management. Changing the ownership structure will affect firm behaviour and the resulting price and quantity decisions. This takes into account new incentives for the merged entity, but also the reactions of competitors to the merger.

In evaluating these effects we shall proceed step by step.

1. In a first step, we assume that the actions of the competitors are unaffected by the merger. To do that, we will have to make precise what is meant by their actions. When goods are imperfect substitutes any change in the pricing or the production of one product affects the demand for the other products. The prices and the sales of competing products cannot both remain unaffected. We will then distinguish between the case where the prices of the competing products remain fixed with sales adjusting to demand, and the case where the sales of competing products remain unchanged and their prices adjust. The former case corresponds to price competition, while the latter case corresponds to quantity competition.
2. In a second step we examine the reactions of competitors to the merger, and thus depending on the context the change in their pricing or production decisions.
3. In the final step, we combine the effects to discuss the overall equilibrium effect of the merger.

The general conclusion of the analysis for markets with *substitutable products* will be that, compared to the pre-merger situation, the post-merger equilibrium involves:

i) *Higher prices for all the products in the market;*

ii) *Smaller sales for the merged entity;*

iii) *Larger sales for the competitors of the merging firms.*

Beyond this general conclusion, the nature of competition affects the magnitude of the effects, as well as the relative importance of the changed behaviour of the merging parties and the reactions of competitors. A proper evaluation of the merger will therefore need to understand the similarities and differences between price and quantity competition.

We shall also see that in the case where products are complements, the conclusions are reversed, the merger tending to have a positive effect on consumer surplus by lowering prices and/or increasing outputs.

We focus on the analysis of products that are substitutes, which is the case that tends to matter for merger control. We briefly discuss the case of complements in a separate section. We start with the case where firms compete in prices, as described in the first part of the report. We then describe how the analysis has to be changed for quantity competition, and discuss the link with the single dominance test.

In a second part, we adapt the analysis to account for the various factors that may affect the market structure as a result of a merger, such as efficiency gains, product line choices, or the dynamics of entry and exit.

a. Price competition

Let us consider a market with n competitors, each producing a different good.[21] The goods produced are (possibly imperfect) substitutes. Each firm is thus characterized by a

[21] The analysis extends easily to situations where each firm sells several products.

product and a cost function. In all that follows we will consider that the variable unit cost of production is constant for each firm, meaning that they will be no difference between the marginal cost and the average variable cost.[22] Fixed costs are irrelevant for the first (benchmark) analysis as they do not affect the short-run pricing and production decisions; they may matter in the discussion of efficiency gains, entry/exit, dynamics...

The sales (in volume) of firm *i* depend not only on its own price, denoted p_i, but also on all other firms' prices. This relation between prices and sales translates into the demand function[23]

$$q_i = D_i(p_1,p_2,....,p_n)$$

which gives the sales of firm *i* for any prices. Notice that it depends on the prices of all the products. Indeed any change in the price of competing products induces some substitution by consumers, which affect the demands for all the products.

The sales of a firm decrease when its price increases, reflecting the fact that some of the customers of the firm will react to the price increase by switching to competing goods or stopping buying the good altogether. This can be measured by the *own-price elasticity of demand* as defined in section 2 of part I, the percentage reduction in demand for a 1% increase in price. This elasticity $\varepsilon_i(p_1,p_2,....,p_n)$ also depends on all the prices. It is directly related to the degree of substitutability between goods: when goods are highly substitutable, any price increase by firm *i* induces a large amount of substitution. Thus, the more substitutable the products, the higher the own-price elasticity of demand, at any given level of prices.

---

[22] While economists often insist on the difference, it does not alter the fundamental conclusions. We will explain when it matters in the text. In practice, given the short timeframe involved in merger control, and unless there are specific reasons to assume a non-linear cost structure, most cost and econometric analyses are based on average variable costs.

[23] There are several alternative approaches that can be used to derive demand functions : the characteristics approach (Lancaster (1966,1971,1979) with the particular case of location models (Hotelling (1929)) surveyed by Gabszewicz and Thisse (1992), the representative agent approach (Spence (1976), Dixit and Stiglitz (1997)), the discrete choice approach (Luce (1959), Anderson, de Palma and Thisse (1992), Besanko, Perry and Spady (1990), Berry (1992)). Surveys can be found in Eaton and Lipsey (1989) or Vives (1999).

i) Oligopoly theory and the dependence of a firm's price on the prices of competitors

Before we turn to the consequences of a merger, we analyze the firms' pricing behaviour and the resulting equilibrium.[24] Under price competition, each firm sets its price to maximize profits, taking its competitors prices as given. This is equivalent to maximizing the difference between the revenue from sales p_iD_i and its variable cost.

For any given prices of the other firms, when firm i modifies its price, its sales change according to the demand function D_i defined above. This relation between price and quantity is referred to as the *residual demand curve.*[25] The residual demand curve captures the basic trade-off that the firm faces when it chooses its price.

If demand were fixed (completely price inelastic), then increasing the price would simply increase revenue. Indeed a 1% increase in price would simply raise profit by an amount equal to 1% of the revenue from sales p_iD_i.[26]

But we need to account also for the fact that a 1% price increase reduces demand by a percentage equal to the own-price elasticity. This reduction in sales implies a percentage reduction in profit of ε_i %. [27]

---

[24] An extensive treatment of oligopoly can be found in Vives (1999), Tirole (1988) or Shapiro (1989).

[25] In what follows, it is not necessary for the firm to observe its competitors' prices. All is needed is for the firm to be aware of its residual demand curve, or at least to be able to adjust optimally on this residual demand curve through some tâtonnement process.

[26] The production cost is unchanged as the volume of sales is supposed fixed. Each unit of sales generates additional revenue equal to 1% of the price, hence a total of 1% of p_iD_i for the D_i units.

[27] We evaluate here the profit loss due to sales reduction solely at a given price. The profit margin (price minus unit variable costs) on each unit sold is thus fixed so that the percentage reduction in profits is equal to the percentage reduction in sales. For this the assumption that the average cost equals the marginal cost matters, since it implies that the profit margin at a given price is independent of the scale of production. Otherwise the reduction in profit should be based on the marginal cost, and equal to (price-marginal cost) x elasticity x sales.

Overall the total effect of a 1% increase in price is thus a change in profit equal to, in monetary unit percentage points:

$$Change\ in\ profit\ =\ revenue(i) - \varepsilon_i . profit(i)$$

where *revenue(i)* stands for the revenue generated by sales of product *i*, and *profit(i)* stands for the variable profit earned on product *i*. The first term thus captures the benefits of increasing the unit margin, while the second effect captures the loss in terms of foregone sales. The firm will then raise the price as long as profit increases, which occurs if the former effect dominates the latter.

Define the Lerner index of firm *i*, denoted L_i, in this context as the ratio of the variable profit over revenue:

$$Lerner\ index\ =\ \frac{variable\ profit}{revenue}\ =\ \frac{price - marginal\ cost}{price}.$$ [28]

The general conclusion is that the optimal price for firm *i* is such that the Lerner index is equal to the inverse of the own-price elasticity of the residual demand, which writes as:

$$L_i = \frac{1}{\varepsilon_i}$$

This formula captures the basic issue faced by the firm. The left hand side is a measure of the profit margin. On the right hand side is a measure of the substitutability of the product of the firm with other products. Given that the price elasticity captures the substitution possibilities of consumers, it implies in particular that:

The closer substitute the products are, the closer is the price to marginal cost.

---

[28] The equality between these two ratios is only valid if the marginal cost is equal to the average variable cost. In what follows, when the marginal cost is affected by the scale of production, the correct definition of the Lerner index is the last one, based on the marginal cost, which captures the variation of the cost for a small change in the volume produced.

It is worth noting how the interaction among firms is playing in the context of price competition. The Lerner index is the decision of the firm; it depends only on its price and its variable cost. Thus the pricing decision of a firm is only affected by the other firms' strategies through the change that they may induce in the own-price elasticity of this firm. In other words, firm *i* is affected by the other firm's behaviour only in so far that it affects the substitution opportunities of its consumers.

A first and intuitive consequence of the analysis is that the optimal price is positively related to the unit variable cost. For a given own-price elasticity, the price that equalizes the Lerner index with the inverse elasticity rises when the unit variable cost increases. Thus an increase in unit variable costs is translated into an increase in the price, although not on a one-to-one basis.

Second, suppose that demand increases by a fixed amount (the same amount at all prices). The degree of substitutability thus remains unchanged in absolute terms (the slope of the demand curve is unchanged) and a 1 % price increase induces the same volume of sales reduction as before. But since the volume of sales has increased, the *percentage* reduction in demand is now lower, and thus the own-price elasticity is itself lower. The firm then favours a higher Lerner index and consequently sets a higher price.[29]

Once the individual behaviour of a firm is understood, the equilibrium analysis follows. In the market equilibrium, each firm optimally sets its price given the prices set by the other firms. Because product demands are inter-related, this calls for a joint determination of all the prices.

In order to understand the equilibrium of the market, it is crucial to assess how substitution evolves when prices vary.

The typical situation when products are substitutes is that given firm *i*'s price, the own-price elasticity of demand for product *i* is lower for higher levels of competing prices. This is because following an increase in firm *i*'s price, consumers will be less tempted to switch to

[29] The same reasoning implies that a proportional increase of demand does not affect the optimal price when the marginal cost is not affected by the scale of production.

competing products when these products are more expensive. This is because it is now more expensive to use them as substitutes for the product of firm *i*.

Another direct effect is that the demand for the product of firm *i* is higher if the prices of competing goods are higher. As explained above, for a fixed amount of substitution, the firm should then raise its price.

These two remarks lead to a key conclusion for the equilibrium analysis. Because at higher prices of competing goods, the firm faces less competitive pressure, it will set higher prices:

Typically, when goods are substitutes, the higher are the prices of competing firms, the higher is the optimal price of a firm, as well as its volume of sales.

This property is usual referred to in the technical literature as the "strategic complementarity" of prices: if for some exogenous reason, a competitor increases its prices, the firm reacts by raising its own price. This is due to the fact that it faces a (higher and) less elastic residual demand curve, which changes the trade-off between the profit margin and the volume of sales.

Notice that at the same time, its sales increase, although not to the extent that would occur were its price to remain constant. The direct effect of an increase of the competitors' prices is that the firm sells more. It then uses this opportunity to increase its price, which offsets partially the demand rise but not completely. The firm thus sells more at a higher price.

Example:

Suppose that there are only two firms, 1 and 2, and that the demands are linear in prices. The demand addressed to firm 1 is given by $D_1(p_1, p_2) = D - p_1 + 0.5p_2$, where σ is parameter that lies between 0 and 1.

Then the own-price elasticity of demand for firm 1 is

$$\varepsilon_1(p_1, p_2) = \frac{p_1}{D - p_1 + 0.5 p_2}.$$

The elasticity ε_1 decreases with the price of the competing product. Let c_1 denote the unit variable cost. For a given p_2, the optimal price for firm 1 is

$$p_1 = \frac{D + c_1}{2} + 0.25 p_2.$$

It increases with the price of the competing product.

Any increase in the price of one firm thus generates an increase of all the prices in the market (and similarly for decreases). To give an example, suppose that one firm innovates and reduces its unit production cost. As already mentioned, it then becomes desirable for this firm to reduce its price. To fix ideas, suppose that at the pre-innovation market prices, the innovating firm would find it optimal to reduce its price by *5 %*. The reaction of its competitors faced to this price cut is to reduce their own prices. But then the innovator would face a smaller demand than the pre-innovation one and would thus further reduce its price. The market will finally stabilize on a new equilibrium where all prices have been reduced, and the innovator has reduced its own price by more than *5 %*.

ii) Effect of a merger

We now turn to the effect of a merger. For this we assume that firm *i* and firm *j* merge and analyze the impact on equilibrium prices. In this part we wish to abstract from any structural effects of mergers apart from the fusion of the activities. So the post-merger entity has the same technological possibilities: it produces the product *i* with the variable cost of the former firm *i,* and the product *j* with the variable cost of the former firm *j*. Thus we assume that there are no synergies between the production units of firm *i* and firm *j,* no reallocation of capital, no change in the product design....

In this context the only difference between the pre-merger situation and the post-merger situation is that in the latter case the two products i and *j* are produced by the same firm, which cares about the total profit generated by the two products, instead of two separate entities each interested in only one product. To understand the impact, we first compare the

behaviour of this entity with the previous situation, and then derive implications for the equilibrium analysis.

a) Coordination of merging firms' pricing strategies

The first step in merger analysis is to understand the behaviour of the new merged firm, and how it compares with the pre-merger situation. For this purpose, suppose that the prices of the competing products (all the products except *i* and *j)* remain unchanged after the merger. The pre-merger prices of product *i* and *j* are those analyzed before. In the absence of any technological gain, putting two firms under the same ownership and management implies that their pricing decisions will be coordinated so as to maximize the total profit on both products. This implies in the case of substitutable products that prices increase. We describe here the mechanism at work.

The main difference in the behaviour of the merged entity is that when the firm considers the pros and cons of increasing the price of one product, say product *i,* it takes into account the fact that increasing this price will induce some substitution of product *j* to product *i.* This reduces the monetary cost of losing customers on product *i* since part of the demand cut is compensated by additional sales of product *j.*[30]

As before consider the impact on the total profit of the merged entity of a 1% increase of the price of good *i.* In addition to the previous effects (higher margin but less sales), we need to account for the effect on the sales of good *j.* This effect is captured by the *cross-price elasticity of demand* between product *j* and product *i*, defined in section 2, part I. Again this elasticity $\eta_{ji}(p_1,p_2,....,p_n)$ depends on all prices and measures the percentage increase in product *j* sales. Increasing the price of product *i* by 1% reduces sales of product *i* by ε_i % as consumers substitute other product, but part of this substitution is made with other products sold by the firms: it then raises the profit earned on product *j* by η_{ji} %.

Since, the two products are sold by the same firm, the total variation in the profit of the merged entity for a 1 % increase in the price of good *i* is (again in percents of monetary units):

[30] This analysis extends to multi-product firms. The key point is that a merger increases the basket of products that a single firm offers on the market.

$$Change\ in\ profit = revenue(i) - \varepsilon_i.profit(i) + \eta_{ji}.profit(j)$$

The change in the total profit earned on the two products is thus more positive (or less negative) than the change in the profit earned on product *i* alone. The consequence is that the optimal prices will be higher than the prices that would be chosen by two separated firms, which translates into larger Lerner indices:

$$L_i > \frac{1}{\varepsilon_i},$$

$$L_j > \frac{1}{\varepsilon_j}.$$

The exact values are provided in a separate mathematical box. A first conclusion is thus:

Internal coordination:

Consider a merger between firms selling imperfect substitutes. For given prices of the products of non-merging firms, the optimal post-merger prices of the products of merging firms are higher than pre-merger prices.

The magnitude of this effect clearly depends on the degree of substitutability of the products sold by the merging firms. If these products are only barely substitutes, a very small fraction of demand reduction of product *i* is reported on product *j* when the price of product *i* increases. There is little to coordinate, and the effect of the merger on pricing behaviour will be small:

The internal coordination effect is stronger, the more substitutable are the products offered by the merging firms.

The limit to this effect is clearly the competitive pressure imposed by the presence of other competitors. If their products are close substitutes for the products of the merging parties, any attempt to raise the prices of the latter will induce strong substitution and thus a strong reduction in sales.

The internal coordination effect is smaller, the more substitutable are the products offered by the non-merging firms.

Thus what matters for this effect is the relative degree of substitutability of the merging firms' products, compared to the degree of substitutability with non-merging firms' competing products.

To summarize, the internal coordination effect is strong when the products of the merging firms are close substitutes for each other, and poor substitutes for the products of non-merging firms. It is small when the merging firms' products are poor substitutes or when competitors offer close substitutes for them.

The internal coordination of prices can be seen as the initial effect of the merger. It is the most obvious one and the easiest to estimate. Indeed it assumes that the merger affects only the prices set by the merging firms. Thus to obtain an empirical estimate of this effect, it is sufficient to obtain a joint estimate of the residual demands and production costs of the products sold by these firms, which can be done using only data on these products, and ideally on the competing product prices. With this, one can then estimate the would-be increase in prices. But we will see below that such a procedure may be misleading: first, it under-estimates the impact of the merger on the prices of the merging firms, second it ignores the fact that a merger may increase the effective market power of a competitor. As we will see, in the case of quantity competition the same procedure over-estimates the impact.

Mathematically, the optimal prices for the merged firm at given prices of competing products are given by the relations

$$L_i = \frac{1}{\varepsilon_i - \eta_{ji} z_{ji}}$$

$$L_j = \frac{1}{\varepsilon_j - \eta_{ij} z_{ij}}$$

where $z_{ji} = \frac{profit(j)}{profit(i)}$ measures the relative share of profits that are generated by product *j*.

The difference between the levels of prices set by the merged entity and two separated firms depends on the cross-elasticity of substitution between the products of the merging firms, higher cross-elasticities generating higher prices. Notice also that the price of one product increases more if the other products generates a higher level of profit; this is because in this case, in relative terms, the gain on the other products induced by substitution is higher than the loss due to the reduction in the product demand.

b) Reaction of competitors

As already mentioned, equilibrium prices result from the interaction between all the firms on the market, and any change in the behaviour of one firm has consequences for the pricing decisions of all the firms. A proper assessment of the impact of a merger thus requires taking into account the consequence of the merger on the reactions of competitors, and ultimately on the post-merger equilibrium prices.

The tendency of merged firms to set higher prices is the basic ingredient for this analysis. From the viewpoint of competitors, the merged firm acts less competitively since it sets higher prices.

A merger reduces the competitive pressure faced by the non-merging firms.

Indeed, given that the merged entity raises the prices of its products, the demand for the products of competitors is higher in the post-merger situation. Moreover, as the discipline imposed by the prices set by the merged firm diminishes and its products become less attractive to consumers, competitors will face a lower risk of losing their clientele by

substitution toward these products. Typically, competitors will raise their own prices in reaction to the merger.[31]

The reaction of competitors to the merger is to raise prices.

As mentioned above, the demand faced by the competitors of the merged entity increases as a consequence of the less competitive behavior of the merged entity. The competitors react by increasing their own prices, but it should be pointed that although this reaction mitigates the initial increase in their demand, it will not offset them completely. In other words, the reaction of competitors to a price increase by the merged entity is typically such that both the prices and the sales of these firms will be higher than in the pre-merger situation.

c) The Feedback effect on the merged entity

While the previous effects give the intuition of the qualitative impact of the merger, to understand the final global impact, it is necessary to understand how these two effects interact.

Consider for instance the pricing behaviour of the merged entity. We have seen that if the prices of competitors were to remain unchanged, it would increase its own prices by some amount, say $x_i\%$ on product *i and* $x_j\%$ on product *j*. But competitors will react and increase they own prices, and the merged entity must account for this when setting its prices. As we have seen, under price competition the optimal price of one firm increases when the prices of competitors increase. This means that once it accounts for the reaction of its competitors, the merged entity should increase its prices by more than $x_i\%$ *and* $x_j\%$.

We refer to this effect as the *positive feedback effect.* Clearly it tends to magnify the effect of the merger on prices:

[31] By typical, we mean markets that fit general regularity conditions. In particular we always assume that given the market structure and the type of behavioural pattern examined, the market equilibrium is unique (see Vives (1999) for an exposition and a discussion of regularity conditions).

The merged entity price increase is larger than the one that would be optimal at the pre-merger competing products prices.

The positiveness of the feedback effect is the consequence of the "strategic complementarity" of prices. Facing less competitive pressure than the pre-merger independent firms, because competitors react to the merger by pricing less aggressively, the merged entity increases its price. The feedback effect thus tends to magnify the impact of the merger on prices.

d) Equilibrium effects

Notice that a similar feedback effect holds for competitors; if we compute only their reaction to the initial $x_i\%$ price increase by the merged entity derived at pre-merger prices, we underestimate their final reaction, because they will ultimately react to the final increase of the merged entity which will be higher.

Thus the two effects, internal coordination and reaction of competitors, reinforce each other. Overall this will not affect the qualitative impact of the merger, which can be summarized as

A merger in a market with substitutable products induces a global increase of all the prices on the market.

Typically it also induces a reduction of the sales of the merged firms, and an increase in the sales of its competitors.

However, the feedback effects will affect the magnitude of the impact on prices and quantities. As we have seen, the merged firm sets prices that are higher than those that would be predicted assuming that the merger does not affect the prices of competing products. This means that there is some multiplier effect that intensifies the effect of the merger.

The equilibrium increase of the prices of the products sold by the merging firms is higher than would be predicted by assuming that competitors do not react to the merger by changing their prices.

Thus even if one focuses only on the prices of the merging firms, ignoring the equilibrium analysis may lead to misleading conclusions. It is for example possible that at the pre-merger prices of competing products the merged firm increases prices by 4%, but once the equilibrium effect is accounted for, the prices of competing product increases by 3% while the prices of the merged firm increase by 6%.

The same hold true for competing products: if we evaluated only the reaction of competitors to the price increase of the merged entity predicted in the first step, we would underestimate the final price increase.

The general conclusion here is that a proper evaluation of the impact of the merger on prices requires a full fledged equilibrium analysis of the market.

Remark: Complementary products

The mechanisms described above still apply but in the opposite direction when the merging firms sell complementary rather than substitutable products.[32] For instance consider a merger between two firms selling complementary products, each competing with other firms selling substitutes to their products. As was shown by Cournot (1838), the internalisation effect gives the merged entity incentives to set prices for complementary products at levels that are smaller than their pre-merger levels.[33] This arises from the fact that, when goods are complements, the demand faced by one firm decreases with the price of the product of the other firm (as opposed to the positive cross-effect of prices found for substitutes). This leads the merged entity, which takes into consideration the profit earned on the other product when computing its optimal price for a product, to reduce its prices.

---

[32] Products are complements when the utility that a consumer derives from each unit of consumption of one product increases with the level of the consumption of the other products. This is in particular the case of goods that are consumed together as part of a system. Video players and video tapes are an example of such complementarities.

[33] Similarly, in the case of quantity competition the internalisation effect would give an inventive to produce more of each product.

If we are in the case where non-merging firms sell substitutes for one of the products of the merging firms, the rest of the analysis follows as before except now that competitors react to a price reduction by the merged entity. The internalisation effect of the merger will thus lead to a global reduction of prices, an increase in the sales of the merged firm and a decrease in the sales of the competing firms.

b. Quantity competition

The above analysis is relevant for markets where firms fix their prices and adjust production to satisfy the demand they face. In other words firms choose prices and adjust supply to demand. This requires enough flexibility in production capacities. Many industries involve some rigidity (or lead-time requirements) in production decisions.[34] In this case, firms choose production and then adjust prices so as to equate their residual demand to their supply. We now examine this situation.

Let us consider a market in which firms choose the production they bring to the market, and then set the prices that allow them to sell this production. In this market, we denote as before q_i the production chosen by firm i. Given quantity choices by the firms, the prices at which the firms will sell their production depends are the prices $p_1, p_2 \ldots p_n$, at which the demands for the products of the firms are precisely $q_1, q_2 \ldots q_n$. Notice that in such a situation the price at which one firm sells its production depends not only on its own production, but also on the productions of all the other firms active in the market, since consumers can substitute products. We can summarize this by the relation:

$$p_i = P_i(q_1, q_2, \ldots, q_n)$$

[34] Agricultural markets where production decisions are at sowing periods and products are marketed after harvesting are examples of such markets. Typical examples of markets with price competition are markets where firms produce on order with catalogue prices.

which gives the final price of the product of firm i as a function of all the quantities produced by the firms on the market. These relations are referred to as *inverse demands*.

In the case of quantity competition, the firm then chooses the quantity it brings to the market. But in doing so it must account for the fact that its price will have to be adjusted if it changes its quantity.

Homogeneous products

When products are true homogeneous products, consumers do not distinguish between the products and thus buy the cheapest available (note that this assumes that different outlets do not incur different transport costs). In this case, when all firms sell their production, they face the same price p that is function solely of the total quantity produced

$$p_i = p = P(q_1 + q_2 + ... + q_n)$$

This is known as the Cournot model with a homogeneous good and it is extensively used in the economic literature. We shall use this model to illustrate some of the effects discussed because it is analytically convenient. But we should stress here that this model leads to rather strong conclusions on post-merger market shares that may not be robust to different circumstances. For instance, when combined with the assumption of constant variable costs, this model predicts that a merger has the same price effect as if the firm with the higher marginal cost simply exited the market. See Salant et al (1983) for an analysis of mergers under Cournot competition.

It should be pointed that consumers' choices remain based on market prices. This means that for given product characteristics the set of price-quantity relations expressed by the n demand curves $q_i = D_i(p_1,p_2,....,p_n)$ linking the final sales of the products to the n prices is the same as the set of relations expressed by the n inverse demands $p_i = P_i(q_1, q_2, ..., q_n)$ linking the n prices to the n quantities. Indeed the inverse demands can be derived from the

demands.[35] There are simply expressed here the other way round to account for the different strategic situations that the firms face.

Moreover, the firm must choose as before a price-quantity pair lying on its perceived demand curve. Thus any difference between price and quantity competition reflects not the variable that the firm itself chooses but what it takes as given in the choices of its rivals. In the case of price competition, alternative prices (and therefore quantities) on the part of one firm imply different sales for the other firms at unchanged prices. In contrast, in the case of quantity competition alternative quantities (and therefore prices) on the part of one firm imply different prices of the other products at unchanged quantities sold.

Alternative interpretation:

One other interpretation of the Cournot model that is popular is that it is a representation of the strategic interactions between firms at a stage where they choose their production capacities. Indeed suppose that every year firms choose their production capacities at the beginning of each year and that it lasts for one year. During the year firms compete in prices but they are constrained by their initial capacity choice. In this context the prices that prevail at a given date depend on the capacities of firms. If it is the case that firms sell up to capacity during the period, [36] than the prices are given by the inverse demand curve evaluated at the full capacity production. In this case q_i can be interpreted as full capacity production, and the Cournot equilibrium represents the equilibrium capacity choices of the firms. [37]

---

[35] That is, the system of inverse demand curves is obtained by inverting the system of demand curves.

[36] This occurs in particular when the cost of building capacity is substantially higher than the production cost (Kreps and Scheinkman (1983), Davidson and Deneckere (1985), Herk (1995)). Vives (1999) presents a survey of this approach in its comprehensive study of the game theory approach to oligopoly.

[37] In this interpretation the unit variable cost should include the cost of building the capacity as well as the production cost.

i) Oligopoly equilibrium

Let us consider as before the problem faced by a firm when it chooses its quantity. The problem of the firm is the same as described in the section on price competition. It is basically a choice between *high margin/low sales* and *low margin/high sales.* Indeed increasing its quantity allows the firm to benefit from its margin on larger sales, but at the same time it forces the firm to reduce its price and thus its margin. To draw the parallel with the section on price competition let us consider the percentage reduction in demand of firm *i* that would correspond to a final increase of *1%* of firm *i*'s price. Recall that in the case of price competition, this percentage was ε_i the own-price elasticity of demand. Denote by $e_i(q_1,..,q_n)$ this percentage in the case of quantity competition.[38] Then, by the same reasoning as before, reducing its quantity by e_i % and thus increasing its price by *1%* would yield a change in profit for firm *i* equal to

$$Change\ in\ profit\ =\ revenue(i) - e_i.profit(i)$$

The firm should reduce production, thereby increasing the sale price, as long as this yields additional profits.

As a result the optimal quantity choice of firm *i* is such that the Lerner index is equal to:

$$L_i = \frac{1}{e_i}.$$

We see that the nature of the strategic choice of the firm is unchanged. Were the percentage $e_i(q_1,..,q_n)$ equal to the own-price elasticity of demand $\varepsilon_i(p_1,..,p_n)$ for all the firms, then quantity competition would give the same outcome as price competition. But the nature of the balance between margin and sales is changed when firms compete in quantity. In particular, when we compare $e_i(q_1,..,q_n)$ for given quantities with the own-price elasticity of

[38] Formally, $e_i = -\dfrac{P_i(q_1,...,q_n)}{q_i \dfrac{\partial P_i(q_1,...,q_n)}{\partial q_i}}$.

demand $\varepsilon_i(p_1,...,p_n)$, evaluated at the prices that prevail for these quantities,[39] the former is smaller than the latter.[40] This means that, starting from the same market outcome (same prices and quantities for all products), the same increase in the price of one firm generates a smaller reduction in its sales.

One way to see the difference is the following. For a firm in a monopoly situation, the demand it faces determines the quantity it can sell at any given price, or equivalently, the price it has to charge to sell any given quantity. Such a firm could therefore reason indifferently in terms of price or quantity. In an oligopolistic market, however, demands are interrelated, so that any change in the pricing or quantity decision of one firm implies some adjustment by competitors. Thus, when a firm evaluates the price-sales trade-off, the relevant elasticity depends on its conjecture about the likely adjustment of competitors. The own-price elasticity ε_i is relevant when the firm considers that its competitors will maintain their prices and adjust sales. In the case of quantity competition, the firm considers that competitors will adjust in such a way as to maintain their sales (thus changing their prices). [41]

Under quantity competition, when a firm reduces its production, thereby increasing its price, the immediate effect is to induce some displacement of the demand of its product toward the products of competitors. But competitors were already selling their production at the prevailing prices; therefore, if they do not increase their supply, the prices of competing goods must increase:

> *When a firm reduces its quantity, the prices of all products (the firm's product and the competing ones) rise.*

As their prices increase, competing products are less attractive substitutes so that the firm is less constrained by the presence of competing products. This tends to magnify the price increase associated with a given quantity reduction: given that the same price increase

---

[39] At the prices that allow to sell precisely the quantities $q_1,...,q_n$ of each products.

[40] Mathematically, $e_1 = \varepsilon_1 - \frac{\eta_{12}\eta_{21}}{\varepsilon_2} < \varepsilon_1$.

[41] See Scherer (1991) for a discussion of this interpretation of Cournot competition in terms of conjectures on conducts.

can be achieved with a smaller reduction in sales under quantity competition than under price competition, the firm tends to choose smaller sales and higher prices in the former case than in the latter.

Example:

Consider again the situation with two firms, 1 and 2, and linear demands for firms 1 and 2, given respectively by $D_1(p_1, p_2) = D - p_1 + 0.5p_2$ and $D_2(p_1, p_2) = D - p_2 + 0.5p_1$. Then the inverse demands correspond to the relations:

$$p_1 = 2D - \frac{4}{3}q_1 - \frac{2}{3}q_2,$$

$$p_2 = 2D - \frac{4}{3}q_2 - \frac{2}{3}q_1.$$

At given prices p_1, p_2, and quantities q_1, q_2, we obtain:

$$\varepsilon_1 = \frac{p_1}{q_1} \quad and \quad e_1 = 0.75\frac{p_1}{q_1}$$

Thus e_1 is smaller than ε_1.

In other words, under quantity competition, prices adjust in a way that limits substitution effects. The firm then faces less competitive pressure and, as a result, prices tend to be higher, while quantities tend to be smaller.

Example: Cournot competition with a homogeneous product

Consider again the case $p_i = p = P(q_1 + q_2 + ... + q_n)$. Assume that the n firms are active in equilibrium. Let $Q = q_1 + q_2 + ... + q_n$ be the total production. Then the aggregate demand for the product is given by $p = P(Q)$. Let ε denote the price elasticity of this aggregate demand. Consider firm i, and let s_i be its market share (q_i/Q). In order to increase the market price by *1%*, it must reduce the total production by ε *%*, which amounts to reduce its own production by $e_i = \frac{\varepsilon}{s_i}$ *%*. It follows that the optimal production for firm i satisfies:

$$L_i = s_i \frac{1}{\varepsilon}.$$

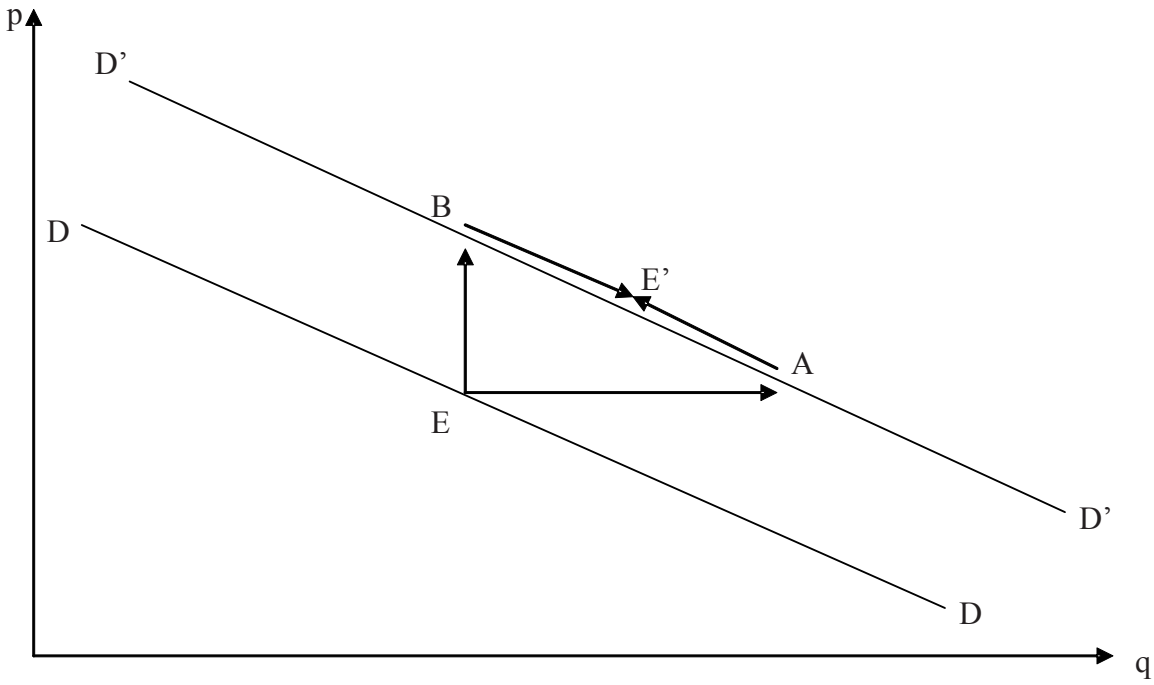
Thus the Lerner index $\frac{p - c_i}{p}$ is proportional to the market share and the inverse of the price elasticity of demand. In particular, the smaller the marginal cost, the higher the market share.

Once the behaviour of individual firms is understood, the equilibrium is obtained when each firm acts optimally.

As in the case of price competition, any exogenous reduction of the quantity produced by one firm relaxes the competitive pressure on its competitors. These competitors will be able to sell the same quantity at higher prices. Their optimal reaction will then be to increase their sales:

Typically, under quantity competition, the optimal quantity supplied by one firm is higher, the smaller are the quantities supplied by competing firms.

This property is usually referred to in the economic literature by saying that quantities are strategic substitutes. This does not reflect a different pattern of behaviour by the firm, but the fact that firms are affected differently by the competitors' strategic choices than under price competition. When a competitor raises its price under price competition, the effect is to raise the sales of the firm since its price is its decision variable. The firm then reacts by raising its price. When a competitor reduces its production under quantity competition, the effect is an increase in the price of the firm at given sales. Here the firm reacts by raising its production. This is illustrated in the next figure.



In the graph, the firm initial residual demand is DD. The firm chooses the point E on this residual demand. Now suppose that the residual demand increases to D'D' (either because competitors raise their price or because they reduce their production). Then in the case of price competition, the initial effect is a shift from E to A. The firm reacts by raising its price and chooses the point E'. In the case of quantity competition, the price adjusts so that the initial effect is a shift from E to B. The firm chooses the same point E' on the new residual demand which correspond to a smaller quantity.

ii) Effect of a merger

The analysis of internal coordination effects is basically the same as for the case of price competition, except that the choice variables are the quantities and the relevant demands are the inverse demands for quantities.

a) Internal coordination

At given quantities produced by the other firms, a merged firm produces less than what two uncoordinated firms would produce, thereby inducing higher prices for its products. The merger induces a supply squeeze by the merging firms, increasing the prices of all the products. The magnitude of the effect will be different however, as the nature of rivalry is changed. As explained before, prices of competing products increases as the merged firm reduces its productions. This means that the optimal price-quantity change evaluated holding the production of competitors constant at its pre-merger level would involve a higher price than the optimal price-quantity change evaluated holding the prices of competitors constant at their pre-merger levels.

b) Reaction of competitors

As before, the merger reduces the competitive pressure on the competing firms. Faced with a less aggressive competitor and higher demands, the other firms will react by producing more.[42]

Competitors react to the merger by increasing their supply.

Notice that the effect is similar in nature to the one described for price competition. In both cases the firm strikes a balance between increasing its sales and increasing its prices. The result of the trade-off is that the reaction of competitors reduces the impact of the merger on prices without offsetting it. That is, the reaction generates again both higher sales and higher prices for the competing products.

[42] See for instance Davidson and Deneckere (1985).

However, the fact that strategic choices are different (quantities instead of prices) has implications for the analysis of the feedback effect.

c) Feedback effect and equilibrium.

Combining the effects to obtain the final impact requires as before an analysis of the feedback effect.

Again consider the behaviour of the merged entity. Let $x_i\%$ be the reduction in supply that would be predicted by an evaluation of the internal coordination effect at pre-mergers supplies of competitors. As the result of this supply cut, competitors' prices increase. The firm should thus anticipate that competitors will increase their supply in reaction to the merger.

This is similar to the case of price competition. However notice that the merged firm is affected differently by the reaction of competitors. Under price competition the price that it has chosen to set remains unchanged and its sales increase, which is beneficial to profit. Under quantity competition, since the sales of the firm remain constant, its price must decrease demand is to remain constant. Thus at the chosen level of production, the merged firm's prices are affected negatively by the reaction of competitors, which is detrimental to profit. In other words, under quantity competition the merged firm is made worse off by competitors' reaction to the merger.

Given that competitors raise their supply, the merged firm's initial reaction should be to reduce even further its supply, with a final reduction larger than $x_i\%$. This reaction mitigates the impact of the competitors' additional supply on the merged firm's prices. In turn, this implies that competitors should raise their supply even further.

While the initial effect of the merger is to increase all prices, this is counterbalanced by the reaction of competitors who raise their supply. The global equilibrium implications of the feedback effect on prices are less clear-cut than for price competition as some quantities increase while other decrease. In a typical situation the feedback effects mitigate but do not reverse the qualitative impact of the merger suggested by the behaviour of the merged entity.

Notice that the feedback effect exacerbates the effect on the individual production levels of the merging firms. As competitors react to the merger by raising their production, the equilibrium reduction of the levels of production of the merged firm is larger than would be predicted assuming that the quantities produced by competitors remain unchanged.

> *Typically, when firms compete in quantities, post-merger prices of all products increase, the sales of the merged entity decrease, and the sales of competing firms increase.*

We see that the qualitative conclusions are the same under price competition and under quantity competition.

If we evaluate the equilibrium in the case of homogeneous production, the overall effect is a reduction in the total supply. This reduction is however smaller than the one predicted by the internal coordination effect evaluated at pre-merger quantities for competitors, so that the final price increase is also smaller. This means that the feedback effects tend to mitigate the impact of the merger on the price. In other words, altogether the reaction of competitors mitigates the negative effect of the merged entity reduction in supply on the final price.

Focusing on final prices in the general case, we see two effects: the merged entity reduction in supplies raises prices, but the reaction of competitors creates a countervailing effect, as they increase their supply which depresses prices. As a result:

> *Under quantity competition, the equilibrium increase of prices is smaller than would be predicted by assuming that the quantities produced by competitors remain unchanged.*

Thus ignoring the equilibrium effect may lead to overestimate the impact of the merger on final prices.

One should be careful in contrasting these conclusions with the case of price-competition. Overall we see that the *qualitative* conclusions are the same for quantity competition and for price competition. However, the quantitative predictions may differ substantially between the two models.

Although the feedback effect tends to stabilize prices in the case of quantity competition, this should not be interpreted as implying that the effect of a merger will be smaller in this case. For one thing the pre-merger price levels will be different under price competition and quantity competition, even if in both cases there are mark-ups above the marginal cost and output is thus already lower than what would be efficient. But the internal coordination effect will be stronger in the case of quantity competition than in the case of price competition. The reason is the same as the one invoked to explain why quantity competition leads *a priori* to higher prices than price competition. In the case of quantity competition, any attempt of the merged entity to raise its price margin by cutting supply is facilitated because the prices of competing products adjust upward. The merged entity will thus induce a higher price increase in this case.

To summarize:

Under quantity competition the internal coordination effect is stronger but it is mitigated by the feedback effect, while in the case of price competition, the internal coordination effect is smaller but it is exacerbated by the feedback effect.

This means that it is not possible to conclude a priori that a merger is more a concern in one or the other situation. This will have to be settled on a case by case basis, with empirical methods and detailed equilibrium analysis. We provide here two simple theoretical examples to illustrate this point.

Example 1:

Consider a market with three firms selling very close substitutes. Under price competition, equilibrium prices will be small, close to marginal costs. In this case the merger between two firms will have little effect on this market, because the third firm imposes a strong competitive pressure: any attempt to raise the price by the merged firm will trigger a substantial migration of consumers to the competing firm. Under quantity competition, the pre-merger prices will be higher, but the impact of the merger will also be stronger. This is because the third firm imposes a small competitive pressure and limits its own supply. The

merged firm will then have more freedom and gains in coordinating the productions at reduced levels.

To be more precise suppose that the products are homogeneous and that the price elasticity of aggregate demand is constant equal to $\varepsilon = 2$, which corresponds to a market demand of the form $\log(Q) = D - 2\log(p)$. Suppose also that all the firms have the same marginal cost c. Then under price competition, the pre-merger equilibrium price is $p = c$ and the variable profit is zero. The post-merger price is also $p = c$. The presence of one competitor is enough to discipline prices, and the merger has basically no effect on prices.

Under Cournot competition the pre-merger price is given by

$$\frac{p-c}{p} = \frac{1}{3.\varepsilon}, \text{ or } p = (1,2)c > c.$$

It is thus higher. Post-merger, there will be only two firms with half of the market each and the post-merger price is

$$p^m = (1,33)c > (1,2)c.$$

The merger results in a price increase of 11%. Thus the effect of the merger is stronger in the case of quantity competition.

Example 2:

Consider now the same situation with only two firms. The merger creates a monopoly. For a monopoly it is irrelevant whether it chooses its price or its quantity: in fine it always chooses a price-quantity pair on its demand curve. The post merger price will be the same in both cases:

$$p^m = 2c.$$

In the case of price competition, the pre-merger equilibrium price is $p = c$ as in the previous example. This corresponds to a 100% increase of the price due to the merger.

In the case of quantity competition the pre-merger price is 1,33c. This means that the merger creates an increase of the price of 50%.

Thus the reduction in consumers' welfare that is generated by the merger is larger here in the case of price competition.

c. Single dominance and equilibrium effects

The test used in the US merger Guidelines, « substantial lessening of competition », allows without ambiguity to account for all the equilibrium effects of a merger. This is so because it applies not only to the merging firms but to the market as a whole. The single dominance criterion on the other hand refers only to the merged entity. This is not to say that equilibrium effects cannot be accounted for, but it raises the question of whether all equilibrium effects can be accommodated. In what follows, for the sake of presentation we interpret the single dominance test as involving the following two conditions:

1 The final market share of the merged entity must be high, and higher than the market share of any of its competitors
2 The merger must result in a substantial price increase for the merged entity

This is clearly an oversimplification but for our concern this is sufficient to highlight the issues.

a) Market power in the absence of any single dominant firm

One issue raised by the market share criterion is the possibility that a merger generates a strong equilibrium effect, although there is no clearly dominant firm in the market. If no firm is dominant after the merger, it will not be challenged under the single dominance test. However there are instances where this type of merger may have a strong impact on prices. This occurs when the market is already concentrated and the merger increases concentration without giving a clear advantage to the merged firms or any of its rivals

To give an example, suppose that we have a market with 5 firms competing à la Cournot with homogenous products with the same marginal cost *c*. The fact that they have the same marginal cost implies that in equilibrium they have the same market share. Suppose that the price elasticity of the aggregate demand is fixed and equal to 1.2. The demand is then $\log(Q) = D - 1,2\log(p)$.

The equilibrium Lerner index is:

$$\frac{p-c}{p} = \frac{1}{5(1,2)} = 16.7\%$$

Suppose that two of the firms merge and that the only effect of the merger on costs is to reduce the fixed costs, by avoiding duplication.[43] The post-merger situation has four firms with equal market shares 25%. Thus there is no dominant firm. But the post-merger Lerner index is

$$\frac{p-c}{p} = \frac{1}{4(1,2)} \approx 20,8\%$$

The post- merger price is 5,2% above the pre-merger price, despite the fact that it does not create a dominant position;

A similar issue arises when considering a situation in which the merger proposed by the firms involves the resale of assets to a third firm. Suppose that two merging firms holding together more than 40 % of the market productive assets (in terms of technology, know-how, physical and human capital, etc.) plan to resell part of these assets to a third firm, in such a way that it re-equilibrates market shares and leave less than a 40 % market share to the merged entity. Indeed there have been several cases in which the merger initial proposal included the voluntary resale of some assets to a third firm.[44] With such a deal, the merged firm can escape from the single dominance test. As firms adapt to regulation and learn how to deal with mergers, situations where a merger avoids the creation of a single dominant position by including such resale of part of the assets to competitors in the proposed deal may become more common. Then one would like to be able to assess the effect of the increased concentration in this case, without relying on collusive arguments.

[43] In this context the merging firms obtain smaller variable profits after the merger than before. Thus there must be some efficiency gains that justify the merger.

[44] See for instance the joint case UPM-Kymmene/Haindl and Norke-Skogg/Parenco/Walsum (M.2498 and M.2499).

b) Mergers between non-dominant firms

The second issue is that some mergers by non-dominant firms may have a negative impact on consumers once the equilibrium effect is accounted for. Consider for instance a situation with one firm with 60% market share, and two firms with 20% market share. Now suppose that the two smaller firms merge. Then our analysis implies that all the prices will increase. Moreover the market share of the dominant firm will increase while the merged entity will end up with less than 40% market share. [45] In this context, the impact may be strong. In evaluating such a situation, one should obviously be cautious and account for all the effects. For instance it may be the case that the merged entity is a more viable competitor in the long run. But it remains true that the short-run effect in the absence of efficiency gains will be detrimental to consumers.

Example:

Assume that firms sell homogenous products and compete in quantities. The elasticity of the aggregate demand is constant: $\varepsilon = 2$. The initial situation has 3 firms with respective market shares 60%, 20%, 20%. This means that the marginal costs of firm 2 and 3 are equal: $c_2 = c_3$, while the first firm has a smaller cost $c_1 = (0.78)c_2$. The pre-merger equilibrium price is then $p = (1.11)c_2$. Suppose that the two firms 2 and 3 merge. Post-merger there is firm 1 with a cost c_1, and the merged firm with a cost c_2. Deriving the new post-merger equilibrium we obtain the following. The post merger price is $p^m = (1.185)c_2$ so that the price increases by 6,75%. The market share of firm 1 is 69% while the market share of the merged entity is 31%.

Thus the key difference between a single dominance test and a full equilibrium analysis is that the latter encompasses a greater range of anti-competitive outcomes than the former.

[45] Notice that one could conceive challenging the merger on the basis that it increases the dominant firm's market power. To show that the dominant firm will increase its prices would require an equilibrium analysis as discussed below. We follow here the standard ECJ interpretation that the merged entity must be dominant to be challenged.

However, this does not imply that undertaking a full equilibrium analysis necessarily makes merger control more restrictive, since the equilibrium effects of a merger can sometimes make anti-competitive outcomes seem less likely than those based on a single dominance test. For instance, suppose two firms with 22% market share merge in an industry in which quantity competition is the norm. Their merger would initially create a firm with 44% market share which would normally be enough to create a presumption of dominance. However, the equilibrium response of other firms would be to increase their own capacities, in ways that might significantly mitigate the initial impact of the merger on prices.

c) Evaluating the price increase

Whenever the market share criteria are met because one of the firms is dominant or because it brings together enough market shares, there is less difficulty. Indeed it is possible and desirable to include all the equilibrium effects in the evaluation procedure used to assess the final impact on the merger on prices.

A first point is that, since the internal coordination of the merger is a key driver of the global effect, evaluating optimal prices on the basis of estimates of the merging firms' residual demands in the pre-merger situation already provides useful information.[46] Indeed it gives an idea of the magnitude of the coordination effect.

However, ignoring equilibrium effects amounts to assume that the other firms do not react. As we have seen, this would bias the evaluation of post-merger prices: it would underestimate it under price competition and overestimate under quantity competition. In fine, whether this is done or a proper full-fledged equilibrium analysis is done may lead to big differences in the final evaluation.

Another issue is whether one should interpret the single dominance test as suggesting that the focus should be on the prices and production of the merged entity solely.

It is worth pointing out that doing so may be misleading. Since all the prices of all the firms are affected by the merger, a proper evaluation of the impact on consumers should be

[46] See the work of Baker and Bresnahan (1985, 1988).

based on a global market analysis. To give a simple example, a merger, with say a 40% market share, that leads to a price increase of 5% for the products of the merged entity may be more detrimental to consumers than one with a 7% increase, if the former induces a 4% increase of the prices of the competing products and the latter only 1%.

The general conclusion is that when evaluating the impact of the merger on prices and ultimately on consumers, it is better to rely on a full equilibrium analysis and to evaluate the effect on all prices.

We should point out that using equilibrium analysis cannot be considered as imposing a stronger requirement on merging parties, compared with an evaluation that would hold the behavior of competitors fixed, since the predicted price increase can be larger or smaller depending on the characteristics of the market under consideration.

d. Concentration indices

Concentration indices are statistics of the degree of concentration of the industry that can be used to help the evaluators during their assessment of a merger. For merger cases, concentration per-se is not the issue, but rather the level of market power and the likely effect of the merger on this market power. The key question related to these indices is thus their ability to capture the market power of the firms.

Under the single dominance test, a natural index is the combined market shares of the merging parties. There is some support in the economic literature for greater concerns on mergers involving large firms. In their analysis of mergers under quantity competition, Farrell and Shapiro (1990) show that mergers have little impact on prices when they involve firms with small market shares. Some support for the single dominance test can be found in McAfee and Williams (1992) who suggest that mergers creating or involving the largest firm on the market will have the most detrimental effect. According to this line, mergers that involve only firms with small market shares could receive an a priori favourable treatment.[47]

[47] Because small merging firms have little effect on prices, there should also be a stronger presumption that they aim at substantial efficiency gains (see below for a discussion of efficiency gains).

The best known index is the *Herfindahl-Hirschman Index (HHI)*, given by the sum of the squares of the market shares (in percentage terms) of all the firms participating to the market. For instance the US Merger Guidelines use the post-merger HHI (with thresholds 1000 and 1800) and the change between the pre-merger and the post-merger (ΔHHI, threshold are 100 and 50 depending on the post-merger HHI) as a first screening device. The HHI is a summary that captures both the number of firms and the dispersion of the market shares. Its value is 10000 for a monopoly while it is 10000 divided by n if there are n firms with equal market shares. For example a HHI of 1000 obtains for 10 firms of equal size but also with 1 firm with a 30% market share and 49 small firms each with a 1.43 % market share. A market with a firm holding a 35% market share or more would have a HHI larger than 1225. If a firm hold a 40% market share, the HHI is larger than 1600. The change in the HHI is equal to twice the product of the market share of the firms. For instance a merger between a firm holding a 35% market share and a firm holding a 2% market share raises the HHI by 140.[48]

The main rationale for the HHI can be found in the Cournot model with homogeneous products. Indeed in this case the mark-up over unit variable cost (the Lerner index) is proportional to the market share of the firm (with a coefficient equal the inverse elasticity of the market demand). Using that, one obtains that the mark-up of the price over the average market unit cost is proportional to the HHI (for a given elasticity of demand).

HHI and the Cournot model[49]

Consider the situation of quantity competition with homogenous product, and aggregate demand $Q = D(p)$. Then we have seen that the equilibrium price verifies for all firms $\frac{p - c_i}{p} = \frac{s_i}{\varepsilon}$, where $s_i = \frac{q_i}{Q}$ is the firm i's market share and ε is the price-elasticity of the aggregate demand. The average unit cost (total variable cost divided by total production) is $c = \sum_i s_i c_i$. Define $H = \sum_i \left(s_i\right)^2$, the HHI is H multiplied by 10000. Taking a weighted average of the Lerner indexes we obtain that

[48] All this shows that a screening test of single dominance based on a 40% or a 35% market share would select less cases than the US merger guidelines HHI test.

[49] See Cowling and Waterson (1976), Dansby and Willig (1979), Farrell and Shapiro (1990).

$$\frac{p-c}{p} = \frac{H}{\varepsilon} = \frac{HHI}{10000.\varepsilon}.$$

Thus for a fixed elasticity of demand, the mark-up over mean unit cost is proportional to HHI. It is also possible to show that the total average profit is proportional to the product of the HHI and of the total revenue of the market$\left(H \frac{pQ}{\varepsilon} \right)$.

Thus in the case of the Cournot market game, the HHI captures in a nice way the average market power. We should point here that this true for the pre-merger HHI, but that under the Cournot analysis, the post-merger HHI is not a good predictor of the final market power. This is so because the model also predicts that the post-merger market share of the merged firm will be smaller than the combined market-share of the merging firms. Thus the post-merger HHI overestimates the final value. In addition, it should be pointed out that, while the evolution of the HHI matches that of various measures of market power, the HHI level does not provide absolute measures of market power. That is, the same HHI level can reflect different levels of market power or prices in different industries.[50]

Still, in spite of these qualifications, the HHI can be considered a good indicator in the case of quantity competition and products that are close substitutes.

However, as pointed out by Willig (1991) in his discussion of market share indicators, the HHI is a poor indicator of market power in the case of product differentiation and price competition. As we have seen the effect of a merger in this context will depend mostly on the cross-elasticity of the products within the merging firms and between the merging firms and the others. For this, market shares may not be very informative as two firms selling rather imperfect substitutes may have both a large market share. In this case it would be more appropriate to base the analysis on some measure of the substitutability of products than on

[50] For example consider a simple Cournot model with linear demand of the form $D(p) = d - p$ and a uniform, constant linear cost c. Multiplying the demand parameter d and the cost parameter c by the same factor has no impact on equilibrium quantities and HHI levels, but affects consumer surplus, profit and total welfare.

market shares.[51] For instance some evaluation of the ratios between the cross-elasticities of the products and the own-price elasticities could provide some useful information.

2. Structural effects

We have assumed so far that the technologies, products and costs where unaffected by the merger. Most mergers do involve such structural changes. Indeed these changes will often be the motives of the merger.

It was also assumed that the only effect of the merger on the market structure was to bring two firms under the same ownership, other firms remaining unaffected. Since a merger is a major structural change in an industry, it may induce reactions of competitors that go beyond the mere pricing and productive decisions. Indeed it will affect the whole industrial strategy of the competitors. In particular competitors may introduce new products in reaction to the merger, or new competitors may decide to enter the market.

From an evaluation perspective it seems judicious to start a merger review by evaluating as above the would-be impact of the merger, when no structural characteristic other than ownership is affected by the merger.[52] A strong argument for proceeding in this way is that such an evaluation can be based on past market data, and minimize the reliance on prospective analysis. It is thus the most reliable part of an evaluation procedure. However it

---

[51] Willig points however to a class of model that is extensively used in the econometric studies of market equilibrium for which market shares provide good predictors of cross-elasticity. The model is a « logit random utility discrete choice model » as developed in Anderson et al (1992), or Besanko, Perry and Spady (1990). These models are developed in the part of the report devoted to econometric methods. These are models in which the relative likelihood that a consumer chooses product *i* over product *j* is independent of the prices of the other product. The derivative of the demand for one product with respect to the price of another product is equal to the product of the market shares of the two products.

[52] We will see below that it is possible to include in the equilibrium analysis some merger related changes in the cost structure, in particular those related to the reallocation of productions within the production units of the merging firms. But beyond this point, things become more prospective.

can only provide the benchmark used to evaluate the merger, and it is necessary to account for the other effects of the merger, either on the technologies or on market structure.

a. Efficiency gains

Efficiency gains are not the object of this report, and are a matter for study in themselves.[53] However there are clear links between the evaluation procedure for the likely impact of a merger and the treatment of efficiency gains. We discuss here some of these links.

Efficiency gains can take many forms. First they may be achieved in the short-run or in the long-run, which may call for a different treatment. There may be generated by a better exploitation of the tangible assets of the firms: [54]

- rationalization through the reallocation of the production
- exploitation of economies of scale (e.g., eliminating redundancies), or economies or scope
- investment

There may also be generated by the exploitation of intangible assets such as:[55]

- sharing of know-how
- management
- R&D and innovation
- product line redefinition
- purchasing power

Some of these efficiency gains will be passed on to consumers, either through lower prices, or through the introduction of new products, or an improvement of the quality of the products. Other efficiencies, for instance the reduction of fixed costs, will translate only into larger profits.

---

[53] Efficiency gains are discussed at length on the issue N°5, 2001, of European Economy. We build on this issue for the discussion.

[54] See for instance Perry and Porter (1985), Farrell and Shapiro (1990)

[55] See Scherer and Ross (1990).

One way or another, these effects have to be included in the evaluation procedure despite the fact that they are in general difficult to evaluate and require a lot of prospective analysis. The reason is that in the benchmark situation with no structural change other than ownership, it is always the case that prices increase. Only the level of the effect needs to be evaluated. Thus, from a general perspective, the motive for allowing mergers and blocking only some of them is precisely that there is a presumption that mergers may improve efficiency and ultimately result in better products being brought to the market at lower prices.

Following the merger analysis by Williamson (1968), the whole issue is to balance the anti-competitive effects of mergers with the efficiency gains that they bring.

The key problem with efficiency gains is that assessing their value is usually an extremely difficult exercise.

For one thing, efficiencies are only potential. At the time the merger is reviewed, efficiencies are not realized. Thus, it is necessary to have an ex-ante evaluation. But ex-ante evaluation may be in some cases almost impossible to obtain. Firms have special expertise on their activities that no outside party has. Thus merging parties will usually have access to superior information than the evaluators. The manipulability of the information transmitted by the firms to regulatory authorities may then undermine the reliability of the assessment, although the advocacy process can help there.

One may think about solving this problem with a post-merger review but such an approach raises serious problems.

- Long-run efficiencies could not be addressed under such a procedure because the review would have to be done after too great a delay. Other efficiencies may involve business secrets that cannot be transmitted to any qualified independent expert for evaluation. For instance when firms have in perspective a new process innovation based on some specific knowledge that can only be protected by secrecy, it is not possible to have an independent evaluation without giving the knowledge to the external expert, thereby losing all protection.

- Even in the case of short-run effects, one should bear in mind that, even from the firms' perspective, most efficiency gains are uncertain. They may or may not be realized, and their magnitude is hard to predict. It is then very difficult ex-post to distinguish between situations where firms failed to realize efficiency gains although they attempted to do so, and situations where they falsely claimed efficiency gains with no intent to realize them. Thus an ex-post review would put the merger in a very risky situation.
- Last but not least, once a merger has been accepted and realized, which has to be done in a short time, the ability to correct wrong decisions ex-post is limited. Divestiture is a very costly process, and may create further inefficiencies. Financial penalties have a limited scope, and may be disruptive if they impede seriously the financial position of the firm.

For these reasons, it seems illusory to rely on ex-post reviews for efficiency gains.

Given that efficiency gains have to be accounted for at an ex-ante stage, there are basically two ways to proceed.

First, based on the general presumption that mergers involve some efficiencies, it is possible to account somewhat arbitrarily for these efficiencies by setting thresholds that do not rely on explicit quantifications of efficiency gains. This amounts to designing the procedure in such a way that mergers that do not impede competition too much are accepted. This is one interpretation of the current review procedure, and this could be extended using concentration indexes, or price increase thresholds for the above benchmark analysis. The advantage is that it is simple and fast, and that it does not impose an extra burden on the evaluation procedure. It is however quite imperfect and limited. Indeed they may be mergers that have a high effect on competition but also large efficiency gains that compensate them. Thus there is the risk of blocking some mergers that would be highly desirable.

It therefore seems desirable to introduce an explicit efficiency defense. This is the second way to proceed.[56]

[56] See European Policy, N°5, 2001.

Remark: Ideally one would like to rely on a proper equilibrium estimate of all the effects of a merger. But given the difficulty raised by the nature of most efficiency gains,[57] this is just not feasible. We should point here that some efficiency gains can be imbedded in the econometric procedure used to evaluate the impact of the merger (thus on the benchmark). So far as the procedure evaluates the structural parameters of the markets, in particular demand functions and costs, it will allow evaluating as part of the equilibrium analysis, the optimal reallocation of productions and inputs that the merger may induce. How far it can go depends on the level of details of the econometric model, on the available data and on time constraints. This remains in practice limited, and the meagre economic literature on this subject (Farrell and Shapiro (1990), Werben and Froeb (1994)) suggests that this type of efficiency will not be sufficient to offset the negative impact of the merger on prices. In other words, although part of these efficiencies will be passed on to consumers, this only limits the price increase. If the criterion is that consumers must benefit from the merger, which in particular rules out the elimination of fixed costs duplication, then an efficiency defense will have to be based on the other types of efficiencies. For these other efficiency gains, in particular those that are long-run or based on intangible assets, the quantification is a more difficult, and in any case, it would be only indicative and will have to be complemented by a qualitative analysis.

Notice that the two routes are not contradictory. A proper account of efficiencies would rather need to find the right balance between the two. It is not the subject of the present study, but we need to point out that one cannot discuss properly the test used in the assessment of the likely impact of a merger on prices and quantity without at the same time making explicit how efficiency gains are accounted for in the procedure.

---

[57] For instance, the link between the competitiveness of an industry and the innovation process is complex, and it is fair to say that currently we do not have a sufficient understanding of this link to embed it safely in a formal review procedure, or to quantify this link (see the recent work of Aghion et al (2002)), or Tirole (1988) for an exposition of the issues).

b. Entry, exit and potential competition

The second aspect that must be accounted for is the impact of the merger on the market structure.

a) Potential competition

. First, a merger may induce a new firm to enter the market.[58] Since the merger reduces the competitiveness of the industry, there is an increased scope for entry: the post-merger profitability of entry is higher than the pre-merger profitability of entry. Such entry could reduce and even eliminate any negative impact of the merger.

Clearly the likelihood of entry is higher when barriers to entry are low. Thus, an assessment of barriers to entry is required. It seems preferable to conduct this assessment in a separate part. Typically it will be based on different information than that used for the benchmark evaluation, and include qualitative judgments on such things as the know-how required or human capital.

We should point out here the link with the discussion of efficiency gains. A reason for adopting a lenient attitude when barriers to entry are low is not only that there are less competitive concerns but also that there is a stronger presumption in favour of efficiency gains. Indeed firms are aware of potential competition when they decide to merge. When barriers to entry are low, the scope to reduce competition through a merger is limited so that firms will not even attempt to do so. Thus it is more likely in this context that firms that wish to merge do so because they anticipate large efficiency gains.

This reinforces the desirability of a lenient attitude: *the absence of barriers to entry should be a factor that strongly favours the approval of a merger*. In other words, entry

[58] Similarly, a firm already active could introduce a new product.

barriers should be ranked high in a priority list of factors, and they constitute a potential candidate for a pre-review screening list.

b) Exit

The last point to address is whether one should be concerned with the possible exit of currently active firms. In fact there is limited scope for that.

As explained in section 1, a merger typically reduces competition. Indeed, it has been seen that, albeit any change in the cost structure, all market participants benefit from a merger. By increasing their profitability, the merger in fact reduces firms' incentives to exit the market.

This is not to say that exit cannot occur, but when this happens it is due to some other effect of the merger. In particular, an inefficient firm may exit the market if the merger creates an entity that is far more efficient than the pre-merger entity, thus if there are efficiency gains. But this occurs precisely when efficiency gains are so strong that the post-merger prices would be lower than their pre-merger levels in the absence of exit. Thus this occurs in situations where the merger is quite desirable. From a welfare perspective, there should be less concern about that, since efficiency gains will compensate for the exit of an inefficient producer. Indeed, the process by which inefficient firms are replaced by more efficient and innovative firms is one of the main engines of progress in an industry, described at length since the work of Schumpeter.[59] It is thus a healthy process, and the phenomenon by which a merger creates so much efficiency as to drive inefficient competitors out of the market should be considered as part of this process. It is clearly desirable that merger control interferes as least as possible with such a fundamental process and be innovation friendly.

[59] Schumpeter (1943), *Capitalism, Socialism and Democracy,* see also Aghion and Howitt (1998), *Endogenous Growth Theory*.

c) Strategic barriers to entry

For potential competition to be effective, the merged entity must not be in a position to exploit its increased market power strategically to raise entry barriers through its practices. The same applies to the analysis of exit: one may be concerned that the merger raises the ability to engage in predation. Indeed there is a well-known relation between predation and strategic barriers to entry, as the same practices, such as limit pricing or tying, may serve the two purposes. Given that these practices by dominant firms fall already under the legislation on the abuse of dominant position, the issue could be left for ex-post intervention.

One may however include in some cases an evaluation on the effect of the merger on the ability to raise barriers to entry, for instance when tying possibilities are created by the merger.

II. Selected Bibliography

1. Aghion P and P. Howitt, 1998, *Endogenous Growth,* Boston: MIT Press.
2. Aghion P., Bloom N., Blundell R., Griffith R. and P. Howitt, 2002, Competition and innovation: an inverted U relationship, IFS working paper W02/04.
3. Anderson S., de Palma A. and J.-F. Thisse, 1992, *Discrete Choice Theory of Product Differentiation*, MIT Press.
4. Baker J. and T. Bresnahan, 1985, "The gains from merger or collusion in product differentiated industries", *Journal of Industrial Economics* 33: 427-444.
5. Baker J. and T. Bresnahan, 1988, "Estimating the residual demand curve facing a single firm", *International Journal of Industrial Organisation* 6: 283-300.
6. Besanko D, Perry K. and R.H. Spady, 1990, The logit model of monopolistic competition, *Journal of Industrial Economics*.
7. Berry, S.T., 1994, Estimating discrete choice models of product differentiation, *Rand Journal of Economics* 25:242-262.
8. Bulow J., Geanakoplos J. and P. Klemperer, 1985, Multimarket oligopoly theory: strategic substitute and strategic complements, *Journal of Political Economy* 93: 488-511.
9. Chamberlin E.H., 1933, *The Theory of Monopolistic Competition*, Harvard University Press.
10. Cheng L., 1985, Comparing Bertrand and Cournot equilibria: a geometric approach, *Rand Journal of Economics* 16: 146-152.
11. Cournot A., 1838, *Recherches sur les principes mathématiques de la théorie de la richesse*, Paris: Dunod, 2001.
12. Cowling K. and M. Waterson, 1976, Price cost margins and market structures, *Economica* 43: 267-274.
13. Dansby R.E. and R. Willig, 1979, Industry performance gradient indexes, *American Economic Review* 69: 240-260.
14. Davidson C. and R. Deneckere, 1986, Long-run competition in capacity, short-run competition in price, and the Cournot model, *Rand Journal of Economics* 17: 404-415.
15. Davidson C. and R. Deneckere, 1985, Incentives to form coalitions with Bertrand competition, *Rand Journal of Economics* 16: 473-486.

16. Dixit A. and J. Stiglitz, 1977, Monopolistic competition and optimum product diversity, *American Economic Review* 67: 297-308.
17. Eaton C. and Lipsey R., 1989, Product Differentiation, in Schmalensee R. and Willig R. eds, *Handbook of Industrial Organization*, Amsterdam: North Holland.
18. Farrell J. and C. Shapiro, 1990, Horizontal mergers: An equilibrium analysis, *American Economic Review* 80: 107-126.
19. Friedman J., 1988, On the strategic importance of prices versus quantities, *Rand Journal of Economics* 19: 607-622.
20. Gabszewicz J. and J.F Thisse, 1992, Location, in Aumann R., Hart S. (eds.), *Handbook of Game Theory with Economic Applications*, Amsterdam: North Holland.
21. Herk L.F., 1993, Consumer choice and the Cournot in capacity constrained duopoly competition, *Rand Journal of Economics* 24: 399-417.
22. Horizontal Merger Guidelines, 1992, US Department of Justice and the Federal Trade Commission.
23. Hotelling H., 1929, Stability in competition, *Economic Journal* 39: 41-57.
24. Kreps D. and J. Scheinkman, 1983, Quantity pre-commitment and Bertrand competition yield Cournot outcome, *Bell Journal of Economics* 14: 326-337.
25. Lancaster K.J., 1966, A new approach to consumer theory, *Journal of Political Economy* 74: 132-157.
26. Lancaster K.J., 1971, *Consumer Demand: A New Approach*, New York: Columbia University Press.
27. Lancaster K.J., 1979, *Variety, Equity and Efficiency*, New York: Columbia University Press.
28. Luce R.D., 1959, Individual *Choice Behavior: Theoretical Analysis*, John Wiley and Sons.
29. McAfee P. and M. Williams, 1992, Horizontal mergers and antitrust policy, *Journal of Industrial Economics* 40: 181-187.
30. Neven D., Nutall R. and P. Seabright, 1993, *Merger in Daylight: the economics and politics of European merger control*, London: Centre for Economic Policy Research.
31. Novshek W. 1980, Cournot equilibrium with free entry, *Review of Economic Studies* 52: 86-98.
32. Perry M.K. and R.H. Porter, 1985, Oligopoly and the incentive for horizontal merger, *American Economic Review* 75: 219-227.

33. Rey P., Seabright P. and J. Tirole, 2001, The activities of a monopoly firm in adjacent competitive markets: economic consequences and implications for competition policy, IDEI Working Paper.
34. Robinson J., 1933, *The Economics of Imperfect Competition*, New York: Macmillan.
35. Salant S., Switzer S. and R. Reynolds, 1983, Losses due to merger: The effects of an exogenous change in industry structure on Cournot-Nash equilibrium, *Quarterly Journal of Economics* 98: 185-199.
36. Scherer F.M. and D. Ross, 1990, *Industrial Market Structure and Economic Performance*, 3. ed., Boston: Houghton Mifflin.
37. Scherer F.M., 1991, Comment on Willig R., Merger Analysis, Industrial Organisation Theory, and Merger Guidelines, *Brooking Papers: Microeconomics*.
38. Schmalensee R. and R. Willig, 1989, *Handbook of Industrial Organization*, Amsterdam: North Holland.
39. Schumpeter J, 1943, *Capitalism, Socialism and Democracy*, London: Unwin University Books.
40. Shapiro K., 1989, Theories of Oligopoly Behavior, in Schmalensee R. and Willig R. eds, *Handbook of Industrial Organization*, Amsterdam: North Holland.
41. Spence M., 1976, Product selection, fixed costs and monopolistic competition, *Review of Economic Studies* 43: 217-235.
42. Sutton J., 1991, *Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration*, Cambridge: MIT Press.
43. Tirole J., 1988, *The Theory of Industrial Organisation*, MIT Press.
44. Vives X., 1999, *Oligopoly Pricing*, MIT Press.
45. Viscusi W.K, Vernon J.M. and Harrington J.E., 1997, *Economics of Regulation and Antitrust*, Cambridge: MIT Press.
46. Weitzman M., 1974, Prices vs. quantities, *Review of Economic Studies* 41: 477-491.
47. Werben and Froeb, 1994, The Effects of mergers in Differentiated Products Industries: Logit Demand and Merger Policy, *The Journal of Law, Economics and Organization*, 10:407-426.
48. Williamson O.E., 1968, Economies as an antitrust defense: the welfare tradeoffs, *American Economic Review*.
49. Willig R., 1991, Merger Analysis, Industrial Organisation Theory, and Merger Guidelines, *Brooking Papers: Microeconomics*.

Part C: 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.[60] 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.[61] 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;

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.

---

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

[61] 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).

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:[62]

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 $p = c$.[63] If the firms have the same discount factor δ, by sticking to the collusive price, each would earn

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

[62] 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 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 $\delta = 1/(1+R)$.

[63] See Friedman (1971).

If instead one firm slightly undercuts the other,[64] 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

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

that is, if [65]

$$\delta \geq \delta^* \equiv \frac{1}{2}. \qquad (4)$$

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 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.[66] 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

[64] 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.

[65] 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 $1/2 \geq 1-\delta$.

[66] 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.

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.

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.

I. 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.[67]

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. [68]

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

[67] 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).

[68] 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.

$$\frac{\pi^C}{n}\left(1+\delta+\delta^2+...\right)\geq \pi^C+\delta\times 0, \qquad (5)$$

that is, if

$$\delta \geq \delta^*(n) \equiv 1-\frac{1}{n}. \qquad (6)$$

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.[69] 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

$$R \leq R^*(n) \equiv \frac{1}{n-1}. \qquad (7)$$

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.

[69] 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

$$s\pi^C\left(1+\delta+\delta^2+...\right) \geq \pi^C + \delta \times 0, \qquad (8)$$

or, equivalently,

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

which in turn implies that

$$\delta \geq \delta^*(s) \equiv 1-s. \qquad (9)$$

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.[70] 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 [71]

[70] 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).

[71] This uses the fact that

$$1+(1-\mu)\delta+(1-\mu)\delta^2+\ldots=\mu+(1-\mu)\left(1+\delta+\delta^2+\ldots\right)$$
$$=\mu+\frac{1-\mu}{1-\delta}=\frac{1-\mu\delta}{1-\delta}.$$

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

and is thus sustainable if

$$\frac{\pi^C}{2}+(1-\mu)\frac{\delta}{1-\delta}\frac{\pi^C}{2}\geq\pi^C+\delta\times 0, \qquad (10)$$

that is, if

$$\delta\geq\delta^*(\mu)\equiv\frac{1}{2-\mu}. \qquad (11)$$

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.[72] 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.[73]

We have therefore:

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

[72] 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).

[73] 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 $1/2$.

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.[74]

This idea can be illustrated by the US government's practice[75] 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 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, $T+1$, $2T+1$, and so forth. A more frequent interaction means a smaller number of "waiting periods" T. Then, collusion is sustainable if

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

that is, if

[74] 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.

[75] See Scherer (1980).

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

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

$$\frac{\pi^C}{2}\left(1+\delta+\delta^2+...\right) \geq \pi^C\left(1+\delta+\delta^2+...+\delta^{T-1}\right)+\delta^T \times 0, \qquad (14)$$

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

$$\delta \geq \delta^*(T) \equiv \frac{1}{2^{1/T}}. \qquad (15)$$

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

$$V = \frac{1-\mu}{1-\delta\left(1-\mu+\mu\delta^T\right)}\frac{\pi^C}{2}. \qquad (16)$$

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

$$V = (1-\mu)\left(\frac{\pi^C}{2} + \delta V\right) + \mu\delta^{T+1}V \geq (1-\mu)\pi^C + \delta^{T+1}V, \qquad (17)$$

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 (17) is equivalent to:

$$\delta\left(1-\delta^T\right)V \geq \frac{\pi^C}{2}, \qquad (18)$$

and thus (since the left-hand side decreases when T increases) requires price wars to be long enough.[76] An infinite price war (T infinite) would effectively "maintain" collusion (up to the first occurrence of a shock on demand) if (combining (17) and (18) for T infinite) if

$$\delta \geq \frac{1}{2(1-\mu)}, \qquad (19)$$

[76] 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.[77] 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 (18). 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[78] 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.[79] The time lag elapsed between the pricing period and the 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

[77] In particular, if this probability exceeds 50% the right-hand side in (19) exceeds 1.

[78] 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.

[79] See for example Kühn (2001).

"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

$$\frac{\pi^C}{2} + \delta(1+g)\frac{\pi^C}{2} + \delta^2(1+g)^2\frac{\pi^C}{2} + \ldots \geq \pi^C + \delta(1+g)\times 0, \qquad (20)$$

that is, if

$$\delta \geq \delta^*(g) = \frac{1}{2(1+g)}. \qquad (21)$$

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.[80] 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.[81] 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.

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

[81] 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.[82] By sustaining a collusive price p^C, each firm thus gets an expected discounted profit

$$V = \frac{\pi^C}{2}\left(1+\delta+...\right) = \frac{1}{1-\delta}\frac{\pi^C}{2}. \qquad (22)$$

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

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

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:

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

that is, if

$$\delta \geq \delta^*(\varepsilon) = \frac{1+\varepsilon}{2+\varepsilon}. \qquad (24)$$

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 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

$$V^+ = (1+\varepsilon)\frac{\pi^C}{2} + \delta V^-, \quad V^- = (1-\varepsilon)\frac{\pi^C}{2} + \delta V^+, \qquad (25)$$

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 (23) becomes:

$$\delta V^- \geq (1+\varepsilon)\frac{\pi^C}{2}. \qquad (26)$$

This condition is more stringent than the condition (23) 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 (24), 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[83]

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

$$= \frac{\pi^C}{2}\left(\frac{1}{1-\delta(1-\rho)}\right) + \delta\frac{\rho}{2}V^I\left(\frac{1}{1-\delta(1-\rho)}\right). \qquad (27)$$

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 firm expected gains are as follows

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

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

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

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

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

[83] 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.

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.[84] By sustaining a collusive price p^C, as long they survive the two incumbents get an expected rent given by

$$V = \frac{\pi^C}{2} + \delta(1-\rho)\frac{\pi^C}{2} + \delta^2(1-\rho)^2\frac{\pi^C}{2} + ... = \frac{1}{1-(1-\rho)\delta}\frac{\pi^C}{2}. \qquad (30)$$

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[85]

$$\delta \geq \delta^*(\rho) = \frac{1}{2(1-\rho)}. \qquad (31)$$

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.

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

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

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 implications.[86] 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.[87] 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.[88]

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.[89] To see this, let us come back to our simple duopoly model but assume that the 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

---

[86] 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.

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

[88] 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).

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

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

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

that is,

$$\delta\geq\frac{1}{2}, \tag{33}$$

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

$$\left(r-c_L\right)\frac{D}{2}\left(1+\delta+\ldots\right)\geq\left(r-c_L\right)D+\delta\left(c_H-c_L\right)D\left(1+\delta+\ldots\right). \tag{34}$$

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 (35) then determines the threshold for the discount factor, below which collusion is not sustainable:

$$\delta\geq\delta^*\left(\gamma\right)=\frac{1}{2-\gamma} \tag{35}$$

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

$$\left(r-c_L\right)\alpha D\left(1+\delta+\ldots\right) \geq \left(r-c_L\right)D+\delta\left(c_H-c_L\right)D\left(1+\delta+\ldots\right) \qquad (36)$$

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

$$\left(r-c_H\right)\left(1-\alpha\right)D\left(1+\delta+\ldots\right) \geq \left(r-c_H\right)D. \qquad (37)$$

that is,

$$\delta \geq \alpha. \qquad (38)$$

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, $\alpha = \delta > 1/2$.[90]

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

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.[91] Of course, this "asymmetry" can be along other dimensions (see below).

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[92] have confirmed this apparent ambiguity.[93]

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

---

[91] 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.

[92] 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).

[93] 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.

studies.[94] Lambson (1996) shows for example that introducing a slight 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.[95]

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.[96]

If the firms sustain the collusive price $p^C = r$ with market shares α_L and $\alpha_S = 1 - \alpha_L$,[97] 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.[98] 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.

---

[94] 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.

[95] 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.

[96] 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.

[97] 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.

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

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:

$$\delta \geq \delta^*\left(K_L, K_S\right) = \frac{K_L}{K_L + K_S} = \frac{1}{1+\lambda}, \qquad (39)$$

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.[99] 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

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

counterbalancing impact on retaliation power. In this situation, therefore, any additional extra capacity tends to make collusion more difficult (even in symmetric situations).[100]

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 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.[101] The conclusions of the previous discussion thus readily apply. The high quality firm is more tempted to cut prices, because it enjoys a

[100] 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.

[101] 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 $c_L = c-b$.

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 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).[102] 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.

[102] 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.[103]

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.

Illustration.

Formally, they will need to leave a market share $\alpha = 1 - \delta$ to the competitor in the second market,[104] and will thus share the remaining fraction, δ, of that market. They will thus stick to the collusive path as long as

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

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

[104] 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 $\alpha \geq 1 - \delta$.

that is, if

$$\delta \geq \frac{3}{5} \qquad (41)$$

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:

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 $\pi^C = (p^C - c)D(p^C)$ if the short-term gains from a deviation are offset by the cost of a future price war, that is, if

$$\frac{\pi^C}{2}\left(1+\delta+\delta^2+...\right) \geq \pi^C + \delta \times 0, \tag{42}$$

or

$$\delta \geq \delta^* \equiv \frac{1}{2}. \tag{43}$$

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, $\pi^{joint} = (p-c)D(p)$. 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 $\varepsilon(p) = pD'(p)/D(p)$. 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.[105] 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.[106]

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

[105] 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.

[106] 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).

investing less in the venture.[107] For these reasons, collusion is more likely to appear in markets where competitors are tied through structural links.

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.[108] 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.

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

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

[108] 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).

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.[109] 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.[110] 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:

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

[109] 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.

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

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

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

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.[111] 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.

[111] 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).

II. 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.[112] 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.

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.

---

[112] 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.

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.[113]

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:

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

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.

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.[114]

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

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

III. 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.[115] 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 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).[116]

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

---

[115] 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.

[116] 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.

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.

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.

IV. Selected Bibliography

Abreu, D. (1986), "Extremal Equilibria of Oligopolistic Supergames," *Journal of Economic Theory*, 39:191-223.

Abreu, D., D. Pearce and E. Stachetti (1985), "Optimal Cartel Equilibria with Imperfect Monitoring," *Journal of Economic Theory*, 39:251-269.

Armstrong, M. (1998), "Network Interconnection in Telecommunications," *The Economic Journal*, 108:545-564.

Bain, J. (1948), "Output Quotas in Imperfect Cartels," *Quarterly Journal of Economics*, 62:617-622.

Bernheim, D. and M. Whinston (1990), "Multimarket Contact and Collusive Behavior," *Rand Journal of Economics*, 21:1-26.

Booth D.L., Kanetkar V., Vertinsky I. and D. Whistler (1991), "An empirical model of capacity expansion and pricing in an oligopoly with barometric price leadership: a case study of the newsprint industry in North America," *Journal of Industrial Economics*, 3:255-276.

Brock, W.A. and J. Scheinkman (1985), "Price Setting Supergames with Capacity Constraints," *Review of Economic Studies*, 52:371-382.

Compte, O., F. Jenny and P. Rey (2002), "Capacity Constraints, Mergers and Collusion," *European Economic Review*, 46(1):1-29.

Compte, O. and P. Jehiel (2002), "Multi-party negotiations," mimeo, CERAS.

Christensen L.R. and R. Caves (1997), "Cheap Talk and Investment Rivalry in The Pulp and Paper Industry," *The Journal of Industrial Economics,* 1:47-73.

Davidson, C. and R.J. Deneckere (1984), "Horizontal Mergers and Collusive Behavior," *International Journal of Industrial Organization*, 2:117-132.

Davidson, C. and R.J. Deneckere (1990), "Excess Capacity and Collusion," *International Economic Review*, 31:521-541.

Evans, W.N. and I.N. Kessides (1994), "Living by the 'Golden Rule': Multimarket Contact in the U.S. Airline Industry," *Quarterly Journal of Economics*, 109:341-366.

Friedman, J. (1971), "A non-cooperative Equilibrium for Supergames," *Review of Economic Studies*, 28:1-12.

Fudenberg, D. and Maskin, E. (1986), "The Folk Theorem in Repeated Games with Discounting or with Incomplete Information," *Econometrica*, 54(3): 533-554.

Gertner, R. (1994), "Tacit Collusion with Immediate Responses: The Role of Asymmetries," mimeo, University of Chicago.

Gilbert, R. and M. Lieberman (1987), "Investment and coordination in oligopolistic industries," *Rand Journal of Economics,* 18:17-33.

Green, E. and R. Porter (1984), "Non-Cooperative Collusion under Imperfect Price Information," *Econometrica*, 52:87-100.

Haltiwanger, J. and J. Harrington (1991), "The impact of cyclical demand movements on collusive behavior," *Rand Journal of Economics*, 22:89-106.

Harrington, J. (1989), "Collusion Among Asymmetric Firms: The Case of Different Discount Factors," *International Journal of Industrial Organization*, 7: 289-307

Jullien, B. (2003), "Dynamic Oligopoly, Quantity Competition and Collusion," Report for the European Commission.

Jullien, B. and P. Rey (2002), "Resale Price Maintenance and Collusion," mimeo, University of Toulouse.

Klemperer, P. (2002), "How (Not) to Run Auctions: the European 3G Telecom Auctions," *European Economic Review*, 46 (4-5): 829-845.

Kühn K.U. (2001): "Fighting collusion by regulating communication between firms," *Economic Policy*, 32:169-204.

Laffont, J.-J., P. Rey and J. Tirole (1998), "Network Competition: I. Overview and Nondiscriminatory pricing," *Rand Journal of Economics*, 29(1):1-37.

Lambson, V.E. (1987), "Optimal Penal Codes in Price-Setting Supergames with Capacity Constraints," *Review of Economic Studies*, 54:385-397.

Lambson, V.E. (1994), "Some Results on Optimal Penal Codes in Asymmetric Bertrand Supergames," *Journal of Economic Theory*, 62:444-468.

Lambson, V.E. (1996), "Optimal Penal Codes in Nearly Symmetric Bertrand Supergames with Capacity Constraints," *Journal of Mathematical Economy*, forthcoming.

Martin, S. (1993), "Endogenous Firm Efficiency in a Cournot Principal-Agent Model", *Journal of Economic Theory*, 59:445-50.

Martin, S. (1995), "R&D Joint Ventures and Tacit Product Market Collusion," *European Journal of Political Economy*, 24:357-379.

Mason, C.F., O.R. Phillips and C. Nowell (1992), "Duopoly Behavior in Asymmetric Markets: an Experimental Evaluation," *Review of Economics and Statistics*, 662-670.

Osborne, M., and C. Pitchik (1983), "Price Competition in a Capacity-Constrained Duopoly," *Journal of Economic Theory*, 38:238-260.

Parker, P.M. and L.-H. Röller (1997), "Oligopoly and the Incentive for Horizontal Merger," *American Economic Review*, 75:219-227.

Pénard, T. (1997), "Choix de Capacités et Comportements Stratégiques : une Approche par les Jeux Répétés," *Annales d'Economie et de Statistique*, 46:203-224.

Porter, R. (1983), "A Study of Cartel Stability: The Joint executive Committee, 1880-1886," *Bell Journal of Economics,* 14: 301-314.

Raith, M. (1996), "Product Differentiation, Uncertainty and the Stability of Collusion," London School of Economics-STICERD Discussion Paper Series EI/16:49.

Ross, T. W. (1992), "Cartel Stability and Product Differentiation," *International Journal of Industrial Organization*, 10:1-13.

Rotemberg, J., and G. Saloner (1986), "A Supergame-Theoretic Model of Business Cycles and Price Wars during Booms," *American Economic Review*, 76:390-407.

Scherer, M. (1980), *Industrial Market Structure and Economic Performance*, Chicago: Rand-McNally.

Schmalensee, R. (1987), "Competitive Advantage and Collusive Optima," *International Journal of Industrial Organization*, 5:351-368.

Snyder, (1996), "A Dynamic Theory of Countervailing Power," *Rand Journal of Economics*, 27:747-769.

Staiger R. and F. Wolak (1992), "Collusive Pricing with Capacity Constraints in the Presence of Demand Uncertainty," *Rand Journal of Economics,* 23:203-220.

Stigler, G. (1964), "A Theory of Oligopoly," *Journal of Political Economy*, 72:44-61.

Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press.

Part D: Quantitative Procedures for Competition Policy

I. Introduction

a. Development of Quantitative Analysis in Industrial Economics

Somehow replying to policymakers' concern for anticompetitive practices and benefiting from the body of theoretical literature on the subject, a significant effort has been made to provide empirical support for items like the presence of market power, the effect of mergers or the existence of collusive behaviour. Due to a lack of relevant tools and data, these efforts are recent and they have been developed mainly in the last two decades.

The paucity and/or accessibility of detailed data at the firm or product level have certainly constrained the development of empirical analysis for a long time. The improvement of computer technology has considerably reduced the cost of managing the large data sets generated by the working of some markets, industries and companies. The availability of richer data sets and the lower cost of handling those data sets do not suffice to explain the development of empirical tests and estimation in industrial organisation. Since the eighties, econometric methodology, too, has improved considerably. Economists now better understand which regressions can be trusted and have developed more sophisticated interpretations of empirical results. They have provided answers to the problems caused by the analytical complexity of the theoretical models. At the same time, economic theory has achieved remarkable progress by applying game theory to the study of imperfect competition. Progress in econometrics, economic theory and computer science, as well as adequate combinations of results from these three domains, allowed the growth of a new field called Applied Industrial Organisation.

The objective of this report is to identify the procedures that have been part of the research agenda in Applied Industrial Organisation and have been applied in order to help investigators in their task of

- Evaluating the effects of mergers,

and

- Assessing collective dominance.

Note that the report is not intended to provide an exhaustive review of results derived in the empirical literature whose purpose is to evaluate how far and/or strong is the empirical support to the theoretical predictions that has been previously presented.[117]

b. Empirical Techniques for Competition Policy

The use of quantitative techniques in competition policy has surged considerably, in particular in the European Union. The main instance where quantitative analysis is applied is for defining the relevant market. However each of the available techniques can be applied for the more general purpose of measuring market power.[118]

The toolbox of quantitative techniques that can be implemented for investigations under competition laws can be divided in two segments. The first segment, which is very large, contains all the statistical techniques that can be used to provide empirical evidences on issues raised by antitrust cases. Regression analysis, factor analysis, correlation analysis, Granger causality and cointegration tests are examples of such methods. The choice of a particular technique depends on the features of a case, as well as on the nature and quality of the available data. We refer to this segment of quantitative analysis as *empirical reduced-form analysis*, in the sense that the relationship that can be established between a case and economic models is either indirect, either incomplete or informal.

[117] Since Bresnahan's article (1989), there is no complete survey on the recent empirical literature. See however Phlips (1998) and Europe Economics (2001).

[118] For surveys on quantitative techniques in competition analysis, see Bishop and Walker (1999) and LECG (1999).

When it is too loosely or indirectly related to a theory, the use of a statistical technique can excessively depend on the specificity of a particular case. The reduced-form analysis is a heuristic approach that involves useful techniques for the purpose of assessing departures from competition and/or helping in the delineation of relevant markets. It may be harder to use it for defining a benchmark.

The second segment of techniques for competition policy is called *empirical structural-form analysis*. Here, the quantitative analysis is driven by an economic model. This economic model serves as a tool to interpret the relations that exist among the data measuring the phenomenon under scrutiny as the result of an equilibrium. So the main feature of the approach is that the analyst needs first to provide a modelling of the behaviour of economic agents and to measure the external and/or technical constraints that they must face. It is thus a behavioural approach.

The main advantage of the structural analysis is its coherence with economic theory. This approach faces two main issues. First, it must show its relevance for the case under investigation. Second, since its applicability is often a function of the availability and the quality of data, it must account for the quality of data, and when data are faulty, it must explain how results are affected.

Choosing between a reduced-form analysis and a structural analysis is mainly a matter of data availability. For instance, when data on quantities are absent and only price series are available, obviously one cannot expect to calibrate a full equilibrium model while price correlation analysis can be implemented. However, often the results obtained from a reduced-form analysis are interpreted in terms of the ingredients of the economic model that would constitute the basis of the structural model which has not been taken up. Pursuing on the example, evidence of strong correlation among series of prices must be explained by some equilibrium conditions achieved by the underlying economic model. In other words, the two segments of techniques are complements rather than substitutes.

Below we first emphasize the structural approach because it provides a natural link with the theoretical part of this report and it is at the forefront of quantitative procedures for antitrust analysis available to practitioners. In addition it permits to shed light on some reduced-form approaches that we discuss afterwards.

c. Data and Quantitative Analysis

Needless to say that the use of quantitative techniques requires data. The question is not their availability as data sources are numerous in our modern computerised economies, firms and institutions. The critical issue is to collect reliable data that are appropriate for implementing the inference technique selected by the analyst. It is useless to apply a powerful method with deficient or inappropriate data.

In practice the ideal data set is rarely met. Data are incomplete in the sense that they do not cover all aspects of the process or case under investigation. For instance, they could only bear on a limited number of periods and/or economic units; they could measure variables imperfectly or with errors. One may then wonder whether a quantitative analysis is helpful in these conditions. While the reply certainly depends on the case under investigation, it is particularly critical to provide an equal access to the data in an antitrust case. This point is again discussed later.

Strengths and weaknesses of quantitative techniques are strongly related to the type of available data. First it varies according to the degree of *aggregation*. The most disaggregated data are individual data collected in surveys. For instance a household survey representative of the whole population may provide all the necessary information to measure car ownership at a given period of time. From these data, one may easily evaluate market shares in terms of the sales of the year or in terms of the stock of automobile. In addition such a survey provides data on prices. Another example of individual data is the so-called scanner data which collect all individual point-of-sale transactions. However these data are rarely available at this level for technical reasons. They are aggregated for a geographic area, for a given channel of distribution, for a specific market segment, for a given period of time. The aggregation process is not neutral as it could affect the result of quantitative analysis.[119]

The usual types of database are the following: Samples of individual units; cross-sections which provide aggregate information on a set of units (for instance all households on a

geographic area) at a given period of time; time series which correspond at aggregate data over some periods of time; and finally panel data sets which are time series of cross sections. Each type of data raises specific issues which are well documented in the statistical and econometric literature. These issues must be recognized and taken into account in quantitative analysis for competition analysis. In the sequel, we abstract from the type of data when it is possible in order to focus attention on the procedures rather on the details on their practical implementation.

II. The Structural Procedure

The theoretical part shows that competition analysis must account for a large number of factors interacting among themselves, as market size, number and variety of products, number and heterogeneity of agents, time horizon, and uncertainty. The nature of competition is the result of these interdependences. A quantitative structural analysis is aimed at providing a tool to measure the effects of these different factors, to test the validity and the robustness of relationships among these factors and to evaluate the different issues. In addition to provide an approximation to the working of the real world, a structural analysis provides ways to simulate or to predict effects of change of factors, like the change in the numbers of firms in an industry.

The structural analysis is usually associated with *econometric analysis*, which always involves the statistical *estimation* of an economic model. Estimation consists in ways of finding values for the parameters of an economic model in order to obtain the best approximation of the process that has generated the economic data. When data are not available or are too incomplete to implement statistical estimation, the analyst may proceed to a *calibration* of the model, that is to say, the analyst assigns to the model parameters, values that are the most accurate given the available information. Calibration allows building a tool for understanding the issues at stake in a particular case under investigation.[120] However it

[119] Aggregation is a major methodological issue in economics. See, for instance, Deaton and Muellbauer (1980) for a basic presentation.

[120] For examples of calibrated models and their use in competition analysis, see Werden and Froeb (1994, 1996, 1998) and Jayaratne and Shapiro (2000).

cannot provide any measure of robustness and/or significance of the results, what econometric analysis does. The strength of econometric analysis is indeed to provide a set of tests of the importance of different factors that play a role in a particular situation. In particular, the decisive advantage of econometric analysis is that it also allows performing tests of specification, i.e., performing a statistical selection among the possible approximations of the real world. Apart this advantage, the two approaches share the same objectives.[121] In the sequel, we assume that an econometric analysis is possible.

We introduce a procedure for evaluating the effects of mergers and assessing collective dominance based on an empirical structural-form analysis. For this reason we refer to it as the *structural procedure*. The merger policy in North America can be viewed as a practical implementation of this procedure.[122] Our presentation below draws from examples showing how econometric methods are applied in competition analysis. Three frequently quoted examples are the Staples/Office Depot merger[123], the L'Oreal/Maybelline merger[124] and the Kimberley-Clark/Scott merger.[125] A more recent example is the Volvo/Scania merger.[126] However, we mainly draws from the literature in applied industrial organization, notably the literature that has grown considerably since Hausman, Leonard and Zona (1994) argue for econometric models as a richer tool for assessing the effects of mergers.[127]

a. Overview

The setting of the structural procedure is a static oligopoly with differentiated products as this general case underlies most of modern economic analysis. Here market power does not result from the small number of competitors only; it also depends on the degree of substitutability among products. The procedure comprises different steps that are displayed below in a somewhat simplified way. (See Diagram 1.)

---

[121] This report does not address the question of using experimental methods in competition analysis as they have been rarely applied, probably because of the methodological and practical issues in implementing them. See Bykowsky, Kwasnica and Sharkey (2002).

[122] See Shapiro (1996).

[123] See Baker (1999).

[124] See Robinson (1996).

[125] See Hausman and Leonard (1997).

[126] See Ivaldi and Verboven (2003).

In the sequel we assume that at least data on prices and market shares are available. We consider throughout a simple generic example that is intended to introduce the main issues but should not be taken as a benchmark.

b. Step 1: Specification of the demand model

A first step is to define a demand model to approximate the behaviour of consumers in this industry. As the demand for a particular product is a relationship that relates the quantity of this product to its price and the price of other products, a demand model allows us to measure own and cross price elasticities. The mathematical specification of a demand model and its estimation (or calibration) play a crucial role for the results of the whole procedure. This is why it is an important source of debate among econometricians. However we may present the structural procedure in quantitative competition analysis with a specific model without loss of generality. We return on the specification issue later.

For the sake of exposition we use the following example throughout. Consider a duopoly with firms, *i* and *j*. Each firm produces one product. These two products are substitutes. The consumer has the choice between these products and another product called the outside good to which one refers by the index *o*. (For instance, product *i* is apple juice, product *j* is orange juice and the outside good is all other types of beverages.) The role of the outside good is here to account for the existence of other potential substitutes and the effect of the price index of all other products. In this sense it accounts for the size of the market which is an unknown parameter to be measured.[128]

Let y_i be the quantity of product *i* and *N* be the market size. Then the market share of product *i* is $s_i = y_i / N$. Accordingly, y_o is the quantity of the outside good, and the market size is the sum of all quantities, namely $N = y_1 + y_2 + y_o$.

---

[127] See, in addition to the articles already mentioned, Nevo (2000) and Pinske and Slade (2000).

[128] The outside good could be viewed as a way to treat the question of inventories when goods are storable. The outside good could comprise all the goods consumed in another period. Nonetheless it is a stopgap. For a discussion of the effect of inventory behavior, see Hendel and Nevo (2002).

With respect to this outside good, assume that the market share s_i of product *i* is all the highest as its quality is high and its price is low. Then the task of the econometrician consists in measuring these effects of the quality and prices on market shares using observed data on prices and market shares.

Assume that the market share s_i of product *i* is proportional to the market share of the outside good by a factor specific to the product, w_i, according to:

$$s_i = w_i s_o . \tag{44}$$

We call the factor , w_i, the "utility" of product *i*. In other terms, according to Equation (44), the market share of product *i* is proportional to the utility of the product.

The factor, w_i, results from the comparison of the quality and the cost of products. Specifically, assume that the logarithm of the utility of product *i,* W_i, is a function of the difference between the unknown monetary value of the "quality", defined by the parameter b_i, and the cost of the product according to

$$W_i = \ln w_i = b_i - ap_i , \tag{45}$$

where the parameter a measures the effect of price and is unknown.[129] In other words, Equation (45) means that utility (more precisely the logarithm of utility) is a linear combination of quality and price where the parameter *a* can be viewed as an exchange rate between quality and price. Quality is here a generic term to define the value associated with a product by the representative consumer.

The task of the econometrician consists in estimating the b_is and *a*, using observed data on prices and market shares. Combining Equations (44) and (45) yields the demand function as

$$\ln s_i = \ln s_o + b_i - ap_i . \tag{46}$$

For this type of specification, the consumer surplus *CS* can be computed according to[130]:

$$CS = \frac{1}{a} \ln\left(1 + w_i + w_j\right). \tag{47}$$

---

[129] This propery is satisfied by the so-called logit model.
[130] See Anderson, de Palma and Thisse (1992).

Under this specification, the *own price elasticity* ε_{ii} of demand for product *i*, that is to say, the relative change in the market share of product *i* due to a one percent change in its price, is proportional to its price and to the market share of all other products. Mathematically, the *own price elasticity* ε_{ii} of demand for product *i*, is given by[131]:

$$\varepsilon_{ii} = -ap_i\left(1-s_i\right) = -ap_i\left(s_o + s_j\right). \tag{48}$$

Note that the knowledge of market shares and prices allows to evaluate elasticities up to a parameter. Note also that elasticities are not constant.

The *cross price elasticity* ε_{ij} of demand for product *i* with respect to the price of product *j*, that is to say, the relative change in the market share of product *i* due to a one percent change in the price of product *j*, is proportional to the price and market share of product *j*. It is given by:

$$\varepsilon_{ij} = ap_j s_j. \tag{49}$$

Again the cross price elasticities can be evaluated up to a constant of proportionality, as soon as data on prices and market shares are available.

Note that the *diversion ratio* between products, which provides the proportion of sales lost by one product due to its price rise that is captured by the other product, is here easily computed from prices and market shares. Indeed the diversion ratio D_{ij} between *i* and *j* is obtained as the ratio of cross price elasticity of product *i* with respect to product *j* to the own price elasticity of product *i*. Here it is given by:

$$D_{ij} = \frac{\varepsilon_{ij}}{-\varepsilon_{jj}}\frac{s_i}{s_j} = \frac{p_i s_i}{p_j\left(1-s_j\right)}. \tag{50}$$

Note that, in this example, the diversion ratios can be directly computed from observed prices and market shares.

For our example, if two observations are available (for instance, if the industry is observed at two different periods of time, or if the industry is observed in two different geographic areas) then one can measure the parameters of the demand model, i.e., *a* and b_i's.

A numerical example is presented in Table 1. There are two firms *i* and *j* each producing one product. These two firms are observed at two different periods, which provides two observations.

The parameter values are obtained by applying the ordinary least squares method which is available in statistical software.[132] Note that we do not take into account the fact that prices and market shares are simultaneously determined at the equilibrium. At this point the numerical example allows us to illustrate how to completely characterise the demand equations. Using the estimated parameters, Equation (46) becomes, for each product,

$$\ln s_i = \ln s_o - 0.208 - 0.372\, p_i$$

and

$$\ln s_j = \ln s_o - 1.005 - 0.372\, p_j .$$

With these relations, the levels of market shares of both products can be computed as far as the share of the outside good (and so the market size) and the prices are known.

We can also evaluate elasticities and diversion ratios by applying Equation (48)-(49)-(50). Their values are given in Table 2. Note that the values of elasticities differ at the two different observations. Note also that these values depend on the value chosen for the market size.

Table 1: Numerical example

		Firm/Product *i*		Firm/Product *j*	
		Share	Price	Share	Price
Observations	Observation #1	15%	7.0	10%	5.0
	Observation #2	10%	8.4	8%	5.5
Estimation	Parameters	$a = 0.372$	$b_i = -0.208$	$b_j = 1.005$	

[131] In the econometric literature it is usual to report elasticities with their sign. We adopt here this practice. The own price elasticity is always negative, which explains the negative sign in equation (48).

[132] Given the small number of observations, this technique cannot produce very good estimate, but it allows to solve the overidentification problem, since we have three parameters to estimates and four equations (two products and two observations). This procedure must be understood here as an exercise of calibration.

Table 2: Elasticities and diversion ratios (Numerical example)

	Observation #1	Observation #2
Own price elasticity of demand for product *i*	-2.22	-2.81
Own price elasticity of demand for product *j*	-1.68	-1.88
Cross price elasticity of demand for product *i* with respect to price of product *j*	0.19	0.16
Cross price elasticity of demand for product *j* with respect to price of product *i*	0.39	0.31
Diversion ratio from product *i* to product *j*	0.13	0.07
Diversion ratio from product *j* to product *i*	0.16	0.13

c. Step 2: Specification of the supply model

The supply model comprises two elements for each firm: A cost function and an objective function. This latter element plays a crucial role in the determination of the type of equilibrium.

The cost function is the economic description of the technology that firms face in an industry. Applied production analysis is a domain of econometrics devoted to the objective of fitting cost function on observed data. Knowledge of the cost function allows us to measure economies of scale and scope and to evaluate cost complementarities in particular. This could be useful in the perspective of assessing efficiency gains from mergers.

In our example above, assume that each firm i faces a fixed cost F_i and a constant marginal cost c_i when producing its product. The total cost for producing the quantity y_i, i.e.,

$$C_i = c_i y_i + F_i, \tag{51}$$

is the sum of variable and fixed costs.

The second element to specify in this step is the objective function. Consider two polar cases defining the strategic behaviour of firms. In one case, firms choose their price for maximising their own profit, assuming that their competitors are acting in a similar way. This

is the Bertrand assumption. In the other case, firms set their prices by maximizing their joint profit. This corresponds to tacit collusion.

Other conducts could be considered as well. For instance, firms could be Cournot players; or one particular firm could be a Stackelberg player, the other firms being followers. We focus on the two polar cases defined above in the sequel. However it must be understood that *each assumption on the firms' conduct results in a set of specific price equations*, and that conclusion may be affected by the choice of conducts.

Example (Cont.): Consider the Bertrand (price competition) assumption. Then the firm *i* maximises his profit π_i that results from the difference between its revenue $p_i y_i$ and its cost C_i as:

$$\pi_i = p_i y_i - C_i = \left(p_i - c_i\right) y_i - F_i . \tag{52}$$

Recall that the quantities are obtained from the market shares as $y_i = Ns_i$ where *N* is the market size.

In order to achieve its objective, the firm has to satisfy the familiar rule that its gain must correspond to the willingness-to-pay of its customers. The willingness-to-pay is measured by the inverse of the own price elasticity. When the own price elasticity, which indicates how the quantity of the product change when its price changes everything being equal, is low, the willingness-to-pay for product *i* is high and the firm can charge a higher price. The rule says that the price-cost margin ratio (i.e., the difference between price and marginal cost divided by the price) must be equal to the inverse of the own price elasticity, that is to say,

$$\frac{p_i - c_i}{p_i} = -\frac{1}{\varepsilon_{ii}} . \tag{53}$$

This rule can be translated in our simple example as follows. By applying Equation (53) with the specified example, the margin of firm (product) *i*, m_i, (i.e., the difference between price and marginal cost) is inversely proportional to the combined market share of all other products, that is to say,

$$m_i = p_i - c_i = \frac{1}{a\left(1 - s_i\right)} . \tag{54}$$

Note that due to differentiation (each firm produces one product), price is not equal marginal cost and the firm exercises some market power measured by the level of the margin.

Note that Equation (54) tells us is that knowledge of prices, market shares and demand elasticities allows us to evaluate marginal costs.

Consider now the case of a merger between firms *i* and *j*. The merged firm maximises the joint profit, that is to say, they look for prices $\tilde{p}_i$ and $\tilde{p}_j$ that maximize

$$\pi_i + \pi_j = p_i y_i - C_i + p_j y_j - C_j = \left(p_i - c_i\right) y_i + \left(p_j - c_j\right) y_j - F_i - F_j . \tag{55}$$

Note that, in this simple setting, this case is indistinguishable from the case of tacit collusion. The pricing rule gets more complicated than in a Bertrand equilibrium as it accounts for the substitutability among products. It is set as:

$$\frac{\tilde{p}_i - c_i}{\tilde{p}_i} = \frac{1}{-\tilde{\varepsilon}_{ii}} + \frac{\tilde{p}_j - c_j}{\tilde{p}_j} \tilde{D}_{ji} \frac{\tilde{p}_j}{\tilde{p}_i} . \tag{56}$$

Note that the effect of the merger clearly depends on the level of the diversion ratio, that is to say, on the level of substitutability of products. The tilde refers to values computed after the appearance of the merger (or tacit collusion).[133]

Simple algebra shows that Equation (56) simplifies in our simple example as:

$$\tilde{m}_i = \tilde{p}_i - c_i = \frac{1}{a\tilde{s}_o} . \tag{57}$$

In other terms, if the two firms merge or if they collude, the margin of each product is identical and is proportionate to the inverse of the market share of the outside good.

Compare the pricing rules given by Equation (53) (by Equation (54) in our example) when the conduct corresponds to the Bertrand assumption and by Equation (56) (Equation (57) respectively) when the firms have merged or have entered in tacit collusion. They are different. Then one can evaluate the potential effect of mergers (or tacit collusion) by forming the difference of margins under Equation (57) and under Equation (54).

[133] Note that the sign "tilde" does not appear above the marginal cost *c* because it is assumed constant. It would depend on after-merger values if it is supposed function of the production level. Considering a more flexible cost function is technically feasible at the price of more complicated expressions.

More generally, there exists a pricing rule associated with each equilibrium type. We could have derive the pricing rule under a Stackelberg equilibrium with firm *i,* say, playing the leader. It would have been different from Bertrand or tacit collusion. So at this point the question is to discuss the estimation of these equilibrium and the methods to select the relevant equilibrium.

d. Step 3: Estimation, robustness and specification test

This step is specific to econometrics. It describes how the econometrician proceeds to the estimation of the economic model, that is to say, uses statistical methods for fitting the economic model to the observed data. This task allows the analyst to obtain values for the parameters of interest, i.e., the parameters of demand and cost models. When these parameters are known the equilibrium relationship between prices and market shares are completely determined. This step also presents the statistical selection of equilibria.

Estimation

The choice of an adequate estimation method is a critical issue which is also source of debate among econometricians. The availability of numerous software packages offering a large range of statistical and econometric methods and techniques eases the comparison of alternative techniques that could be applied in a particular situation. However, the debate, when there is one, cannot be restricted to the choice of a technique by itself because it is not independent of the type of data used in the analysis and the specification of the economic model itself. Nonetheless, at this point, it is important to recall the two estimation strategies that are available to estimate the type of model we have introduced.

The first method consists in estimating the demand model without taking into account the pricing rules. This is precisely what we have done in the numerical above. This approach raises the question of endogeneity of prices since prices are determined at the equilibrium jointly with the market shares. If one does not account for this simultaneity, the estimation may not satisfy the required criteria of statistical quality. To avoid this problem, econometricians usually apply instrumental variable methods. Assuming that this problem is solved, the analyst can go on to the next step, which is to evaluate costs and marginal costs by

solving the pricing equations afterwards.[134] Then the analyst has all the elements required to perform simulation of mergers for instance.

The second method consists in estimating together the demand and pricing equations for each type of economic conduct considered. Identification of such equilibrium models in the econometric sense, i.e., the possibility to find meaningful values for the parameters of interest, requires extraneous information, usually in the form of exogenous variables, that is to say, variables that are determined outside the model.[135]

Whatever the estimation method applied, the analyst produces different sets of parameters according to the hypothesis made on the conduct of firms.

Example (Cont.): Assume that the estimates of demand parameters i.e., a and b_i s of the numerical example above are correct. Then we solve Equation (54) (Bertrand assumption) and Equation (57) (tacit collusion). Not surprisingly the estimates of marginal costs and price-cost margins under these two hypotheses of conduct are different. (See Table 3.) It is in general what it is expected: Whatever the methods, parameter estimates of the demand models should be close because we expect to well instrument the demand equations; differences, if any, should only affect parameters affecting marginal costs. The question is now to choose among these estimates.

Table 3: Estimates of marginal costs and margins (numerical example)

		Firm / product i		Firm / product j	
		Bertrand	Collusion	Bertrand	Collusion
Marginal cost	Observation #1	3.84	3.42	2.02	1.42
	Observation #2	5.41	5.13	2.58	2.23
Price-cost margin	Observation #1	0.45	0.51	0.60	0.72
	Observation #2	0.35	0.39	0.53	0.60

[134] Hausman, Leornard and Zona (1994) and Goldberg (1995) are two regularly quoted examples of this approach.

[135] On the definition of identification in econometrics, see for instance Kennedy (1998).

Model selection

For selecting among competing estimated models, one way is to compare the estimates of marginal costs to observed marginal costs when they are observable. This is however rarely the case. Indeed, the usual source of data for evaluating marginal cost could be the accounting system of firms. The complex task of allocating certain costs among products means that estimates of marginal cost from this source have fair chances to drastically differ from those obtained from economic models. Then the alternative way to choose among models is to implement tests available in the econometric toolbox.

Procedures of model selection are one possible tool.[136] Two types of procedure have been applied in the context of competition analysis. The first type is based on the Vuong test.[137,138] It is a non-nested test because each of the two models that are statistically "compared" cannot be derived from the other by simple mathematical algebra. The rationale behind this test is to compare the goodness-of-fit of each model on an equal basis. This test is asymptotically distributed as a standard normal density function. Above some positive critical value, one model is considered as performing significantly better than the other; under the symmetric negative critical value, the other model is considered as performing significantly better; in between, the two models cannot be distinguished.

For instance, the following table, extracted from an article published in 2002 by Jaumandreu and Lorences in the European Economic Review, shows the comparison of several types of conduct among the Spanish banks on the loan market in terms of values of the statistic associated with the Vuong test.

	Cournot	Collusion	Four biggest banks colluding
Bertrand	3.41	1.68	-2.26
Cournot		1.56	-3.36
Collusion			-1.84

[136] The toolbox also contains other tools like the specification tests à la Hausman (1978) for instance.
[137] See Vuong (1989) and White (2000).
[138] The Vuong test has been applied by different authors. See for instance Gasmi and Vuong (1991), Gasmi, laffont and Vuong (1992), Jaumandreu and Lorences (2002).

The table shows that an equilibrium where some firms are cooperating seems always better than equilibria involving non-cooperative conducts. Indeed Bertrand and Cournot perform poorly against the equilibrium where the four largest banks collude. The values of the statistic for these two cases are respectively -2.26 and -3.36, much lower than the critical value of -2 corresponding to a 5% level of significance. On the contrary Bertrand seems to perform better than Cournot. Note that the Vuong test provides a comparison of models on relative terms, that is, it provides pairwise comparisons.

The second type of model selection test that has been applied for competition analysis is a Davidson-MacKinnon type of test.[139,140].The intuition of this test is simple. If the margin estimated from model A has a significant effect on the price-cost margin estimated from model B, it means that model B is somewhat incomplete to represent correctly the data and should be discarded. The test can be run in the other way. The advantage of this test is that it is fairly easy to implement it.

At this point the analyst has estimated the alternative models and has performed the required statistical tests to assess their goodness-of-fit and their statistical quality and to compare them.[141] It remains to proceed at the welfare and market power analysis.

e. Step 4: Welfare and market power analysis

This step consists in simulating changes in conduct of firms and evaluating the associated changes in consumer surplus or welfare. In the context of case we consider here – Bertrand versus collusion in an industry – the following simulations can be proposed, depending on the outcome of model selection tests.

Example (Cont.): Suppose that a test has concluded that, in our example, collusion performs statistically better than the Bertrand assumption. The conclusion is that the

[139] See Davidson and MacKinnon (1993) and White (2000).

[140] For applications of the Davidson-MacKinnon type-test in the context of competition analysis, see Feenstra and Levinsohn (1995) and Foncel (2002).

[141] The analyst could also use external information to evaluate the realism of the estimated models. For instance customer surveys could be used to confront the model predictions to the customer declared preferences. Experts' opinions could also be a source for checking the quality of estimates.

parameter values obtained under the collusion assumption should be retained as the true values and should be used in the welfare analysis. In particular one can evaluate what would have been the prices, market shares and consumer surplus if the firms have been Bertrand players. To do so, we plug the parameter values obtained under the assumption of collusion in the equations defining a Bertrand equilibrium and we solve for prices and market shares. Note that here, given that we assume that the parameters of demand, namely the b_is and a, are identical in the two considered market conducts, the procedure consists in using the marginal costs estimated under the assumption of collusion. Table 4 gathers the result of this simulation, where the initial situation corresponds to observation #1 of Table 1 and is interpreted as resulting from a collusive behaviour. We conclude that collusion implies a loss of 12.6% from the level of consumer surplus in a competitive outcome. Note also the change in margins.

Table 4: Change in consumer surplus and market power due to collusion (numerical example)

		Price		Margin		Consumer surplus
		Product *i*	Product *j*	Product *i*	Product *j*	
Observed conduct:	Collusion	7.00	5.00	51%	72%	0.76
Simulated conduct:	Bertrand	6.64	4.44	49%	68%	0.87

In this simple example, with only two firms in the industry, the effect of tacit collusion and the effect of a merger are indistinguishable. In larger oligopoly, if one has detected tacit collusion by means of the specification tests presented above, it is unclear what would be the outcome of an evaluation of the effects of a merger in such an industry. This is outside the scope of an econometric analysis.

On the contrary assume now that a test has concluded that in our example, the Bertrand assumption performs statistically better than collusion. Assume further that the two firms have announced their intention to merge. The question is to measure the potential effects of this merger. Assume that the true parameters are those obtained under the Bertrand assumption, the merger can be simulated. The results are given in Table 5. As expected prices increases, market power raises and consumer surplus decreases.

Table 5: Change in consumer surplus and market power due to a merger (numerical example)

		Price		Margin		Consumer surplus
		Product i	Product j	Product i	Product j	
Observed conduct:	Bertrand	7.00	5.00	45%	60%	0.76
Simulated conduct:	Merger	7.30	5.47	47%	63%	0.68

Whether the measure of the effects of a merger derived by applying the previous procedure is robust is a crucial question. Recall that market shares and elasticities are affected by the chosen market size. Moreover, as the price increase due to a merger is a complex non linear function, deriving confidence intervals for the change in prices due to mergers is not a trivial task. One way is to apply bootstrap techniques as in Ivaldi and Verboven (2003).[142]

In the case of a larger oligopoly, the same type of exercise can be performed. However, in addition to simulating the notified merger, the analyst can simulate other additional mergers that could be expected in the future among the remaining firms in the oligopoly, alternative mergers that could be notified if the notified merger is not accepted, or even a merger among all firms in the industry that would be indistinguishable from a collusive agreement.[143]

Hence the procedure allows us to evaluate market power and change of market power by measuring the margins of firms in three situations:

- The initial state of the industry: At this stage, market power is assumed to come entirely from product differentiation;
- The industry after a notified merger or any foreseeable merger: Compared to the initial state, the change in market power is a measure of unilateral effects, i.e., a measure of concentration effects / effects of mergers.

[142] It is worth emphasizing at this point the potential role of studies of prior mergers in the industry as a way to obtain benchmark cases.

[143] Comparison of these different cases results in the decomposition of market power that is suggested by Nevo (2001) and by Slade (2002). See also Ivaldi and Verboven (2003) on the alternative experiments that can be tested.

- The industry in case of tacit collusion (or a merger of all firms, i.e., a monopoly): Compared to the initial state, the change in market power is a measure of coordinated effects, i.e., a measure of the effect of collusion.

While this decomposition of market power can be implemented using existing econometric and quantitative tools, the question of predicting the likelihood of a situation (additional mergers or collusion for instance) with respect to the initial state of the industry is still on the research agenda. It must be noticed however that it exists statistical techniques like boostrapping that could offer ways to address this issue. It is too early to refer to them.

In other terms, the procedure allows us to test for the existence of collusion and to evaluate the effects of mergers or collusion. The question of how a merger could affect the probability that collusion occurs remains unanswered in the setting presented here.

III. Issues

When implemented on real data, the above procedure faces several technical issues that are discussed below.[144]

To these issues, one must again stress the data problem. When presenting the structural procedure, we have assumed the availability of data on prices and market shares. When we turned to the question of estimating differentiated-products models we observed that extraneous information is required in the form of exogenous variables or instrumental variables. This information is not always available. In the case of instrumental variables it can be particularly hard to find or to build in practice.

a. Functional forms for modelling demand

The demand model is a crucial component of the procedure. It is known that the outcomes of differentiated-products models are highly sensitive to assumptions on consumer

[144] Hosken, O'Brien, Scheffman and Vita (2002) address these issues in more details.

preferences.[145] Ideally a demand model should not restrict the pattern of substitutability among market products at all. For this, the demand model must be "flexible" enough, that is to say must contain a sufficient number of parameters. The challenge is that, when dealing with differentiated-products market, the number of products can get very large and so the number of parameters to be estimated. Even if the necessary conditions implied by the assumption of a rationale and well-behaved representative consumer are imposed, which usually reduces the number of parameters, it remains large enough to raise serious estimation problem.

Two strategies are followed in the literature to face this problem. The first approach consists in adopting the restrictions imposed by the assumption of multi-level budgeting.[146] In this setting the representative consumer allocates its income among certain "upper level" expenditure groups. Then it allocates each group's expenditure among goods within the group. And so on. At the lowest stage (the brand choice, usually), the demand equations are specified according to the so-called AIDS (Almost Ideal Demand System) model.

This approach faces three problems. First the allocation of products into groups is somewhat ad hoc, although the underlying assumption of separability of consumer preferences can be tested. Second, it is not clear how to account for consumer heterogeneity and to address the problem of aggregating consumer preferences in this setting. Third, the approach is intractable when the number of brands per group remains very large.

This last drawback is avoided by the second approach that encompasses all sorts of logit-type models.[147] Indeed the main advantage of these models is the parsimony in the number of parameters. It is known that the pure logit model, which underlies the demand model we use in the example presented in the previous section, imposes strong restrictions of the pattern of substitutability. However the nested logit model and the more recent version of these models - the random coefficient logit model - exhibit larger flexibility. These models assume that consumers make discrete choices among a set of products and that each product can be represented in the characteristic space which is much smaller than the product space. This

[145] See Dixit and Stiglitz (1977) and Perloff and Salop (1985).
[146] This approach is advocated by Hausman, Leonard and Zona (1994) and Hausman and Leonard (1997). On multi-level budgeting, see Deaton and Muellbauer (1980.)
[147] See Berry (1994), Bery, Levinsohn and Pakes (1995), Verboven (1996), and Nevo (2000).

gives rise to a model which is easily tractable. However when one accounts for unobserved heterogeneity on consumers and products, the estimation procedure can become very cumbersome.

On this issue, research is still going on.[148] The trend is towards an increasing availability of complex methods.

b. Measuring efficiency gains

Mergers are advocated on the basis of possible cost synergies which could compensate the price increases due to the internalisation of substitution effects among products by the merging firms. This point has received attention in the theoretical part.[149] Two remarks can be added here.

The only synergies which should be meaningful in the static model we have used to present the structural procedure above should concern marginal costs. As far as it is possible to assess how the synergies affect the marginal costs, one can account for these effects in the simulation of post merger prices by modifying the values of marginal costs.[150] The rate at which these synergies are passed through to consumers is an important issue in this context.[151]

Synergies do not account for scale economies.[152] In industries with increasing returns it would be useful to know if synergies and scale effects are playing together or against each other.

There is a lack of empirical analysis on these points which call for further research.

---

[148] For instance, Pinske, Slade and Brett (2002) advocates the use of the so-called Distance Metric model.
[149] See also Röller, Stennek and Verboven (2000).
[150] See for instance Werden and Froeb (1994) and Ivaldi and Verboven (2003).
[151] See Ashenfelter, Ashmore, Baker and McKerman (1998) and Froeb, Tschantz and Werden (2001).
[152] See Farrell and Shapiro (2001) and Werden, Froeb and Tschantz (2001).

c. Testing for the market conduct using conjectural-variations and dynamic models

In our presentation of the structural procedure, each market conduct is tested separately. When the number of possible conducts to be tested is high, this approach could be cumbersome. An alternative approach is to model the strategic behaviour of firms using the concept of conjectures.[153] The advantage of this approach is to let the data to choose a parameter that measures the firms' strategic behaviour. Then the analyst can test whether there is competition or not.

This methodology has been criticized on theoretical grounds.[154] The major drawback of this analysis is that each firm's conjecture does not fully recognize the other firms' reactions. In other words this methodology attempts to escape from the constraints of a full dynamic analysis of competition.

Since the seminal article by Pakes and McGuire (1994), several researchers have contributed recently to a structural econometric analysis of the dynamics of industry.[155] They have developed algorithms in order to evaluate the impact of mergers on entry and investment or to assess the change in entry and investment costs. To our knowledge, these algorithms have not been applied to real antitrust cases, but the roads they are happening seem particularly fruitful.

d. Bidding markets

In many situations, the competition is said to be for the market. This concerns all bidding markets. Assessing competition in these markets is a specific task.

The structural econometric analysis of auctions has also considerably developed during the last decade. In addition to the question of the design of auctions, one focus of the literature in this domain is the effect of the number of bidders on prices depending on the type of

[153] See Bresnahan (1989) for the presentation of the econometrics of conjectural variations models.
[154] See Tirole (1989).for a discussion.

auctions. In other words the focus is on detecting collusion in auctions.[156] Recently the concern has turned to questions like measuring the effects of mergers.[157] This literature has not been directly applied in real antitrust cases so far but has influenced some studies in antitrust cases.[158]

IV. Alternative or Complementary Procedures

This section is concerned by different methods that have (and are) used in competition analysis. Historically they often existed before the development of structural procedures. Their use is often explained by a lack of data availability and by the need of illustrating the competition process or providing preliminary investigations.[159] They are usually interpreted as reduced-form analysis in the sense that they are not directly related to an economic model. However some are mainly driven by the statistical techniques while others are somewhat built from economic theories.

a. Statistical Methods

i) Price correlation analysis

Price correlation analysis has been routinely applied in competition analysis. It can be easily implemented as soon as time series of prices are available, a requirement which is usually achievable in most industries. This technique is used for defining the relevant market but can also be used for bringing evidences of collusive agreements.

---

[155] Ericson and Pakes (1995), Benkard (2001), Fershtman and Pakes (2000), Park (2002).

[156] See for instance Porter and Zona (1993), Laffont, Ossard and Vuong (1995), Pesendorfer (2000), Cantillon (2000) and Bajari (2001).

[157] See Froeb, Tschantz and Crooke (1997).

[158] See Bishop and Walker (1999) for a presentation of empirical analysis in cases where the bidding process is a crucial issue.

[159] These techniques are reviewed in details in Bishop and Walker (1999), LECG (1999) and NERA (1999).

The idea is simple. When the prices of two products are moving together, the coefficient of correlation between the two series of prices is positive and high. Then the conclusion is that the two products should belong to the same relevant market. If, on the contrary, the price series of two products exhibit a negative correlation, then the two products should not be in the same market. The question is of course to know where the exact threshold level is located between the two situations. Indeed, what conclusion can be drawn from a positive but small correlation? Finding a benchmark is a solution to this threshold problem but it is somewhat ad hoc. The literature does not answer this question, whatever the type of data considered, whether it is panel data or cross-sections.

However the main drawback of this analysis is spurious correlation. Two price series could be correlated just because they share a common component. For instance the price of raw materials could strongly affect the price of two different goods in the same direction, creating a spurious correlation. This is why standard price correlation analysis is often complemented with more sophisticated techniques, like Granger causality tests and cointegration tests. In part these techniques have indeed been designed to solve this problem of spurious correlation.

Whatever the technique that is finally applied in order to detect a "stable" and "strong" relationship between two price series, the question remains to provide an economic interpretation behind this statistical result, that is to say, to identify the sources of this relationships.[160]

ii) Other statistical methods

This category includes regression-based analysis used to exhibit or invalidate the existence of price differentials, while controlling for potential changes in product quality. This analysis requires data on prices and on product characteristics. It is called hedonic price analysis.

[160] See also Werden and Froeb (1993) for a strong critique of price correlation analysis.

As changes in prices reflect both demand and supply-side effects, just controlling for changes in product quality might not be sufficient to care all sources of variability. This could give rise to debate on the interpretation of results.

b. Model-Based Methods

Some techniques have a stronger relationship with theory and are useful tools in competition analysis.

i) Residual demand analysis

Residual demand analysis is very powerful as it can be applied to any market and requires a limited set of data.[161] It can be implemented as soon as time series on price and quantity for one firm (or a small subset of firms in the oligopoly) and data on some cost shifters are available. It is often applied for defining the antitrust market but can be extended to measure effects of mergers or collusion.[162]

The residual demand function is the relationship between one firm's price and quantity, taking into account the supply response of all other firms. A firm operating in a perfectly competitive market faces an infinitely elastic residual demand curve. The higher the elasticity of the residual demand curve, the lower is the capacity of the firm to raise its prices. This is the rationale for an empirical test.

From any differentiated-products model, the residual demand function for each firm can be derived. It is in this sense that this approach is related to an economic model. The main advantage of this approach is that it avoids the computation of cross price elasticities.

To perform the test, in addition to the data on the firm's price and quantity, some additional data to control for the supply response of other firms are needed. Usually cost

[161] See Scheffman and Spiller (1987), Baker and Bresnahan (1988), Werden and Froeb (1991, 1993) and Carlton and Perloff (1994).

[162] See Baker and Bresnahan (1985).

shifters are excellent candidates for the job. However observing the costs of other firms is not so easy. So usually analysts use proxies that could introduce sources of measurement errors, whose presence could in turn strongly biased the results of the analysis.

This method becomes useless as soon as data are available for all firms in the industry. Applied to all firms it should be equivalent to performing a structural analysis!

ii) Price-concentration studies

The objective of price concentration studies is to evaluate the relationship between price and concentration in a given industry. They are based on the structure-conduct-performance paradigm. The idea is that market structure measured by the level of concentration affects market performance measured by the level of price. Where there is a strong positive correlation between price and concentration, a merger which has a significant impact on concentration should raises concerns from the competition authority.

Regression analysis is the tool applied to test for the correlation between price and concentration levels. Usually some other variables are added to the regression of prices on concentration levels, depending on the context.

When this approach is performed with data at firm level, it faces an endogeneity problem. The level of concentration as measured by the firm's market share is usually not independent of the level of price itself. If this feedback effect is not taken into account, results from the regression of prices on the concentration variable could be badly affected. However this should not automatically invalidate the analysis since the potential bias should be in the right direction. When it is possible (and here it is the case since data at firm level are available), a structural analysis avoids such problems.

This methodology has been criticized on economic grounds as it does not account for efficiency gains and the existence of differentiated products.[163]

[163] See Baker and Bresnahan (1992).

V. Empirical Best Practice

This report has presented several techniques that can be applied in competition analysis. It has emphasized the use of a structural procedure. Indeed econometrics based on the differentiated-products static equilibrium model provides a useful and powerful illustration of the working of markets. However econometric results depend on the quality of data, the careful application of statistical inference and estimation, and the capacity to evaluate the effect of necessary simplifying assumptions.

VI. Selected Bibliography

Anderson, S., A. de Palma and J.-F. Thisse (1992), *Discrete Choice Models of Product Differentiation*, Cambridge: The MIT Press, 423p.

Ashenfelter, O., D. Ashmore, J.B. Baker and S.M. McKerman (1998), "Identifying the Firm-specific Cost pass-through Rate, Federal Trade Commission, Working Paper No. 217.

Bajari, P. and L. Ye (2001), "Comparing Competition and Collusion in Procurement Auctions: A Numerical Approach," Stanford University, http://www-econ.stanford.edu/faculty/workp/swp01001.pdf.

Baker, J.B. (1999), "Econometric Analysis of FTC v. Staples," *Journal of Public Policy and Marketing*, 18.

Baker, J.B. and T.F. Bresnahan (1985), "The Gains from Merger or Collusion in Product-Differentiated Industries," *Journal of Industrial Economics*, 33, 427-444.

Baker, J.B. and T.F. Bresnahan (1988), "Estimating the Residual Demand Curve Facing a Single Firm," *International Journal of Industrial Organization*, 6, 283-300.

Baker, J.B. and T.F. Bresnahan (1992), "Empirical Methods of Identifying and Measuring Market Power," *Antitrust Law Journal*, 61, 3-16.

Benkard, L. (2001) "A Dynamic Analysis of the Market for Wide-bodied Commercial Aircraft," http://www.stanford.edu/~lanierb/research/deq.pdf.

Berry, S. (1994), "Estimating Discrete Choice Models of product Differentiation," *Rand Journal of Economics*, 25, 242-262.

Berry, S., J. Levinsohn and A. Pakes (1995), "Automobile prices in Market Equilibrium," *Econometrica*, 63, 841-890.

Bresnahan, T.F. (1989), "Empirical Studies of Industries with Market Power," in R. Schmalensee and R.D. Willig, editors, *Handbook of Industrial Organization*, Amsterdam: North-Holland, 1011-1057.

Bishop, S. and M. Walker (1999), *The Economics of EC Competition Law*, London: Sweet & Maxwell.

Bykowsky, M.M., A.M. Kwasnica and W.W. Sharkey (2002), "Horizontal Concentration in the Cable Television Industry: An Experimental Analysis," Federal Communications Commission, OPP Working Paper Series, number 35.

Cantillon, E. (2000), "The Effect of Bidders' Asymmetries on Expected Revenue in Auctions," Cowles Foundation Discussion Paper 1279, http://cowles.econ.yale.edu/P/cd/d12b/d1279.pdf.

Carlton, D.W. and J.M. Perloff (1994), *Modern Industrial Organization*, New York: Harper Collins.

Davidson, R. and J. MacKinnon (1993), *Estimation and Inference in Econometrics*, New York, Oxford: Oxford University Press.

Deaton, A. and J. Muellbauer (1980), *Economics and Consumer Behaviour*, Cambridge: Cambridge University Press.

Dixit, A. and J. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review,* 67*,* 297-308.

Ericsson, R and A. Pakes (1995), "Markov-perfect Industry Dynamics: A Framework for Empirical Work," *Review of Economic Studies*, 62, 53-82.

Europe Economics (2001), "Study on Assessment Criteria for Distinguishing between Competitive and Dominant Oligopolies in Merger Control," *Final Report for the European Commission Enterprise Directorate General*, London: Europe Economics.

Farrell, J. and C. Shapiro (2001), "Scale Economies and Synergies in Horizontal Mergers Analysis," *Antitrust Law Journal*, 68, 685-710.

Feenstra, R.C. and J. Levinsohn (1995), "Estimating Markups and Market Conducts with Multidimensional Product Attributes," *Review of Economic Studies*, 62, 19-52.

Fershtman and Pakes (1999), "A Dynamic Oligopoly with Collusion and Price Wars," NBER Working Paper 6936.

Foncel, J. (2002), "Selection of Market Conducts in the Telephone Equipment Market in France," mimeo.

Froeb, L., S. Tschantz and G. Werden (2001), "Pass-through Rates and the Price Effects of Mergers," Owen Working Paper, http://mba.vanderbilt.edu/luke.froeb/papers/ptr.pdf.

Froeb, L., S. Tschantz and P. Crooke (1997), "Mergers in First vs. Second price Asymmetric Auctions," Owen Working Paper, http://mba.vanderbilt.edu/luke.froeb/papers/sealed.pdf.

Gasmi, F, and Q. Vuong (1991), "An Econometric Analysis of some Dupolistic Games in Prices and Advertising," in G. Rhodes and T. Fomby, editors, *Advances in Econometrics*, Volume 9, JAI Press, 225-254.

Gasmi, F, J.J. Laffont and Q. Vuong (1992), "Econometric Analysis of Collusive Behavior in a Soft-drink Industry," *Journal of Economics & Management Strategy,* 1, 277-311.

Goldberg, P.K. (1995), "Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry," *Econometrica*, 63, 891-951.

Hausman, J.A. and G.K. Leonard (1997), "Economic Analysis of Differentiated Products Mergers Using Real World Data," *George Mason Law Review*, 5, 321-346.

Hausman, J.A., G.K. Leonard and D. Zona (1994), "Competitive Analysis with Differentiated Products," *Annales d'Econométrie et de Statistique*, 34, 159-180.

Hausman, J.A. (1978), "Specification Tests in Econometrics," *Econometrica*, 46, 1251-1272.

Hendel, I. and A. Nevo (2002), "Sales and Consumer Behavior," NBER Working Paper n° W9048.

Hosken, D., D. O'Brien, D. Scheffman and M. Vita (2002), "Demand System Estimation and its Application to Horizontal Merger Analysis,".

Ivaldi, M. and F. Verboven (2003), "Quantifying the Effects from Horizontal Mergers in European Competition Policy," IDEI Working Paper.

Jaumandreu, J. and J. Lorences (2002), "Modelling Price Competition Across Many Markets (An Application to the Spanish Loans Market)," *European Economic Review*, 46, 93-115.

Jayaratne, J. and C. Shapiro (2000), "Simulating Partial Asset Divestitures to 'Fix' Mergers," *International Journal of the Economics of Business*, 7, 179-200.

Kennnedy, P. (1998), *A Guide To Econometrics*, Cambridge, MA: The MIT Press.

Laffont, J.J., H. Ossard and Q. Vuong (1995), "Econometrics of First Price Auctions," *Econometrica*, 63, 953-981.

LECG Ltd (1999), "Quantitative Techniques in Competition Analysis," Office of Fair Trading Research Papers, 17.

Nevo, A. (2000), "Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry," *Rand Journal of Economics*, 31, 395-421.

Nevo, A. (2001), "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, 69, 307-342.

NERA (1999), "Merger Appraisal in Oligopolistic Markets," Office of Fair Trading Research Papers, 19.

Pakes, A. and P. McGuire (1994), "Computing Markov-Perfect Nash Equilibrium: Numerical Implications of a Dynamic Differentiated Product Model," *Rand Journal of Economics*, 25, 555-589.

Park, S. (2002), "Quantitative Analysis of Network Externalities in Competing Technologies: The VCR Case," http://ms.cc.sunysb.edu/~sanpark/NE-VCR.pdf.

Perloff, J. and S. Salop (1985), "Equilibrium with Product Differentiation," *Review of Economic Studies*, 52.

Pesendorfer, M. (2000), "A Study of Collusion in First Price Auctions," *Review of Economic Studies*, 67, 381-411.

Phlips, L.(1998), *Applied Industrial Economics*, Cambridge: Cambridge University Press.

Pinske, J. and M.E. Slade (2000), " Mergers, Brand Competition, and the Price of a Pint," http://www.econ.ubc.ca/slade/beer.pdf.

Pinske, J., M.E. Slade and C. Brett (2002), "Spatial Price Competition: A Semi-parametric Approach, *Econometrica*, 70, 1111-1153.

Porter, R.H. and J.D. Zona (1993), "Detection of Bid Rigging in Procurement Auctions," *Journal of Political Economy*, 101, 518-583.

Robinson, C.K. (1996), "Quantifying Unilateral Effects in Investigations and Cases," *George Mason Law Review Symposium*, U.S. Department of Justice.

Röller, L-H, J. Stennek and F. Verboven (2000), *Efficiency Gains in Mergers*.

Scheffman, D.T. and P.T. Spiller (1987), "Geographic Market Definition under the U.S. Department of justice Merger Guidelines," *Journal of Law & Economics*, 30, 123-147.

Shapiro, C. (1996), "Mergers with Differentiated Products," *Antitrust*, Spring, 23-30.

Slade, M.E. (2002), "Market Power and Joint Dominance in UK Brewing," http://www.econ.ubc.ca/slade/mkpw6.pdf.

Tirole, J. (1989), *The Theory of Industrial Organization*, Cambridge, MA: The MIT Press.

Verboven, F. (1996), "International Price Discrimination in the European Car Market," *Rand Journal of Economics,* 27, 240-268.

Vuong, Q. (1989), "Likelihood Ratio Tests for Model Selection and Non-nested Hypotheses," *Econometrica*, 57, 307-333.

Werden, G.J. and L.M. Froeb (1991), "Residual Demand Estimation for Market Delineation: Complications and Limitations," *Review of Industrial Organization*, 6, 33-48.

Werden, G.J. and L.M. Froeb (1993), "Correlation, Causality and All That Jazz: The Inherent Shortcomings of Price Tests for Antitrust Market Delineation," *Review of Industrial Economics,* 8, 329-353.

Werden, G.J. and L.M. Froeb (1994), "The Effects of mergers in Differentiated Products Industries: Logit Demand and Merger Policy," *The Journal of Law, Economics and Organization*, 10, 407-426.

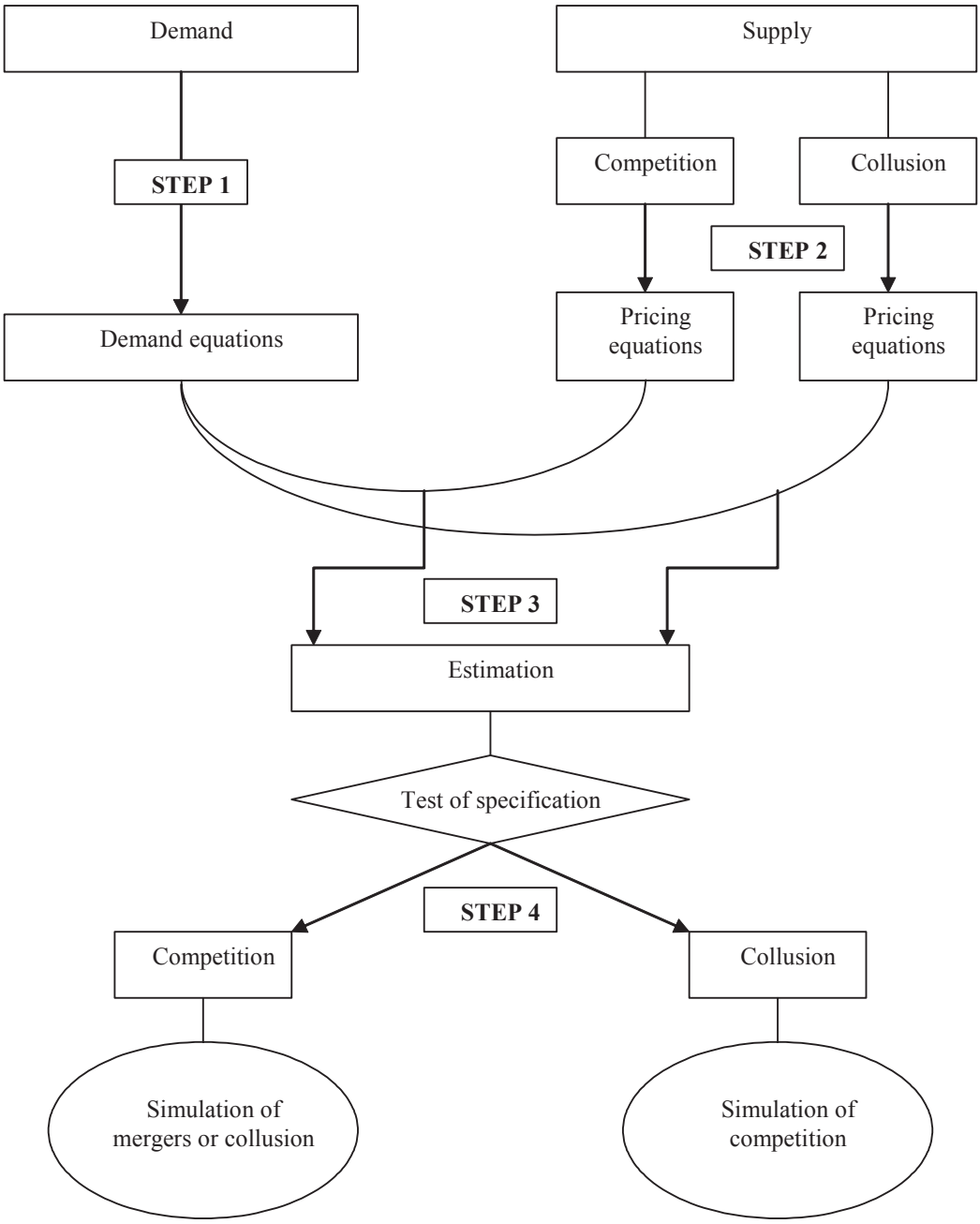
Werden, G.J. and L.M. Froeb (1996), "Simulation as an Alternative to Structural Merger Policy in Differentiated Products Industries," in M. Coate and A. Kleit, editors, *The Economics of the Antitrust Process*, Boston: Kluwer Academic Press, pp 65-88.

Werden, G.J. and L.M. Froeb (1998), "The Entry-inducing Effects of Horizontal Mergers: An Exploratory Analysis," *The Journal of Industrial Economics*, 46, pp 525-543.

Werden, G.J., L.M. Froeb and S. Tschantz (2001), "The Effects of Merger Synergies on Consumers of Differentiated Products," Owen Working Paper, http://mba.vanderbilt.edu/luke.froeb/papers/ptr.attny.pdf.

White, W.H. (2000), *Econometric Analysis*, London: Prentice-Hall International.

VII. Diagram 1: Overview of the structural procedure



European Commission

The Economics of Horizontal Mergers: Unilateral and Coordinated Effects

Luxembourg: Office for Official Publications of the European Communities

2006 — ii, 158 pp. — 21 x 29,7 cm

ISBN 92-79-00409-3

Price (excluding VAT) in Luxembourg: EUR 15