Penalising on the basis of the severity of the offence: A sophisticated revenue-based cartel penalty

Katsoulacos, Y.; Motchenkova, Evgenia; Ulph, D.

2017

document version
Publisher's PDF, also known as Version of record

TILBURG UNIVERSITY

TILEC

TILEC Discussion Paper

DP 2017-014

Penalizing on the basis of the severity of the offence: A sophisticated revenue-based cartel penalty

By
Yannis Katsoulacos, Evgenia Motchenkova, David Ulph

May 2017

ISSN 1572-4042

ISSN 2213-9419 http://ssrn.com/abstract=2970395

Penalising on the basis of the severity of the offence:

A sophisticated revenue-based cartel penalty[1]

Yannis Katsoulacos[2]
Evgenia Motchenkova[3]
David Ulph[4]

Abstract

In Katsoulacos, Motchenkova and Ulph (2015) we examined the welfare properties of a number of monetary penalty regimes for tackling cartels, including revenue-based penalties (the most widely used regime), illegal gains-based penalties, and overcharge–based penalties. We showed that the latter regime welfare-dominates the others. However it is subject to criticism on the grounds of legal uncertainty and high implementation costs. In this paper we focus on analysing an alternative regime: a *sophisticated revenue-based penalty regime* in which the penalty *base* is the revenue of the cartel but the penalty *rate* depends on (and increases with) the cartel overcharge rate. Thus, in contrast to the currently employed simple revenue-based regime, the proposed regime penalises cartels taking also into account the severity of their offence in terms of the height of their overcharge. We show that this hybrid regime can effectively replicate the desirable welfare properties of an overcharge-based penalty structure while having very low levels of legal uncertainty and implementation costs.

JEL Classification: L4 Antitrust Policy, K21 Antitrust Law, D43 Oligopoly and Other Forms of Market Imperfection.

Keywords: Antitrust Penalties, Antitrust Enforcement, Antitrust Law, Cartels.

[1]We are grateful to Joe Harrington, Frederic Jenny and Tom Ross for helpful discussions and comments and to the Tinbergen Institute, Vrije Universiteit Amsterdam, Short-term Visitor Program for financial support.
[2]Department of Economic Science, Athens University of Economics and Business, Patission 76, Athens 104 34, Greece. Email: ysk@hol.gr
[3]Department of Economics, Vrije Universiteit Amsterdam, TILEC and Tinbergen Institute, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands. Email: emotchenkova@feweb.vu.nl
[4] School of Economics and Finance, University of St Andrews St Andrews, KY16 9AR, Scotland. Email: du1@st-andrews.ac.uk

1. Introduction

The imposition of sanctions have been regarded as the most important *ex ante* intervention instrument that Competition Authorities (hereafter CAs) can use in antitrust and, more specifically, cartel violations.[5] Their continuing significance is confirmed by extensive empirical evidence which suggests that cartels are still very active throughout the world and pervasive in a variety of markets.[6]

The current paper concentrates on sanctioning methods as a part of the *public enforcement* of Competition Law on cartel cases.[7] There is a variety of different types of sanctions with different emphasis placed on each type over time and in different countries. In this paper we concentrate on financial, or monetary, penalties on corporations.[8] Our main objective is to contribute to the growing recent literature on monetary penalty regimes[9] by suggesting an alternative regime to the ones currently utilised or that have been proposed in the recent literature, which, as we show below, is superior to all these other regimes when account is taken of a number of assessment criteria for evaluating them.

While economists have concentrated on a comparison of the welfare properties of the different regimes, and while this comparison is very important in identifying regimes that are superior in terms of their welfare impact, in order for the comparison to have policy significance, that is in order to guide policy makers in making choices of the sanctioning policy that should be adopted by CAs, a number of other policy-relevant dimensions of the

[5] The theory of sanctioning on dominant firm abuses is still undeveloped . Other important *ex ante* instruments of competition law enforcement in the area of cartels are the prohibition of *facilitating practices* (which can increase the viability of cartels) and the use of merger policy (to reduce the likelihood of cartels emerging after mergers). *Ex post* measures include the improvement of detection and prosecution rates, the adoption of measures to keep industries competitive after prosecution (prevent recidivism) and the application of leniency policies.

[6] See e.g. Levenstein and Suslow (2011, 2012, 2014), Schinkel (2007), Veljanovski (2007), Connor and Lande (2008), Allain et al. (2011), Boyer and Kotchoni (2015) or Spagnolo and Marvão (2016) for an overview.

[7] There is a distinction between public enforcement sanctioning and private damage actions as these serve primarily different purposes. Public enforcement focuses on the detection and investigation of cartels the objective being to bring cartel activity to an end and imposing sanctions for infringements which aims to punish and to deter future violations. Private damages on the other hand, focus on compensating those who have suffered harm. So, the two methods are complementary but each can contribute to the objectives of the other. Public enforcement can facilitate and stimulate private damage actions and private damage actions can contribute to deterrence and provide incentives to customers to discover and report price-fixing.

[8] The other main types of sanctions in public enforcement are: financial penalties on managers involved in price-fixing, criminal sanctions/imprisonment of individuals involved in price-fixing, debarment of individuals involved in price-fixing, from further employment in a position from which they could again violate antitrust laws. See for a review Katsoulacos et al. (2017).

[9] See e.g. Harrington (2004, 2005), Buccirossi and Spagnolo (2007), Harrington (2010), Houba et al. (2010), Bageri et al. (2013), Katsoulacos and Ulph (2013), Dargaud et al. (2015) and Katsoulacos et al. (2015), Bos et al. (2016).

regimes have to be assessed and compared. Specifically, a complete comparison has to take into account the following three dimensions / assessment criteria:

(i) **Implementability**. This involves considerations relating to the administrative cost of the penalty regime,[10] the extent to which it minimises delays in the CA enforcement process[11] and the extent to which it minimises the costs of appeals in the judicial review process.[12] The latter will be higher the more the appeals that are induced, against the CA's penalty decisions, by a penalty regime. The number of appeals will be greater the more likely it is that the penalty regime can lead to estimation errors and/or when penalty decisions can be easily challenged as been discriminatory.

(ii) **Legal Certainty**. Penalty regimes differ in terms of how easily and accurately firms can predict the fine that they will be facing IF they are prosecuted and are found to violate the law. When firms cannot predict the estimates of penalties that the CA will make were it to investigate and condemn their conduct we have legal uncertainty. Since penalties are generally calculated as a fraction of a *"penalty base"* (such as revenues or profits) and since penalty guidelines only specify that this fraction (the *"penalty rate"*)[13] will fall within a range that will depend on a large number of mitigating and aggravating circumstances, there is always some legal uncertainty in predicting the CA's penalty estimate in any specific case. This uncertainty increases as it becomes more difficult to obtain accurate estimates of the "penalty base" and to calculate the appropriate "penalty rate".

(iii) **Welfare properties**. While the traditional economics literature has identified first-best optimal penalties, emphasizing their deterrence properties, the more recent literature has focused on comparing penalty regimes in a second-best world. Since it is then assumed that, as is true in practice, penalties cannot be set so as to deter all or even most cartels,[14] it is important to address also the price effects of the

[10] The cost required in order to collect the necessary information and to undertake the estimation of the penalty by the CA and the firms.

[11] The more the information required by a penalty regime and the more difficult it is to obtain reliable data on this information the more lengthy will be the process of estimation and hence the greater the delay in reaching decisions.

[12] That is, the cost for the CA of defending its decisions in Courts of Appeal and the cost that the firms have to incur when appealing against the CA's decisions.

[13] So the penalty is equal to the product of the penalty base (e.g. revenue) and the penalty rate chosen when a given base is chosen.

[14] For example, due to bankruptcy considerations and in order not to violate the legal "proportionality principle" (see also below) most countries have legal ceilings on antitrust fines set at 10% of annual turnover. Many authors showed that this penalty is insufficient (see e.g. Buccirossi and Spagnolo (2007), Harrington (2010),

penalty regimes on cartels that are not deterred. So, a proper second-best welfare comparison has to take into account of both the deterrence and the price effects of penalty regimes. The most extensive and rigorous recent comparison of the welfare properties of the penalty regimes described below is contained in Katsoulacos et al. (2015).

Clearly a penalty regime is better than another one if it easier to implement, it generates less legal uncertainty and has a superior overall welfare impact. Unfortunately, regimes that are superior in terms of their welfare properties are not superior (and may be inferior) in terms of the other assessment criteria we mentioned above. This makes it very difficult to translate results regarding the welfare properties of different regimes into proposals concerning which of these regimes should be adopted and implemented by CAs in practice.

The literature on the optimal design of antitrust monetary penalties has examined four main regimes: damages-based regime, illegal gains-based regime, revenue–based regime and overcharge–based regime. In this paper we focus on analysing an alternative (fifth) regime: the *sophisticated revenue-based penalty regime* in which the penalty *base* is the revenue of the cartel but the penalty *rate* depends on (and increases with) the cartel overcharge rate (see for more details the next section). Thus, in contrast to the currently employed simple revenue-based regime, the proposed regime penalises cartels taking also into account the severity of their offence in terms of the height of their overcharge.

The structure of the paper is as follows. Section 2 provides a brief descriptions of the main penalty regimes including the one proposed in this paper and of how they perform in relation to the three assessment criteria above. Section 3 analyses price effects and deterrence properties of the sophisticated revenue-based penalty regime and shows its superiority. Section 4 offers a brief comparison with other penalty regimes while section 5 concludes.

2. Brief review of alternative monetary penalty regimes and main results

The existing literature has identified and analysed four main monetary penalty regimes. Below we start with brief descriptions of these regimes and of an alternative (fifth) regime, which we analyse in this paper and of how they perform in relation to the three assessment criteria above.

Bageri et al. (2013) and Katsoulacos and Ulph (2013)). As a result these ceilings make antitrust policies either completely ineffective or at best partially effective in such a way that only low prices are deterred, while high prices are still sustainable. See also Houba et al. (2017) for more detailed discussion.

1. Damages-based regime. That penalties should be based on the damages that the unlawful conduct generates to others was proposed in the seminal article of Becker (1968) examining optimal (first-best) penalties – under the assumption that the objective of the enforcing agency is to maximise (total) social welfare. However, damages to others are very difficult to estimate accurately and their estimation is likely to be subject to quite significant errors. Thus though the welfare properties of damage-based penalties are very good, inducing cartel prices that are below the monopoly level,[15] such penalties have very significant implementability problems and can create a significant amount of legal uncertainty. For these reasons they have never formed the basis of antitrust sanctioning in practice.
2. Illegal gains-based regime. Penalties based on illegal gains were early identified for their welfare properties and their adoption was proposed most forcefully by Lande (1982) as most appropriate for enforcing authorities whose objective is to deter conduct that does not generate any efficiencies (such as price fixing) in order to avoid the reduction in consumer surplus that results from such conduct. Illegal gains are defined as cartel's profits over and above the counterfactual level of profits.[16] The welfare properties of these penalties in a second-best world[17] are *not* very good since they induce cartel prices that are equal to the monopoly level.[18] Further, as explained in Figure 3 in Appendix 1, it is difficult to estimate accurately illegal-gains based penalties in most cases and their estimation is likely to be subject to quite significant errors. Thus, such penalties have significant implementability problems and can create a significant amount of legal uncertainty. Nevertheless, because they are thought to have very good welfare properties through dissuasion of cartel activity they are included in the penalty structures adopted in many countries, though they are very rarely implemented as in practice antitrust authorities mainly use revenue-based structures.
3. Revenue–based regime. This is the regime most often adopted and implemented by CAs for estimating monetary penalties throughout the world. The main reason seems

[15] See also Appendix 1 for detailed derivations.
[16] In the special case where the counterfactual price is the marginal cost (competitive price), the illegal gains are the same as the cartel profits.
[17] Where penalties are lower than their first best-level of illegal gains weighted by the inverse probability that the illegal conduct is detected and penalized and, therefore, cartels do form and survive for long periods of time. Adopting first-best penalties would violate the legal "principle of proportionality" and would create very significant legal uncertainty.
[18] See Bageri et al. (2013), Katsoulacos et al. (2015) and Appendix 1 for a brief description and formal arguments that support this result.

to be that it scores very high in terms of easiness of implementability and also legal uncertainty problems are minimized. On the other hand, as the recent theoretical literature has emphasized, revenue-based regimes are very weak in terms of their welfare properties. In particular, when their "toughness" is set so as to generate the same deterrence as other regimes,[19] revenue-based regimes generates prices above the monopoly level as well as a number of other distortions (see Bageri et al. (2013), Katsoulacos et al. (2015)).

4. Overcharge-based regime. This has been shown to be superior in terms of its overall welfare impact relative to the revenue-based and profit-based regimes (see Katsoulacos et al., 2015). However, its calculation is based on obtaining estimates of the overcharge (the difference between the cartel and the counterfactual price) and, more importantly, the counterfactual volume of sales.[20] This implies that this regime is difficult to implement and creates substantial legal uncertainty.

In this paper we propose an alternative penalty regime and examine its properties, the following.

5. Sophisticated revenue-based penalty regime. In this, the penalty base is the revenue of the cartel but the penalty rate depends on (and increases with) the cartel overcharge rate. So, in calculating the penalty, the CA needs to estimate revenue, as under the revenue-based regime and also has to estimate the price overcharge, as under the damages-based, illegal gains-based and overcharge-based regimes. In the latter three regimes, however, additional information is required in order to obtain an accurate estimate of the penalty base, on top of that related to the overcharge, information which is quite hard to obtain and is easily open to dispute. Specifically, for an estimate of the illegal gains-based penalty one must also calculate how the but-for output and price differ from the output and price corresponding to perfectly competitive situation.[21] Thus our proposed regime is relatively easier to implement and performs well on legal uncertainty - better in terms of these assessment criteria than the damages-based, illegal gains-based and overcharge-based regimes. Further, while it is inferior on implementability and legal uncertainty compared to the revenue-

[19] That is, when they are deterrent-equivalent to other regimes.
[20] It is the product of these that forms the "penalty base" of this regime.
[21] See also the discussion below (with Figure 3) and the Appendix 1 clarify this contention.

based regime it is, as we show below, much better than the latter (and similar to the overcharge based regime) on welfare grounds.[22]

The following Table summarizes the above discussion and the conclusions reached in Section 3.

Table 1

Assessment criterion / Penalty Regime	Implementability difficulties	Legal Uncertainty	Welfare impact
Damages-based	High	High	Strong
Illegal gains-based	High	High	Moderate
Overcharge-based	High	High	Strong
Revenue-based	Low	Low	Poor
Sophisticated revenue-based	Moderate	Moderate / Low	Strong

As mentioned above, most CAs throughout the world have guidelines on the calculation and imposition of antitrust penalties that prescribe revenue-based monetary penalties for cartels in which the penalty rate depends on a number of aggravating and mitigating circumstances but not on the cartel overcharge.[23] Many countries also provide in their statues for the imposition of penalties based on illegal gains (see e.g. antitrust fining guidelines of the US, Germany, Chile, or China).[24] In these cases, it is interesting to note that the penalties based on illegal gains are supposed to constitute an additional penalty that is combined with the revenue-based penalty in order to reach the overall penalty figure imposed on law violators. However, illegal gains-based penalties are rarely implemented – for example in US in only one case has the imposition of a penalty based on illegal gains been implemented.[25] Nevertheless, in many of the younger jurisdictions in which competition law in relation to the imposition of sanctions is formulated, CAs have opted for including illegal gains-based penalties as an potential additional element that can be taken into account in calculating

[22] It is also better or not worse, with respect to welfare criterion, than the other regimes – damages-based and illegal gains-based.
[23] See for example Bageri and Katsoulacos (2014).
[24] For detailed overview of the penalty structures implemented in OECD countries see OECD Report (2002).
[25] As we have been informed in a private communication with Greg Werden.

monetary penalties[26], though this has not improved the implementation record of illegal gains-based penalties because of the difficulties in their estimation and the legal uncertainty that they create[27] – despite their having a more favourable welfare impact than revenue-based regimes.

Our main contribution in this paper is to show that a sophisticated revenue-based regime has superior welfare properties that replicate the welfare properties of an overcharge-based regime demonstrated in Katsoulacos et.al (2015) and is *also* superior in terms of the other two assessment criteria (implementability and legal uncertainty). And, this regime can achieve its superior welfare impact without being combined with any other penalty regimes.

So, in section 3 – the bulk of the paper - we focus on examining the sophisticated revenue-based regime and showing that it has the same welfare properties as the overcharge – based regime – which, as we have previously shown, welfare dominates others - but avoids its problems of legal uncertainty and implementability. We also undertake a systematic comparison with the simple revenue-based penalty regime that is currently widely employed, showing that the sophisticated regime will achieve lower prices and can outperform it in terms of deterrence. In Section 4 we undertake a brief comparison with other penalty regimes. Section 5 offers our conclusion that such a modification of the current revenue-based structure may have a significant positive impact, if adopted by CAs.

3. Analysis of a sophisticated revenue-based regime

In this section we derive the welfare properties of what we call a *sophisticated* revenue-based penalty regime whereby the base for the penalty is the revenue actually earned by any cartel that a CA successfully prosecutes, but where the penalty rate applied to that base varies depending on the (percentage) overcharge, θ, that was set by the cartel, according to a formula $\rho(\theta) \geq 0$. Moreover, in order to avoid legal uncertainty we take it that this formula is the same across all cartel cases and is pre-announced.[28]

[26] For example, on 17 June 2016, the Chinese CA enforcing CL in the area of price-related anticompetitive conduct (NDRC) published "Draft Guidelines on the Determination of Illegal Gains and Fines in Relation to Undertakings' Monopoly Conduct which are expected to be introduced formally this year. With these Guidelines the NDRC attempts to make illegal-gains an important part of penalty setting in China and this has been commended by Koren W Wong-Ervin et.al.(2016) – the Chinese authorities have tried to calculate illegal gains in setting penalties in only about 10% of the cases since 2008 when the anti-monopoly law was introduced. Also Chilean Competition Authority has adopted penalties based on illegal gains in 2014.

[27] "Difficult to be estimated" and "Easy to be challenged" is the standard way of explaining why penalties based on illegal gains are rarely used. Appendix 1 also provides more formal analysis to support these arguments.

[28] In practice CAs often adjust penalties to reward/punish other behaviours such how cooperative firms have been in assisting the investigation. Since we don't model these other behaviours we will focus on the adjusted

More specifically our aim is to determine the class of such penalty-rate functions that share the major property of overcharge-based penalty regimes, namely that they induce all cartels to set an overcharge that is below the monopoly overcharge. In addition, in this section we will contrast the performance of such a *sophisticated* revenue-based penalty regime with that of the widely used *simple* revenue-based penalty regime in which the penalty rate applied to cartel revenue is independent of the overcharge set by cartels but, again for reasons of legal certainty, is also pre-announced and constant across all cartel cases. In the following section we will compare the performance of the *sophisticated* revenue-based penalty regime with that of other penalty regimes.

3.1 *Model Setup*

The model is the repeated game model of cartel formation and pricing behaviour employed in Katsoulacos et al. (2015), though it is specified differently since, given the structure of the penalty regime, the cartel overcharge is the key decision variable of interest in the current paper. We consider an economy comprising a range of industries. There are *n* firms in the industry producing a homogeneous product, each having the same constant unit costs of production, $c > 0$. Demand for this product is given by the downward-sloping demand function $Q(p)$ with the properties that the elasticity, $\eta(p) = -\frac{pQ'(p)}{Q(p)} > 0$ is non-decreasing in p and $\exists \tilde{p} \geq 0$ s.t. $\eta(p) > 1 \; \forall p > \tilde{p}$. We assume the counterfactual to be Bertrand competition with the "but-for" price equal to *c* and the "but-for" output equal to $Q(c)$. For a cartel to have any effective ability to raise price, above the "but-for" price all *n* firms will have to be members. So, an industry is characterised by the industry parameters: *n*, *c, Q*(*p*) and hence $\eta(p)$.

If a cartel forms and sets a price $p > c$ then the percentage overcharge is $\theta = \frac{p-c}{c}$. So $p = c(1+\theta)$. For any given overcharge set by the cartel the associated operating profits, π, (respectively revenue, *R*) will be $\pi = c\theta Q\left(c(1+\theta)\right)$, $\left(\text{resp. } R = c(1+\theta)Q\left(c(1+\theta)\right)\right)$.

There is a Competition Authority (CA) that investigates, discovers, prosecutes and penalises cartels. Let β, $0 \leq \beta < 1$ be the constant probability that in each period a cartel is detected, successfully prosecuted and penalised according to the penalty schedule specified

---

penalty, and how it should be set in relation to the behaviours that we do model: cartel formation and the cartel pricing decision.

above. We assume that the value of β is known by all firms at the time they decide to form a cartel and determine what price the cartel will set. We assume that, in the course of its investigation into any given cartel case, *k*, the CA discovers the overcharge, θ_k set by that cartel and the revenue R_k earned by the cartel, and so calculates the penalty $\rho(\theta_k)R_k$ that it will impose in that case. Since there is a single pre-announced formula, $\rho(\theta)$, the cartel can in principle calculate for every overcharge θ it might want to set the penalty $\rho(\theta)c(1+\theta)Q(c(1+\theta))$ it will suffer if it is successfully prosecuted and so has no legal uncertainty with regard to penalties.

Similar to e.g. Motta and Polo (2003) and Chen and Rey (2013), we assume the cartel re-establishes following a successful prosecution. Given this and other assumptions, the expected present value of profits of any firm that is a member of the cartel in a given industry that has set an overcharge θ is:

$$V(\theta) = \frac{c\theta Q(c(1+\theta)) - \beta\rho(\theta)c(1+\theta)Q(c(1+\theta))}{\Delta} \qquad (1)$$

where, $\delta, 0 < \delta < 1$ is the discount factor, and

$$\Delta \equiv n(1-\delta) \qquad (2)$$

is what we call the *intrinsic difficulty* of holding the cartel together.[29]

In case of defection, cartel members implement standard *grim trigger strategy* and set the competitive price, *c*, for ever more. We also assume that defecting firm is immune from future prosecution by the CA.[30] Since the overcharge set by a cartel could be above the monopoly overcharge, θ^M - for example when a *simple* revenue-based penalty regime is employed - a defecting firm trying to make the maximum profits in the single period before the *grim trigger strategy* is implemented will set the monopoly overcharge whenever the cartel overcharge is above the monopoly, but will set an overcharge just a fraction below the cartel overcharge whenever this is at or below the monopoly overcharge, thereby capturing the entire cartel profits. So defection profits are

$$\pi^d(\theta) = \begin{cases} \pi(\theta^M), & \theta > \theta^M \\ \pi(\theta), & \theta \le \theta^M \end{cases} . \qquad (3)$$

For a cartel to be stable it has to satisfy the cartel stability condition:

$$V(\theta) \ge \pi^d(\theta). \qquad (4)$$

[29] Intrinsic difficulty parameter was introduced in Katsoulacos et al (2015).
[30] Note the opposite assumption would not affect the main qualitative results of the paper.

We now determine how the penalty regime used by the CA affects both the price/overcharge set by the cartel and cartel stability/deterrence.

3.2 *Analysis of Cartel Pricing*

The cartel overcharge will be set so as to maximise $V(\theta)$ subject to the cartel stability condition (4). This calls for analysis of two situations: unconstrained pricing solutions in which the stability condition does not bite; constrained pricing solutions in which the stability condition bites. We analyse these in turn.

3.2.1 Unconstrained Pricing Solutions

To understand the effects of the penalty regime on the resulting overcharge, we analyse three cases: the benchmark case where a CA is absent; the case where a CA is present but operates a simple revenue-based penalty; and the case of interest where a CA is present and operates a sophisticated revenue-based penalty regime.

In the absence of CA, maximising expected cartel profits in (1) is equivalent to maximising $X(\theta) = c\theta Q\big(c(1+\theta)\big)$. So a cartel will act like a monopolist and choose θ that satisfies (5):

$$X'(\theta) = Q\big(c(1+\theta)\big) + \theta c Q'\big(c(1+\theta)\big) = Q\big(c(1+\theta)\big)\left[1 - \frac{\theta}{1+\theta}\eta\big(c(1+\theta)\big)\right] = 0 \qquad (5)$$

So the monopoly overcharge, θ^M is the solution to the equation:

$$\eta\big(c(1+\theta)\big) = \frac{1+\theta}{\theta} \ . \qquad (6)$$

Since the RHS of (6) is a strictly decreasing function of θ, it follows that every industry satisfying the above assumptions[31] has a unique well-defined monopoly overcharge $\theta^M > 0$. Clearly the monopoly overcharge can vary across industries, and, in principle, any $\theta > 0$ could be the monopoly overcharge for some industry.

In the presence of CA operating a *Simple* Revenue-Based Penalty Regime with penalty rate $\rho(\theta) \equiv \rho_0 > 0$ [32] and toughness $\tau_0 = \beta\rho_0 > 0$ maximising expected cartel profits in (1) is equivalent to maximising:

[31] Specifically the assumption that the function $\eta(.)$ is non-decreasing

[32] A simple revenue-based penalty regime is just a special case of the penalty regime considered above where the penalty rate function takes the form $\rho(\theta) \equiv \rho_0$.

$$Y_{\tau_0}(\theta) = \theta Q\big(c(1+\theta)\big) - \tau_0(1+\theta)Q\big(c(1+\theta)\big).^{33\ 34} \tag{7}$$

It is easy to see that we have

$$Y_{\tau_0}'(\theta) = Q\big(c(1+\theta)\big)\left\{\left[1-\frac{\theta}{1+\theta}\eta\big(c(1+\theta)\big)\right] - \tau_0\left[1-\eta\big(c(1+\theta)\big)\right]\right\}. \tag{8}$$

Using (6) and evaluating this expression at θ^M, we get

$$Y_{\tau_0}'\left(\theta^M\right) = Q\big(c(1+\theta^M)\big)\frac{\tau_0}{\theta^M} \geq 0; \tag{9}$$

We then have the following result.[35]

Proposition 1: Under a *simple* revenue-based penalty regime:

(i) In every industry there is a unique unconstrained cartel overcharge, $\hat{\theta}_0^C$, which is the solution to the equation:

$$\eta\big(c(1+\theta)\big) = \frac{1-\tau_0}{\frac{\theta}{1+\theta}-\tau_0} \equiv \psi(\theta,\tau_0);^{36} \tag{10}$$

(ii) if $\tau_0 > 0$ then $\hat{\theta}_0^C > \theta^M$.

Proposition 1 just re-establishes the result previously proved in Katsoulacos and Ulph (2013), Bageri et al. (2013) and Katsoulacos et al. (2015), and highlights the fundamental weakness of the *simple* revenue-based penalty regime. For, evaluated at the monopoly overcharge, revenue and hence the penalty that the cartel will pay is a *decreasing* function of the overcharge. By thus effectively punishing cartels less the more harm they cause, *simple* revenue-based penalty regimes give cartels an incentive to raise the overcharge above the monopoly overcharge.

Finally, in the presence of CA operating a *Sophisticated* Revenue-Based Penalty Regime with penalty rate $\rho(\theta)$, which varies with the cartel overcharge, maximizing the expected present value of cartel profits in (1) is equivalent to maximizing $Z(\theta) \equiv \theta Q\big(c(1+\theta)\big) - \beta\rho(\theta)(1+\theta)Q\big(c(1+\theta)\big)$. So we have

$$Z'(\theta) = Q\big(c(1+\theta)\big)\left\langle\left[1-\frac{\theta}{1+\theta}\eta\big(c(1+\theta)\big)\right] - \beta\left\{\rho(\theta)\left[1-\eta\big(c(1+\theta)\big)\right] + (1+\theta)\rho'(\theta)\right\}\right\rangle \tag{11}$$

Using (7) we can evaluate this at θ^M and obtain:

---

[33] Notice $Y_0(\theta) = X(\theta)$

[34] Note also that if $\hat{Y}(\tau_0) = \underset{\theta}{MAX}\, Y_{\tau_0}(\theta)$, then by envelope theorem we have $\hat{Y}'(\tau_0) = -\left(1+\hat{\theta}_0^C\right)Q\left[c\left(1+\hat{\theta}_0^C\right)\right] < 0$.

[35] For detailed proof of Proposition 1 see appendix 2.

[36] For there to be any solution to this equation we clearly need $\tau < 1$.

$$Z'(\theta^M) = Q\left(c(1+\theta^M)\right)\left\langle \beta\left\{\frac{\rho(\theta^M)}{\theta^M} - (1+\theta^M)\rho'(\theta^M)\right\}\right\rangle \qquad (12)$$

As noted above, in principle any $\theta > 0$ could be a monopoly overcharge, so if the penalty-rate function $\rho(\theta)$ satisfies the property that:

$$\forall\, \theta > 0 \quad \frac{\rho'(\theta)}{\rho(\theta)} > \frac{1}{\theta(1+\theta)}, \qquad (13)$$

then we have $Z'(\theta^M) < 0$ and the following proposition holds. [37]

Proposition 2: Under a *sophisticated* revenue-based penalty regime:

(i) *The unconstrained cartel overcharge,* $\hat{\theta}_1^C$*, is a solution to the first-order condition:*

$$\eta\left(c(1+\theta)\right) = \frac{1-\beta\rho(\theta)-\beta(1+\theta)\rho'(\theta)}{\frac{\theta}{1+\theta}-\beta\rho(\theta)} \equiv \varphi(\theta,\beta). \qquad (14)$$ [38]

(ii) If $\rho(\theta)$ *satisfies property* (13) *then in every industry* $\hat{\theta}_1^C < \theta^M$

(iii) For the class of sophisticated revenue-based penalty regimes for which $\varphi(\theta,\beta)$ *is a decreasing function of* θ*, in every industry there is a unique solution to* (13).

In Figure 1 we illustrate the key results of Propositions 1 and 2 by showing the determination of $\theta^M, \hat{\theta}_0^C, \hat{\theta}_1^C$. [39]

[37] See appendix 2 for detailed proof of Proposition 2.

[38] Note that in the special case of a *simple* revenue-based penalty regime whereby $\rho(\theta) \equiv \rho_0 \geq 0$, (13) does not hold, and, moreover, it follows that $\varphi(\theta,\beta) = \psi\left(\theta,\tau_0\right)$ and so $\hat{\theta}_1^C = \hat{\theta}_0^C > \theta^M$.

[39] Purely for simplicity we have drawn the function $\eta\left(c(1+\theta)\right)$ as being linear in θ.

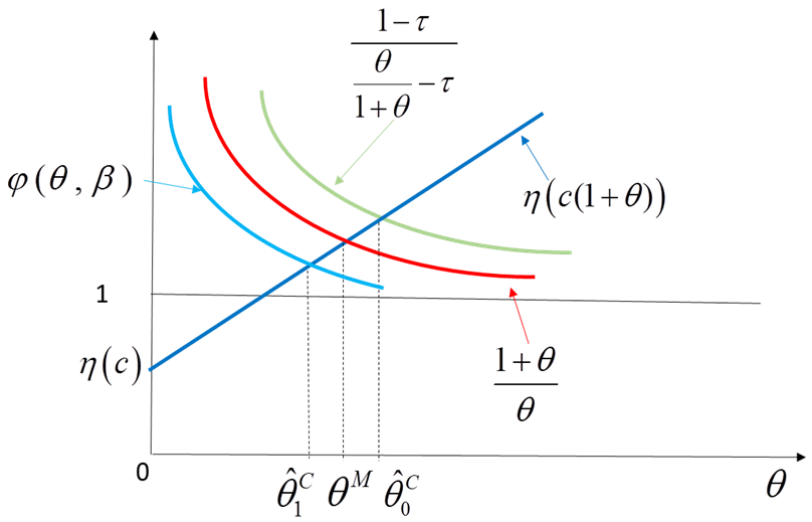

Figure 1: Unconstrained Cartel Overcharges in three setups.

Proposition 2 tells us that in order to overcome the disadvantage of the *simple* revenue-based penalty regime whereby the penalty is a decreasing function of the overcharge, the CA needs to raise the penalty rate sufficiently fast with the overcharge so that now the penalty truly increases with the magnitude of the harm/overcharge and so gives firms an incentive to price below the monopoly overcharge. The formula in (13) just makes precise what "sufficiently fast" means. Indeed, before proceeding, consider the case of an overcharge-based penalty regime as specified in Katsoulacos et al. (2015), whereby a cartel that sets an overcharge θ faces an expected penalty $\rho_O \theta c Q(c)$. By expressing this as fraction of revenue it is easy to see that an overcharge-based penalty regime can be thought of as a *sophisticated* revenue-based penalty regime where the penalty-rate function is:

$$\tilde{\rho}(\theta) = \rho_O Q(c) \frac{\theta}{(1+\theta) Q\left(c(1+\theta)\right)}, \tag{15}$$

which implies

$$\frac{\tilde{\rho}'(\theta)}{\tilde{\rho}(\theta)} = \frac{1}{\theta(1+\theta)} + \frac{\eta\left(c(1+\theta)\right)}{1+\theta} > \frac{1}{\theta(1+\theta)}. \tag{16}$$

What this shows is that:

a) In the unconstrained solution case an overcharge-based penalty regime "works" – i.e. generates cartel overcharges below the monopoly overcharge – because it is effectively equivalent to a sophisticated revenue-based penalty regime that satisfies (13) and so for which Proposition 2 applies.

b) However it doesn't satisfy the legal uncertainty conditions we imposed on a sophisticated regime because:

   i. From (15) the level of the penalty-rate function depends on $Q(c)$ and so would vary across cases.

   ii. From (16) the percentage rate of change of the penalty rate depends on the elasticity function $\eta\left(c(1+\theta)\right)$ so varies across cases/ industries.

Notice that the lower bound on the derivative of the penalty rate function that is given by (13) is a function purely of the overcharge and doesn't depend on industry parameters and so any penalty-rate function satisfying this condition can be the same across all industries.

Obviously, infinitely many functions can satisfy condition (13). The question is how to identify the appropriate structure of the penalty rate, which would score sufficiently well on all the three assessment criteria (implementability, legal uncertainty and welfare impact). An important consideration in picking which particular function to use is that the penalty rate function should have a very simple shape otherwise there will be appeals on the grounds that there are disproportionate increases in the penalty rate. With this in mind, we consider the class of functions satisfying

$$\frac{\rho'(\theta)}{\rho(\theta)} = \frac{1}{\theta(1+\theta)} + \frac{\varepsilon}{(1+\theta)}, \quad \varepsilon > 0,^{40} \tag{17}$$

where ε is a parameter that reflects the strength of desire of the CA to drive price below the monopoly price. In order to solve this differential equation we have to specify the value of $\rho(0)$. We set $\rho(0) = 0$ on the grounds that, since no harm would be caused with a zero overcharge, a positive penalty would be subject to appeal on the grounds of lack of proportionality.[41] Given this assumption the solution to (17) is $\rho(\theta) = \rho_1(1+\theta)^{\varepsilon}\left(\frac{\theta}{(1+\theta)}\right)$, where $\rho_1 > 0$ is a constant of integration. But then notice that in the special case where $\varepsilon = 1$ we have a **linear** penalty-rate function:

$$\rho(\theta) = \rho_1\theta, \quad \rho_1 > 0\,. \tag{18}$$

Consequently, on the grounds of ease of implementation, in what follows we will confine attention to this class of **linear** penalty-rate functions. Similarly to the discussion of the

[40] The formula is not dissimilar to that in (16) that arises for overcharge-based penalty regimes, the key difference being that the numerator in the second term on the RHS of the expression is industry independent and no longer bears any interpretation as an elasticity.

[41] Notice that if we had set $\rho(0) > 0$, then (17) implies $\rho'(0) = \infty$ which would give rise to concerns over proportionality of penalties for small overcharges.

parameter $\tau_0 = \beta\rho_0$, we will let $\tau_1 = \beta\rho_1$ denote the toughness of the *sophisticated* revenue-based penalty regime and impose the restriction that $\tau_1 < 1$.

3.2.2 Constrained Pricing Solutions

We now consider what form of solution might arise when the cartel stability condition bites. Again it helps to consider separately the three cases discussed above.

If there is no CA ($\beta=0$) an unconstrained cartel sets the monopoly price, in which case, from (3) the defection profits are just the cartel profits. Then from (1) and (4) the cartel stability condition is given by

$$\frac{\pi(\theta)}{\Delta} \geq \pi(\theta) \quad \Rightarrow \quad \Delta \leq 1 \tag{19}$$

Hence, this implies constraint on Δ, but not on θ. So in the absence of CA, cartel overcharge θ^M is given by the solution to equation (6). The *overall overcharge* in the absence of CA is illustrated by the red line in Figure 2.

With an active CA (β > 0) operating a *Simple* Revenue-Based Penalty Regime an unconstrained cartel sets a price above the monopoly price in which case the defection profits are just the monopoly profits. Then, from (1), (4), and footnotes 32 and 33, the cartel stability condition becomes:

$$\frac{Y_{\tau_0}(\theta)}{\Delta} \geq \hat{Y}(0) \Rightarrow \frac{\hat{Y}(\tau_0)}{\Delta} \geq \hat{Y}(0) \Rightarrow \Delta \leq \frac{\hat{Y}(\tau_0)}{\hat{Y}(0)} < 1 \ , \tag{20}$$

where the final inequality follows from footnotes 33, which shows that $\hat{Y}(\tau_0)$ is a decreasing function of τ_0. Note as above (20) implies a constraint on Δ, but not on θ. So, under a *simple* revenue-based penalty regime the cartel overcharge is just the unconstrained overcharge $\hat{\theta}_0^C$ for all values of Δ satisfying (20). And the *overall overcharge* under a Simple Revenue-Based Penalty Regime is illustrated by the green line in Figure 2.

With active CA (β > 0) operating a *Sophisticated* Revenue-Based Penalty Regime following the discussion in sub-section 3.3 we restrict attention to **linear** *sophisticated* revenue-based penalty regimes $\rho(\theta) = \rho_1\theta$, which implies an unconstrained overcharge $\hat{\theta}_1^C$ below the monopoly overcharge θ^M. Then, from (1), (3) and (4) the cartel stability condition becomes:

$$V(\theta) = \frac{c\theta Q\big(c(1+\theta)\big) - \tau_1\theta c(1+\theta)Q\big(c(1+\theta)\big)}{\Delta} \geq c\theta Q\big(c(1+\theta)\big) = \pi^d(\theta)$$

This implies

$$\theta \leq \frac{(1-\tau_1)-\Delta}{\tau_1}. \qquad (21)$$

This upper bound on θ is a linear decreasing function of Δ taking the value zero when $\Delta = 1-\tau_1 < 1$. So there are certainly values of $\Delta \approx 1-\tau_1$ for which the upper bound in (21) lies below the unconstrained overcharge. But then the overall cartel overcharge under a **linear** *sophisticated* revenue-based penalty regime is:

$$\theta_1^C = MIN\left[\hat{\theta}_1^C, \frac{(1-\tau_1)-\Delta}{\tau_1}\right], \quad 0 \leq \Delta \leq 1-\tau_1 < 1. \qquad (22)$$

Obviously if $\frac{(1-\tau_1)}{\tau_1} > \hat{\theta}_1^C$ there will be a range of positive values of Δ over which the cartel overcharge will be the unconstrained overcharge. Figure 2 illustrates the overall cartel overcharge under a *sophisticated* penalty-based regime by the blue line.

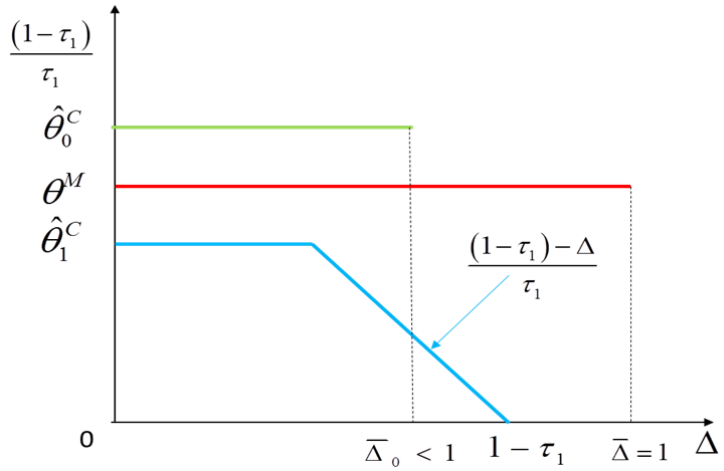

Figure 2: Cartel Overcharge Under *Sophisticated* Revenue-Based Penalty Regime (blue line); Cartel Overcharge Under *Simple* Revenue-Based Penalty Regime (green line); Monopoly Overcharge in the absence of CA (red line)

3.3 *Analysis of Cartel Stability and Deterrence*

As in KMU (2015) we define the critical level of the intrinsic difficulty of holding a cartel together, $\overline{\Delta}$, as the value of Δ below which stable cartels exist and above which no stable cartel exists.[42]

From (19) we see that if that there is no active CA (i.e. $\beta = 0$) then $\overline{\Delta} = 1$; while, from (20), if there is an active CA that operates a *simple* revenue-based penalty regime with *toughness* τ_0 then $\overline{\Delta}_0 = \frac{\hat{Y}(\tau_0)}{\hat{Y}(0)} < 1$, while, from (22), if there is an active CA that operates a *sophisticated* revenue-based penalty regime with *toughness* τ_1 then $\overline{\Delta}_1 = 1 - \tau_1 < 1$. We denote the *degree of deterrence* achieved by an active CA by $D = 1 - \overline{\Delta}$, which measures the fraction of stable cartels that would have formed had there been no CA which now do not form in the presence of a CA.

By taking a first-order Taylor approximation of $\hat{Y}(\tau_0) = \underset{\theta}{MAX}\, Y_{\tau_0}(\theta)$ around $\tau_0 = 0$ it is easy to see that the degree of deterrence achieved under a *simple* revenue-based penalty regime is:

$$D_0 = \tau_0 \frac{\left(1+\theta^M\right)}{\theta^M} = \beta\rho_0 \frac{\left(1+\theta^M\right)}{\theta^M}, \tag{23}$$

while that under a sophisticated revenue-based penalty regime is:

$$D_1 = \tau_1 = \beta\rho_1. \tag{24}$$

Comparison of (23) and (24) gives rise to the following:

Proposition 3:

(i) The degree of deterrence achieved by a simple revenue-based penalty regime varies across industries, being a strictly decreasing function of the monopoly overcharge;

(ii) *The degree of deterrence achieved by a* ***linear*** *sophisticated revenue-based penalty is the same across all industries*.

So another advantage of our proposed **linear** *sophisticated* revenue-based penalty regime gives a CA deterrence certainty, while, with the widely-used *simple* revenue-based penalty regime, it is much harder for a CA to determine the degree of deterrence that it is achieving,

[42] This is analogous to the more conventional discussion of deterrence in terms of critical discount rates but recognises more explicitly that the other parameter that governs the desirability of defection is the number of firms in the industry, *n*.

and it would need to carry out an investigation industry by industry.[43] Alternatively, to get deterrence certainty with a *simple* revenue-based penalty regime, the penalty rate would have to vary across industries in a way that exactly offset the effects of the varying monopoly overcharge. This would give rise to issues of legal uncertainty and consequent appeals.

Since the *sophisticated* revenue-based regime achieves the same degree of deterrence across all industries while the degree of deterrence is a decreasing function of the (monopoly) overcharge for the *simple* revenue-based penalty regime, we can claim the following:[44]

Proposition 4:

Suppose that the slope of the linear sophisticated revenue-based regime, ρ_1 , is set so that:

$$\rho_1 = \rho_0 \left(\frac{1+\overline{\theta}^M}{\overline{\theta}^M} \right) > \rho_0 \qquad (25)$$

*where $\overline{\theta}^M$ is the average monopoly overcharge. Then, in comparison with the simple revenue-based penalty regime, a **linear** sophisticated revenue-based regime will achieve the same degree of deterrence for industries with the average monopoly overcharge and **higher** degrees of deterrence in those industries with above-average monopoly overcharges.*

So, in terms of the degree of deterrence, the sophisticated regime works better where it matters most.

To see the potential implications of this for the value of ρ_1 implied by (25) and for the levels of penalties to which it gives rise, we first need to determine some estimates of the average monopoly overcharge, $\overline{\theta}^M$. We start from studies of the average cartel overcharge, $\overline{\theta}^C$. A meta-analysis in Connor and Bolotova (2006) suggests a value of $\overline{\theta}^C = 0.31$ while a more recent study by Boyer and Kotchoni (2011) that claims to correct for various biases in that study gives figures of 13.6% and 17.5% depending on the sample used. So we set a High estimate of $\overline{\theta}_H^C = 0.3$ and a Low estimate of $\overline{\theta}_L^C = 0.15$. If these are cartel overcharges emerging under widely used *simple* revenue-based regimes then, from Proposition 1, the average monopoly overcharge will be lower.

[43] Note also that as long as the requirements of legal certainty dictate that penalty rates are restricted to being the same across all industries then one can no longer employ deterrence equivalence notion introduced in Katsoulacos et al. (2015) and set penalty rates in the different regimes so as to achieve deterrence equivalence industry by industry.

[44] Proof of Proposition 4 follows immediately (23), (24) and Proposition 3.

So let us assume that associated High and Low estimates of this are, respectively $\overline{\theta}_H^M = 0.25$ and $\overline{\theta}_L^M = 0.125$. The typical penalty rate used in *simple* revenue-based penalty regimes is $\rho_0 = 0.1$. So plugging these figures into (25) the associated figures for ρ_1 would be 0.5 and 0.9 respectively.

If we calculate the actual penalty rate that would be charged on cartels setting what one took to be the average cartel overcharge, then, if one thought that the average overcharge was $\overline{\theta}_H^C = 0.3$ the penalty rate that would be applied to the cartel's revenue under a sophisticated revenue-based penalty regime would be 15%, whereas if one thought that the average overcharge was $\overline{\theta}_L^C = 0.15$ then, under a sophisticated revenue-based penalty regime, any cartel setting such an average overcharge would face a penalty equal to 13.5% of its revenue.

Given the linear nature of our proposed sophisticated revenue-based penalty regime the penalty rates that would be applied to cartels setting overcharges that were a factor f of the average cartel overcharge – i.e. for which $\theta = f\overline{\theta}^C$ would be just $0.15f$ and $0.135f$ respectively. So the penalties applied to cartels setting overcharges that were 3 or 4 times the average would be facing penalties of around 50% - the sort of figure proposed in a number of papers by Connor and Lande – e.g. Connor and Lande (2008).

In summary, the main conclusion from these calculations is that the precise penalties that would be imposed under the linear sophisticated revenue-based penalty regime that we propose are not very sensitive to the underlying estimate of the monopoly overcharge that is assumed. However penalties do rise quite sharply with the overcharge that is actually set by cartels.

4. Comparison with other penalty regimes

Section 3 provided a detailed comparison of our proposed sophisticated revenue-based penalty regime with the simple revenue-based penalty regime that is widely used, demonstrating its superiority. As mentioned in Section 2, the regime proposed here is also superior to the other potential penalty regimes.

The first is illegal gains – the difference between the profits that are made by a cartel and those that the cartel would have made in the counter-factual situation of competition. These counter-factual profits are difficult to estimate which makes this penalty base problematic from the point of view of implementability and legal certainty. In Appendix 1 we show that

under such a penalty regime cartels would set the monopoly price, so it fares worse than the sophisticated penalty regime on this dimension of welfare. For the special case assumed in both this paper and our previous paper – Katsoulacos, Motchenkova and Ulph (2015) – where the counterfactual profits are zero, then, by suitable choice of penalty rate the illegal gains penalty would achieve exactly the same level of deterrence as the sophisticated revenue-based penalty – this deterrence level also being constant across industries. Thus, the overall welfare impact of illegal gains-based penalties are inferior to the regime proposed here (by virtue of their impact on cartel pricing) and are also inferior in terms of their implementability and legal uncertainty properties.

The second potential penalty regime is a damages-based penalty regime. In Appendix 1 we show that such a regime acts like a combination of a profits-based penalty, an overcharge-based penalty and an output subsidy, and so has similar welfare properties to the regime proposed here, as both set prices below the monopoly price. However, like an overcharge-based regime it would be subject to severe implementability and legal uncertainty concerns since damages are very difficult to calculate with any precision. .

5. Conclusions

We conclude that a sophisticated revenue-based penalty regime in which the penalty rate that is applied to revenue rises linearly with the level of overcharge that a cartel is found to have set, according to a pre-announced formula, will welfare-dominate the existing widely-used simple revenue-based penalty regime in terms of both the prices that it induces cartels to set and the levels of deterrence achieved. Moreover it is easy to implement and does not give rise to legal uncertainty concerns: the rate at which the penalty rises with the overcharge can be readily justified and calculated from publicly available information. For all these reasons we believe that this proposed new regime deserves serious attention and consideration from policy makers.

Appendix 1

In this Appendix we provide a brief description of penalties based on illegal gains and on damages – the latter was not formally examined in Katsoulacos et al. (2015).

Consider industry with homogeneous product; demand $Q(p)$ and inverse demand $p^{-1}(Q)$; and constant unit costs c, $0 < c < p^{-1}(0)$. The perfectly competitive price and output, $\left(p^0, Q^0\right)$ are defined by $p^0 = c$, $Q^0 = Q(c)$, and so $\pi^0 = \left(p^0 - c\right)Q^0 = 0$.

The monopoly price and output $\left(p^M, Q^M\right)$ satisfy $p^M = \arg\max_{p \geq c} (p-c)Q(p)$, $Q^M = Q\left(p^M\right)$, so $p^M > c = p^0$; $Q^M < Q^0$; $\pi^M = \left(p^M - c\right)Q^M > 0$.

The potentially imperfectly competitive "but-for" price and output $\left(p^B, Q^B\right)$ satisfy $c \leq p^B < p^M$, $Q^B = Q\left(p^B\right)$, so $Q^M < Q^B \leq Q^0$; $\pi^M > \pi^B = \left(p^B - c\right)Q^B \geq 0$.

Illegal Gains

A simple diagram can be used to indicate the difficulties in estimating illegal gains- based penalties (see Figure 3). Illegal gains are defined as cartel's profits over and above the counterfactual level of profits. Since counterfactual level of profits is difficult to estimate accurately, in most cases estimation of illegal-gains is likely to be subject to quite significant errors. Thus, penalties based on illegal gains have significant implementability problems and can create a significant amount of legal uncertainty.

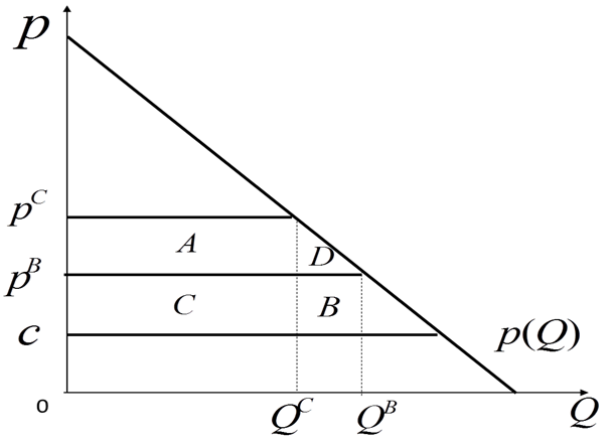

Figure 3: Diagram showing calculation of illegal gains-based penalty

If the industry cartelises and the cartel sets a price $p^C \geq p^B \geq c = p^0$ the illegal gains are the increase in profits compared to those in the counterfactual "but-for" situation. So the illegal gains are given by the area *A-B* in Figure 3 above, which analytically can be represented as $\left(p^C - c\right)Q\left(p^C\right) - \left(p^B - c\right)Q^B = \left(p^C - c\right)Q\left(p^C\right) - \pi^B$.[45] Consequently, expected profits with penalty rate $\rho > 0$ on Illegal gains are:

$$\left(p^C - c\right)Q\left(p^C\right) - \tau\left[\left(p^C - c\right)Q\left(p^C\right) - \pi^B\right]$$
$$= (1-\tau)\left[\left(p^C - c\right)Q\left(p^C\right)\right] + \tau\pi^B$$

where $\tau = \beta\rho$ (β, 0<β<1, being the probability that the cartel is detected and successfully prosecuted by the CA). So if $\tau = 1$ then there is no possibility of getting more than but-for profits. If this first-best outcome is ruled out as being unrealistic and so $\tau < 1$ then cartel sets $p^C = p^M$. So we can conclude that the welfare properties of these penalties are also *not* very good since they induce cartel prices that are equal to the monopoly level.

Damages

Damages is the reduction in consumer surplus compared to what would have accrued under the counter-factual "but-for" situation. In Figure 3 damages are illustrated by the area *A+D* and so are given by:

$$\left(p^C - p^B\right)Q\left(p^C\right) + \frac{\left(p^C - p^B\right)\left(Q^B - Q\left(p^C\right)\right)}{2} = \frac{1}{2}\left[\left(p^C - p^B\right)Q\left(p^C\right) + \left(p^C - p^B\right)Q^B\right]$$
$$= \frac{1}{2}\left[\left(p^C - c\right)Q\left(p^C\right) + \left(p^C - p^B\right)Q^B - \left(p^B - c\right)Q\left(p^C\right)\right]$$

So, expected profits with penalties on damages are:

$$\left(p^C - c\right)Q\left(p^C\right) - \frac{\tau}{2}\left[\left(p^C - c\right)Q\left(p^C\right) + \left(p^C - p^B\right)Q^B - \left(p^B - c\right)Q\left(p^C\right)\right] =$$
$$\left(1 - \frac{\tau}{2}\right)\left(p^C - c\right)Q\left(p^C\right) - \frac{\tau}{2}\left[\left(p^C - p^B\right)Q^B - \left(p^B - c\right)Q\left(p^C\right)\right]$$

So we can see that:

- A tax on damages acts like a combination of a tax on profits (first term on expression on RHS above), plus an overcharge-based tax (second term on RHS), plus a subsidy to output (third term on RHS).

[45] Note simple profit based penalty will not provide a proper value for the penalty based on illegal gains as both $\left(p^C - c\right)Q^C$ and $\left(p^C - p^B\right)Q^C$ overestimate the true illegal gains.

- In the "first-best" world where $\tau = 2$, a cartel would set $p^C = p^B$ - there is no possibility of getting more than but-for profits.
- In a second-best world where $\tau < 2$ it would set a price *below* the monopoly price, as under an overcharge-based regime. If the cartel was faced with a penalty on profits (first term on RHS only would be relevant) then it would set the monopoly price. The second term (tax on overcharge) induces the cartel to reduce price (given the fixed counterfactual output volume) and the third term (subsidy on output) induces the cartel to increase its output: thus the second and third terms explain why the cartel's optimal price under a damages-based penalty regime would be below the monopoly price.

Appendix 2

Proof of Proposition 1: (i) follows from setting the derivative in (8) to zero, and noting that for all $\tau_0, 0 \le \tau_0 < 1$ the function $\psi(\theta, \tau_0)$ is a strictly decreasing function of θ; (ii) follows from (6) and the fact that the function $\psi(\theta, \tau_0)$ is a strictly increasing function of τ_0 with $\psi(\theta, 0) = \frac{1+\theta}{\theta}$.

Proof of Proposition 2: (i) Follows by setting the derivative in (11) equal to zero. But notice that there are implicit restrictions on the nature of the penalty regime to ensure that $\varphi(\theta, \beta) > 0$ for relevant values of θ[46] - e.g. we require $\beta\rho(\theta) < \frac{\theta}{1+\theta}$. (ii) Follows from (6), the assumption that the function $\eta(.)$ is non-decreasing, and the fact that if (13) holds then, from (14), $\varphi(\theta, \beta) < \frac{1 - \frac{1+\theta}{\theta}\beta\rho(\theta)}{\frac{\theta}{1+\theta} - \beta\rho(\theta)} = \frac{1+\theta}{\theta}$; (iii) also follows from the assumption that the function $\eta(.)$ is non-decreasing.

[46] These are analogous to the restriction $\tau_0 < 1$ that we made in the case of a simple revenue-based penalty regime.

References

Allain, Marie-Laure, Marcel Boyer and Jean-Pierre Ponssard (2011). "The determination of optimal fines in cartel cases: Theory and practice". *Concurrences - Competition Law Journal* 4-2011, 32-40

Bageri, V., Y. Katsoulacos and G. Spagnolo (2013), "The Distortive Effects of Antitrust Fines Based on Revenue", *The Economic Journal*, 123 (572), 545-557.

Bageri, V., and Y. Katsoulacos (2014), "A Simple Quantitative Methodology for the Setting of Optimal Fines by Antitrust and Regulatory Authorities", *European Competition Journal*, Volume 10, 2014, 253-278.

Becker, G.S. (1968), "Crime and Punishment: An Economic Approach", *Journal of Political Economy*, 76, 169-217.

Bos, I., S. Davies, J. Harrington and P.L. Ormosi, (2016), "Does enforcement deter cartels? A tale of two tails", *mimeo*, *paper presented at EARIE 2016 conference*.
https://editorialexpress.com/cgibin/conference/download.cgi?db_name=EARIE43&paper_id=97

Boyer and Kotchoni (2015), "How Much Do Cartel Overcharge?", *Review of Industrial Organization*, 47, 119-153.

Buccirossi, P. and G. Spagnolo (2007) "Optimal Fines in the Era of Whistle blowers - Should Price Fixers Still Go to Prison?" in *The Political Economy of Antitrust*, by V. Goshal and J. Stennek (Eds.), Elsevier: Amsterdam.

Chen, Z. and P. Rey (2013), "On the design of leniency programs," *Journal of Law and Economics,* 56, 917-957.

Connor, J.M. and R.H. Lande (2008), "Cartel Overcharges and Optimal Cartel Fines", in S. Waller (ed), Issues in *Competition Law and Policy* , Vol. 3, AMA Section of Antitrust Law, Chapter 88, 2203-2218.

Dargaud, E., A. Mantovani, and C. Reggiani (2015), "Cartel deterrence and distortive effects of fines", mimeo

Harrington, J. (2004) "Cartel Pricing Dynamics in the Presence of an Antitrust Authority," *The Rand Journal of Economics* 35, 651-673.

Harrington, J. (2005) "Optimal Cartel Pricing in the Presence of an Antitrust Authority," *International Economic Review* 46, 145-170.

Harrington, J. (2010), "Comment on Antitrust Sanctions", *Competition Policy International,* 6, 41-51.

Houba, H., E. Motchenkova, and Q. Wen (2010), "Antitrust enforcement with price-dependent fines and detection probabilities," *Economics Bulletin*, 30(3), 2017-2027.

Houba, H., E. Motchenkova, and Q. Wen (2017), "Legal Principles in Antitrust Enforcement", forthcoming in *The Scandinavian Journal of Economics*

Katsoulacos, Y. and E Metsiou (2017), "The Economics of Antitrust Sanctioning: a Brief Review", In Bonakele Tembinkosi, Eleanor Fox and Liberty Macnube (Editors) *Competition Policy for the New Era: Insights from BRICS and Developing Countries*, Oxford University Press, 2017.

Katsoulacos, Y. and D. Ulph (2013) "Antitrust Penalties and the Implications of Empirical Evidence on Cartel Overcharges", *The Economic Journal*, 123 (572), 558-581.

Katsoulacos, Y., E. Motchenkova and D. Ulph, (2015). "Penalizing Cartels: The Case for Basing Penalties on Price Overcharge", *International Journal of Industrial Organization*, 42, pages 70-80.

Koren W Wong-Ervin, D H Ginsburg, A Slonim, B H Kobayashi, J D Wright (2016) "Monetary Penalties in China and Japan", GMU Antonin Scalia Law School, DP 16 – 40. Landes W.M. (1983), 'Optimal Sanctions for Antitrust Violations', *The University of Chicago Law Review*, vol 50(2).

Lande, M. (1983), "Optimal Sanctions for Antitrust Violations", *The University of Chicago Law Review*, 50, 652-678.

Levenstein, M.C. and V.Y. Suslow (2011), "Breaking Up Is Hard to Do: Determinants of Cartel Duration", *Journal of Law and Economics* 54, 455- 92.

Levenstein, M.C. and V.Y. Suslow (2012), "Cartels and Collusion - Empirical Evidence". Ross School of Business Paper No. 1182. Available at SSRN: http://ssrn.com/abstract=2182565

Levenstein, M.C. and V.Y. Suslow (2014) "Price fixing hits home: an empirical study of price fixing conspiracies in the US", mimeo, University of Michigan, Jan. 2014.

Motta, M. and M. Polo (2003), "Leniency Programs and Cartel Prosecution", *International Journal of Industrial Organization,* 21, 347-379.

O.E.C.D. (2002a): \Fighting Hard Core Cartels: Harm, Effective Sanctions and Leniency Programmes," Paris, http://www.oecd.org/dataoecd/41/44/1841891.pdf.

Schinkel M.P. (2007), "Effective Cartel Enforcement in Europe, World Competition" 30 (4), 539-572.

Spagnolo, G. and C. Marvão (2016), "Cartels and Leniency: Taking stock of what we learnt", SITE Working Paper Series, 39, October 2016.

Veljanovski, C. (2007), "Cartel Fines in Europe: Law, Practice and Deterrence", World Competition 29.

Werden, G.J., (2008). "Assessing the effect of antitrust enforcement in the United States" *De Economist* 156 (4), 433.451.