Towards a Theory of Competition Policy*

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Abstract

This paper reviews some recent advances in the theory of competition policy and advocates for further developments, taking into account implementation problems.

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1 Introduction

Decades ago, one of the main regulatory debates was opposing marginal cost pricing rules to average cost or more sophisticated Ramsey-like pricing rules.[1] Since then, a huge effort has been made to account for the fact that a regulator must not only *choose* the pricing rule, but also *implement* it.[2] For example, cost-based pricing rules require information about costs which is not usually readily available. In addition, firms are better informed than regulators about their costs; it is all the more unfortunate that, in general, firms have little incentive to report this information truthfully, knowing that the information will be used to determine their prices. Policymakers must therefore take into consideration the information acquisition problem when designing the regulation.

Consider the following example. A firm has a linear cost $C(q) = cq$ and its

[1] See Laffont (2000), chapter 6, for an overview of this debate.

[2] This is not to say that this issue had not been recognized before. For example, an argument –which goes back to Smith (1776)– in favor of average cost or budget balance pricing was the lack of information about the desirability of the projects. But it is only in the (19)80's that this and related points have been built into theory.

regulator seeks to maximize consumers' net surplus, given by

$$U(q) - t,$$

with $U' > 0 > U''$, subject to the firm's budget constraint

$$t - cq \geq 0.$$

The first-best regulation consists in equating marginal cost to marginal utility, which leads to a marginal cost pricing rule: the first-best level of production, $q^{FB}(c)$, and the first-best price, p^{FB}, are defined by

$$p^{FB} = U'\left(q^{FB}\right) = c.$$

However, the regulator cannot implement this rule if he or she does not know the value of the marginal cost. Suppose for example that the marginal cost can take two values, a low value $\underline{c}$ or a high value $\bar{c} > \underline{c}$. If only the firm knows the true value, it would have an incentive to report a high cost $\bar{c}$, even if it has a low cost $\underline{c}$: by doing so, it would secure a positive gain, equal to $(\bar{c} - \underline{c}) D(\bar{c})$. In other words, the first-best marginal cost pricing rule does not induce the firm to truthfully reveal its cost.

Recognizing this issue, regulation theorists have refined the analysis by mod-

elling the constraints imposed by the firm's incentives to manipulate the information on its cost, and incorporating these informational constraints in the design of the regulator's problem.[3] In the simple case just described, assigning an output level $\bar{q}$ to a high-cost firm requires to leave a low-cost firm an informational rent $(\bar{c} - \underline{c})\,\bar{q}$: since the high-cost firm must get a transfer $\bar{t}$ sufficient to cover its cost ($\bar{t} \geq \bar{c}q$), by reporting a high cost, a low-cost firm can indeed secure itself

$$\underline{\pi} = \bar{t} - \underline{c}\bar{q} \geq (\bar{c} - \underline{c})\,\bar{q}.$$

The "second-best" regulation accounts for this informational rent, which leads to lower the production required from a high-cost firm. Formally, the regulator's problem can be summarized as:

[3]Baron and Myerson (1982) provide the first analysis of this refined regulatory problem. Baron and Besanko (1984a) study the role of audits, while Baron and Besanko (1984b) consider a multi-temporal extension of the Baron-Myerson model with commitment. Caillaud *et al.* (1988) offers a review of this literature.

$$\max_{\underline{q},\bar{q},\underline{t},\bar{t}} \Pr(c=\underline{c})\left[U\left(\underline{q}\right)-\underline{t}\right]+\Pr(c=\bar{c})\left[U\left(\bar{q}\right)-\bar{t}\right]$$

$$\text{subject to} \quad \underline{t}-\underline{c}\underline{q}\geq\bar{t}-\underline{c}\bar{q}, \qquad (IC)$$

$$\bar{t}-\bar{c}\bar{q}\geq 0 \qquad (IR)$$

where the (IC) constraint represents the low-cost firm's incentive condition and the (IR) constraint represents the high-cost firm's participation constraint. These are the only two relevant conditions,[4] and they are both binding. Using those conditions to express the required transfers as a function of desired quantities, the regulator's problem can be rewritten as

$$\max_{\underline{q},\bar{q}} \Pr(c=\underline{c})\left[U\left(\underline{q}\right)-\underline{c}\underline{q}-(\bar{c}-\underline{c})\,\bar{q}\right]+\Pr(c=\bar{c})\left[U\left(\bar{q}\right)-\bar{c}\bar{q}\right].$$

The second-best level price and production for a high-cost firm are thus given by

$$\bar{p}^{SB}=U'\left(\bar{q}^{SB}\right)=\bar{c}+\frac{\Pr(c=\underline{c})}{\Pr(c=\bar{c})}(\bar{c}-\underline{c});$$

the price is therefore higher –and the production lower– than for the first-best.

This simple example contains two lessons. First, recognizing the implementation problem, generated here by the asymmetric information between the firm

[4]Intuitively, a high-cost firm cannot gain by pretending to be more efficient than it is. And a low-cost industry is willing to participate since it can get at least as much as a high-cost one by mimicking it.

and the regulator, leads to modify the regulation –and the merit of the approach is to indicate how the regulation should be modified. Second, the appropriate way for designing the regulation consists in first characterizing the set of "implementable" rules –here, the incentive condition (IC)–, in order to find out the "second-best" rule –among those that are implementable. The same approach has since then been adopted to account for additional implementation issues, such as the regulator's limited commitment, regulatory capture, multitasking, etc.[5]

Compared with regulation theory, the theory of competition policy is still in its early stages of development, with little attention devoted to implementation issues. To be sure, understanding how oligopolistic industries work already constitutes a challenging task; this certainly explains why much effort has been devoted to the analysis of firms' interaction, leaving less room for the study of the supervision of these industries. As a result, most of the work on competition policy has focused on the analysis of firms' strategic interaction, under alternative (and often ad hoc) restrictions on their strategy spaces, meant to reflect different competition policy rules. More recently, however, some attention has been paid to implementation issues. This paper offers an outlook of recent advances

[5]See Laffont and Tirole (1993) for an extensive review of these developments.

in this direction, in various areas of competition policy, and advocates a fuller recognition of implementation problems in policy design.

The paper is organized as follows. Section 2 focuses on the enforcement of cartel laws, where implementation is the main issue. Section 3 turns to merger control. Finally, Section 4 offers some suggestions for further research, based on a better understanding of competition authorities' implementation problems.

2 Price-fixing agreements

This facet of competition policy is a natural candidate for discussing the role of implementation in policy design. First, there is a consensus, at least in practice, that price-fixing agreements should be forbidden;[6] the main issue is therefore not

[6] Selten (1984) however points out that intensifying price competition may deter some firms from entering the market; fighting price-fixing agreements may thus "backfire" through a decrease in the number of participants. [A similar observation applies to the size of endogenous sunk costs, as emphasized by Sutton (1991, 1998).]

D'Aspremont and Motta (2000) note however that if intensifyng competition reduces the number of participants, it also selects the most efficient ones; in their model, a moderate softening of competition may have a positive impact on welfare, but allowing full collusion (price-fixing agreements) always reduces welfare. [Symeonidis (2000) studies the impact of

what to do but, precisely, how to do it. Second, some effort has already been made to account for implementation problems in this area.

The economic analysis of price cartels has initially focussed on the stability of *explicit cartels* and on the sustainability of *tacit collusion*. The first strand of literature studies the formation of explicit cartels: Assuming that firms can operate a cartel as a joint profit maximizing entity, what is the optimal or the equilibrium size of the cartel? The main insights build on two observations: first, cartel members may not always gain from forming a cartel –except if it includes all firms in the industry;[7] second, non-member firms usually gain from the creation of a cartel– and actually gain even more by staying outside the cartel than by joining it.[8] The second strand of literature characterizes the set of prices that

cartel policy on firms' profits, using a panel data set of UK manufacturing industries. He finds that the introduction of cartel laws in the UK in the late 50's caused an intensification of the price competition and had a strong effect on the structure of the markets that were previously cartelized, but little impact on firms' profits.]

[7]See Selten (1973) and Salant-Switzer-Reynolds (1983).

[8]See d'Apremont *et al.* (1983). For example, in standard Cournot models, the creation of a cartel always benefits outsiders, since it leads cartel members to reduce their aggregate supply; however, a "small" cartel will typically not be profitable –for instance, in the symmetric case with linear demand and costs, a cartel between two firms is never profitable when there are at

can be sustained in a non-cooperative equilibrium when competition is repeated over time.

The first literature assumes that firms can enter in (long-term) binding agreements.[9] The analysis is therefore more useful for understanding the formation of explicit cartels such as OPEC,[10] than for the design of an appropriate policy against those cartels. in particular, declaring such agreements illegal and void will have little impact if firms can rely on hidden or implicit ways to enforce their agreements –the analysis may however help identifying good "target" industries for investigation.

More promising is the second literature, which identifies factors and practices

least three firms.

Attention has also been devoted to the design of (binding) cartel contracts in the presence of asymmetric information – see for example Roberts (1985), Cramton-Palfrey (1990) and Kihlstrom-Vives (1992).

[9]The analysis relies on the assumption that, once cartels are formed, all entities (cartels and remaining individual firms) maximize their (joint or individual) profits and play some oligopolistic competition game. This supposes that the cartel structure remains durably fixed, as compared with the strategic variables involved in the competition game.

[10]Whether OPEC actually operates as a binding cartel is a debated issue. For an opposing view, see Crémer and Salehi-Isfahani (1989).

that facilitate *tacit* collusion, i.e., that allow the emergence of equilibria with higher prices in situations of repeated competition. Short of attacking tacit collusion *per se*, competition authorities can then fight those facilitating practices.

Fighting collusion *per se* is a different issue. In particular, fighting tacit collusion comes close to regulating prices,[11] something that competition authorities and courts are generally reluctant to do.[12] However, in practice collusion often leaves significant pieces of evidence: notes of meetings, compromising fax ex-

[11]For example, in a repeated Bertrand duopoly where firms have the same unit cost and use the same discount factor $\delta > 1/2$, any price between the competitive and monopoly ones can be sustained as a noncooperative, subgame-Perfect equilibrium. In principle, the equilibria involving supra-competitive prices could be ruled out by restricting the set of admissible strategies to, say, Markov strategies; in practice, however, this may be as difficult as directly dictating the level of the prices.

[12]In the US, Section 2 of the Sherman Act condemns "monopolization", not the exploitation of a rightfully acquired market power. An inventor, say, can thus sell the product of its invention at a monopoly price if it wishes to. In the European Union, charging an excessive price can constitute an "abuse of dominant position", sanctioned by Article 81 of the Treaty of Amsterdam (formerly Article 86 of the Treaty of Rome). However, apart from some early cases, no firm has been fined for such abuses. [Whether competition authorities should attack tacit collusion, where by definition firms set prices non-cooperatively, is itself a debated issue.]

changes, emails, etc.[13] Competition authorities can thus try to identify cartels and recover those pieces of evidence. Building on this insight, a significant effort has been developed in the last decade, to explicitly model the implementation of the ban on price-fixing agreements.

I now discuss in turn enforcement policies against both collusion and facilitating practices.

2.1 Fighting collusion *per se*

Starting with Becker's (1968) seminal paper, a large effort has been devoted to the economic analysis of enforcement policies against illegal behavior.[14] It is only recently, though, that this literature has addressed enforcement policies against *concerted* illegal actions, involving several participants. I present below some of the advances in this domain, first in a static and then in a dynamic framework.

[13]The appropriate model may thus be neither of the explicit cartel type, nor of the purely tacit collusion type; it may involve features from both paradigms: firms rely on secret contracts, which are not legally enforceable and are instead tacitly enforced thanks to repeated interaction. The next section develops a framework along those lines.

[14]See Polinski-Shavell (2000) for a recent survey.

2.1.1 Fighting collusion in a static setting

Assuming that the law forbids collusion on prices, competition authorities' main problem is to detect and prove such collusion. Besanko and Spulber (1989) have been the first to study formally the implications of this informational problem for cartel policy. In their model, firms have the same constant unit cost c and choose whether to compete, in which case they set their price at a competitive level $p^c(c) = c$,[15] or collude, in which case they jointly determine their supply decisions –since they are symmetric, there is always a consensus as to which price is best for them. Besanko and Spulber capture the implementation problem by assuming that the competition authority observes prices and/or quantities but neither the cost of the industry nor the occurrence of collusion. More precisely:

i) the authority does not observe the cost c, which can take two values, a low value $\underline{c}$ or a high value $\bar{c}$. Observing prices thus does not suffice to detect collusion, but the authority can use prices or quantities to identify "suspect" industries;

ii) the authority can audit the industry; an audit costs C but determines

[15] Baniak and Phlips (1996) extend the analysis to the case where the competitive outcome is the Cournot equilibrium.

whether there is collusion, in which case a maximal fine F can be imposed on the firms.[16]

The industry audit can be interpreted as a "hunt for evidence" (dawn-raids, etc.) that allows the authority to discover formal proofs of price-fixing agreements –but not the actual level of costs; in particular, if the price is above c, the audit reveals collusion but does not allow cost-contingent fines.

Besanko and Spulber characterize the policy that maximizes expected total welfare, net of audit costs. Feasible policies consist, for each level of the price or output, in an audit probability μ and a fine f in case the audit reveals that the price was above the competitive level. The optimal policy boils down to picking two prices or, equivalently, two levels of output, one for the high-cost industry, $\bar{p} = P(\bar{q})$, and a lower one for the low-cost industry, $\underline{p} = P(\underline{q})$, attached with two probabilities of audit, $\underline{\mu}$ and $\bar{\mu}$, and two levels for the fine, $\underline{f}$ and $\bar{f}$, in case of detected collusion. As usual, the relevant conditions are the high-cost firms' participation constraint (IR) and the low-cost firms' incentive constraint (IC). In addition here, "transfers" are limited to fines, which can be imposed only when

[16] The upper bound on the fine, F, can be derived from firms' limited liability; it is supposed large enough to offset any gain from collusion.

an audit reveals collusion. The authority's problem can then be summarized as:

$$\max_{\underline{q},\bar{q},\underline{\mu},\bar{\mu},\underline{f},\bar{f}} \quad \Pr(c=\underline{c})\left[U\left(\underline{q}\right)-\underline{c}\underline{q}-\underline{\mu}C\right]+\Pr(c=\bar{c})\left[U(\bar{q})-\bar{c}\bar{q}-\bar{\mu}C\right]$$

$$\text{subject to} \quad \left[P\left(\underline{q}\right)-\underline{c}\right]\underline{q}-\underline{\mu}\underline{I}\underline{f}\geq\left[P(\bar{q})-\underline{c}\right]\bar{q}-\bar{\mu}\bar{f}, \qquad (IC)$$

$$\left[P(\bar{q})-\bar{c}\right]\bar{q}-\bar{\mu}\bar{I}\bar{f}\geq 0, \qquad (IR)$$

where I is an indicator variable for collusion: for each type of industry, I equals 0 if $P(q)=c$ and 1 otherwise.

Besanko and Spulber show that the optimal policy has the following features:

Proposition 1 *Audit takes place only for high prices:* $\underline{\mu}=0$.

Since high-cost firms have no incentive to adopt the lower price $\underline{p}$, there is no point undertaking costly audits when the price is $P\left(\underline{q}\right)$.

Proposition 2 *The fine is set at its maximum for the case where an audit reveals that low-cost firms have adopted a high price:* $\bar{f}=F$.

This is a standard property of optimal policies with costly audits: the low-cost firms' incentives to mimick high-cost ones are driven by the expected fine $\bar{\mu}\bar{f}$, and the least costly way to generate a given expected fine is to make the actual fine $\bar{f}$ as large as possible, in order to reduce the probability of audit $\bar{\mu}$.

Proposition 3 *Low-cost firms are allowed to charge supra-competitive prices:* $P\left(\underline{q}\right) > \underline{c}$.

A small departure from the competitive price $\underline{p} = \underline{c}$ generates only a second-order negative impact on total welfare, but allows a first-order reduction in the audit probability (and thus its expected cost) in the event of the higher price $P\left(\bar{q}\right)$.[17] It is therefore optimal to tolerate a limited collusion in low-cost industries.

Proposition 4 *It may be optimal to allow high-cost firms to charge supra-competitive prices as well.*

This more surprising result comes from the low-cost industry's incentive constraint (IC). If the difference in the two costs is very large (for example, if the low-cost monopoly price is lower than high cost), an increase in the price assigned

[17] This probability is determined by (IC):

$$\bar{\mu}\bar{f} = \left(\bar{p} - \underline{c}\right) D\left(\bar{p}\right) - \left(\underline{p} - \underline{c}\right) D\left(\underline{p}\right),$$

implying

$$\left.\frac{\partial\left(\bar{\mu}\bar{f}\right)}{\partial \underline{p}}\right|_{\underline{p}=\underline{c}} = -D\left(\underline{c}\right) < 0.$$

to the high-cost industry makes it less attractive for the low-cost industry and relaxes (IC), thereby allowing the authority to reduce the audit probability. This result however relies somewhat on the assumption that the number of types is assumed to be discrete.[18]

This analysis yields several insights for policy design. For example, investigations must be launched when prices are "high", not because these prices are necessarily collusive[19] but, rather, to deter low-cost firms from unduly adopting those high prices. Several assumptions are however worth discussing.

First, some of the constraints imposed on the authority seem rather arbitrary. For example, the absence of transfers between the firms and the authority (or more generally, with the collectivity), other than fines in the event of proven collusion, is meant to reflect a restriction commonly observed in practice, but the underlying reason for this restriction is not explicitly modelled. In particular, the reason cannot be found in the authority's prior lack of information: in their model, the authority could in general perform better if allowed to use additional

[18] See Souam (1997) for an analysis of the case of a continuum of values.

[19] In the realistic case where it is best to forbid any higher price than $\bar{c}$, it is optimal to audit precisely the firms that do not collude in equilibrium – and only those.

transfers.[20] A first reason may be found in a prohibitive social cost of transfers. Another reason, which deserves further exploration, is that competition authorities and courts ill-fitted to manage such transfers. There may exist a suspicion about the authority's use of public funds (risk of capture), and this concern may be exacerbated by the lack of control by taxpayers and the fact that taxpayers' representatives ("advocates") are not sufficiently involved in the management of those transfers. Yet another explanation might be found in the authority's lack of commitment; ruling out transfers could for example be seen as a (drastic) way to impose a "hard budget constraint" on the industry.[21] I will come back in Section 4 on those underlying reasons, but note here that little progress has been made in the analysis of how those reasons contribute to shape cartel law enforcement.

Second, Besanko and Spulber assume that firms can perfectly collude if they wish to, and that competition authorities cannot affect the sustainability of collusion. This leads them to treat the industry as a single entity –their analysis

[20]The problem of the competition authority studied here can be viewed as a standard regulation problem with audit, as studied by Baron-Besanko (1984a), with the additional restriction that the fines constitute the only allowed transfers.

[21]See Lafffont-Tirole (2000), chapter 2, for a discussion of restrictions on transfers in regulatory contexts.

would formally be the same if there was only one firm in the industry. This rules out some important means of intervention, such as playing firms against each other. More generally, the multiplicity of participants in the industry might allow to move from a "police patrol" to a "fire alarm" mode of operation, to use the terminology of McCubbins-Schwartz (1984).

In particular, Besanko and Spulber rule out any communication between the firms and the competition authority. Formally, the authority is confronted with an information acquisition problem: firms know whether they collude or not, while the authority does not. The authority could therefore try and devise revelation mechanisms à la Maskin, in order to induce the firms to report this information.[22]

And indeed, in practice, competition authorities often design leniency programs to allow cartel members to benefit from a favorable treatment if they bring information that help competition authorities to dismantle the cartel. In the US, firms bringing information before an investigation is opened benefit from such a leniency program since 1978. Since 1993, a colluding firm can now also

[22]Building on the pioneering work of Maskin (1977), the literature on Nash and Subgame Perfect implementation has confirmed the intuition that "a secret is no longer a secret when it is shared by several agents". See Moore's (1992) for a very nice survey.

avoid those sanctions if it reveals information once the investigation has been opened, as long as the Department of Justice has not yet been able to prove collusion.[23] The EU has adopted a leniency program in 1996, which allows firms that bring information to benefit from reduced fines.[24] In the UK, when a new Competition Policy Act has been implemented two years ago, the Director General of the Office of Fair Trading introduced a leniency program close to the US model. In France, following a recent bill passed last year a leniency program is currently being implemented.

Revelation mechanisms may not be very effective in the case of "soft" information, when no evidence is left to be discovered by competition inspectors. In particular, as long as this information relates to past behavior and has no direct effect on firms' capabilities or objectives in the future, little can be done to extract this information. Things change, however, when collusion produces pieces

[23]See US Department of Justice (1993). Thanks this new leniency program, on average 2 cartels are now disclosed every month, and the fines often exceed 100 million $ (not to mention jail for some managers). In 1999 only the Antitrust Division secured more than 1 billion $ in fines, which is more than the total sum of fines imposed under the Sherman Act since its adoption more than a century ago.

[24]See European Union (1996).

of "hard" information that can be transmitted to the competition authority, as implicitly assumed by Besanko and Spulber. The competition authority could then encourage firms to report any collusion (i.e., provide hard evidence of it), reward informants and use the information against the other firms.

Of course, the effectiveness of such mechanisms depends on the extent to which the industry can again collude at the revelation stage. If firms cannot collude at all at the revelation stage, the authority may be able to deter collusion *at almost no cost*. For example, consider the following mechanism: once supply decisions have been undertaken, the competition authority selects randomly one firm and confronts it with the following choice:

- either it reports collusion, in which case all other firms are heavily fined but the reporting firm is exempted from any fine;
- or it denies collusion, in which case the competition authority audits with an arbitrarily small probability ε and all firms are fined if collusion is detected.

If firms cannot collude at this stage, it is then a strictly dominant strategy for the selected firm to report collusion whenever it takes place, and ex ante the

threat of being fined then deters collusion.[25]

If firms can instead perfectly collude and behave as a single entity at the revelation stage, this revelation mechanism would not work anymore: non-selected firms would have an incentive to bribe the selected one and induce it not to report collusion. But then, the competition authority could in theory try to elicit information on this second form of collusion, and so on. A relevant analysis of this issue requires a deep understanding of how firms organize the collusion.[26]

[25] If there are n firms in the industry, the maximal fine would only need to be large enough to offset the gains from collusion when applied with probability $1 - 1/n$. In addition, as pointed out by Kaplow and Shavell (1994) in the context of single-party law enforcement, the selected firm would be induced to report as long as the reduced fine is lower than the *expected fine* it would face otherwise. A difference with single-party enforcement contexts, however, is that here the competition authority can use the information brought by one cartel member against the other members; hence, if ρ denotes the probability of being caught and F the level of the fine, collusion can be deterred whenever $(1 - 1/n + \rho) F$ offsets the gains from collusion.

[26] A large effort has been devoted to the study of collusion in organizations, both with hard information and soft information. While the earlier literature assumed that colluding parties shared their information, attention has recently been devoted to the incentive constraints that colluding parties may face when they have private information. See Tirole (1992) for a first extensive survey, Laffont and Rochet (1997) for an update overview and Laffont and Martimort

Of course, in practice competition between firms is rarely of the "one-shot" type analyzed above: colluding firms know that they will be competing again in the future and will therefore be reluctant to report past collusion, since this will likely reduce the scope for collusion in the future. To tackle this issue, however, one needs to develop a dynamic framework.

2.1.2 Fighting collusion in a dynamic setting[27]

Analyzing the struggle against collusion in a dynamic setting raises of course additional intricacies. To keep things tractable, I will therefore highly simplify the above framework and assume that the authority does not observe any relevant information in the absence of audit. This assumption is meant to capture the fact that, in practice, the competition authority has very little information about supply and demand conditions and cannot in general infer collusion from the mere observation of prices.[28]

(1997,2000) for recent advances in the modelling of collusion between privately informed agents.

[27]This section draws on Aubert-Kovacic-Rey (2000).

[28]Competition authorities could in principle try to infer collusion not only from the current level of prices, but also from the pattern of their evolution. In the famous Woodpulp case, for example, the European Commission observed a parallel evolution of the prices quoted in dollars, despite substantial variations of exchange rates between the producing countries, as

Two firms ($i = 1, 2$) play an infinitely repeated game: in each period, they can either "compete" or "collude"; gross profits are given by

Firm 1 / Firm 2	compete	collude
compete	(π^C, π^C)	$(\pi^D, \underline{\pi})$
collude	$(\underline{\pi}, \pi^D)$	(π^M, π^M)

Table 1

with $\underline{\pi} \leq \pi^C < \pi^M < \pi^D$ and $\underline{\pi} + \pi^D < 2\pi^M$: firms gain from collusion, but

well as a remarkable stability over time, except for a six-month price war. It asserted that this pattern was conclusive evidence of collusion, but this decision was overruled in appeal by the European Court of Justice, which concluded that the Commission failed to establish that this pattern of prices was not compatible with competitive behavior.

Kühn (2000) offers a detailed discussion of the difficulties in detecting collusive behavior from observable behavior, beyond the lack of information on cost. First, information on actual prices and quantities may be unavailable. Second, even in the ideal case when reliable price and output data would allow quantitative studies, the conclusions may be too sensitive to functional form specifications. This is illustrated by the divergence of the findings of two studies of the US railroad cartel of the 1880's, based on the same dataset. While Porter (1983) concludes that firms observed mark-ups were consistent with Cournot behavior, by allowing for auto-correlation on the demand side Ellison (1994) obtains instead an estimate close to full collusion.

each firm may benefit at the expense of the other from "cheating", i.e., from "competing" when the other "colludes".[29] Collusion moreover generates hard information:

- whenever collusion is successful (i.e., both firms "collude"), it generates a piece of evidence that is found with probability ρ by the competition authority; ρ can be thought of as the exogenous probability of a successful audit.

- in addition, each of them can then bring a piece of hard information to the competition authority.[30]

To keep the analysis simple, I will assume that any piece of hard information disappears after one period. This limits the scope for revelation mechanisms, which can apply only to "current" collusive behavior. The maximal fine F that

[29]This assumption is for example relevant for situations where "colluding" amounts to maintain the monopoly price. If instead "collusion" were to involve an agreement that "takes two to tango", one might expect $\pi^D = \underline{\pi} = \pi^C$.

[30]This assumption allows the competition authority to design revelation games, as suggested in the previous section, while ruling out trivial strategies where a firm would unilaterally "collude" just to report collusion and get a reward for doing so.

can be imposed in case of proven collusion is large enough to deter collusion if collusion is detected with certainty, but not sufficient if collusion is detected only with probability ρ:

$$F > \pi^M - \pi^C > \rho F.$$

In the absence of any revelation mechanism, the net expected payoffs of the stage game are thus given by

Firm 1 / Firm 2	compete	collude
compete	$\left(\pi^C, \pi^C\right)$	$\left(\pi^D, \underline{\pi}\right)$
collude	$\left(\underline{\pi}, \pi^D\right)$	$\left(\pi^M - \rho F, \pi^M - \rho F\right)$

Table 2

If both firms use the same discount factor δ, collusion is sustainable if

$$\pi^D - \left(\pi^M - \rho F\right) \leq \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right). \tag{1}$$

Indeed, the most profitable collusive strategy is to collude in each period and to punish deviations by returning for ever to the static competitive equilibrium.[31]

[31]The competitive outcome is both the Nash equilibrium and the minmax of the stage game.

Let us now introduce revelation mechanisms. The competition authority could ask the firms to reveal their choice (compete or collude), both before and after it audits the industry. The scope for such revelation mechanisms depends on whether the messages sent by one firm are observed by the other firm. Inducing reporting is clearly easier when not observed by rivals, but keeping such reports secret may be difficult in practice. I consider both situations in turn.

Secret reporting

Let us start with the case where firms can report collusion secretly. More precisely, suppose that firms only observe whether the competition authority has evidence of collusion, but not the origin of its information nor the fines or rewards possibly paid by or to the rival. Then, the competition authority can easily prevent "perfect collusion". The following mechanism would for example do the trick. At the beginning of each period, offer each firm to report collusion in order to benefit from a slightly reduced fine in the event of a successful audit. Then, it cannot be the case that firms plan to collude in every period, even after a successful audit by the competition authority. Indeed, in that case it would be

Therefore, an indefinite reversal to the competitive situation constitutes the harshest credible punishment that can be imposed on deviators.

a strictly dominant strategy for the selected firm to report collusion whenever it takes place, since doing so reduces the expected fine it will have to pay (due to the possibility of a successful audit) and does not trigger any retaliation by the rival.[32]

To deter such reporting and sustain some collusion, firms will therefore have to plan periods of "competition" whenever the competition authority imposes a fine on them.[33] Furthermore, an increase in the amount of the reward exacerbates the temptation to deviate and report, and thus requires longer periods of competition. To see this, suppose that in each period the competition authority offers a (secret) reward R for (secret) reports; the firms can then adopt the following strategy: "collude and do not report as long as the authority imposes no fine; when the authority imposes a fine, compete for T periods before returning to collusion; furthermore, whenever a firm competes when it is supposed to collude, revert to

[32]The threat of being fined would therefore deter collusion whenever the maximal fine F is large enough to offset the gains from collusion when applied with probability $1/2$.

[33]The analysis is reminiscent of that of Tirole (1988)'s version of Green-Porter (1984), for the case of unobservable demand shocks.

competition for ever." If both firms adopt this strategy, they obtain:

$$V = \pi^M - \rho F + \delta \left[(1-\rho) V + \rho \hat{V} \right],$$

where

$$\begin{aligned} \hat{V} &= \left(1 + ... + \delta^{T-1}\right) \pi^C + \delta^T V \\ &= \frac{1-\delta^T}{1-\delta} \pi^C + \delta^T V, \end{aligned}$$

so that

$$V = \frac{\pi^M - \rho F + \delta \rho \frac{1-\delta^T}{1-\delta} \pi^C}{1 - \delta + \delta \rho \left(1 - \delta^T\right)}.$$

This value thus decreases when the number of competitive periods (T) increases.

Adopting this strategy constitutes an equilibrium if:

- Firms have no incentive to compete when they are supposed to collude, i.e.

$$V \geq \pi^D + \frac{\delta \pi^C}{1-\delta}; \tag{2}$$

or

$$\delta \frac{1 - \rho \left(1 - \delta^T\right)}{1 - \delta + \delta \rho \left(1 - \delta^T\right)} \left(\pi^M - \rho F - \pi^C\right) \geq \pi^D - \left(\pi^M - \rho F\right);$$

the left-hand side of this condition, which I will denote $A_1(T)$, satisfies $A_1'(T) < 0$. This condition is thus of the form

$$T \leq T_1\left(\frac{\pi^M - \rho F - \pi^C}{\pi^D - (\pi^M - \rho F)}\right),$$

with $T_1' > 0$: to prevent firms from deviating in this way, the value of collusion must be sufficiently large, and thus the duration of competition sufficiently short. Note that this condition is independent of the reward R.

- Firms have no incentive to secretly report collusion, i.e.

$$V \geq \pi^M + R + \delta\hat{V}; \tag{3}$$

or

$$\delta\frac{(1-\rho)\left(1-\delta^T\right)}{1-\delta+\delta\rho\left(1-\delta^T\right)}\left(\pi^M - \rho F - \pi^C\right) \geq R + \rho F;$$

the left-hand side of this condition, $A_2(T)$, increases with T. This condition is thus of the form

$$T \geq T_2\left(\frac{\pi^M - \rho F - \pi^C}{R + \rho F}\right),$$

with $T_2' < 0$: the larger the reward, the longer the duration of the competitive phases needed to prevent firms from reporting collusion.

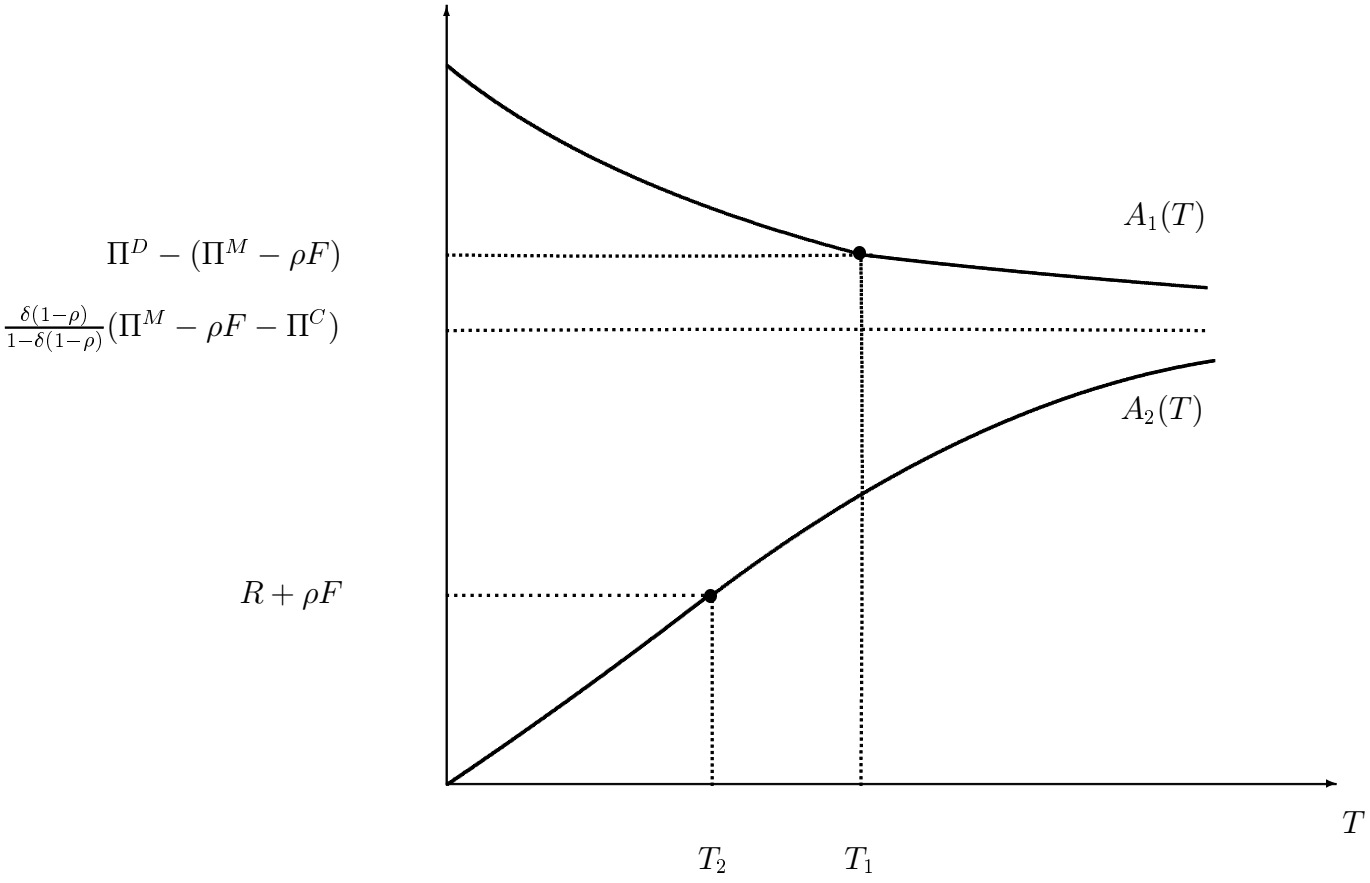

Figure 1

Figure 1 illustrates the situation. Note that A_1 and A_2 converge towards the same limit $\left(\frac{\delta(1-\rho)}{1-\delta(1-\rho)}\left(\pi^M - \rho F - \pi^C\right)\right)$ when T goes to infinity. Thus, if

$$R + \rho F > \frac{\delta\left(1-\rho\right)}{1-\delta\left(1-\rho\right)}\left(\pi^M - \rho F - \pi^C\right),$$

i.e., if the reward is large enough:

$$R > \hat{R} \equiv \frac{\delta\left(1-\rho\right)\left(\pi^M - \pi^C\right) - \rho F}{1-\delta\left(1-\rho\right)},$$

then this collusion is not sustainable.

Furthermore, even if $R < \hat{R}$, only some limited collusion is sustainable and the minimal duration of competition phases, given by $T_2(.)$, increases with the amount of the reward for reporting collusion. Of course, increasing the probability of successful audit (ρ) or the maximal fine (F) further contributes to make collusion more difficult to sustain; in particular, a simple leniency program ($R = 0$) suffices when

$$\frac{\rho F}{1-\rho} > \delta\left(\pi^M - \pi^C\right).$$

Public reporting

Things are more difficult when reports cannot be kept secret. In particular, in that case a leniency program that only offers a reduced fine cannot help the competition authority:

Proposition 5 *Suppose that the competition authority can only impose fines (that is, it can "reward" informants through lower fines, but cannot make positive transfers to them). Then, revelation mechanisms do not help preventing collusion.*

Proof. The proof is straightforward. First, it is not possible to make firms

reveal past decisions, since hard information disappears after one period –and past decisions do not affect firms' preferences over their future choices, so that soft information cannot be acquired. Therefore, revelation mechanisms can only serve to induce firms to report collusion in the current period.

Second, the competition authority cannot induce firms to report collusion ex post, once the result of its audit is known. If the authority does not detect collusion, firms have no incentive to report it and get (even moderately) fined. And if the authority detects collusion, there is no longer any need to induce firms to cooperate with the authority;[34] as stressed by Motta-Polo (2000) and Spagnolo (2000a) offering a reduction of the fine would then actually erode the deterrence power of the authority's audit (in the case of a successful audit, firms would have an incentive to "report" ex post collusion, in order to benefit from the reduced fine, so that the right-hand side of (1) would be further increased).[35]

[34]This may not be true anymore if firms' cooperation enhance the authority's ability to prosecute the cartel –see below.

[35]Spagnolo (2000a) notes that offering reduced fines could however help deter collusion by limiting the punishments that can be imposed on deviating firms. Suppose for example that "optimal penal codes" à la Abreu would allow firms to sustain expected profits levels *below* the static competitive equilibrium; then, introducing a leniency program may allow deviators

Last, whenever condition (1) holds, firms have no incentive to report collusion *ex ante* either, before they know the outcome of the authority's audit, even if they benefit then from a reduced fine $f < F$: such reporting would trigger retaliation (no collusion in the future) and would thus not be a profitable strategy, since (1) implies:[36]

$$\pi^D - \rho f - \left(\pi^M - \rho F\right) \leq \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right).$$

■

to benefit from the authority's action and avoid such punishments, thereby making collusion more difficult to sustain.

Spagnolo (2000b) stresses instead that badly designed leniency programs may actually help collusion. This will for example be the case if the leniency program eliminates criminal sanctions but does not prevent civil damages. Since profits are reduced when the other firm deviates from the collusive agreement, the non-deviating firm may have higher incentives to report collusion in that case. Such a partial leniency program may therefore make credible the threat to denounce collusion whenever the other firm deviates from the cartel agreement, thereby contributing to enforce the agreement.

[36]That is, if collusion is sustainable in the absence of reporting, then as long as firms do not get any additional information they have no incentives to report collusion and get fined, even moderately. Malik and Schwab (1991) make a similar point for the enforcement of laws against single-party crimes (tax amnesty programs).

To convince a firm to report collusion, the competition authority must therefore promise a *reward* R, sufficient to reverse the above incentive condition; that is, this reward R should be such that:[37]

$$\pi^M + R + \frac{\delta \pi^C}{1-\delta} \geq \frac{\pi^M - \rho F}{1-\delta},$$

which is equivalent to

$$R + \rho F \geq \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right),$$

or

$$R \geq \bar{R} \equiv \frac{\delta\left(\pi^M - \pi^C\right) - \rho F}{1-\delta}. \tag{4}$$

The minimum reward $\bar{R}$ required to induce a firm to report collusion may thus be quite large[38] –it goes to infinity when δ gets close to 1. This raises

[37]It is clearly more effective to ask firms to report collusion before the audit of the industry: there is no need for acquiring this information if the audit brings evidence of collusion, and if it does not, the information would be more costly to acquire (the term ρF would disappear from the left-hand side). Note also that, in this formulation, firms must collude in order to report. I discuss below the (possibly more realistic) case where firms can cheat on collusion at the time they report it.

[38]In particular, it is larger than the minimal reward $\hat{R}$ required to deter collusion in the case of secret reports.

several issues. First, granting large rewards may not be credible: the competition authority may be limited in the amount it can promise for reporting collusion. Second, large rewards may exacerbate social or political issues: the public opinion may be particularly reluctant to grant large amounts ... to colluding firms; more generally, granting rewards involves some transaction costs, which are likely to increase with the magnitude of the rewards.[39] Third, large rewards may have the perverse effect of generating additional incentives to collude, or different ways to do so. For example, it may become profitable for the firms to collude and "take turns" for reporting collusion.[40]

[39] Spagnolo (2000a) points out that restricting eligibility to the first informant may help limiting those transaction costs while achieving the same deterrence effect.

[40] If the reward is made available to any reporting firm, the two firms would optimally collude (and this would be sustainable whenever condition (1) is satisfied).

To counter this, the authority may restrict the reward to the case where only one firm reports. Consider then the strategy that consists in colluding and selecting randomly one firm (with equal probability) for reporting the collusion to the authority. The value of such a strategy would be

$$\frac{1}{1-\delta}\left(\pi^M + \frac{R-F}{2}\right)$$

and such collusion would thus be sustainable under (1) as soon as $R > (1+2\rho)F$.

Extensions

Many lines of research are still open. In particular, considering the possibility of long-lasting pieces of hard information opens new perspectives. Also, it would be useful to further analyze the determinants of hard information generation. For example, following Spagnolo (2000a) and Motta-Polo (2000), I have assumed that collusion leaves evidence only when it is successful, i.e., when no firm deviates. This can be an appropriate assumption in some instances, but in other situations firms may wish to denounce collusion precisely when they decide to cheat, and may well be able to bring convincing evidence even in that case. Here is a two-step collusion stage that captures this idea:

- step 1: firms choose simultaneously to either "consider collusion" or "refuse collusion". Whenever at least one firm refuses collusion, the outcome is the competitive one $\left(\pi^C, \pi^C\right)$. If instead both firms are open to collusion, an agreement is signed, say, which generates the hard information described above; in that case the game proceeds to step 2;

- step 2: firms choose simultaneously to "compete" or "collude"; payoffs are those given by *Table* 1.

There are thus now three relevant strategies for the firm, which can be interpreted as "compete", "collude" and "cheat"; the net expected payoffs for these strategies are:

Firm 1 / Firm 2	compete	collude	cheat
compete	(π^C, π^C)	(π^C, π^C)	(π^C, π^C)
collude	(π^C, π^C)	$(\pi^M - \rho F, \pi^M - \rho F)$	$(\underline{\pi} - \rho F, \pi^D - \rho F)$
cheat	(π^C, π^C)	$(\pi^D - \rho F, \underline{\pi} - \rho F)$	$(\pi^C - \rho F, \pi^C - \rho F)$

Table 3

Collusion is less fragile than before since deviating does not guarantee to escape the fines; it is now sustainable if

$$\pi^D - \pi^M \leq \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right), \tag{5}$$

which is less restrictive than condition (1). But leniency programs (i.e. here, offering a reduced fine f when reporting collusion) can now help deter collusion even in the case of public reporting. Since a deviating firm abandons any hope of collusion for the future, it is willing to report collusion as long as the leniency

program is sufficiently attractive, that is, if $f < \rho F$. A leniency program is therefore useful to deter collusion when

$$\pi^D - \pi^M \leq \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right) < \pi^D - \pi^M + (\rho F - f)\,. \tag{6}$$

After some learning period, firms will likely adapt to the use of leniency programs and other bounty mechanisms, and will try to minimize the amount of information that could be found by the competition authorities. But hard information may still be required to implement collusion in an effective way. For example, memos may be needed when collusive agreements are too complex to be left to the sole accuracy of individuals' memories. Furthermore, if a firm delegates the negotiation of the collusive agreement to an agent, this agent will need to report to the head of the firm; there again, hard information about the details of the agreement may be required to minimize the agency problems associated with delegation. Cartel policies could take advantage of these intrinsic agency problems and try to exacerbate them.[41]

[41]Exacerbating internal agency problems may however have a cost, since firms delegate decisions not only for collusive purposes, but also for "good" efficiency-enhancing reasons.

In the US individuals, too, benefit from a leniency program, which shields them from criminal sanctions (including jail). There are however no positive incentives to report information. In

Suppose for example that n employees have access to the hard information generated by collusion. Then, even if reporting is public, introducing a reward r for individual informants would force colluding firms to compensate each employee for preventing them to become whistleblowers, thereby reducing the benefits from collusion. If employees are protected from retaliation by the industry (i.e., they can leave the firm in any period and cannot be threatened about their future job opportunities) then, in order to discourage whistleblowing, the firms must promise *each employee* the equivalent of r; the best way to do this would be to grant them in each period, as long as that whistleblowing does not occur, a bonus

$$b = (1 - \delta)\, r.$$

contrast, under the Civil False Claim Act, individuals that inform the government on fraud in procurement contracts can get up to 30% of the damages paid by convicted suppliers. [See Kovacic (1996) and Tokar (2000) for a discussion of this whistleblowing mechanism.]

The minimal reward $\underline{r}$ needed to deter perfect collusion would then be such that:[42]

$$\pi^D - \pi^M = \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right) - n\underline{r}, \tag{7}$$

and is likely to be lower than the minimal reward $\underline{R}$ needed to extract the information directly from the firm, given by (4) set to equality:

$$\underline{R} + \rho F = \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C\right) = \pi^D - \pi^M + n\underline{r}.$$

Such a bounty mechanism would be *a fortiori* more effective if the employees did not stay for ever within the firm. For example, if employees work for only one period, the firm should grant in each period a bonus $B = r$. The minimal reward $\underline{\hat{r}}$ needed to deter perfect collusion would then be given by:

$$\pi^D - \pi^M = \frac{\delta}{1-\delta}\left(\pi^M - \rho F - \pi^C - n\underline{\hat{r}}\right), \tag{8}$$

[42] In practice, firms may try to retaliate – in particular, the employee's job opportunities would become more uncertain. However, the reward r could easily represent a huge sum compared with the employee's expected discounted lifetime salary (think of a sizeable fraction stream of the fines imposed on the firms, as in the US bounty device for procurement fraud). Furthermore, it may be easier to keep reporting secret in the case of a single individual, as compared with that of a firm.

and would thus be much lower than $\underline{R}$ when δ is close to 1, since

$$\underline{R} = \pi^D - \pi^M - \rho F + \frac{\delta}{1-\delta} n \underline{\hat{r}}.$$

Rewards do not come without a cost. In particular granting secret rewards for secret reports is likely to exacerbate the enforcer's temptation to abuse of public funds. This cost has been discussed at length by political scientists but how does this cost –and, more generally, the underlying reasons for limiting secret or public rewards– interact with the design of antitrust enforcement still remains an open issue.

Leniency programs In practice, competition authorities rarely offer rewards for reporting collusion. Instead, the leniency programs seek to encourage defection from cartel agreements by giving amnesty from criminal prosecution. Amnesty may be offered only to the first informant, or may be extended to later informants if they bring additional evidence that increases the likelihood of success of the prosecution. Likewise, the program may apply only to information given before an enquiry is launched, or may be extended to information

given after an investigation has been started.[43] These leniency programs have been successful, particularly in the US, both in terms of the number of successful prosecutions and in the record levels of the fines. This may sound surprising in the light of the above analysis, since in practice reporting has hardly been kept secret –and the above analysis suggests that leniency makes collusion rather more appealing in the case of public reporting.[44]

[43]In the US, amnesty is offered to the first informant only. The EU program offers a 75-100% reduction of the fine to the first cartel member to inform the European Commission before an official investigation is started, as well as a lower 50-75% reduction to the first cartel member that would bring information once an investigation has started. But in addition, cartel members that "cooperate" with the Commission during the prosecution can benefit from a 10-50% reduction of the fine. This applies not only to any member that provides "evidence that materially contribute to establishing the existence of the infringement", but it applies as well to a member that "informs the Commission that it does not substantially contest the facts on which the Commission bases its allegations."

[44]There are of course various reasons why a cartel member may wish to report collusion in practice. For example, a maverick firm or a new and efficient entrant may want to shake out existing arrangements in order to gain a better position in the market. Also, some individuals may act as whistleblowers because they disagree with their employers' participation in a cartel, or because they seek revenge for having been badly treated –for wrong or good reasons– by

As emphasized by Motta and Polo (2000), leniency programs may however help competition authorities to successfully prosecute a case once an investigation has been launched. This may be particularly useful if the competition authority can impose some restriction on firms' conduct once a cartel has been exposed. I have assumed so far that competition authorities could impose fines but not dictate firms' conduct –Spagnolo (2000a) supposes instead that, once a cartel has been exposed, the competition authority can discipline the industry and force the competitive outcome for ever. In practice, a successful prosecution is likely to have a discipline effect for at least a limited time. In that case, improving the chances of detection and successful prosecution has two benefits: it contributes as before to discourage firms from colluding, and helps competition authorites to break-up existing cartels.

To study this further, change the above framework as follows. In each period, the competition authority audits with probability α; if it opens an investigation and a firm reports collusion, the authority imposes a reduced fine f and can force the competitive outcome in that period; otherwise, it must prosecute and can force the competitive outcome –and impose the maximal fine F– only with some

their employers.

probability p.[45]

Three strategies are relevant for the firms: "Compete" (always compete), "Collude" (always collude and never report collusion) and "Report" (always collude and report collusion whenever an investigation is opened). The value attached to both following the first strategy is

$$V^{Compete} = \frac{\pi^C}{1-\delta}.$$

If firms instead collude and never report; in each period they get the cartel profit, π^M, except when there is an audit followed by a successful prosecution, which happens with probability αp, in which case the competitive outcome is implemented:

$$V^{Collude} = \frac{(1-\alpha p)\,\pi^M + \alpha p\left(\pi^C - F\right)}{1-\delta}.$$

Last, if firms choose to collude but cooperate with the authority when an investigation is launched, they lose the cartel profit whenever there is an audit

[45] In addition, Motta and Polo suppose that firms' cooperation also speeds up the prosecution stage. In their model, when the authority opens an investigation in period t, it can force the competitive outcome in period $t+1$ if firms cooperate, otherwise, it must prosecute in period $t+1$ and can force the competitive outcome (with probability p) only in period $t+2$.

but benefit in that case from the reduced fine:

$$V^{Report} = \frac{(1-\alpha)\,\pi^M + \alpha\left(\pi^C - f\right)}{1-\delta}.$$

Intuitively, a Report equilibrium exists when the probability of investigation is not too large, since the firms' payoff to colluding is then large –and whenever $f < F$, each firm has an incentive to report collusion when an investigation is opened, if it expects the others to do so. A Collude equilibrium also exists when α is small, and this equilibrium is more profitable for the firms if the prosecution effort p is not too large. Last, the competition authority can deter collusion if it is very active (only the Compete equilibrium exists when α and p are both close to 1). Welfare (gross of enforcement costs) is highest in the Compete regime: in the Report equilibrium, it is lower both because collusion occurs with some probability $(1-\alpha)$ and because collusion deterrence occurs *ex post*, with a lag of one period. In the Collude regime, welfare is further reduced by the additional prosecution delay (the competition authority needs two periods to enforce competition in one period).

To determine the optimal enforcement policy, Motta and Polo suppose that

the authority faces a budget constraint of the form

$$B(\alpha, p) \leq \bar{B},$$

where $B(\alpha, p)$ denotes the budget expenses associated with the audit probability α and the quality of prosecution p, and $\bar{B}$ represents the authority's maximal budget. Motta and Polo first characterize the best policy for each type of equilibrium. As usual, in order to deter collusion as effectively as possible, it is always best to impose the largest fine in the absence of cooperation from the firms. It is further shown that, to induce cooperation with the competition authority (the Report regime) the best policy is "full leniency" ($f = 0$): in order to induce firms to report collusion, the competition authority can either reduce the fine ($f < F$) or increase the quality of prosecution; but the latter has a cost –it requires increasing teams' size, thereby lowering the probability of investigation.

Conversely, the best policy in a Collude regime consists in avoiding any leniency ($f = F$). This has no impact on the equilibrium path (since firms never cooperate with the authority) but eliminates the perverse pro-collusive effect of leniency programs, by reducing the expected fines imposed in the case of an audit.

Similarly, the best way to completely deter collusion (i.e., to impose the Com-

pete regime) is granting no leniency. This is not completely straightforward here, since in principle the competition authority could try to destabilize collusion by inducing reports once an audit is launched. However, one must bear in mind that introducing leniency generates additional ways of collusion. For example, firms may choose to always collude and report whenever there is an audit. This is an equilibrium whenever pure collusion (without reporting) is an equilibrium and reporting is profitable.[46] Therefore, leniency could help preventing collusion only if

- the Collude regime was sustainable in the absence of leniency, which in particular implies:

$$\pi^C \leq (1 - \alpha p)\, \pi^M + \alpha p \left(\pi^C - F\right), \tag{9}$$

[46] To see this, note first that no firm has an incentive not to report collusion if it expects the other to report it. Thus the only relevant constraint is

$$\pi^D - \pi^M \leq \delta \left(\hat{V}^R - \frac{\pi^C}{1-\delta}\right),$$

which is less restrictive than the one for the Collude regime,

$$\pi^D - \pi^M \leq \delta \left(\hat{V}^M - \frac{\pi^C}{1-\delta}\right),$$

whenever the Report regime is more profitable (implying $\hat{V}^R > \hat{V}^M$).

- and this Collude regime is more profitable than the Report regime, which is the case only if $V^{Collude} > V^{Report}$:

$$(1-\alpha p)\,\pi^M + \alpha p\left(\pi^C - F\right) > (1-\alpha)\,\pi^M + \alpha\left(\pi^C - f\right),$$

or:

$$(1-p)\,\pi^M + p\left(\pi^C - F\right) > \pi^C - f,$$

that is, if the audit has a low probability of success:

$$p < \bar{p}\,(f) \equiv \frac{\pi^M - \pi^C + f}{\pi^M - \pi^C + F}. \tag{10}$$

But when the two conditions (9) and (10) are satisfied, a firm has no incentive to deviate from the Collude regime even once an audit is launched. Such deviation would yield

$$\pi^C - f + \frac{\delta\pi^C}{1-\delta} < (1-p)\,\pi^M + p\left(\pi^C - F\right) + \frac{\delta}{1-\delta}\left[(1-\alpha p)\,\pi^M + \alpha p\left(\pi^C - F\right)\right],$$

where the right-hand side is precisely the firm's expected profit once an audit is launched, in the absence of reporting.

Last, Motta and Polo determine the optimal enforcement policy, as a function of the resources of the competition authority. It is of course optimal to deter

collusion if the authority has sufficient resources to do so and, as we just saw, the best way to achieve this result is to rule out any leniency. If the authority has less resources, it must choose between two colluding regimes: a regime without reporting –in which case it is best not to introduce leniency– and one in which firms report once an investigation is launched –thanks to a "full-length" leniency program, together with a high prosecution effort.[47] The trade-off between those two regimes is as follows. Inducing reporting through a leniency program improves the success of audit but requires a commitment to a high prosecution effort ($p > \bar{p}$) in order to convince firms that it is in their interest to report.[48] In contrast, ignoring the possibility of reporting allows the competition authority to save on prosecution and devote more resources for launching additional investigations.

[47] As pointed out above, firms must find it profitable to agree on reporting in the case of audit, which is the case only if $p > \bar{p}$.

[48] Note that the quality of prosecution plays no role in fine if firms report collusion. Still, in order to induce reporting, the competition authority must maintain a credible high probability of successful prosecution and thus spare the needed resources.

2.2 Fighting facilitating practices

Short of fighting collusion directly, competition policy can try to attack practices that facilitate firms' coordination. These practices may for example:

- help firms to "agree" on the terms of the collusive agreement –e.g., informal gatherings giving the opportunity to engage in "cheap-talk" leading to the selection (or negotiation) of the desired terms of agreements;[49]

- serve its implementation –e.g., communication devices allowing firms to exchange hard or soft information and better adapt their strategies to the environment;

- contribute to its enforcement –e.g., practices that enhance the detection of deviations from a collusive agreement and/or the severity of the punishments that can be inflicted on deviators.

I discuss here some illustrations of the latter two aspects.

[49] McCutcheon (1997) points out that, by facilitating the renegotiation of the continuation equilibria once a deviation has occurred, meetings in "smoke-filled rooms" can actually make collusion more difficult to sustain (since they reduce the magnitude of the punishments that can be inflicted on deviators).

2.2.1 Communication devices

It has long been recognized that communication can facilitate collusion.[50] First, communication may help firms to coordinate themselves on a particular equilibrium. This coordination problem is particularly acute in the context of repeated games, where the set of equilibria can be very large.[51] Second, information about rivals' past behavior –be it direct observation of their strategies, or enhanced information on the environment that allow a more accurate inference of their behavior– allows firms to better detect deviations and trigger punishments. For example, in a standard repeated Bertrand duopoly with linear costs, if prices are publicly observed firms can sustain collusion if and only if

$$\frac{\pi^M}{2} \geq (1-\delta)\,\pi^M + \delta \times 0,$$

that is, whenever $\delta \geq 1/2$. However, if firms observe their rival's price only every T periods, then collusion becomes sustainable only if

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

[50] See Kühn (2000) for a recent discussion. There is also a substantial empirical literature –see e.g., Van Huyck-Battalio-Beil (1990) and Cooper-Dejong-Forsythe-Ross (1989).

[51] Farrell (1987) has been among the first to formalize the idea that "cheap talk" can help resolve this "strategic uncertainty" problem.

that it whenever $\delta \geq \delta^*(T) \equiv (1/2)^{1/T}$. Thus, collusion is more difficult to sustain when firms observe each other's price less often ($\delta^*(T)$ increases with T and tends to 1 when T grows infinitely). Relatedly, Green and Porter (1984) have shown that collusion is more difficult to sustain when firms cannot observe or infer each other's behavior.[52]

Last, communication may help devising more efficient collusive agreements, particularly when firms have private information about cost or demand conditions. Communication may for example allow firms to allocate production to the most efficient firm. Athey and Bagwell (1999) analyze this issue by considering a duopoly where firms' unit costs can take two values, high or low,[53] with independent draws in each period; each firm knows the realization of its costs but does not observe that of its rival. In addition, demand is stationary and inelastic; the monopoly price is thus equal to consumers' reservation price, which is constant over time. In the absence of communication between the firms, productive effi-

[52]From a different perspective, Compte (1998) and Kandori-Matsushima (1998) argue that in games in which players have private information about the history of play, introducing public communication gives a recursive structure to the game and thus allows the use of dynamic programming techniques.

[53]Athey-Bagwell-Sanchirico (1998) consider the case of a continuum of types.

ciency, which requires the low-cost firm to serve the entire market whenever the two costs differ, cannot be achieved if firms want to maintain the monopoly price in each period.[54]

In this context, to be sustainable collusion must meet two types of constraints:

- "Off-schedule" constraints: these are the standard constraints that must be met even in the absence of asymmetric information; a firm may be tempted to cheat and undercut its rival if the short-term gains from such a deviation outweigh the loss of profits in the following periods.

- "On-schedule" constraints: these constraints derive from the asymmetry of information between the firms; among the prices or quantities that are compatible with the collusive strategy, a firm must be induced to select the one that corresponds to the realization of its cost.

Athey and Bagwell point out that, when firms are patient, only the later constraints are relevant. In that case, firms will maintain the monopoly price,

[54]This feature of the model captures the essence of the role of communication. In richer models, in the absence of formal communication firms could use additional variables (e.g., prices) to reveal part of their information.

with or without communication; forbidding communication can thus have the adverse effect of simply preventing firms from achieving productive efficiency. However, if firms are more impatient, preventing collusion may force them the charge lower prices.

2.2.2 Resale price maintenance

Competition authorities' attitude towards vertical restraints treats generally price restrictions more severely than non-price restrictions such as exclusive territories, selective distribution, etc. In particular, Resale Price Maintenance (RPM) is often viewed as *per se* illegal or, at the very least, as most probably undesirable. This consensus against RPM contrasts with the economic analysis of vertical restraints, which shows that both price and non-price vertical restrictions may either improve or harm economic efficiency –and often provide alternative ways to achieve the same objective. Furthermore, many arguments used in court in favor of non-price restrictions would apply as well to RPM. One argument made in practice against RPM, however, is that it could facilitate horizontal agreements. For example, in *Sylvania* and *Business Electronics*, the Supreme Court repeatedly relied on that argument to justify the *per se* illegality of RPM:

"Our opinion in GTE Sylvania noted a significant distinction between vertical non-price and vertical price restraints. That is, there was support for the proposition that vertical price restraints reduce inter-brand price competition because they "facilitate cartelizing".... The authorities cited by the Court suggested how vertical price agreements might assist horizontal price fixing at the manufacturer level (by reducing the manufacturer's incentive to cheat on a cartel, since its retailers could not pass on lower prices to consumers) or might be used to organize cartels at the retailer level. Similar support for the cartel-facilitating effect of vertical non-price restraints was and remains lacking".[55]

As stated, the argument that RPM can facilitate collusion by reducing the manufacturer's incentive to deviate and lower its wholesale price is not very convincing: a manufacturer could "cheat" on the cartel agreement by modifying both the retail price and the wholesale price at the same time –RPM might actually make such deviation more appealing, by ensuring that the cut in wholesale price is not partially appropriated by retailers. Jullien-Rey (2000) explores the issue further, starting from the idea that, under RPM, retail prices are centrally set by the manufacturer and thus do not fully adjust to local variations on retail costs

[55] 485 U.S. 717 (1988) at 725-6.

or demand; as a result, retail prices are more uniform under RPM, and deviations from a tacit agreement are thus more easily detected; it follows that RPM, while being less efficient since it generates less flexible prices, can be adopted to facilitate interbrand collusion.

Consider the following framework. Two infinitely-lived producers ($i = 1, 2$) sell to short-sighted retailers. In each period, each producer signs an exclusive contract with a retailer. Demand is linear in prices and stochastic:

$$D_i(p_i, p_j) = d + \varepsilon_i - p_i + \sigma p_j, i \neq j = 1, 2,$$

where the shocks ε_1 and ε_2 are independently and uniformly distributed on the interval $[-\bar{\varepsilon}, \bar{\varepsilon}]$. Production and retail costs are normalized to 0, and manufacturers face a fixed cost k. At the contracting stage, the shocks ε_1 and ε_2 are unknown to all parties and manufacturers have all the bargaining power. Then, ε_i is observed by retailer i but not by the manufacturers nor the other retailer.[56]

In the absence of RPM, each manufacturer i offers a contract composed of a franchise fee A_i and a wholesale price w_i; under RPM, it can moreover set the retail price p_i. The timing of the stage game is thus as follows:

[56] A similar analysis applies to the case of independent shocks on retailers' costs.

- first, each manufacturer i secretly offers a contract (A_i, w_i) or (A_i, w_i, p_i) to a retailer, who accepts it or not;

- second, each retailer i observes ε_i and, if it has accepted the contract, sets the retail price p_i (at the level chosen by the manufacturer under RPM);

- third, demands and profits are realized; each manufacturer further observes the retail prices and the nature of the contract signed by its competitor.

In the absence of RPM, if it accepts the contract (A_i, w_i) retailer i will set its price to[57]

$$p_i = p_i^e + \frac{\varepsilon_i}{2}, \tag{11}$$

where the expected price, p_i^e, is the best response to retailer j's expected price p_j^e:

$$p_i^e \equiv \frac{d + w_i + \sigma p_j^e}{2}; \tag{12}$$

By setting the franchise fee A_i so as to recover expected retail profits, producer

[57] Only the rival's expected price matters, due to the linearity of the demand function and the independence of the two demand shocks.

i can thus get an expected profit equal to

$$\pi\left(p_i^e, p_j^e\right) \equiv p_i^e\left(d - p_i^e + \sigma p_j^e\right) - k.$$

Furthermore, through its wholesale price each producer can perfectly monitor the expected retail price of its good.[58] Therefore, the stage game is formally identical to one in which each producer i "chooses" p_i^e –thereby generating a distribution of retail prices given by $p_i = p_i^e + \frac{\varepsilon_i}{2}$ and expected profits $\pi\left(p_i^e, p_j^e\right)$. If both producers pick the same expected price p^e, their expected profit is then given by

$$E\left[\left(p^e + \frac{\varepsilon_i}{2}\right)\left(d + \varepsilon_i - \left(p^e + \frac{\varepsilon_i}{2}\right) + \sigma p^e\right) - k\right] = \pi\left(p^e, p^e\right) + v, \qquad (13)$$

where

$$v \equiv \frac{\bar{\varepsilon}^2}{12}$$

denotes the variance of the retail prices.

Restricting attention to symmetric equilibria, and using the fact that shocks are uniformly distributed, it can be shown that the best collusive strategy is a trig-

[58] This applies both along an equilibrium path and along a unilateral deviation, since retailer i's expected price only depends on w_i and the anticipated value of p_j^e.

ger strategy of the form: "choose an expected price p^e; stick to p^e as long as realized prices are compatible with this agreement (i.e., $p_i, p_j \in [p^e - \bar{\varepsilon}/2, p^e + \bar{\varepsilon}/2]$), otherwise play $\underline{s}$ (the strategy that supports the equilibrium with the lowest payoff, $\underline{\pi}$)."

If both manufacturers follow this strategy, their expected profit is equal to $\pi(p^e, p^e) + v(\bar{\varepsilon})$. If a deviation was always detected with probability 1, no deviation would thus be profitable if

$$\max_p \pi(p, p^e) - \pi(p^e, p^e) \leq \frac{\delta}{1-\delta} \left[\pi(p^e, p^e) + v - \underline{\pi}\right]. \tag{14}$$

However, a small deviation ($p_i^e \in [p^e - \bar{\varepsilon}, p^e + \bar{\varepsilon}]$) will only be detected with probability $|p^e - p_i^e| / \bar{\varepsilon} < 1$. In particular, it can be checked that a "small" deviation (p_i^e slightly different from p^e) will not be profitable only if:

$$\bar{\varepsilon} \left| d - (2-\sigma)p^e \right| \leq \frac{\delta}{1-\delta} \left[\pi(p^e, p^e) + v - \underline{\pi}\right]. \tag{15}$$

It turns out that the two conditions (14) and (15) are actually necessary and sufficient for the sustainability of collusion. In the absence of RPM, the most profitable collusive strategy thus consists in maintaining in each period the expected price, p^F, which maximizes $\pi(p^e, p^e)$ subject to (14) and (15).

When producers adopt RPM and impose the same rigid price $p_i(\varepsilon_i) = p^e$, they ignore their retailers' information about the demand shocks and thus generate lower expected profits ($\pi(p^e, p^e)$, instead of $\pi(p^e, p^e) + v$ as before). Adopting RPM thus facilitates collusion by making deviations easier to detect, but it also hurts collusion by making deviations more attractive –deviating with franchise contracts generates an additional profit v compared with RPM.[59] Collusion on a rigid price p^e is sustainable if and only if

$$\max_p \pi(p, p^e) + v(\bar{\varepsilon}) - \pi(p^e, p^e) \leq \frac{\delta}{1-\delta}\left[\pi(p^e, p^e) - \underline{\pi}\right]. \tag{16}$$

RPM thus allows to ignore condition (15) –i.e., it facilitates detection– but results in a more stringent condition than (14) –because price rigidity, by itself, hurts profits.

[59] As long as the nature of the contract (RPM or not) is public, allowing RPM increases the set of equilibria; in particular, the equilibria described above resist deviations involving RPM since: (i) any such deviation is detected with probability 1; and (ii) profits from those deviations are lower than those achieved with simple franchise contracts, since RPM makes no use of the retailer's information.

Besides improving the detection of deviations, RPM can also facilitate collusion by allowing for tougher punishments. I will ignore this aspect here.

Jullien-Rey (2000) shows that if the noise is not too important (the adverse effect of price rigidity on profits otherwise dominates), there exists a range of values for the discount factor where the most profitable collusive strategy uses RPM. This is the case for "intermediate" values of the discount factor: when it is close to 1, it becomes possible to sustain the expected prices at the monopoly level even with franchise contracts, which is more profitable since this makes use of the retailers' information; and for very low values of the discount factors, only prices close to the level of the static Nash equilibrium can be sustained both with or without RPM, so that again it is better not to impose rigid prices on retailers. There exists a middle range, however, where RPM allows producers to sustain higher prices, which more than compensate the loss of profitability attached to price rigidity.

This analysis has welfare implications. Note first that imposing price rigidity may be good for consumers: consumer surplus is a convex function of the demand $(d + \varepsilon_i - p_i + \sigma p_j)$, so that, for a given expected price, consumers prefer prices that do not adjust to demand shocks –they would however favor prices that adjust to cost shocks. Furthermore, in the case of demand shocks, and despite its

negative impact on profits, price rigidity increases total welfare.[60] However, firms will find it profitable to adopt RPM in equilibrium only if it leads to an increase in prices, sufficient to offset the adverse impact of price rigidity. Building on this, it can be shown that whenever the scope for collusion is substantial, banning RPM is socially optimal.[61]

[60] Using $\partial S/\partial p_i = -D_i$ and $\pi_i = p_i D_i$, the total expected surplus is given by:

$$\begin{aligned}
\frac{\partial W}{\partial p_i}(p_1, p_2; \varepsilon_1, \varepsilon_2) &= \left(\frac{\partial S}{\partial p_i} + \frac{\partial \pi_i}{\partial p_i} + \frac{\partial \pi_j}{\partial p_i}\right)(p_1, p_2; \varepsilon_1, \varepsilon_2) \\
&= -(d + \varepsilon_i - p_i + \sigma p_j) + (d + \varepsilon_i - 2p_i + \sigma p_j) + (\sigma p_j) \\
&= -p_i + \sigma p_j.
\end{aligned}$$

Integrating, the total surplus is thus given by:

$$W(p_1, p_2; \varepsilon_1, \varepsilon_2) = C(\varepsilon_1, \varepsilon_2) - \frac{1}{2}\left(p_1^2 + p_2^2 - 2\sigma p_1 p_2\right).$$

If the two prices have the same expected value p^e, the expected total surplus is thus:

$$W^e = C^e - (1 - \sigma)(p^e)^2 - \frac{1}{2}\left(Var[p_1] + Var[p_2]\right).$$

[61] Banning RPM is actually always socially optimal in the case of shocks on retail costs. In the case of demand shocks, banning RPM is still desirable for instance when the best collusive price

3 Merger control

Merger control differs significantly from cartel law enforcement. Whereas the latter case focuses on the sanction of past behavior, merger control requires instead the assessment of future conduct. Furthermore, while there is a general consensus against price-fixing agreements, there is more divergence in the competition authorities' policies towards proposed mergers. The general principle is to balance the efficiency gains that can be generated by the merger (due to economies of scale and scope, sharing of know-how, synergies, etc.) against the increase of market power in the industry. There is less agreement, however, on how to solve this trade-off.[62]

with franchise contracts is above half the monopoly level, as well as when the best collusive price with RPM is larger than the difference between the monopoly and static competitive levels.

[62]The US Merger guidelines allow for some efficiency defense. EU merger control focuses instead on the creation or reinforcement of a "dominant position" (more than a 50% market share, say), which has led in the past to "efficiency offenses": efficiency gains that enhance the merged entity's competitive hedge may contribute to create a dominant position. For example, in its first negative decision since the adoption of the Merger Regulation in 1989, the European Commission argued that the merger would have given the combined Alenia-de

A substantial literature has been devoted to this trade-off. I argue in the next section that insufficient attention has been devoted to the implementation aspects in this area.

3.1 The efficiency-market power trade-off

Several papers have explored the trade-off between efficiency gains and increased market power.[63] Farrell and Shapiro (1990) analyze this issue in the context of

Haviland the unique ability to offer a full range of commuter airplanes (from small to large ones), thereby creating a competitive edge over its competitors (since airlines benefit from dealing with a unique supplier for all their needs). Similarly, in the ATT-NCR case, the Commission mentioned that the venture could benefit from potential synergies between the parents' know-how in telecommunications and terminal equipments, but cleared the merger on the basis that these synergies were too unlikely to materialize (previous similar attempts had failed).

These, however, were early cases in European merger control. Furthermore, the fact that mergers which do not create a dominant position are more easily accepted than inter-firm agreements can be interpreted as accepting an efficiency defense for structural changes, as long as firms' combined market share does not exceed 40%-50%.

[63]Salant-Switzer-Reynolds (1983) and Perry-Porter (1985) consider a symmetric Cournot model with linear demand and, respectively, linear and quadratic costs, while Deneckere-

a general Cournot oligopoly (without a priori restrictions on costs and demand). They first analyze the impact of the merger on consumer surplus, summarized in this context by the evolution of prices, and show in particular that, under reasonable conditions (namely, when supply decisions are strategic substitutes[64] and the equilibrium is stable[65]), a merger necessarily raises prices in the absence of synergies –even taking into account the reallocation of production from less to more efficient technologies. The intuition is as follows. First, strategic substitutability and stability imply that the "aggregate response" of any k firms to the quantity supplied by the remaining $n-k$ firms is itself a decreasing function, with a slope lower than unity.[66] It thus suffices to show that the merging firms will reduce their supply, assuming that the others do not change their own decisions. This would be obvious if the merging firms were equally efficient, since they would internalize the negative externality that an increase in one firm's supply imposes on the other's margin. A nice revealed preference argument shows that

Davidson (1985) analyse a model of Bertrand competition.

[64]I.e., firm i's best response $q_i = R_i(q_i) = \max[P(q_i + q_{-i})\, q_i - C_i(q_i)]$ is a decreasing function of the rivals' aggregate quantity q_{-i}.

[65]Namely, Dixit's (1986) stability condition $C_i''(q_i) > P'(q)$.

[66]See Dixit (1986).

this is still the case when the merging firms have different technologies. Farrell and Shapiro also address the impact of a merger on total welfare. They propose to focus on "external effects" (the impact on consumer surplus and outsiders' profits), for which they provide a simple test: A small reduction in the merging firms' output has a net positive external effect on outsiders and consumers if and only if[67]

$$\Sigma_{i \in Outsiders} \lambda_i s_i > \Sigma_{j \in Insiders} s_j,$$

where the $s_i = q_i/q$ denotes firm i's market share and λ_i is related to the slope of firm i's best response function

$$\lambda_i = \frac{-R_i'}{1 + R_i'}.$$

The apparent simplicity of this test makes it very appealing. In particular, a merger between small firms ($\Sigma_{j \in Insiders} s_j$ small) is likely to have a positive external effect, implying that any proposed such merger should be accepted.

This paper and the related literature on the efficiency/market power trade-off has been criticized for relying excessively on specific assumptions (e.g., Cournot

[67] Farrell and Shapiro also show that this test applies to mergers (i.e., non-infinitesimal changes) under some additional assumptions – namely, $P'', P''' \leq 0 \leq C_i'''$.

model with homogenous good, versus Bertrand competition with differentiated products, pre-specified functional forms for cost or demand, no tacit collusion, etc.).[68] But even within these specifications, the above analysis is in practice only moderately useful for merger policy. For example, evaluating the above λ_i parameters is not straightforward. Using equilibrium conditions, λ_i can be expressed as

$$\lambda_i = -\frac{P'(q) + q_i P''(q)}{C_i''(q_i) - P'(q_i)},$$

and thus involves a detailed knowledge of both demand and supply conditions –a knowledge that would probably allow the competition authority to directly compute the post-merger Cournot equilibrium. In practice unfortunately, it is unlikely that such information would be readily available. Besides, if merger control policy was based on the λ_i parameters, firms may wish to modify their behavior so as to manipulate the policy, an issue not addressed in the above analysis.

From a theoretical viewpoint, the competition authority faces again an infor-

[68] Building on the development of econometric models with differentiated products (see Berry (1994) and Berry-Levinsohn-Pakes (1995)), Hausman, Leonard and Zona (1994) have advocated for relying more on existing data in the design of the appropriate framework.

mation problem: Firms have privileged information about their motivations for the merger (efficiency gains, increased market power, enhanced scope for collusion, etc.), which the authority should try to extract. For example, suppose that merging firms have private information only over the efficiency gains generated by the merger. The firms could in that case been asked to "pay" in one form or another for any negative external effect of the merger, so as to ensure that only socially desirable mergers are proposed. More generally, the competition authority could try to screen merger proposals using transfers or quasi-transfers in the form of concessions, undertakings, restrictions on future behavior, etc.

In many cases, however, extracting information may be difficult because of the inherent conflict of interest between the merging parties and the merger control office. For example, suppose that firms have instead private information about their ability to monopolize the market or about the impact of the merger on the scope for collusion in the industry. The authority would prefer mergers that generate only a small increase in market power, but it is precisely the firms with the highest ability to exert market power that will be the most eager to get their merger accepted. As a result of this conflict of interest, the best policy is likely

to be a "pooling" policy, which does not try to extract any information from the merging parties.[69] This issue, however, is still an avenue for further research. Of particular interest is the possibility to rely on the information brought by third parties (be it customers or rivals); a careful analysis of these parties' incentives (e.g., under which conditions are rivals and customers likely to benefit or lose from the merger) would probably be very useful.

Short of modelling this informational problem explicitly, an alternative approach consists in providing practical guidelines for evaluating the impact of the

[69] This situation is an example where preferences are "non-responsive" in the terminology of the principal-agent literature –see Caillaud *et al.* (1988). It can occur in regulatory contexts when a welfare-maximizing regulator supervises a labor-managed firm exhibiting the so-called Ward pathology –a more efficient firm then seeks to reduce the number of workers and thus its output; see Ward (1958) and Vanek (1970).

Caillaud and Tirole (2000) study a similar phenomenon for funding infrastructure projects, when an incumbent operator has private information about market profitability. The infrastructure owner may try for example to screen projects by requiring from the incumbent a higher capital contribution in exchange for protection from competition; but the incumbent is unfortunately willing to pay more for protection precisely when competition would yield the highest benefits.

merger on "market power".

There has been some success along this line for assessing the impact of mergers on "market power", using static Cournot models. Dansby and Willig (1979) show for example that the average mark-up in the industry is related to the Herfindahl index, defined as the sum of the squares of firms' market shares.[70] Relatedly, Cowling-Waterson (1976) points out that, when marginal costs are constant,

[70]In equilibrium, each firm maximizes its profit, of the form

$$P\left(q_{-i}+q_i\right)q_i - C_i\left(q_i\right),$$

where q_{-i} denotes the aggregate supply of the rivals. The first-order condition leads to (with p denoting the equilibrium price):

$$p - C_i' = -P'q_i = p\frac{s_i}{\varepsilon\left(p\right)},$$

where $s_i = q_i/q$ denotes firm i's market share and $\varepsilon\left(p\right)$ represents the demand elasticity. Therefore, in equilibrium, firm i's Lerner index, $L_i \equiv \frac{p-C_i}{p}$, is equal to $\frac{s_i}{\varepsilon(p)}$. The industry average mark-up or Lerner index is thus equal to;

$$L = \Sigma_i s_i L_i = \frac{\Sigma_i s_i^2}{\varepsilon\left(p\right)} = \frac{H}{\varepsilon\left(p\right)},$$

where $H \equiv \Sigma_i s_i^2$ is the Herfindahl index for the industry.

the Herfindahl index is also linked to the industry profit (gross of fixed cost),[71]

[71] If $C_i(q_i) = c_i q_i$, each firm i's equilibrium variable profit is given by

$$\pi_i = (p - c_i) q_i = \frac{p - c_i}{p} \frac{q_i}{q} pq = s_i^2 \frac{pq}{\varepsilon(p)}.$$

The aggregate variable profit is thus equal to

$$\pi = \Sigma_i \pi_i = H \frac{pq}{\varepsilon(p)},$$

and can thus be expressed as a function of the total revenue (pq), the elasticity of demand (ε) and the Herfindahl index (H).

while Dansby and Willig (1979) show that it is related to total welfare.[72] This prominent role of the Herfindahl index has been translated into the US merger guidelines, which use the Herfindahl index as a "filter".[73]

[72] Consider a small change of firm's output, $(dq_i)_i$, starting from the Cournot outcome. The impact on the total welfare, defined as the sum of consumer surplus and firms' profits:

$$W = \int_{P(q)}^{+\infty} D(p)\, dp + \Sigma_i \left(P(q) - c_i\right) q_i,$$

is given by (using again the first-order equilibrium conditions)

$$\begin{aligned} dW &= \Sigma_i \left(p - c_i\right) dq_i = \Sigma_i \left(-P'(q)\right) q_i dq_i \\ &= -P'(q)\, d\left(\frac{1}{2} q^2 H\right) = -P'(q) \left[qH dq + \frac{1}{2} q^2 dH\right]. \end{aligned}$$

The impact thus depends on total production and on the change of concentration, as measured by the Herfindahl index. In particular, the impact of a change in production dq is larger when the industry is more concentrated. A second effect arises from allocative efficiency: since in equilibrium firms with lower marginal costs have larger market shares, an increase in concentration ($dH > 0$) tends to move production to the larger and thus more efficient firms.

[73] The first guidelines issued in 1968 considered the four-firm ratio of concentration –the sum of the market shares of the four biggest firms in the industry. This index was replaced in 1982 by the Herfindahl-Hirshman index (HHI) –the Herfindahl index with market shares expressed as percentages: each market share thus varies from 0 to 100, and the HHI lies between 0 (no concentration, a multitude of infinitesimal firms) and 10000 (monopoly).

The HHI is used as a screening device, as follows:

Beyond this success, no practical quantitative criteria has been proposed when it comes to evaluating the trade-off between efficiency and market power. Furthermore, by focusing mainly on static models, this literature has ignored important dynamic issues, such as the possibility of entry and predation, or the risk of collusive behavior.[74] As a result, those concerns are in practice treated in a harsh way. For example, in the US they are mentioned but rarely analyzed in practice. In the EU, the Commission has adopted a rather rigid attitude which prevents any merger creating a dominant position even if it generates huge efficiency gains;[75]

- post-merger HHI is below 1000: clearance;
- post-merger HHI above 1800: in-depth review,
- post-merger HHI between 1000 and 1800: clearance if the merger increases the HHI by less than 50, in-depth review if the HHI increases by more than 100 (other factors apply when the increase lies between 50 and 100).

[74]The extent to which using econometric models can solve this issue is still unclear; for example, if a merger provokes a change of structure that allows a previously competitive industry to sustain collusion, observing past behavior may not suffice to predict the change of behavior. Relatedly, to predict the impact of the merger on the outcome of market competition, empirical studies must make assumptions on the size of efficiency gains.

[75]To take an extreme example, according to the current policy, a merger creating a monopoly

this can be interpreted as reflecting the belief that a dominant firm can successfully prevent the entry of more efficient competitors –in contrast with the static analyses such as described above, which tend to predict that mergers encourage entry. Any help identifying relevant factors that are likely to be available and could contribute to assess the risk that a dominant firm could so abuse its position would certainly be welcome. Similarly, the risk of collusion is not likely to be taken into account in the absence of practical guidelines, based on accessible information.[76] The following section describes a recent attempt to make progress in that direction.

would be banned even if "drastic" efficiency gains allowed the new entity to reduce its cost to the point that the monopoly price, based on that reduced cost, was lower than the pre-merger cost.

[76]In the US, for example, the merger guidelines mention the concern about future collusive behavior, but this concern is rarely evaluated and does not contribute in practice to the decision. The EU merger policy developed in the past years the concept of a "collective dominant position" that could be interpreted as an attempt to account for this risk; however, in the recent Airtours case, the Commission starts with a list of relevant factors affecting the scope for collusion, but eventually bases its decision using a static Cournot-like framework.

3.2 Assessing the collusion concern: the role of capacity constraints

Capacity constraints affect the scope for collusion in two opposite ways: they reduce firms' incentives to deviate from a collusive agreement but also limit the ability to punish such deviations. Most analyses of these two effects have focused on *symmetric* situations, where all firms have the same capacity,[77] or on duopolistic industries, which is not very helpful for merger analysis.[78]

Analyzing tacit collusion in oligopolistic industries with asymmetric capacities is not an easy task. Lambson (1994) provides partial characterizations and shows for example that the optimal punishments are such that the firm with the largest capacity gets no more that its minmax profit, while smaller firms get more

[77] See e.g. Abreu (1986) for an analysis of symmetric Cournot supergames and Brock and Scheinkman (1985) for a first analysis of symmetric Bertrand supergames, later extended by Lambson (1987).

[78] Capacities are unlikely to be symmetric both before and after the merger, and the collusion concern is relevant for merger policy only when initially there are at least three competitors. Davidson and Deneckere (1984) provide a first exploration of the issue, using standard trigger strategies and exogenous market sharing rules, and starting from a situation with symmetric capacities.

than their respective minmax profits (except if firms are very patient).[79] A few studies, however, have suggested that asymmetry in firms' capacities hurts tacit collusion. Mason, Phillips and Nowell (1992) note for example that in experimental duopoly games, cooperation is more likely when players face symmetric production costs.[80] In a Bertrand-Edgeworth setting, Lambson (1996) shows that introducing a slight asymmetry in capacities hurts tacit collusion; and Davidson and Deneckere (1984), (1990) and Pénard (1997) show that asymmetric capacities make collusion more difficult in duopolies.[81]

[79]Lambson also provides an upper bound on the punishments that can be inflicted on small firms using penal codes proportional to capacities.

[80]Relatedly, Bernheim and Whinston (1990) show that, in the absence of capacity constraints, tacit collusion is easier when firms have symmetric costs and market shares.

[81]Davidson and Deneckere study the use of grim-trigger strategies in a Bertrand setting, while Pénard relies on minmax punishments (which can be sustained if the asymmetry is small) in a linear Cournot setting; both papers also address capacity investment decisions, whereas we focus on the distribution of exogenous capacities. In a duopoly with sequential capacity choices, Benoît and Krishna (1991) show that the second mover cannot enhance its gains from collusion by choosing a capacity different from the first mover's capacity – however, their analysis relies on the assumption that firms share demand equally when charging the same price. Gertner (1994) develops a framework of "immediate responses", where firms can react at once to each

3.2.1 A simple model

Compte-Jenny-Rey (2000) further explore the issue, by simplifying the demand and cost sides but allowing for an arbitrary number of firms and asymmetric capacities.[82] The model is a repeated Bertrand-Edgeworth competition game between n firms with zero cost but fixed capacities. It is useful to distinguish the firms' actual capacities, denoted by $k = (k_i)_i$, from their *relevant capacities*, given by $\hat{k}_i \equiv \min\{k_i, M\}$. The demand is inelastic and of size M as long as the price does not exceed a reservation price (thus equal to the monopoly price), normalized to 1. In each period, firms simultaneously set their prices, which are perfectly observed by all buyers and firms; then, buyers go to the firm with the lowest price and decide whether or not to buy; if they are rationed they go to the next lowest priced firm, and so forth, as long as the price offered does not exceed their reservation price.[83] If several firms charge the same price, consumers

other's price cuts, and shows that asymmetric capacities may prevent firms from colluding perfectly.

[82] Fershtman and Pakes (2000), too, study the interaction between collusion and the industry structure, allowing for entry and exit as well as asymmetric sizes, and using a particular class of (markovian) pricing policies.

[83] Since demand is inelastic there is no need for being more specific about rationing schemes.

divide themselves as they wish between those firms. Competition is assumed to be effective, which is the case if firms' aggregate capacity is larger than the market size ($\Sigma_i k_i > M$), and $\underline{\pi}_i \equiv \max\{0, M - \Sigma_{j \neq i} k_j\}$ denotes firm i's minmax profit.

Last, all firms use the same discount factor $\delta \in (0,1)$ and maximize the expected sum of their discounted profits, $\sum_{t \geq 1} \delta^{t-1} \pi_i^t$. To define collusion, define the *value* of an equilibrium as the normalized expected sum of discounted profits that firms obtain along the equilibrium path: $v = (1-\delta) E\left[\sum_{t \geq 1} \delta^{t-1} \sum_i \pi_i^t\right] / M$.[84] *Collusion* is sustainable if a subgame perfect equilibrium of the infinitely repeated game generates a higher value than the expected aggregate profit generated by any Nash equilibrium of the stage game, and *perfect collusion* is sustainable if there exists a subgame perfect equilibrium with a value equal to 1. The goal is to characterize, for any distribution of capacities k, the lowest discount factor $\delta(k)$ for which (perfect) collusion is sustainable.

The difficulty in characterizing the set of collusive equilibria comes from the fact that maximal punishments also depend on capacities. A simple case is when small firms are not "too small", namely, when any subset of $(n-1)$ firms can

[84] v can vary from 0 (perfect competition without capacity constraints) to 1 (complete monopoly or collusion).

serve the entire market; the static Nash equilibrium then yields zero profits and obviously constitutes the optimal punishment. Denoting by $\alpha = (\alpha_i)_i$ the distribution of market shares (with $\alpha_i \leq k_i$ and $\Sigma_i \alpha_i \leq M$), collusion can then be sustained if and only if:

$$\alpha_i \geq (1-\delta)\hat{k}_i, i = 1, ..., n.$$

Hence collusion is sustainable if and only if $\delta \geq 1 - \max_i\{\alpha_i/\hat{k}_i\}$; the market shares that are most favorable to collusion are thus proportional to the relevant capacities[85] and, for those market shares, collusion is sustainable if and only if:

$$\delta \geq \delta(k) = 1 - \frac{M}{\hat{K}}. \tag{17}$$

The sustainability of collusion thus only depends in that case on the aggregate relevant capacity, not on its distribution.[86]

3.2.2 α-equilibria

The analysis is more difficult when small firms are indeed "small", that is, when the $(n-1)$ smallest firms cannot serve the entire market. A simple analysis can

[85] $\max_i\{\alpha_i/\hat{k}_i\}$ is smallest when $\alpha_i/\hat{k}_i$ is the same for all firms, i.e., $\alpha_i = \hat{k}_i M/\hat{K}$.

[86] A redistribution of capacity may however affect the sustainability of collusion if it modifies firms' relevant capacities.

however be made in that case for a particular class of equilibria, where firms maintain constant market shares: define an α-*equilibrium* as a subgame perfect equilibrium such that, on any equilibrium path, each firm i obtains the same share α_i.[87]

The analysis is made easy by the following Lemma:

Lemma 6 *Fix* $\alpha = (\alpha_i)_{i=1,...,n}$ *satisfying* $0 \leq \alpha_i \leq k_i$ *for* $i = 1, \ldots, n$ *and* $\sum_i \alpha_i \leq M$.

i) If there exists a collusive α*-equilibrium, there exists a per period value* v *satisfying, for* $i = 1, ..., n$*:*

$$\alpha_i v \geq \underline{\pi}_i, \tag{P_i}$$

$$\alpha_i \geq (1-\delta)\hat{k}_i + \delta\alpha_i v. \tag{E_i}$$

ii) If there exists v *satisfying conditions* $\{(E_i), (P_i)\}_{i=1,...,n}$*, then there exists an* α'*-equilibrium with value* v' *for any value* $v' \in [v, 1]$ *and any market shares* $\alpha' = (\alpha'_i)_{i=1,...,n}$ *satisfying* $\alpha_i \leq \alpha'_i \leq k_i$ *for* $i = 1, \ldots, n$ *and* $\sum_i \alpha'_i \leq M$. *In*

[87] The restriction applies to all continuation equilibrium paths, including those that follow a deviation, but not to possible deviations.

particular, perfect collusion ($v' = 1, \sum_i \alpha_i' = M$) *is sustainable with any such market shares* α'.

By construction, in a collusive α-equilibrium, firm i's continuation payoff is proportional to its market share and thus of the form $\alpha_i v$, for some continuation value v. Condition (P_i) asserts that firm i's continuation payoff cannot be worse than its minmax, while condition (E_i) asserts that the threat of being "punished" by $\alpha_i v$ deters firm i from deviating from the collusive path. These conditions are clearly necessary; the Lemma establishes that, together, they ensure that the value v (and any larger value) can be sustained as an α-equilibrium. To see this, consider the following path (reminiscent of Abreu's optimal codes for symmetric firms), where p_t denotes the price charged in the t^{th} period of the punishment:

$$p_t = \begin{cases} 0 \text{ for } t = 1, ..., T, \\ p \text{ for } t = T+1, \\ 1 \text{ for } t = T+2, ..., \end{cases}$$

where $T \geq 0$ and $p \in [0, 1]$ are chosen so that $\delta^T [(1-\delta)p + \delta] = v$. No deviation from this path is profitable if it is punished by returning to the beginning of the path. This is obvious for the first T periods, since a deviating firm cannot then

get more than its minmax payoff. Condition (E_i) ensures that it is also true in the periods following $T+1$. In period $T+1$, the best deviation consists in either charging the monopoly price (if p is low) or in undercutting the rivals (if p is high, namely, if $\alpha_i p > \hat{k}_i$). In the former case, the no-deviation condition is given by

$$\delta^{-T}\alpha_i v \geq (1-\delta)\underline{\pi}_i + \delta\alpha_i v \tag{18}$$

and is thus implied, too, by (P_i). In the latter case, the no-deviation condition is:

$$(1-\delta)\alpha_i p + \delta\alpha_i \geq (1-\delta)\hat{k}_i p + \delta\alpha_i v; \tag{19}$$

Because $\alpha_i \leq \hat{k}_i$, it is most restrictive for $p = p^c$, in which case it is equivalent to (E_i).

A similar reasoning applies to higher values $v \in [\underline{v}, 1]$. To establish the Lemma, it suffices to note that the conditions (E_i) and (P_i) are relaxed by an increase in the market shares α.[88]

An implication of this Lemma is that the conditions $((P_i), (E_i))_i$ characterize

[88]This is obvious for condition (P_i), and is also true for condition (E_i) since $\delta v \leq v < 1$.

the set of equilibrium values: for given market shares $(\alpha_i)_i$, the set of equilibrium values is an interval of the form $[\underline{v}(k,\alpha,\delta),1]$, where $\underline{v}(k,\alpha,\delta)$ is the smallest value satisfying conditions $((P_i),(E_i))_i$. In particular, *perfect* collusion ($v=1$) is sustainable whenever *some* collusion is sustainable.

This Lemma also allows a simple characterization of the sustainability of perfect collusion. Note first that the lowest v satisfying conditions $(P_i)_i$ is

$$\widetilde{v}(k,\alpha) \equiv \max_i \frac{\pi_i}{\alpha_i}.$$

Rewriting conditions $(E_i)_i$ as

$$(1-\underline{v})\frac{\delta}{1-\delta} \geq \max_i \frac{\hat{k}_i}{\alpha_i} - 1,$$

perfect collusion can therefore be sustained only if

$$\frac{\delta}{1-\delta} \geq \frac{\max_i \frac{\hat{k}_i}{\alpha_i} - 1}{1-\underline{v}} \geq \widetilde{\delta}(k,\alpha) \equiv \frac{\max_i \frac{\hat{k}_i}{\alpha_i} - 1}{1-\widetilde{v}(k,\alpha)}.$$

Conversely, if $\delta \geq \widetilde{\delta}(k,\alpha)$, then perfect collusion is sustainable (using the Lemma, with $\underline{v} = \widetilde{v}(k,\alpha)$) and, for any δ satisfying this condition, the set of $\alpha-$equilibrium values is $[\widetilde{v}(k,\alpha),1]$.

Building on this insight, identifying the market shares that most facilitate collusion amounts to minimize $\widetilde{\delta}(k,\alpha)$ with respect to the α. The denominator in

$\widetilde{\delta}(k,\alpha)$ is maximal when $\widetilde{v}(k,\alpha)$ is minimized, that is, for market shares that are proportional to minmax profits. The numerator is instead minimal when market shares are proportional to (relevant) capacities. Since minmax profits are not in general proportional to capacities, there is a conflict between decreasing $\widetilde{v}(k,\alpha)$ (to allow tougher punishments) and decreasing the numerator (to minimize the gains from deviations).[89] Compte-Jenny-Rey (2000) shows that the concern for deviations dominates the concern for punishments,[90] so that the market shares that are best for collusion are proportional to relevant capacities; this result also determines the minimal threshold for the discount factor, above which collusion is sustainable:[91]

[89] This conflict disappears only when firms are symmetric (same capacity).

[90] In particular, $\max_i \frac{\hat{k}_i}{\alpha_i}$ is not differentiable at its maximum; any change away from $\alpha = \alpha^*$ thus generates a first-order increase, which moreover dominates any possible benefit from a higher punishment $1 - \widetilde{V}(\beta,\alpha)$.

[91] Focussing on α-collusive equilibria *a priori* restricts the scope for collusion, by limiting the punishments that can be inflicted on deviating firms; $\delta^*(k)$ thus provides a lower bound for the values of the discount factor for which collusion is sustainable. Compte-Jenny-Rey (2000) shows however that punishments achieved with α-equilibria are at least as effective as those generated by reverting to a Nash equilibrium of the competitive stage game. Thus, the threshold $\delta^*(k)$ is –weakly– lower than for standard trigger-strategy equilibria.

Proposition 7 *The threshold* $\widetilde{\delta}(k,\alpha)$ *is minimized for* $\alpha = \alpha^*(k)$ *defined by*

$$\alpha_i^*(k) \equiv \frac{\hat{k}_i}{\Sigma j \hat{k}_j} M$$

and:

$$\delta^*(k) \equiv \widetilde{\delta}(k, \alpha^*(k)) = \frac{\hat{k}_n}{\hat{K}}.$$

3.2.3 Applications to mergers

The threshold $\delta^*(k)$ can be used to assess the impact of capacity transfers and mergers on the scope for collusion. Denoting by $\hat{K}_L$ and $\hat{K}_S$, respectively, the relevant capacity of the largest firm and the sum of the other firms' relevant capacities, this threshold can be written as:

$$\begin{aligned} \delta^*(k) = \ & 1 - \frac{M}{\hat{K}_L + \hat{K}_S} && \text{if } \hat{K}_S > M, \\ = \ & \frac{\hat{K}_L}{\hat{K}_L + \hat{K}_S} && \text{if } \hat{K}_S \leq M. \end{aligned}$$

In particular, when small firms are "really" small (i.e., when they cannot serve the entire market), exacerbating asymmetry, by transferring capacity from a small firm to the largest one, makes collusion more difficult to be sustained (δ^* increases): this is because this reduces small firms' retaliation ability (since

$\hat{K}_S < M$) and moreover exacerbates the large firm's incentive to deviate if $\hat{K}_L < M$. Building on this insight, Compte-Jenny-Rey (2000) shows that, when capacity constraints really matter, the distribution of capacity that most facilitates collusion, for a given total capacity, is the symmetric one:[92]

Proposition 8 *If the total capacity K is sufficiently small $\left(K \leq \frac{n}{n-1}M\right)$, then the set of capacity distributions for which $\delta^*(k)$ is minimal is $\{k^s \equiv (K/n, ..., K/n)\}$.*

Mergers reduce the number of competitors, which is often thought to facilitate collusion. In particular, keeping punishments constant, it reduces the incentives to deviate.[93] This effect dominates when capacity constraints are not too severe, since in that case a merger would have little impact on punishments profits, which

[92]This result remains valid when considering the most general class of equilibria. Defining $\delta(k)$ as the lowest discount factor for which perfect collusion would be sustainable in any subgame perfect equilibrium (allowing for flexible market shares, mixed strategies, etc.), whenever $K < \frac{n}{n-1}M$, the symmetric distrbution k^s minimizes $\delta(k)$; moreover, for $\delta = \delta^*(k^s)$, perfect collusion cannot be sustained whenever the largest capacity is $n/(n-1)$ larger than the smaller one.

[93]Since the gains from a unilateral deviation come at the expense of all rivals, the gains from a joint deviation are lower than the sum of the gains that each deviator could get through a unilateral deviation.

in any case are close to zero. However, a merger may exacerbate the asymmetry in capacities when it involves the largest firm. This tends to hurt tacit collusion, and this effect dominates when the capacity constraints are more severe or their distribution is very asymmetric.[94]

Policy implications. This analysis suggests merger guidelines that substantially differ from those inspired by static analyses. In particular, for a given number of firms, the Herfindahl test presumes that a more symmetric configuration is more likely to be competitive (the Herfindahl index is minimal for a symmetric configuration). Similarly, the static Nash equilibrium industry-wide profits often decrease with symmetry.[95] The above analysis instead suggests that asymmetry may be pro-competitive, as it may hurt tacit collusion.[96] A sufficiently asymmet-

[94]When small firms are not too small ($\hat{K}_S \geq M$), the reasoning applies both to α-equilibria and to more general ones. When $\hat{K}_S < M$, the discussion that follows is based on the analysis of $\alpha-$equilibria; however, the robustness of the result on the impact of asymmetry suggests that, even for more general collusive equilibria, a merger involving the largest firm is still likely to hurt collusion.

[95]For example, in the above framework each firm i gets $\max\left\{0, M - \frac{n-1}{n}K\right\}$ if the distribution is symmetric and at least $\max\left\{0, \left(M - \hat{K}_S\right)\hat{k}_i/\hat{k}_n\right\}$ otherwise. The industry-wide profits are thus mimized when the capacity K is distributed evenly among the firms.

[96]Kühn and Motta (2000) emphasize the same insight in a a different context, where "size"

ric configuration may even more than compensate for a reduction in the number of firms: If $\hat{K}_S < M$, *any* merger involving the large firm hurts collusion and may thus benefit competition since, although it reduces the number of competitors, it exacerbates the asymmetry between them (the Herfindahl test would in contrast advise that the pre-merger situation is more favorable to competition).[97] Last, the analysis provides a sufficient statistic, based on the distribution of capacities –which in practice are generally relatively easy to evaluate–, for the assessment of the impact of a merger on the scope for collusion.[98]

refers to the number of varieties that a firm offers.

[97]The above analysis also casts some doubt on standard merger remedies, which consist in divesting some of the capacity of the merged firm and transferring it to other competitors: such a remedy tends to maintain a reasonable amount of symmetry between the competitors – in order to avoid the creation of a "dominant position" – but may help tacit collusion.

[98]Compte-Jenny-Rey (2000) discusses in this light the well-known Nestlé-Perrier merger case. An interesting feature of this merger was the parties' proposal to transfer an important spring (Volvic) to the main other player in the industry (BSN, now Danone). This transfer could be seen as a remedy to avoid the creation of the dominant position, allowing the market share of the merged entity to remain below 50%. But the spring Volvic had also huge unused capacity, and BSN did not have much excess capacity before the merger. Hence, the merger would have created a large asymmetry in capacities between the two remaining players while the proposed

4 Research agenda

The thrust of this paper is that more attention should be devoted to implementation problems when building the theory of competition policy. I have tried to illustrate this point in the context of price-fixing agreements and merger control, but it applies as well, with perhaps even more force, to other areas of competition policy such as predation cases or the treatment of vertical restraints.

I have briefly described some recent advances, but much remains to be done. The works I have mentioned suggest a few lines of research, including technical topics such as the equilibrium analysis of repeated games for "moderate" discount factors. [A research agenda helpful for the analysis of factors and practices that affect collusion. Currently, the papers that have made advances in this area often have to restrict attention to particular classes of equilibria –e.g., symmetric equilibria in Jullien-Rey or constant market shares in Compte-Jenny-Rey. It would be nice to have appropriate tools for characterizing more general classes of equilibria.]

transfer restored perfect symmetry – both players could serve the entire market. According to the above analysis, the merger would have actually made collusion more difficult to sustain absent the transfer of Volvic, but easier to sustain with the transfer.

Many interesting topics are related to implementation problems. In particular, we need a better understanding of the underlying reasons for the various limitations that we observe in practice:

- conduct supervision rather than price regulation;
- absence of transfers, except fines for pre-specified conducts;
- intervention mainly ex post; etc.

In practice, we observe many forms of industry supervision, such as regulation, antitrust, or compulsory arbitration, and we can learn a few things from studying what works and when. With this idea in mind, I now briefly sketch a comparison of "regulation" and "antitrust" along various dimensions: procedures and control rights, timing of oversight, information intensiveness and continued relationship, and independence *vis-à-vis* the political environment. I use this rough comparison to discuss how the institutional features may contribute to an effective supervision of industry, taking into consideration the overseer's imperfect knowledge of the cost and demand structure in the industry, the risk that the overseer may be captured by (collude with) specific interest groups, and his or her limited commitment ability.

4.1 Procedures and control rights

Antitrust authorities generally assess the lawfulness of conducts. In contrast, regulators have more extensive powers and engage in detailed regulation; they set or put constraints on wholesale and retail prices, determine the extent of profit sharing between the firm and its customers (as under cost-of-service regulation or earnings-sharing schemes), oversee investment decisions, and control entry into segments through licensing of new entrants and line-of-business restrictions for incumbents.[99]

[99] This general picture of a large number of instruments and of potentially high discretionary power held by regulators is of course to be qualified by the many constraints they face in their decision making: procedural requirements, lack of long-term commitment, safeguards against regulatory takings, constraints on price fixing or cost reimbursement rules (cost-of-service regulation, price caps, etc.), cost based determination of access prices, and so forth.

Also, antitrust authorities and courts sometimes exercise regulatory authority by imposing line-of-business restrictions or forcing cost-of-service determination of access prices. A case in point is judge Greene becoming a regulator of the American telecommunications industry. In Europe, where there has been a growing interest in essential facility and market access issues, the European Commisssion has tried to develop both antitrust and regulatory competences and methods. Still, the pattern described in the text seems fairly general.

There is some convergence of regulatory and competition policy procedures. For example in the US, regulatory hearings are quasi-judicial processes in which a wide array of interested parties can expose their viewpoints. The enlisting of advocates is prominent in both institutions and is a key factor in the reduction of the informational handicap faced by the industry overseer.[100] There are however a couple of differences relative to the role of intervenors. In antitrust enforcement, private parties, although they are more constrained in their access to the oversight process, play a bigger role than in a regulatory process. Competition policy officials occasionally conduct independent industry studies, but the vast majority of cases brought to courts are private suits. Another difference is that interest groups are motivated to intervene in the regulatory process solely by the prospect of modifying policy while they go to court either to modify industry conduct (through a court injunction) or to obtain monetary compensation (e.g., treble damages). Yet another difference between the two institutions is that courts have less control over the agenda than regulators. While courts can throw out a case, they most often examine it first and may easily become overloaded. Conversely, courts can only take cases which are brought to them –competition authorities

[100] See Dewatripont-Tirole (1999) for a formal analysis.

have however more flexibility.

Another distinction between the two institutions is the separation between investigation and prosecution in antitrust. In contrast, regulators conduct regulatory hearings and adjudicate on their basis. One should however not overemphasize this distinction. First, some competition policy makers, such as the European Commission, can both investigate and take action against specific behaviors (subject to the possibility of court appeal). Second, regulatory decisions may be appealed in court in the same way a court decision may be overruled by a higher court.

A last point of departure between the two institutions relates to the consistency requirements. Regulators and courts are both required to apply relatively consistent reasoning. But while precedents play some role in the two institutions, regulators are mainly bound to be somewhat consistent with their previous decisions for the industry they oversee. Courts, in contrast, must also refer to decisions of other courts –particularly in common law systems– as well as to decisions pertaining to other industries. In particular, the uniformity of interventions across industries imposes substantial constraints on the courts' discretion.

4.2 Timing of oversight

An important difference between regulation and antitrust is that the former operates mainly ex ante and the latter ex post. Antitrust authorities assess conduct after the fact while regulators define the rules for price setting, investment and profit sharing ex ante. Again, some qualifiers are in order. Merger control by European and American competition policy officials requires notification for large mergers and is a quasi-regulatory process.[101] Conversely, an agency's decision of disallowing ex post "imprudent investments", that is of excluding them from the rate base in a cost-of-service process, is an illustration of ex post decision making in a regulated environment. But the broad picture is that the timing of regulatory decision making differs from that of antitrust enforcement.

Concomitantly, the regulatory process must be more expedient. The necessity not to halt productive decisions as well as rules constraining the length of investigations often put pressure on regulators (or quasi-regulators such as merger control officers) to converge on rapid decisions. In contrast, the ex post nature

[101] See Neven-Nuttall-Seabright (1993) for a very relevant discussion of institutions in the context of merger control. Except for some licensing agreements, firms may, but are not required to submit vertical agreements for approval to the European Commission.

of antitrust intervention does not call for a similar expediency –with the possible exception of predatory cases, where interim provisions may be necessary to prevent irreversible damages.

Another implication of the timing of government intervention is that the uncertainty about the overseer's decision making differs between the two institutions. Ex ante intervention removes most of the uncertainty about this intervention (although not necessarily about its consequences). It may thus facilitate financing of new investment by alleviating the lenders' informational handicap with respect to this intervention (to the extent that the lenders may have insufficient expertise in the industry and may thus be concerned about the borrower's superior knowledge about this intervention) and by sharpening the measurement of the borrower's performance (by eliminating extraneous noise not controlled by its management).[102]

Ex ante intervention also provides some commitment by the regulator toward

[102] That is, the removal of uncertainty may reduce both adverse selection and moral hazard. Note that the removal of regulatory risk *per se* needs not reduce the risk faced by risk averse investors: to the extent that the regulatory risk in the industry is idiosyncratic, it should be diversified away under perfect capital markets.

the firm.[103] This commitment is desirable whenever the regulator has the opportunity to exploit the firm's demonstrated efficiency or investment by becoming very demanding.

Ex ante intervention may be particularly valuable when coordination problems are important, e.g. as for the design of the articulation between urban and intercity transport networks, or between different modes (rail and buses) of urban transport.

Finally, ex ante intervention may force the firm to disclose information that it would not disclose ex post. Intuitively, it is less risky for the firm to conceal or manipulate information ex post when it knows the state of nature than ex ante when it does not; for instance, the firm may know ex post that a lie about an ex ante information that conditioned some business decision will not be discovered, but it may have no such certainty ex ante.[104]

A drawback of ex ante intervention is that it may foster collusion between

[103] To be sure, competition authorities can publish guidelines to pre-announce their policy. However, those guidelines need not be followed by the courts.

[104] That is, incentive constraints ex ante are pooled, since they are expressed in expectations. It is therefore easier to elicit information ex ante than ex post, because there are fewer incentive constraints.

the industry and the superviser. The industry knows whom it is facing while it is much more uncertain about whether it will be able to capture the (unknown) overseer in a context in which the oversight takes place ex post. This uncertainty about the possibility of capture increases the firm's cost of misbehaving.

A second benefit of ex post intervention is of course the opportunity to take advantage of information that accrues "after the fact". For example, it may over time become clearer what constitutes acceptable conduct. To be certain, ex ante decisions could in principle be flexible enough to allow for ex post adjustments that embody the new information; but describing properly ex ante the nature of future information that will be brought to bear on the determination of acceptability may prove difficult and not generate much gain relative to a pure ex post intervention.

Examples

These various differences suggest as many topics of research. For example, Bergès, Loss, Malavolti and Vergé (2000) develop a framework to study the choice between ex ante notification or ex post audit; they show that notification is preferable when the competition authority has less knowledge about the industry, while

ex post audit is more effective when the decisions of the authority are more accurate and, by the same token, more predictable. And Aubert and Pouyet (2000) have started to study how the regulatory and antitrust modes of intervention could ideally been combined.

4.3 Information intensiveness and continued relationship

Another useful distinction between antitrust and regulation is that regulatory decisions rely on superior expertise. The regulatory advantage in this respect is three-fold. First, a regulatory agency specializes on a specific industry while antitrust enforcers have a fairly universal mandate. Second, regulators are usually involved in a long-term relationship with regulated industries while judges are not. Third, regulators usually have larger staffs than judges and monitor the firms' accounts on a continuous basis rather than on an occasional one. They can also insist on specific accounting principles (such as account separation) as well as disclosure rules. This information superiority can clearly be more or less important according to the context. It is for instance more likely to be substantial in the case of a single-industry firm regulated by a national agency,

as for electricity in the UK or in France, than in the case of a multi-activities firm regulated by local agencies, as for the German *Stadtwerke* or the Italian *Aziende*. Furthermore, this superior sectorial expertise may be nuanced by a more limited experience with mechanisms or solutions applied in other sectors (limited benchmarking).

Superior expertise is of course a benefit in that it allows better informed decision making. For example regulators have for a long time used cost-based rules for retail and wholesale prices even though the determination of costs is often a difficult task. And it is not surprising that antitrust enforcers are more at ease with cases based on qualitative evidence (price discrimination, price fixing, vertical restraints,...) than with those requiring quantitative evidence (predation, tacit collusion, access pricing,...).

Superior expertise however may be a handicap when regulators have limited commitment powers. When a regulated firm lowers its marginal cost through efficiency measures or investment, it is tempting for regulators (or politicians) to confiscate the efficiency gains through lower prices. This "ratchet effect", which is strengthened by the regulator's access to cost information, is an impediment

to efficiency. Similarly, an excessive attention (motivated by superior expertise) may inhibit the firm's initiative. An arm's length relationship may entail more commitment power and help provide better incentives.[105]

A second drawback derives from the way expertise is acquired. Part of the regulatory agencies' expertise stems from the long-term nature of their relationship with the industry. But, as is well-known, long-term relationships are, in any organization, conducive to collusion. And indeed, regulators have often been more captured by interest groups than judges. This may also be related to the fact that, since regulators have deeper knowledge of a particular industry, a natural career evolution is more likely to involve close links with this industry (that is, the regulators' expertise may well reinforce "revolving doors" problems). Also, the need for such industry-focused expertise may impose some constraints on the recruitment of regulators.

Political scientists have repeatedly pointed out that agencies tend to start behaving in the public interest and then become increasingly inefficient, bureaucratized and more eager to please private interests. For example Bernstein (1955) contends that the life cycle of an independent agency can be divided into four

[105] See for example Crémer (1995) and Aghion-Tirole (1997).

periods: gestation (production of a regulatory statute), youth (lack of experience, unclear mandate, creative, aggressive and crusading spirit), maturity (focus on the protection of the agency's existence and power, switch from policing to managing the industry, higher concern with the health of the industry, loss of vitality, desire to avoid conflicts), and old age (extreme conservatism, loss of creativity, growing backlogs and apathetic approach to the public interest in regulation). Martimort (1999) provides a very nice analysis of this issue, using a dynamic model of capture. The idea is that when capture is implemented through repeated interaction, the regulatory stake of any period affects the scope for collusion between the regulator and the industry in all previous periods. Therefore, to reduce the social cost of collusion, regulatory stakes must be more and more reduced over time, that is, regulatory agency must have less discretion and behave more and more like a bureaucrat.

4.4 Independence vis-à-vis the political environment

The final dimension along which we compare regulation and antitrust is their relationship to political power. Antitrust authorities are traditionally described

as being more independent than regulatory agencies. While this view is generally correct, it is important to distinguish among forms of regulation and competition policy: An antitrust authority located within a ministry is more likely to be influenced by politics than an independent regulatory agency.

The Anglo-Saxon institution of regulation by an independent commission seeks to emulate the benefits of an independent judicial system. Independence can be partially obtained by offering long, staggered terms to commissioners, and by limiting the impact of legislative bodies on the agency's budget and jurisdiction.

The benefits of independence are well-known. First, the politicians' concern about public opinion and their taste for campaign contributions make them prone to give in to interest group pressure. Relatedly, an independent agency may be less sensitive to alternative motivations (such as favoring domestic or public operators), which may reduce regulatory uncertainties and offer a better commitment to fair treatment of all competitors.[106] Independent agencies are less vulnera-

[106] Examples of such concerns can be found in the allocation of airport slots and or rail slots. For instance, French private airlines have repeatedly complained about the allocation of slots, charging the State agency (the Direction Générale de l'Aviation Civile, or DGAC) with favoritism towards Air France and Air Inter. (For instance, at some point Euralair had autho-

ble to interest groups, although their officers are not immune to the influence of the revolving door and sometimes of bribes; decisions can then be reached more on efficiency grounds and less on the basis of the relative power of pressure groups. This is of course a substantial advantage of independence. Relatedly, independence may strengthen the agency's commitment power by limiting both opportunistic captures of the firm's rents and "soft-budget constraint" problems. Second, independence allows for more transparency. In France, for instance, the only European country where the air traffic control is directly managed by the State, through the DGAC, airline companies have argued that the accounting system does not provide a clear enough basis for the fees charged to the companies. Many countries have chosen to give the air traffic control to either an independent agency or a non-profit organization, and some countries such as the US are even considering privatizing it.

The cost of independence is also well-known. Independent agencies and courts may lack accountability and follow their own agenda instead of the nation's agenda. For example, in the case of the complex oversight of network industries, the public has an especially ill-informed opinion and often no opinion at

rization for Toulouse-Orly flights but no slots allocated to operate such flights.)

all. In such circumstances, the public cannot verify whether the agency really acts in its interests, which calls for limiting their discretion: procedural requirements, limited commitment power, possibility of appeal, etc.

There has been remarkably little work in economics on the costs and benefits of independence. Lenoir (1991)'s model depicts a three-party hierarchy: a political principal (the legislative body, or more realistically its committees and subcommittees in charge of overseeing the industry), a regulatory agency and the industry (e.g., a monopolist). Lenoir focuses on a particular version of accountability –that the agency does not waste resources: the political principal can adjust the resources of a dependent agency to the latter's real needs, according to circumstances, while an independent agency's budget is protected from political intervention. However, other versions of accountability would be consistent with the overall argument.

The cost of dependency in Lenoir's model is the influence of politics on regulatory decisions. The influence of the interest group (the industry) on the regulatory agency flows through the political principal. Namely, the industry can offer campaign contributions to the political principal, who can threaten to reduce a

dependent agency's budget and thus its rent; the political principal can then offer not to ratchet down its budget to the efficient level in exchange of the agency's lenient treatment of the industry. Thus, a dependency relationship creates a *quid pro quo* and allows the industry to impact indirectly on regulatory decisions.[107]

[107] This is an illustration of the more general point that collusion is enhanced by a mutual power relationship: see Laffont-Meleu (1996).

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