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Are Cartel Fines Optimal? Theory and Evidence from the European Union

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Résumé / Abstract

Dissuader la formation ou le maintien des cartels est un objectif important de la politique antitrust. Nous développons un cadre analytique dynamique pour caractériser le niveau de dissuasion des amendes et indemnisation, fondé sur le fait que la stabilité d'un cartel dépend de la capacité à prévenir les déviations, qui elle-même dépend en partie des amendes infligées en cas de détection et de conviction. Nous montrons que la prise en compte appropriée de la dynamique des cartels joue un rôle clé dans la détermination du niveau des amendes optimales. Nos résultats suggèrent que les amendes imposées par la Commission Européenne au cours des dernières années sont dissuasives, du moins en majorité.

Mots clés : Cartels, amendes, politique antitrust, concurrence.

Detering the formation or continuation of cartels is a major objective of antitrust policy. We develop a dynamic framework to characterize the compensation and deterrence properties of fines, based on the fact that cartel stability depends on the ability to prevent deviation, which itself depends in part on fines imposed in case of detection and conviction. We show that the proper consideration of cartel dynamics plays a major role in determining optimal deterrent fines. Our results suggest that a majority of fines imposed by the European Commission in recent years meet the deterrence objective.

Keywords : Cartels, fines, antitrust policy.

Codes JEL : L13, L41, L42

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1 Introduction

We consider the determination of optimal fines against cartels. A cartel is a group of independent firms which collectively agree to coordinate their supply, pricing or other policies in order to make larger profits than they would in a market where “natural competition” would prevail. By reducing or relaxing competition pressures, cartels typically implement a price increase (the “overcharge”) that generates a net incremental payoff (the “excess profit”). Cartels pursue their goals at the expense of customers’ interests and are harmful for society. Most advanced economies consider therefore cartels as illegal.

Though a number of countries have adopted criminal sanctions against individuals who engaged in hardcore cartels,¹ antitrust authorities rely mainly on financial penalties to enforce laws against cartels. In this article, we focus on fines as the main instrument for antitrust authorities. There is evidence that the amount of fines imposed on convicted cartels has dramatically increased in recent years. In the US, the total amount of fines imposed on convicted cartels thus rose from 889 million dollars over the period 2000-2004 to 3.4 billion dollars over the period 2005-2009,² while in Europe, it rose from 293 million euros over the period 1995-1999 to 3.5 billion euros over the period 2000-2004, 9.4 billion euros over the period 2005-2009, and 5.4 billion euros over 2010-2012.³

The United States Sentencing Guidelines (USSG) recommend the imposition of a base fine of 10% of the affected volume of commerce to a firm convicted of participation in a cartel plus another 10% for the harms inflicted upon consumers. This amount may undergo some adjustments for aggravating and mitigating factors. In the European Union, the amount of the fine takes into account the severity of the damages inflicted upon consumers as well as some aggravating and mitigating factors. However, the total fine must not exceed 10% of the total annual turnover of an undertaking, which may be much larger than the affected sales. Among the 13 largest cartel cases fined in recent years, this legal maximum was attained in four cases.⁴

By imposing fines on convicted cartels, antitrust authorities pursue two main goals: punishment and deterrence. One of the driving factors behind the increase in fines is the desire to make the fines deterrent. Indeed, the 2006 Guidelines by the European Commission (EC) clearly indicate the importance of the deterrence objective in setting the fines:⁵ “The Commission’s power to impose fines [...] is one of the means [...] to

¹For example, the US, Canada and Japan, and only a few countries within Europe (principally Austria, Norway, Ireland, the United Kingdom and, in relation to bid-rigging, Germany).

²Source: Antitrust Division of the Department of Justice.

³European Commission, Directorate General for Competition, <http://ec.europa.eu/competition/cartels/statistics/statistics.pdf>. For a statistical review of the evolution of fines over the 1998-2006 period, see Veljanovski (2010).

⁴In the Hydrogen Peroxide cartel for instance, the annual turnover of Solexis was estimated at 256 million euros in 2005, which led to a reduction in the fine imposed from 31 million to 25,6 million euros.

⁵European Commission Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003 (2006/C 210/02).

carry out the task of supervision entrusted to it by the Treaty. [...] For this purpose, the Commission must ensure that its action has the necessary deterrent effect [...] not only in order to sanction the undertakings concerned (specific deterrence) but also in order to deter other undertakings from engaging in, or continuing, behaviour that is contrary to Articles 81 and 82 of the EC Treaty (general deterrence).”

The economic theory of deterrence of criminal activities relies on two main approaches, which both proceed from the theory developed by Becker (1968) and Landes (1983). One approach puts the emphasis on compensation: the restitution of criminal gains and the proper indemnification of victims or more generally the reparation of the harm that criminal activities have caused to society, which may include the costs incurred for finding and prosecuting criminals. In what follows, we will use the term ”compensatory” to characterize a fine such that the illicit profit of the cartel is seized back.⁶ The compensatory fines collected from all discovered cartels may not be compensatory at the aggregate level as some cartels disappear before being discovered or remain undiscovered forever. Connor (2011) claims that, following the 2006 Guidelines, fines imposed by the European Commission on convicted cartels are compensatory in many cases: “For the first time in antitrust history, I believe we are observing fines that regularly disgorge the monopoly profits accumulated by cartelists.” The other approach puts the emphasis on deterrence, hence punishment. Under the economic theory of crime, cartelists as criminals weigh the expected costs and benefits of breaking the law: in other words, a firm is deterred from participating in a cartel if the expected net incremental profit of doing so is negative, that is, if the expected excess profit is lower than the expected loss, equal to the fine plus other penalties⁷ times the probability of being discovered and convicted. The proper deterrent fine level is that level which per se makes unprofitable the formation of a cartel or unsustainable its continuation. Hence the viewpoint taken in characterizing deterrent fines is that of the firm itself. In contrast to the first approach which focuses on the recuperation of illicit profits and the compensation of victims and society, the second approach considers the incentives of firms to engage in illicit activities.

Designing the optimal fines in antitrust infringements requires the consideration of the following trade-off. Small fines may fail to be deterrent or compensatory, but large fines may also induce social costs as they may violate principles of proportional justice, force companies into bankruptcy, raise too much the intensity of incentives to find and prosecute cartels, thereby increasing the cost of antitrust and raising the probability of type I errors (finding guilty innocent parties). In particular, Wils (2006) warns that bankruptcy entails

⁶This definition is based on the illicit profit and not on the harm caused to the economy. Note that we neglect the interest rates.

⁷Other penalties include loss of reputation as well as negative financial market reactions, costs and penalties from private litigation and class action, and others. In some cases, those other penalties may be more important than fines. In that vein, see the econometric event studies of Bosch and Eckard (1991), Thompson and Kaserman (2001), Gunster and van Dijk (2011), Aguzzoni, Langus and Motta (2013), and the analysis of interviews and surveys by Huschelrath, Leheyda and Beschorner (2011).

costs on innocent stakeholders as it “would hurt not only managers and shareholders, on whom the bankruptcy may be considered to have a desirable deterrent effect, but also all other stakeholders in the firm: employees, suppliers, customers, creditors and tax authorities.” Interactions between predators and preys or enforcers and criminals must be modelled as mixed strategy games, both to avoid bang bang phenomena and to carry forward the idea that it is illusive (too costly) to eradicate all crimes in society.

In this paper, we characterize for many different cartel cases what would be the optimal fine levels, and we compare these levels to the actual fine levels imposed by antitrust authorities. To this end, we first review the process by which deterrent fines are linked to estimated cartel overcharges. We then highlight the essentially dynamic dimensions of firms’ and cartels’ strategic behavior. We show that the proper and explicit consideration of such dynamic dimensions together with the estimation of representative cartel overcharges have a major impact on the determination of optimal deterrent fines.⁸ Relying on the method developed by Buccirosi and Spagnolo (2007) to compute cartel profits, we determine the optimal fine level as a function of four parameters, namely the competitive markup, the cartel overcharge, the elasticity of demand, and the probability of cartel detection. We embed this analysis in a dynamic model of cartel stability where, building on Aubert, Rey and Kovacic (2006), we consider that (illicit) communication is necessary for collusion and that it generates verifiable evidence the antitrust authorities will discover if they audit the industry. The benchmark fine level we recommend satisfies both the deterrence and compensation requirements. We then review the fines imposed on cartel members by the EC (we recovered data from all cartel decisions by the EC over the period of 2005-2010) and we compare them to the optimal fine level we derived and recommend. This comparison shows that fines imposed by the EC are above the deterrence level on average but with a large variance. Our own methodology revisits the recent contribution of Combe and Monnier (2011), yet our empirical results differ from theirs. A preliminary analysis of the reasons for this difference was done in Allain et al. (2011). The present article provides a more complete review of our methodology and makes explicit our underlying game model, while using a more recent and extended data base to provide an evidence-based judgment.

The paper is organized as follows. In section 2, we build a simple dynamic model of repeated interactions to derive the optimal fine formula. In section 3, we use a database of all cartel cases prosecuted by the EC between 2005 and 2010 to compare actual versus optimal fine levels. Section 4 concludes.

⁸We concentrate here on the determination of fines. More generally, antitrust policies can affect both the fine level and the probability of detection and conviction, which may be substitutes or complements. See Boyer, Lewis and Liu (2000) and Garoupa (2001) on these issues.

2 Cartel analysis in a dynamic framework

The analysis of cartels is often conducted in a static context. But clearly cartels operate in a dynamic environment. Although characterizing cartel stability as well as but-for environments is much more demanding in a dynamic framework than in a static one, a dynamic analysis is unavoidable.

In many industries, prices and possibly quantities can be and are adjusted regularly and the decision of each firm to enter, stay in or exit from the cartel given the current and expected economic environment determine the stability of the cartel. The economic theory of crime suggests that an agent (in the present case, a firm) decides to join a cartel or stay in a cartel thereby infringing the competition law or regulations if the expected gain from the infringement is larger than the expected cost or loss. Each individual firm must determine if participating in the cartel will generate a net increase in profits or value net of the expected fine when compared with the no cartel or “but-for” situation. It must also decide, when the cartel has been in effect for some time, if continuing to abide by the cartel agreement is more profitable than deviating from it. The characteristics of antitrust policy, and in particular the setting of fines, obviously influence cartel stability.

2.1 Internal cartel stability in a dynamic environment

The following model provides a simple yet powerful framework to analyze cartel stability in a dynamic environment by introducing a risk of defection by any co-conspirator as well as a risk of detection and punishment by antitrust authorities. We consider a hypothetical industry where a given number of firms, say I , form a cartel, while there is an exogenous annual probability of detection α of the cartel. If the cartel is detected, the cartel is dissolved and each firm pays a fine F in monetary terms, assumed constant over time.

We build on Aubert, Rey and Kovacic (2006) by assuming that (illicit) communication is necessary for collusion and generates verifiable evidence the antitrust authorities will discover if they audit the industry. Each “period” is composed of two stages. In the first stage, firms choose whether to communicate or not; communication by all members is a necessary condition for the cartel to exist. In a second stage, firms choose their respective market strategies: if the cartel exists (all firms did engage in illicit communication in stage 1), each firm can either follow the cartel strategy or deviate. For each firm, we denote the one-period cartel profit as π^M , the one-period deviation profit as π^D and the one-period but-for competitive profit as π , with $\pi^D \geq \pi^M > \pi$.

As outlined previously, the natural competition or “but-for” competitive price in a dynamic setting can mimic different types of static equilibrium. For example, when a price war prevails, the natural competition price will be close to marginal cost. When a “tacit collusion” equilibrium prevails, the natural competition price can be as high as the collusive or monopoly price. When Cournot-type competition prevails, the natural

competition price can be any price in between. We adopt a relatively standard approach, namely, that strategic interactions between firms lead to a dynamic competitive outcome mimicking the repetition of the static competitive outcome.

If firm i deviates in period t while the antitrust authority launches an audit in the industry, then firm i will be convicted even if it did not follow the cartel strategy in stage 2: it is the exchange of information that creates the infringement.⁹ Following the repeated game approach to cartel formation and stability (Fudenberg and Maskin 1986; Tirole 1988), we assume that the interactions are repeated over a large (infinite) number of periods and that all firms have the same cost of capital, hence the same discount factor δ . Firms are assumed to follow trigger strategies: if at least one firm prefers not to communicate, all firms adopt the but-for competitive strategy; if all firms communicate, each player plays the cartel strategy as long as no player has deviated previously; if a cartel member deviates from that strategy at some time, all players play the but-for competitive strategy from then on. The solution concept is the subgame perfect Nash equilibrium. Formally, if the cartel survived up to period $t - 1$, it will survive in period t as a Nash equilibrium outcome if all firms choose to follow the cartel strategy provided that the others do so as well. Figure 1 presents the simplified game tree. Note that we assume without loss of generality that if the cartel is discovered in period t , which happens with probability α , the profits π^M or π^D are nevertheless realized in t before the fine F is paid.

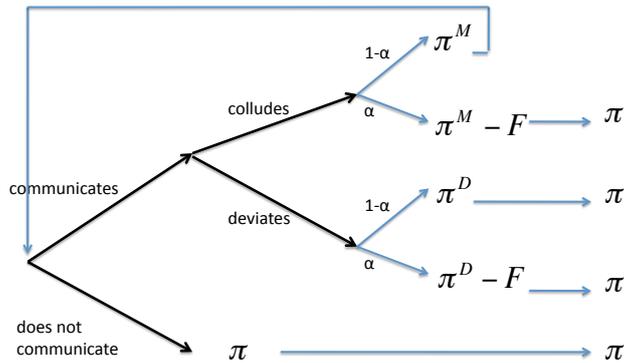


Figure 1: The game tree

Assume now that the cartel has been going on up to period $t - 1$. Assume that in period t all players but firm i play the trigger strategy. Let us consider the choice of firm

⁹Note that deviation without detection by the authorities implies no antitrust penalty.

i. If firm *i* plays the cartel strategy, that is, if it communicates and then sets the cartel price, its value (measured as its discounted profit) is

$$\begin{aligned} V^M &= \pi^M + \alpha(-F + \frac{\delta}{1-\delta}\pi) + (1-\alpha)\delta V^M \\ \Rightarrow V^M &= \frac{\pi^M - \alpha F + \alpha \frac{\delta}{1-\delta}\pi}{1-\delta(1-\alpha)} \end{aligned}$$

Two deviations are possible for firm *i*. First, the firm can choose not to communicate in the first stage; in that case, we assume that the cartel is dissolved. Second, the firm can first communicate and then set a price below the cartel price; in that case, the firm gains market shares and obtains profit π^D , but the other firms detect this deviation and react in the following periods, which switches the industry back to the natural but-for competitive equilibrium with profit π forever (the common and standard punishment assumption).¹⁰ We consider in turn these two possible deviations:

- If the firm chooses not to communicate in stage 1, the cartel is dissolved and the firm's value is $\frac{\pi}{1-\delta}$. Letting $\Delta\pi = \pi^M - \pi$, the firm prefers to deviate in stage 1 if

$$\frac{\pi}{1-\delta} > V^M \Leftrightarrow F > \frac{\Delta\pi}{\alpha}$$

- If the firm deviates by defecting from the cartel price in stage 2 after having chosen to communicate in stage 1 (and all firms play their but-for competitive strategy thereafter), its value is $V^D = \pi^D - \alpha F + \frac{\delta}{1-\delta}\pi$. The firm prefers to deviate in stage 2 if

$$V^D > V^M \Leftrightarrow F > \frac{\pi^M - \pi^D + \delta(1-\alpha)(\pi^D - \pi)}{\alpha\delta(1-\alpha)}$$

Clearly, the second deviation above is more profitable given that $\pi^D > \pi$. A smaller fine will be sufficient to induce a deviation in stage 2 than in stage 1.

Hindering collusion will be more difficult in the extreme case of infinitely patient firms ($\delta = 1$) – as very patient firms give a significant weight to future (excess) profit, hence will be more hesitant to deviate – and minimal deviation profit ($\pi^D = \pi^M + \nu$ where ν is positive but arbitrarily small). Hence a sufficient condition for the fine to be deterrent is

$$F > \frac{\Delta\pi}{\alpha} - \nu \frac{1-\delta(1-\alpha)}{\alpha(1-\alpha)}$$

or, neglecting ν ,

$$F \geq \frac{\Delta\pi}{\alpha} \equiv DF$$

¹⁰There is no recidivism in this model.

The cartel members receive the cartel profit as long as no member deviates and the cartel is not detected. As soon as one of these two conditions no longer prevails, each firm is back to the but-for profit. A low value of the fine F (or a low probability of detection α) makes defection less attractive (as long as the cartel members are patient), even if the members are aware that the cartel will eventually be detected. Increasing F (for a given α) or α (for a given F) reduces the stability of the cartel: the fear of defection deters the formation or maintenance of the cartel.¹¹

Hence, a fine slightly larger than $\frac{1}{\alpha}$ times the annual incremental cartel profit deters maintenance of the cartel. We refer to this fine as the “dynamic deterrent fine”. With such a fine, at least one firm will deviate from the cartel agreement and thereby lead to the dismantling of the cartel. For instance, if the annual probability of detection is estimated at 15%, a fine equal to 6.67 times the *annual incremental profit* is deterrent even under the most pessimistic or difficult conditions (very patient firms, low value of deviation). Hence, if the net annual incremental profit is 7% of sales, then a fine of 46.7% of annual affected sales would be deterrent.

The formula of the dynamic deterrent fine is rather robust as we defined this formula under assumptions favorable to cartel formation and maintenance. In other words, it is larger than necessary in most if not all cases. First, a deviation is assumed to be barely profitable, as the deviation profit π^D is little more than the cartel profit π^M . Second, the firms are assumed to be extremely patient, as δ is assumed to be arbitrarily close to 1. Relaxing either of these two assumptions would reduce the benchmark level of the deterrent fine. Third, we assume that following a deviation, collusion can never be achieved again - that is, we consider a “grim strategy” where the punishment phase consists in playing competitively forever; relaxing this assumption would increase the incentive to deviate and therefore the instability of the cartel. Fourth, we assume that deviating firms do pay the fine if the cartel is detected at that time; assuming that a deviating firm can escape the punishment if the industry is audited because it has not implemented the cartel strategy would increase the incentives to deviate, hence making collusion less stable and reducing the deterrent fine level. Fifth, our analysis can be extended straightforwardly to comprehensive concepts of penalties or sanctions, inclusive not only of financial sanctions or fines but also of the monetary equivalent of all penalties including punitive restrictions of all sorts imposed on corporations as well as personal sanctions on cartel instigators and managers such as debarment and prison terms, and inclusive of more general static and dynamic harm to the economy.

Harrington (2004) develops a more complex dynamic model of cartel stability. He models the sanction as the sum of a fixed fine and damages, which are proportional to

¹¹Boyer and Dionne (1983a, 1983b) showed that if firms (or their managers) were risk averse, they would be more affected by an increase in F than by an increase in α when the two are *equivalent* in expected terms αF . Hence, under risk aversion, an increase in the fine F is more efficient in reducing cartel stability than an *equivalent* increase in α .

the (present and past) welfare losses caused by the cartel. The damages are cumulative: the amount of damages to be paid if the cartel is detected is the sum of the welfare loss in the current period (possibly multiplied by a given factor) plus the damages in the previous periods, discounted to take account of the difficulty to evaluate past welfare losses. With a constant per-period probability of detection, damages grow over time and the collusive payoff declines at a faster rate than is the deviation payoff. Hence the cartel becomes less stable and must lower its prices to avoid deviations.

Along similar lines, Hinlopen (2006) computes the optimal fine in a model that allows the probability of detection to vary across periods: “[fines] and detection probabilities appear to be substitutable instruments as an increase in either reduces [the prospect for cartels]. At the same time the two instruments are complementary in that an increase in prospective fine payments yields more effect the higher are per-period detection probabilities”. This analysis can be useful as we might expect that the annual probability of detection of a cartel increases over the cartel lifetime. One possible reason among others is that leniency programs are more attractive as the cartel duration increases.

2.2 The impact of leniency and compliance programs

Leniency programs modify the deterrence properties of fines. A leniency program might lead firms to deviate from the cartel agreement, thus reducing the duration of cartels and also the cost of investigations if denouncement can be made sufficiently truthful. But a leniency program also reduces the expected cost of anticompetitive behavior, and may thereby increase the ex-ante incentives of firms to participate in a cartel. However, if the program is optimally chosen and calibrated, the former effect dominates and the leniency program improves welfare.¹² In that vein, some researchers have considered the possibility of rewarding whistle-blowers in leniency programs, thus increasing individual incentives to deviate and reducing the cartel stability. For instance, Aubert, Rey and Kovacic (2006) argue that rewarding firms or even individual informants, including firm employees, for denouncing cartels can deter collusion in a more effective way. Spagnolo (2004) shows that leniency programs that reduce or cancel sanctions may deter cartels more efficiently if the program offers protection to the agent who reports the cartel to antitrust authorities from retaliation.

In our model, reducing the fine to zero for a firm that reports the cartel to the antitrust authority makes the strategy of deviating and reporting the cartel even more profitable: the value of such a deviation becomes

$$\pi^r = \pi^D + \frac{\delta}{1 - \delta} \pi$$

¹²See Motta and Polo (2003).

In such a case, the minimum deterrent fine is then

$$\frac{1 - \alpha}{\alpha} \Delta\pi \equiv DF'$$

Note that this new reference threshold DF' is smaller than DF by a factor $(1 - \alpha)$.

A question of interest is whether a commitment to antitrust compliance within a company should be acceptable as a mitigating factor. As acknowledged by Wils (2006), “If they reflect a genuine commitment to antitrust compliance at the highest levels within the company, and are well-designed, compliance programmes can no doubt be very useful both to prevent antitrust violations and to detect such violations as early as possible.” Hence, the use of compliance programs as attenuating factors is a priori justified by the argument that they contribute to the reduction of the harm caused to society by cartels. However, promising fine reductions to firms that introduce a compliance program would reduce ex ante the deterrent effect of the fine. Perhaps, using the absence of a credible compliance program as an aggravating factor might be more efficient in deterring competition infringements.

3 Are EC-imposed fines deterrent or not?

So far, we have provided a theoretical discussion of the optimal characteristics of fines in cartel cases. The next step is to assess the efficiency of fines actually imposed by Antitrust authorities. This is obviously a difficult task. Our assessment is based on an extensive analysis of EC fines over the period 2005-2010.

3.1 A new empirical assessment

We recovered data from all cartel decisions by the EC over the period of 2005-2010. Those cartel cases include 301 firms as members, with aggregate fines amounting to 12.4 billion euros, calculated as the sum of fines imposed by the EC in its decisions minus leniency exemptions and reductions. The average fine is 41.8 million euros per firm. The largest fine is 896 million euros, imposed in 2008 in the Carglass Cartel. The cartels in the sample cover a wide range of sectors: LCD, Animal Feed Phosphates, Prestressing Steel, DRAMs, Calcium Carbide and Magnesium Based Reagents, Bananas, Candle Waxes, Sodium Chlorate, Carglass, Flat Glass, Synthetic Rubber (NBR), Professional Videotapes, Bitumen Nederland, Bitumen Spain, Methacrylates, Rubber Chemicals, Industrial Bags, Italian Raw Tobacco and Thread.

The aggregate amount of fines imposed by the EC has increased from 2005 to 2007 and decreased afterwards. This trend could result from a change in the number of cartel cases detected each year. Fifteen cartels were detected between 2005 and 2007, while thirteen

were detected between 2008 and 2010. For each cartel case, we collected parameters for all firms involved in the infringement. The parameters are as follows:

- The duration in months of competition law infringement by each firm. This information is usually clearly indicated in the published decision, yet sometimes requires some calculation. In the cartel cases of a more complex nature, this duration may contain several distinct figures. For instance, in the EC decision COMP/39.401 in 2009, distinct durations can be found for each firm on German and French markets respectively.¹³
- The size in million euros of firms' annual income in the relevant markets as defined by each decision. This information is missing in many decisions by the EC: the judgment commonly reports an interval. We thus remove from the sample the firms for which data is missing, or for which the decision reports only a maximum amount, and we keep those for which the decision reports an interval. For these firms, the actual turnover on the relevant markets is estimated as the median of the interval reported in the EC decision. Finally, we keep data on 121 individual firms. Among these, we know the exact turnover on the relevant market for one third of the firms (40 firms). For the other firms, we know that the annual turnover on the relevant market is in an interval $[x_1, x_2]$ and we take the average value of the interval, $m = \frac{x_2 - x_1}{2}$, as the estimated annual turnover. This interval is rather small for half the firms (that is, $\frac{x_2 - m}{x_2} < 0.25$ for 69 firms), but is less precise in 12 cases (that is, $0.25 < \frac{x_2 - m}{x_2} < 0.33$).
- When available, we use the amount of fine before mitigating and aggravating factors and before leniency reductions. We select this amount as it stands for the outcome of a general economic analysis of the EC, before any factors specific to the case are taken into account.
- Data do not allow for retrieving the but-for price. Therefore we base our analysis on several reasonable or representative scenarios.

We present more precisely in the appendix the data selection process.

3.2 Estimating the benchmarks

As a second step, we need to estimate the fine benchmarks in order to compare them to our data. The deterrence benchmark is the dynamic deterrent fine DF defined and characterized previously, while the compensation benchmark CF is the total amount of excess profit captured by the firm over the total duration of the cartel, that is, with the

¹³We keep this cartel for the dynamic fines estimations, but we remove it from the sample for the assessment of the compensatory fine.

notations of section 2, $CF \equiv n\Delta\pi$. To do so, we need to assess the price increase due to the cartel, that is, the cartel overcharge, and the excess profit received by cartel members. These two measures are crucial to evaluate the optimal level of the fine in each case.

To assess both the cartel profits and damages to the economy, one needs first to estimate the “cartel overcharge”, that is, the price increase specifically due to the cartel over the “but-for” price. The difficulty comes from the fact that, if the effective price charged by cartel members is usually observable once the cartel is detected, the but-for price is not and must therefore be estimated. Once this cartel overcharge is assessed, there exist some relatively simple economic methods to derive the excess (or illicit) profit realized by the cartel over and above the “natural or but-for” competition level. We first present a method developed by Buccrossi and Spagnolo (2007) that requires parsimonious information on demand elasticity and market competition to assess cartel excess profits.

The Buccrossi and Spagnolo model relies on the following variables and parameters:

- p is the competitive price (the “but-for” price)
- c is the marginal cost (assumed constant)
- m is the competitive but-for mark-up: $m = (p - c)/c$
- k is the percentage price increase specifically due to the cartel, hence above the but-for price: the cartel price is $p^M = p(1 + k)$
- q is the demand at the competitive or but-for price over the period considered (here, the annual demand)
- ε is the absolute value of the demand elasticity at the competitive or but-for price¹⁴
- q^M is the demand at the cartel price over the period considered (here, the annual demand): $q^M = q(1 - \varepsilon k)$
- α is the probability of detection of the cartel over the period considered (here, one year).

Absent the cartel, each firm’s profit over the period considered (annual) is $\pi = q(p - c) = qcm$, while with the cartel each colluding firm’s annual profit is

$$\pi^M = q^M(p^M - c) = qc(1 - \varepsilon k)(m + k + mk)$$

¹⁴Cohen and Scheffman (1989) were among the first to stress the importance of this parameter. They argued that the antitrust authorities did not properly take into account the reaction of customers to a price increase (through the price elasticity of demand) and thus “the Justice Department’s assertion that price-fixing conspiracies would typically result in a mark-up over competitive level of ten percent [...] is not supported by the available evidence. [...] This conclusion has important implications because of the potential inefficiencies that may arise from overdeterrence” (page 349).

Therefore a colluding firm increases its annual profits by

$$\Delta\pi = \pi^M - \pi = qkc((1+m)(1-\varepsilon k) - \varepsilon m)$$

Annual sales (noted S) in the market at the colluding price are

$$S = q^M p^M = qc(1+m)(1+k)(1-\varepsilon k)$$

In our data, we do not observe c , but we observe the annual sales S . From the ratio $\Delta\pi/S$, we can retrieve the annual excess profit $\Delta\pi$ as a function of ε, k, m and S as

$$\Delta\pi = k \frac{((1+m)(1-\varepsilon k) - \varepsilon m)}{(1+m)(1+k)(1-\varepsilon k)} S$$

Observe that if $m = 0$ or $\varepsilon = 0$, this expression reduces to $Sk/(k+1)$.

From this simple model, we can derive the fine benchmarks as follows. The deterrence benchmark DF is

$$DF = \frac{\Delta\pi}{\alpha} = k \frac{((1+m)(1-\varepsilon k) - \varepsilon m)}{\alpha(1+m)(1+k)(1-\varepsilon k)} S$$

A fine will be compensatory if it is at least equal to the following benchmark denoted CF :

$$CF \equiv n\Delta\pi = nk \frac{((1+m)(1-\varepsilon k) - \varepsilon m)}{(1+m)(1+k)(1-\varepsilon k)} S$$

We have determined two benchmarks to assess the deterrence and compensation properties of fines. In order to guarantee that these two objectives are attained by fines, we therefore recommend to set the following level of fine:

$$F^* \equiv \max\{CF, DF\} \tag{1}$$

We now discuss the assumptions on the parameters before testing the deterrence properties of the recent EC-imposed fines as they appear in our data.

3.3 Parameters

3.3.1 The probability of detection

The probability of detection of a cartel is very difficult to assess. Several studies attempt to provide an estimate of this probability, but as the number of undetected cartels remains unobserved, the results are subject to caution. Since we do not attempt to contribute to the debate on the probability of detection of cartels, we simply review briefly the existing literature on this topic. In the empirical part that follows, we use standard values and discuss the robustness of our results to variations of the probability of detection.

Early analyses suggested that the overall probability of detection of a cartel is within a

range of 10% to 33% (see for instance Werden & Simon, 1987; Cohen and Scheffman, 1989; and Landes, 1983). This range is consistent with those observed for other crimes: for burglary, auto theft, and arson, for instance, U.S. arrest rates vary from 13.8% to 16.5% (Polinsky and Shavell, 2000). Bryant and Eckard (1991) estimate the annual probability of detection, before the introduction of leniency programs in the US in 1993. Using data from a sample of US Department of Justice price fixing indictments for the period 1961 to 1988, they propose a statistical model to describe the life-and-death process of cartels as a continuous-time Markov process. They derive a theoretical duration for each cartel and infer the probability of detection from the observed number of detected cartels. They conclude that “the probability of getting caught in a given year is at most between 0.13 and 0.17” (for cartels eventually detected).¹⁵

The probability of detection is influenced by several factors. For instance, Harrington (2004) considers a situation where the probability of cartel detection (and conviction) increases with the magnitude of price changes: bigger price movements are more likely to trigger suspicions and thus detection of the cartel. When the probability of detection is sufficiently sensitive to price increases, the cartel gradually raises price. If, in addition, detection is sufficiently sensitive to price decreases, then deviations are prevented as a sudden price war would trigger suspicion. Another important determinant of the probability of detection is the existence of leniency programs, which are usually assumed to drive an increase in the probability of cartel detection. Indeed, cartels are subject to defection by any member who wishes either to benefit by cutting the cartel price, or to benefit from a leniency program, or both. The presence of a leniency program that ensures that the deviant firm is not fined increases the probability of detection and conviction, and hence cartels can be deterred with a (significantly) lower fine than the fine prescribed by the previous static approach.

We assume in what follows an annual probability of detection of 15%. This assumption is consistent with the fact that our data are all posterior to the introduction of leniency programs in Europe in 1996. Furthermore, we discuss the impact of a variation of the probability of detection on our results.

3.3.2 The assessment of cartel overcharge

The model developed in section 3.2 determines a simple formula of the minimum fine that ensures deterrence of the cartel, as a function of several variables. Estimating the price and profit that would prevail for each firm absent the cartel, that is, the “but-for” price

¹⁵ See also Combe, Monnier and Legal (2008). Note that the link between the overall probability of detection (in a static model) and the annual probability of detection in our dynamic model is simple. Suppose that the cartel duration is known to be n years and that the probability of detection per year is constant and equal to α_1 , the overall n -year probability of detection is equal to $\alpha_n = 1 - (1 - \alpha_1)^n$. In a static model, with $\Delta\pi$ being the cartel annual excess profit, the n -year benchmark for the deterrent fine is given by the following “overall n -year static deterrent fine OF ”: $OF = \frac{n\Delta\pi}{\alpha_n}$.

and profit, is crucial to determine the cartel overcharge as well as the excess profit. Yet these may be very difficult to retrieve: if the cartel price is observed, the “but for” price, by definition, is not. Taking the notations of the previous section, a given markup $\frac{p^M - c}{c}$ for a firm in a cartel reflects both the competitive markup and the cartel overcharge: $\frac{p^M - c}{c} = k(m + 1)$. Retrieving the cartel overcharge k from the observed cartel price thus requires to know the competitive markup m .

It is well known since Friedman (1971), “folk theorems” state that in repeated games the set of observed prices may range from the repetition of pure competitive prices to the repetition of monopoly prices (depending in part on the firms’ patience) as prices above the static pure competitive price can be the “natural” outcome of dynamic market interactions. These outcomes are usually referred to as “tacit collusion”: “Tacit collusion need not involve any ‘collusion’ in the legal sense, and in particular need involve no communication between parties. It is referred to as tacit collusion only because the outcome (in terms of prices set or quantities produced, for example) may well resemble that of explicit collusion or even an official cartel” (Ivaldi et al., 2003). The emergence of such equilibria is favored if there is complete information on the demand functions and the cost structures, a small number of firms, relatively homogenous products, etc. In some cases, these conditions would make the consideration of the Folk theorems unavoidable. In other cases, one may consider that these theorems do not apply and that the static equilibrium provides a satisfactory representation of the but-for world.

However, the repeated game framework lacks important features to properly characterize industry equilibria in the presence of demand growth and volatility, potential entry, and capacity constraints. In the long run, industry structure is determined by the investment strategies of the firms, in particular by the existence of exogenous or endogenous sunk costs and their implications for entry and exit of firms (Tirole 1988, Sutton 1991). Hence, when assessing the but-for-price, it may be necessary to revisit some basic structural factors underlying the current industry situation.¹⁶ Baumol, Panzar and Willig (1982) introduce the notion of contestable markets to explain why, though the number of firms on a market may be small, the market outcomes may still be competitive due to the threat of entry. Similar developments can also be used to formalize Schumpeter’s creative destruction process, through which the most efficient firm emerges as the dominant firm until it is replaced by an even more efficient one. Recent research on the dynamics of competition¹⁷ highlight this complexity.

This discussion underlines the difficulties inherent to the assessment of cartel overcharges: as information about the proper but-for world is missing, the assessment of a particular cartel overcharge and hence of the excess profits relies on hypothetical sce-

¹⁶For instance, it may be the case that a more intense competition would lead to a more concentrated industry. Moreover, a more concentrated industry does not necessarily imply higher market power for firms (Sutton, 1991).

¹⁷See for instance Boyer, Lasserre and Moreaux (2012)

narios of competition. A meta-analysis by Connor and Bolotova (2006) summarizes the findings of past studies on cartel overcharges.

Considering a set of empirical studies of cartels, Connor and Bolotova (2006) perform a meta-analysis in which the overcharge estimate is a function of two groups of regressors. The regressors in the first group (e.g., duration, geographical location) have the potential to explain the magnitude of the actual overcharge whereas those in the second group (publication source, estimation method) capture estimation biases. The analysis conducted by Connor and Bolotova is not intended to assess the magnitude of the actual overcharge, but rather to gauge the sensitivity of the overcharge estimate to the explanatory variables considered. They find that the overcharge estimate in the studies considered is positively related to the duration of the cartel, but does not depend on whether the firm is found guilty or not; it is lower for domestic cartels and for cartels that have operated in the EU; and it declined over time. The authors attribute the latter to the increased severity of antitrust regulation, but increased competition and free trade might have produced similar effects. Interestingly, they find that the explanatory variables of the second group also have significant impacts on the overcharge estimate although the regressors of the first group explain the variability of the overcharge estimates to a greater extent than the regressors of the second group.

Updating the Connor and Bolotova meta-analysis, Connor (2010) finds a mean overcharge estimate of 50.4% with a median of 23.3% for cartels of all types. Boyer and Kotchoni (2012) use a similar but updated database (the Connor database) comprising some 1120 studies of cartels. In this database, the mean overcharge is 45.5% with a median of 23% for the whole sample; for the subsample of studies with strictly positive overcharge estimates, the mean overcharge is 49% with a median of 25%; and for the subsample of studies with overcharge estimates lying strictly between 0% and 50%, which represents 70% of the sample, the mean overcharge is 20.6% with a median of 18.4%.¹⁸ Boyer and Kotchoni insist however on the fact that the Connor overcharge data are overcharge estimates rather than observations and are therefore subject to model error, estimation error and publication bias. They conduct a meta-analysis of cartel overcharge estimates in the spirit of Connor and Bolotova (2006) while controlling for asymmetry (skewness), heterogeneity, publication bias, as well as the presence of a small number of influential observations (outliers) in the data. They find that the mean *bias-corrected* overcharge estimate for cartels with raw positive overcharge estimates under 50% (70% of cartel cases studied) is 13.6% with a median of 13.6% also, while the mean *bias-corrected* overcharge estimate for cartels of all types is 17.5% with a median of 14.1%. Those values must be considered as upper bounds. Boyer and Kotchoni argue that median overcharge values are in this case more informative, reliable, and representative of cartel overcharges.

¹⁸See Boyer and Kotchoni (2012) for other characteristics of the Connor database. The OECD *Report on the Nature and Effect of Cartels, 2002*, estimates that cartel overcharges reach 15% to 20%.

In the subsequent estimates, we assume that the competitive markup is within a range from 5% to 20% and that the cartel overcharge is between 5% and 30%.

3.4 Deterrence properties of the fines imposed by the EC

Connor (2010) concludes that “...penalty guidelines aimed at optimally deterring cartels ought to be increased.” Combe and Monnier (2011) consider 64 cartel cases in the EU and compute restitutive (compensatory) and dissuasive (deterrent) fine benchmarks, in part directly from the court evidence and in part based on Connor (2010). They use the latter benchmarks to gauge the actual fines imposed on the cartels they consider. From their theoretical analysis and empirical estimates, they conclude that “fines imposed against cartels by the European Commission are overall sub optimal.” Our results lead us to very different conclusions.

For each of the 121 individual fines in our database, we compare the actual fine imposed by the EC to the theoretical value of the deterrent fine level DF defined above. Given the data we have, we must make assumptions about some parameters of the model. First, our model defines DF as a proportion of annual sales on the relevant market. Second, the decisions seldom provide information about the cartel overcharge and the but-for markup. We therefore simulate different scenarios using a range of 5% to 20% for the competitive but-for markup m and a range of 5% to 30% for the cartel overcharge k . We also provide simulation results for different values of demand elasticity and probability of detection.

Figure 2 presents the 121 ratios of the actual fine over the theoretical value DF obtained with a competitive markup m of 17%, an elasticity $\varepsilon = 1$, and a cartel overcharge k of 23% from Connor (2010). With these rather demanding parameters, 54 out of the 121 fines (44.6%) are above the deterrence level, while 67 are below. The logarithmic scale highlights that the ratios are significantly dispersed around 1.

In the following tables, we compare for each firm the actual fine imposed to the respective deterrent fine level $DF = \frac{\Delta\pi}{\alpha}$ derived and characterized in the previous section. The reported percentage is the share of actual fines that are above their relevant deterrence threshold. We represent different scenarios, with different values of the parameters ε , k , m and α .

Our methodology follows that of Combe and Monnier (2011) who compare in each case the actual fine with their definition of both the compensatory fine, which corresponds to the annual excess profit as a percentage of cartel sales times the duration of the cartel, and the deterrent fine, which corresponds, in their approach, to the compensatory fine divided by the annual probability of detection. Clearly, since the profitability of a cartel (namely $\Delta\pi$) is reduced if the price elasticity of demand is high, deterrence will be easier if demand is elastic. As a first step, we thus define two benchmarks as in Combe and

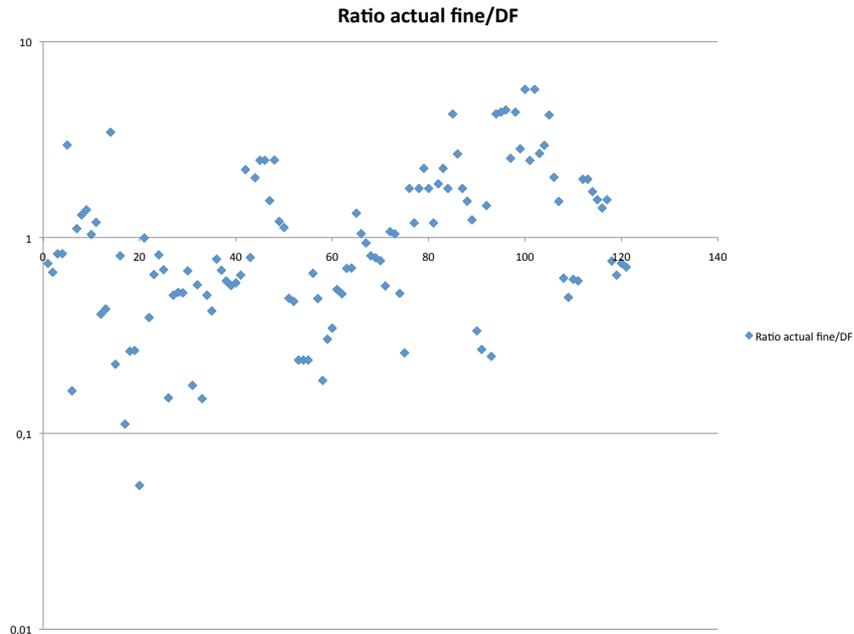


Figure 2: Comparison to the dynamic deterrent fine

Monnier (2011), who compute (for $\alpha = 15\%$) an upper and a lower bound of their deterrent benchmark by using two extreme values of the demand elasticity: the upper bound is obtained for $\varepsilon = 0$, while the lower bound corresponds to $\varepsilon = 2$.

We present in Tables 1 and 2 how the proportion of fines above the deterrence threshold varies with m and k . In Table 1, demand is assumed to be very elastic ($\varepsilon = 2$): a large proportion of the actual fines is above the deterrence benchmark DF . Indeed, in the extreme scenario where the cartel overcharge is very high ($k = 30\%$) in an otherwise relatively competitive sector (the competitive markup in the “but-for” scenario is assumed to be only 10%), 44% of the actual fines appear to be over the deterrent benchmark DF .

Table 1: Proportion of the 121 fines above DF ($\varepsilon = 2$, $\alpha = 0.15$)

	k=5	k=13	k=20	k=30
m=5	83%	60%	44%	38%
m=10	87%	67%	51%	44%
m=20	90%	79%	76%	87%

If demand elasticity is very low, a cartel tends to be very profitable and more difficult to deter. We therefore present in Table 2 how the proportion of fines above the dynamic deterrent level varies in that case, for different values of the competitive markup (column) and the cartel overcharge (row). In the case of Table 2, the benchmark does not depend on the competitive markup m (recall that, with $\varepsilon = 0$, we have $\frac{\Delta\pi}{\alpha S} = \frac{k}{\alpha(1+k)}$). In those scenarios, the actual level of fines imposed is above the deterrence benchmark in more

than half of the cases if the cartel overcharge is rather low (less than 13%) but in less than half of the cases if the cartel overcharge is assumed to be high: if $k = 30\%$, only 30% of the actual fines would be considered to be above the deterrence benchmark.

Table 2: Proportion of fines above DF
($\varepsilon = 0, \alpha = 0.15$)

	k=5	k=13	k=20	k=30
m=5	83%	52%	40%	30%
m=10	83%	52%	40%	30%
m=20	83%	52%	40%	30%

Tables 3 and 4 present intermediate scenarios: in Table 3 the demand elasticity is $\varepsilon = 1$, while in Table 4 it is $\varepsilon = 0.5$.

Table 3: Proportion of fines above DF
($\varepsilon = 1, \alpha = 0.15$)

	k=5	k=13	k=20	k=30
m=5	83%	54%	43%	31%
m=10	83%	58%	44%	33%
m=20	86%	63%	44%	38%

Table 4: Proportion of fines above DF
($\varepsilon = 0.5, \alpha = 0.15$)

	k=5	k=13	k=20	k=30
m=5	83%	53%	40%	30%
m=10	83%	54%	41%	31%
m=20	83%	56%	43%	33%

Table 5 illustrates the sensitivity of those results to variations of the probability of detection α for $m = k = 20\%$. If the demand function is inelastic, cartels are very profitable, but between a quarter and a half of the actual fines are nevertheless above the dynamic deterrence benchmark level. By contrast, with a very elastic demand, a clear majority of fines are above the benchmark even if the probability of detection is low ($\alpha = 10\%$).

Table 5: Proportion of fines above DF ($m = k = 20\%$)

	$\alpha=10\%$	$\alpha=15\%$	$\alpha=20\%$
$\varepsilon=0$	26%	40%	46%
$\varepsilon=1$	33%	44%	60%
$\varepsilon=2$	54%	76%	81%

The main conclusion of this analysis is that we find a much higher proportion of deterrent fines than Combe and Monnier (2011), who concluded that only one out of 64

fines (1.6%) of their sample lies above the relevant deterrent benchmark.¹⁹ Our analysis differs from theirs along several dimensions, including the characterization of the deterrence benchmark and the modeling of the dynamics of cartels.²⁰ First, Combe and Monnier estimates rely in part on Connor (2010) who obtains cartel overcharge estimates of 20% for domestic cartels and 30% for international cartels. Boyer and Kotchoni (2012, Table 6), using Connor’s database (updated but similar otherwise to that used by Connor 2010), find mean and median bias-corrected (from model errors, estimation errors and publication bias) overcharge estimates of 15.3% and 13.4% for domestic cartels and 19.5% and 15.4% for international cartels, claiming that the significant heterogeneity in the data makes median values 13.4% and 15.4% more representative of cartel behavior. Second, Combe and Monnier define the deterrent benchmark fine in a static framework. We showed above that using a static setup tends to produce a higher deterrence benchmark than in a dynamic model: the deterrence benchmark defined by Combes and Monnier is $\frac{n\Delta\pi}{\alpha}$ while our dynamic analysis leads to a benchmark $DF = \frac{\Delta\pi}{\alpha}$, which is lower by a factor of n , the duration of the cartel. Indeed, even with the rather demanding parameter values $\alpha = 15\%$, $\varepsilon = 1$, $m = 20\%$, and a cartel overcharge $k = 20\%$, we find that 44% of the actual fines are above the properly defined dynamic deterrence threshold DF . Third, we use data that is more recent (our sample selects cartel cases from 2005 to 2010, while they use cases from 1975 to 2009). As cartel fines have significantly increased over recent years, we might conclude that the deterrence level of the fines imposed by the EC has increased. Finally, we point out the large heterogeneity between the different cases: some are much too low while others are much too high.

3.5 Compensation properties of the EC-imposed fines

Our analysis suggests that what is traditionally known as the compensatory fine may actually be deterrent in a dynamic context. In this section, we gauge the efficiency of a policy of imposing compensatory fines to convicted cartels. To this end, suppose a cartel has been going on for n years and is contemplating to go on for one more year. During this additional year, the cartel will be detected with probability α and, if detected and imposed with the compensatory fine, it will pay $(n + 1)\Delta\pi$, or a percentage $\frac{(n+1)\Delta\pi}{S}$ of its annual sales. If the cartel goes on one more year, its expected net incremental illicit profit is:

$$\Delta\pi - \alpha(n + 1)\Delta\pi = \Delta\pi[1 - \alpha(n + 1)]$$

The compensatory fine is thus deterrent if $n + 1 > \frac{1}{\alpha}$. If the annual probability of detection is 15%, then the compensatory fine becomes deterrent after six (more precisely

¹⁹See also Combe and Monnier (2013) and Boyer (2013).

²⁰Allain, Boyer and Ponssard (2011) propose a proper recalibration of both the data and the analysis of Combe and Monnier (2011) and find that 60% of fines satisfy the relevant deterrent benchmark.

5.67) years as the expected net incremental profit of one additional year turns out to be negative: the cartel would rationally self-dissolve if not detected. If the probability is 20%, then the compensatory fine becomes deterrent after four years. The compensatory fine is therefore too low to be deterrent for shorter-lived cartels and far above the deterrent level for longer-lived cartels.

Again, the proportion of fines above the compensation benchmark varies according to the scenario considered, but a large majority of fines are compensatory. Table 6 gives the proportion of actual fines above the compensation benchmark for different scenarios regarding the competitive markup m and the cartel overcharge k , with $\varepsilon = 1$ and $\alpha = 0.15$. Table 7 gives the proportion of actual fines above the compensation benchmark for different scenarios regarding the probability of detection α and the demand elasticity ε , with $k = m = 20\%$. A large majority of the actual fines appear to be compensatory.

Table 6: Proportion of fines above the compensation benchmark ($\varepsilon = 1$, $\alpha = 0.15$)

	$k = 5$	$k = 13$	$k = 20$	$k = 30$
$m = 5$	94%	82%	69%	45%
$m = 10$	94%	83%	70%	49%
$m = 20$	94%	85%	75%	61%

Table 7: Proportion of fines above the compensation benchmark ($m = k = 20\%$)

	$\alpha = 10\%$	$\alpha = 15\%$	$\alpha = 20\%$
$\varepsilon = 0$	66%	66%	66%
$\varepsilon = 1$	75%	75%	75%
$\varepsilon = 2$	89%	89%	89%

4 Conclusion

The current orientation of antitrust authorities is to stress deterrence when imposing cartel fines. The proper determination of deterrent fines relies first on a careful definition of the excess profit, which requires an appropriate definition of the competitive but-for mark-up and the demand elasticity.²¹ We showed that a proper dynamic analysis of cartel stability suggests using as a deterrent fine benchmark the annual excess profit divided by the annual probability of being detected. This deterrent benchmark was developed in the context of dynamic repeated games under very demanding assumptions, hence is valid under a wide range of cartel contexts. In some highly concentrated industries the competitive but-for outcome could be closer to the collusive equilibrium than to the static

²¹The Folz et al. report for the French Competition Authority (2010) strongly encourages an explicit use of demand elasticities

equilibrium. In such cases antitrust authorities would need to develop explicit dynamic models to grasp the specificities of these industries.

The comparison of our benchmarks to the actual level of fines imposed by the EC in recent cartel cases (from 2005 to 2010) shows that, according to the different competitive scenarios, approximately 30% to 80% of the fines are deterrent, while 50% to 80% are compensatory. These empirical results could indicate that recent fines are closer to their deterrence and compensation objectives than they used to be. However, a striking feature of our results is the dispersion of the fines : some seem to be much too high, while others are much too low.

The co-existence of two possible objectives such as compensation and deterrence may create confusion in setting fines. The idea that compensatory fines are not deterrent has been used as an argument in favor of increasing fines above recent levels. This argument is clearly incorrect as soon as the duration of the cartel exceeds five years. For longer duration, compensatory fines are overdeterrent. The most effective and politically acceptable policy might be to set the fines at the largest value between the dynamic deterrent fine DF and the compensatory fine CF .

More generally, the determination of optimal deterrent fines should be done in the perspective of selecting the best combination of policy instruments. For instance, leniency programs must form an integral part of the analysis of cartel stability: a proper leniency program is likely to increase the probability of detection and conviction and as such would allow for a reduction in deterrent fine levels.

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6 References

Aguzzoni, L., Langus, G. and M. Motta (2013), “The effect of EU antitrust investigations and fines on a firm’s valuation,” *The Journal of Industrial Economics* (forthcoming)

Allain M.L., Boyer M. and J.P. Ponsard (2011), “The Determination of Optimal Fines in Cartel Cases: Theory and Practice,” *Concurrences* 4-2011, 32-40.

Aubert, C., Rey, P., and W. Kovacic (2006) “The Impact of Leniency and Whistle-Blowing Programs on Cartels” , *International Journal of Industrial Organization* 24, 1241-1266.

Baumol, W., J. Panzar and R. Willig (1982) *Contestable markets and the Theory of Industry Structure* New York: Harcourt Brace Jovanovich. Becker, G (1968) “Crime and Punishment: An Economic Approach” *Journal of Political Economy* 76: 169- 217.

Bosch, J.C. and E.W. Eckard, Jr. (1991), “The Profitability of Price Fixing: Evidence From Stock Market Reaction to Federal Indictments,” *The Review of Economics and Statistics* 73(2), 309-317.

Boyer, M. (2013) “The Fining of Cartels”, *Concurrences* 1-2013, 27-33.

Boyer, M. and G. Dionne (1983a), “Riscophobie et étalement à moyenne constante: Analyse et applications”, *Actualité économique / Revue d’analyse économique* 59(2), 208-229.

Boyer, M. and G. Dionne (1983b), “Variations in the Magnitude and Probability of Loss: Their Impact on Risk”, *Canadian Journal of Economics* 16(3), 411-419.

Boyer, M. and R. Kotchoni (2012), “How much do cartel typically overcharge?”, working paper CIRANO scientific series 2012s-15.

Boyer, M., P. Lasserre, and M. Moreaux (2012), “A Dynamic Duopoly Investment Game without Commitment under Uncertain Market Expansion ”, *International Journal of Industrial Organization* 30, 663-681.

Boyer, M., Lewis, T.R. and W.L. Liu (2000), “Setting standards for credible compliance and law enforcement”, *Canadian Journal of Economics* 33(2), 319-340.

Bryant, P. and W. Eckart (1991), “Price fixing: the probability of getting caught”, *Review of Economics and Statistics* 73, 531-540.

Buccirossi, P. and G. Spagnolo (2007) “Optimal Fines in the Era of Whistleblowers: Should Price Fixers Still Go To Prison?”, pp. 81-122 in Goshal, V., Stennek, J. (Eds) *The Political Economy of Antitrust*, Elsevier: North Holland.

Cohen, M. A. and D. T. Scheffman (1989) “The Antitrust Sentencing Guideline: Is the Punishment Worth the Costs?” *American Criminal Law Review* 27, 331-366.

Combe E., Monnier C. and R. Legal (2008), “The probability of getting caught in the European Union”, Working Paper, College of Europe BEER, no 12.2008

Combe, E. and C. Monnier (2011) “Fines against hard-core cartels in Europe: the myth of over-enforcement”, *Antitrust Bulletin*, 56-2, 235-276.

Combe, E. and C. Monnier (2013) “Quelle est l’ampleur de la sous-dissuasion des cartels en Europe? Compléments sur nos résultats”, *Concurrences* 1-2013, 16-26.

Connor, J. (2010), *Price-fixing Overcharges*, Revised 2nd Edition, 114 pages.

Connor, J. (2011), “Has the European Commission become more severe in punishing cartels? Effects of the 2006 Guidelines”, *European Commission Law Review* forthcoming.

- Connor, J. M. and Y. Bolotova (2006), “A Meta-Analysis of Cartel Overcharges ”, *International Journal of Industrial Organization* 24, pp.1109-1137
- Folz, M., Raysseguier, C. and A. Schaub (2010), Rapport sur l’Appréciation de la sanction en matière de pratiques anticoncurrentielles, 2010.
- Friedman (1971), “A non-cooperative equilibrium for supergames”, *Review of Economic Studies* 38, pp.1-12.
- Fudenberg, D. and E. Maskin (1986), “The Folk Theorem for repeated Game with Discounting and Incomplete Information” *Econometrica* 54 (3), pp. 533-554.
- Ginsburg, D.H. and J.D. Wright (2010) “Antitrust Sanctions”, *Competition Policy International* 6(2), 3-39,
- Günster, A. and M.A. van Dijk (2011), “The Impact of European Antitrust Policy: Evidence from the Stock Market,” mimeo
- Harrington, J. (2004) “Cartel pricing dynamics in the presence of an antitrust authority”, *RAND Journal of Economics* 35 (4), pp. 651-673.
- Harrington (2010) “Comments on Antitrust Sanctions”, *Competition Policy International* 6(2), 41-51.
- Hinlopen, J. (2006) “Internal cartel stability with time-dependent detection probability”, *International Journal of Industrial Organization* 24, pp. 1213-1229.
- Huschelrath, K., Leheyda, N. and P. Beschorner (2011), “The Deterrent effect of antitrust sanctions: Evidence from Switzerland,” *The Antitrust Bulletin* 56(2), 427-460.
- Ivaldi, M., B. Jullien, P. Rey, Paul Seabright and Jean Tirole. (2003) “The Economics of Tacit Collusion” Final Report for DG Competition, European Commission, IDEI Toulouse.
- Landes, W.H. (1983), “Optimal Sanctions for Antitrust Violations”, *University of Chicago Law Review* 50, 652-678.
- Motta, M. and M. Polo (2003) “Leniency programs and cartel prosecution”, *International Journal of Industrial Organization* 21, pp. 347-379.
- Spagnolo (2004) “Divide et impera: optimal mechanisms against cartels (and organized crime), Mannheim WP.
- Sutton, J. (1991), *Sunk Costs and Market Structure*. MIT Press. Cambridge, MA.
- Thompson, J.S. and D.L. Kaserman (2001), “After The Fall: Stock Price Movements and the Deterrent Effect of Antitrust Enforcement,” *Review of Industrial Organization* 19, 329–334.
- Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press.
- Veljanovski, C. (2010) “European Commission Cartel Prosecutions and Fines, 1998-2006 - An Updated Statistical Analysis of Fines Under the 1998 Penalty Guidelines”, Available at SSRN: <http://ssrn.com/abstract=1016014>
- Werden, G. and M. Simon (1987), “Why price fixers should go to prison?”, *The Antitrust Bulletin* 32, 917-937.

Wils, P.J. W (2006), "Optimal Antitrust Fines: Theory and Practice", *World Competition* 29(2):183-208.

Appendix: The Data

Table 8 presents the list of the 20 cartel decisions published by the EC between 2005 and 2010, for which we have sufficient data. For each case, we report the number of firms that we select after dropping those for which the data is non-existent or insufficiently precise. The column “reference fine per firm” indicates the fine we take into account: in most cases, we report the fine “before mitigating or aggravating factors”, in order to rule out those factors that are specific to each case. Our goal is to assess the deterrence properties of the baseline fines before those specific factors are integrated. In two cases (the 2010 Prestressing Steel and the 2008 Carglass decisions) we use a different fine as we do not have the value of the fine before mitigating and aggravating factors.

The column “% error on annual sales (by firm)” in Table 8 gives the precision of the variable that represents the annual sales on the relevant market, that is, the variable “ S ” in our model. In some cases, the EC reports exactly the amount of annual sales. In that case, the column reports 0% of error. But in other cases, the EC gives a range of values: we then report the average value of the range, and the error term indicates the precision of the range. For instance, in the 2008 Candle Wax case, we drop the firms for which the error term is larger than 33%, and we keep 8 firms. We compute the thresholds on the approximate values of the yearly sales, that is, the average of the floor and ceiling turnovers reported in the EC documents. The data we keep for the Candle wax case appear in Table 9.

Increasing the precision of our data reduces the data sample and may increase the selection bias. There is obviously a trade-off in taking approximate values for the turnover. On the one hand, it introduces possible errors in the estimate of the fine thresholds. On the other hand, it enables us to extend the data sample and to reduce the selection bias: data tend to be more imprecise for the largest cases, and we want to take these into account in our study. For instance, there is a positive error on each of the 12 firms with the largest turnovers (error term between 3.5% and 25%) and for the 9 firms with the highest fines (3.5% to 33%). If we reduce the sample to firms for which the error term is less than 25%, with $k = 13\%$, $m = 10\%$, $\varepsilon = 1$ and $\alpha = 15\%$, 51% of the fines are above the deterrence threshold DF , and 83% are above the compensation threshold. Keeping only the firms with an error term less than 16%, with $k = 13\%$, $m = 10\%$, $\varepsilon = 1$ and $\alpha = 15\%$, 30% of the fines are above the deterrence threshold DF , and 75% are above the compensation threshold. Keeping only the firms with a 0% error on the turnover reduces the sample to 40 firms in 10 cartel cases, for which with $k = 13\%$, $m = 10\%$, $\varepsilon = 1$ and $\alpha = 15\%$, 15% of the fines are above the deterrence threshold DF , and 68% are above the compensation threshold.

Table 8: Data sample and precision

Year	Sector	Nb. firms	Reference fine per firm	% error on annual sales (by firm)
2010	LCD	4	before mitigating/ aggravating factors	0 to 16.5%
2010	Animal Feed Phosphate	2	before mitigating/ aggravating factors	50 – 33%
2010	Prestressing Steel	16	before inability to pay	0 %
2010	DRAMs	9	before mitigating/ aggravating factors	7 – 25%
2009	Calcium Carbide and Magnesium Based Reagents	7	before mitigating/ aggravating factors	16 – 25%
2008	Bananas	2	before mitigating/ aggravating factors	0%
2008	Candle waxes	8	before mitigating/ aggravating factors	0 – 33%
2008	Sodium Chlorate	3	before mitigating/ aggravating factors	0%
2008	Synthetic rubber (NBR)	4	before mitigating/ aggravating factors	0%
2008	Car glass	3	settlement	10 – 20%
2007	Flat glass	4	before mitigating/ aggravating factors	16 – 25%
2007	Professional videotapes	3	before mitigating/ aggravating factors	0%
2007	Bitumen Spain	6	before mitigating/ aggravating factors	0 – 4%
2006	Synthetic rubber (BR/ESBR)	4	before mitigating/ aggravating factors	4 – 25%
2006	Bitumen Nederland	13	before mitigating/ aggravating factors	16 – 25%
2006	Methacrylates	3	before mitigating/ aggravating factors	0%
2005	Rubber Chemicals	2	before mitigating/ aggravating factors	16 – 25%
2005	Industrial bags	14	before mitigating/ aggravating factors	8 – 33%
2005	Italian raw tobacco	4	before mitigating/ aggravating factors	0%
2005	Thread	10	before mitigating/ aggravating factors	25 – 33%

Table 9: Data precision ($\varepsilon = 0.5$, $\alpha = 0.15$)

Firm	yearly turnover, floor	yearly turnover, ceiling	yearly sales	% error
ENI	10	30	20	33%
ExxonMobil	10	30	20	33%
Hansen & Rosenthal	20	40	30	25%
Repsol	10.8	10.8	10.8	0%
Sasol Wax GmbH	160	180	170	5.5%
Sasol Wax International AG	160	180	170	5.5%
RWE	10	30	20	33%
Total	20	40	30	25%