The effects of asymmetric costs on cartel damages: The importance of the counterfactual

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Work in progress; comments encouraged.

Abstract

Collusion models are used to estimate cartel overcharges and the resultant welfare losses. Most applications assume symmetric costs and homogeneous products, assumptions that rarely are satisfied in reality. Relaxing these assumptions, we find that model misspecifications result in overestimation of the damage caused by cartels - and possibly in an unfair distribution of the compensation. The estimation error increases with the degree of cost asymmetry and product differentiation.

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1 Introduction

During the last 5-10 years the fight against cartels has changed from being primarily a public concern to rely heavily on private litigation. This is especially true in the US where 90% of the cartel cases stems from private enforcement (Wils, 2003). However the European Commission (2008) has made increased private litigation a top priority and recently published a set of documents aiming to clarify the legal framework in Europe. Private litigation, unlike public enforcement, will not be efficient unless there is a transparent system governing assessment and quantification of damages, since the system relies on claimants being adequately compensated. To ensure that there are incentives to bring private claims, despite uncertainty concerning damage calculations, treble damages are used in the US (ABA, 1986). This route is however not envisaged for Europe and the European Commission's White Paper on damages (European Commission, 2008) refers to the doctrine of full compensation[1]. Since compensation to victims is typically lower in the EU than in the US[2], the rules regarding damages have to be clearer in the EU, for private litigation to become as strong. To facilitate and promote private enforcement, the European Commission recently published a guide on assessment of damages from cartels (Oxera, 2010). In the report, game theoretic collusion models play an important role in determining the negative effects from cartels and are considered one of three main methodological approaches to quantifying cartel damages[3].

[1]This was developed in the Manfredi cases, joined cases C-295-298/04, [2006] ECR I-6619. The Court of Justice stated that "injured persons must be able to seek compensation not only for actual loss (damnum emergens) but also for loss of profit (lucrum cessans) plus interest." There is however no punitive element in the damages, nor a compensation for uncertainty.

[2]It can however be argued that US damages are in reality not treble since prejudgement interest is not awarded. See e.g. Lande (2006).

[3]The other main methods envisaged are comparator based and financial analysis based approaches.

Models of industrial organization can be used to assess the effect of a cartel by providing a theoretical understanding of the market, but also to empirically estimate the effects the cartel gives rise to. As always, it is important that the model reflects the specific conditions of the market at hand and the analyst therefore needs to make explicit assumptions on the type of competition (e.g. price or quantity competition), the degree of product differentiation, the number of active firms, entry and exit conditions, cost structures and the existence of capacity constraints. Otherwise the model runs the risk of providing an erroneous counterfactual. Much analysis is based on standard assumptions: that there are only two firms on the market producing a homogenous product with symmetric costs (Tirole 1998, Cabral 2000). In reality, these assumptions are unlikely to be fulfilled. This paper illustrates how sensitive calculation of cartel overcharges is to misspecification of the model by introducing both product differentiation and cost asymmetries. It also investigates how model misspecification affects perceived welfare, i.e. the damage to society.

The effect of horizontal differentiation on collusion has been widely investigated for many years and there are two strands of models that give somewhat different results depending on their assumptions; non-spatial and spatial (Hotelling) models. In the non-spatial framework that we will apply, the standard mechanism to determine cartel prices is to assume that the cartel members maximize joint profits. This assumption is an artifact from Patinkin (1947) and while not generally correct, it is reasonable when firms are symmetric. With this mechanism, cartel prices are not affected by product differentiation and the cartel will always set monopoly price. Thus, the only effect of product differentiation is the ability to sustain collusion, not the collusive outcome itself[4]. The literature therefore, to a large extent, focuses on the scope for collusion.

The modern supergame approach to collusion with differentiated products was initiated by Deneckere (1983) who developed a two-firm differentiation model with non-spatial product differentiation. Collusive prices are set at the monopoly level, grim trigger strategies are used to sustain collusion and the minimum discount factor that can sustain collusion is found for both Bertrand and Cournot cases. In a subgame-perfect equilibrium, collusive prices are unaffected by product differentiation, but a non-monotonic relationship exists between differentiation and cartel stability when firms compete in prices. Starting from highly differentiated products, less differentiation will initially generate more stable collusion, but for sufficiently homogenous products, further reductions in differentiation will reduce cartel stability. For quantity competition the relationship is monotonically positive and for highly differentiated products collusion is more stable under quantity than price competition. However as products become close substitutes collusion is more stable under price competition. These results also hold for different demand structures (Albæk and Lambertini,1998).

Wernerfelt (1989) extends Deneckeres Cournot model to allow for n-firms and collusion supported by optimal punishment (Abreu, 1986) instead of grim trigger strategies. Contrary to the standard intuition, he finds that product differentiation increases the rewards from cheating and makes punishments harder. The net effect depends on the parameters. For example, differentiation increases the scope for collusion when there are few firms on the market. Cartel prices however, are unaffected by the product differentiation.

The other strand of models is based on spatial differentiation where consumers are assumed to have heterogeneous tastes (rather than love for variety as in the non-spatial

[4]Product differentiation lowers deviation profits and increases Nash profits.

approach). A feature of these models is that the collusive prices change with the degree of differentiation. Chang (1991) uses a duopoly setting where firms compete in prices, collusive prices are set by joint profit maximization and grim strategies are used to sustain the collusion. The effect from differentiation on the collusive price is non-monotonic: the price increases with product differentiation when the products are sufficiently differentiated, but reduces with differentiation when the products are closer substitutes. Also in contrast to Deneckeres findings, there is a monotonic relationship between the sustainability of collusion and product differentiation where collusion is always harder to sustain for products that are closer substitutes. The difference between the models arises from how differentiation is modeled as this affects both collusive and deviation profits[5]. Häckner (1995) illustrates that the result from Chang's model also holds for optimal punishments.

Jehiel (1992) uses a similar setting to that of Chang but allows the collusive price to be determined by Nash bargaining instead of joint profit maximization in a one-shot game. Rather than focusing on conditions for sustainability, he studies whether firms in a cartel will produce differentiated or homogenous products. Since he does not consider subgame perfect collusion, he also introduces the possibility of sidepayments. He finds that when sidepayments are not possible, there will be no differentiation and when payments are allowed, there may be some differentiation since own location becomes unimportant with respect to market shares.

The literature on collusion when costs are asymmetric is much less developed. There are both strategic and computational reasons for that. When firms are asymmetric they no longer have a joint view of the optimal cartel price and deciding on the price becomes more complicated. Extending the model by Bae (1987), Harrington (1991) employs Nash bargaining to establish cartel prices in a price setting framework. The main results are that cost asymmetries makes the cartel instable (less sustainable) and that the cartel price is non-monotonically increasing in the asymmetries. Rothschild (1999), Collie (2005) and Vasconcelos (2005) look at homogenous and differentiated Cournot models in which price is set by joint profit maximization. They find that when the inefficient firm is active, it will receive a lower market share than the efficient firm and therefore have larger incentives to deviate. Further, if a cartel is formed, and one firm deviates, the efficient firm will be disproportionately harmed and therefore wants to deviate from the punishment strategy.

Contrary to the literatures on collusion with product differentiation and with asymmetric costs, we focus on the price effects caused by differentiation and cost asymmetries and only deal with sustainability in passing. Model misspecification arises if the analyst assumes homogeneous goods and identical costs when in fact products are differentiated and costs asymmetric. We find that product differentiation interacts with cost asymmetries in surprising ways. In our set-up the cartel price is determined by take-it-or-leave-it bargaining - a version of Nash bargaining that gives all barganing power to the efficient firm. Cartel prices are relatively unaffected by cost asymmetries and product differentiation but the counterfactual Nash price is strongly affected by both. This in terms mean that the overcharge (cartel price minus Nash price) and the damages caused by the cartel are seriously affected by cost asymmetries and product differentiation. Failure to take these effects into account will result in large estimation errors. [To be made more precise]

In the following we set up our basic model of cost asymmetries and product differentiation in section 2 and solve the non-cooperative equilibria in section 3. We then assume that firms form a cartel where the efficient firm offers a take-it or leave-it offer to the

[5]See Chang (1991) for an analysis of what causes these differences.

inefficient firm and solve the collusive model numerically in section 4. In section 5 we investigate the total damages caused by the cartel, i.e. both the overcharges and the deadweight loss.

2 Model

We base our model on the Singh and Vives (1984) duopoly model for differentiated products[6]. Consumers maximize their net utility and face the problem

$$\max_{q_1,q_2} \alpha_1 q_1 + \alpha_2 q_2 - \frac{\left(q_1^2 + 2\gamma q_1 q_2 + q_2^2\right)}{2} - \sum_{i=1}^{2} p_i q_i \tag{1}$$

This gives the following inverse demand function

$$p_i = \alpha_i - q_i - \gamma q_j \quad \{\ i,j = 1,2, i \neq j\} \tag{2}$$

where q_i is the quantity supplied and γ is a measure of the degree of horizontal product differentiation. We are only interested in the case of competing products and therefore restrict γ to $\gamma \in (0,1)$. When $\gamma = 0$ the products are independent in demand and hence, firms are monopolists on their own product. When $\gamma = 1$, the products are homogenous, i.e. perfect substitutes. Vertical product differentiation, modeled by α, can be interpreted as quality (Häckner 2000), where a higher α indicates a higher quality.

Since we are interested in the effects of cost asymmetries, not vertical differentiation, we assume that both products have the same (perceived) quality, $\alpha_i = 1$. Invert (2) to obtain the following direct demand functions[7]

$$q_i = \frac{1 - p_i - \gamma\left(1 - p_j\right)}{1 - \gamma^2} \text{ where } \{i,j = 1,2;\ i \neq j\} \tag{3}$$

The effect on demand from reducing product differentiation (increasing γ) comes from two sources. First there is a business stealing effect that gives more demand to the firm with lowest price. Second, there is an effect from reduced variety. As the preferences exhibit love of variety (utility is decreasing in γ), reducing product differentiation lowers total demand. If the price difference is very large, the stealing effect is dominant and the quantity of the firm with the lowest price will increase monotonically as the products become less differentiated. When the price difference is smaller, the loss of variety is initially the dominant effect, causing less quantity sold. But, for more homogenous products the stealing effect takes over and quantity increases as the products become more homogenous.

Firms face linear cost functions where c_i denotes the marginal cost for firm i. Although Singh and Vives' (1984) model allows for cost asymmetry, they restrict the space of the model by assuming that both firms produce positive outputs, i.e. that both firms face positive demand when prices are set at marginal cost. This implies that the model is restricted to firms with symmetric costs, as any other situation would force the inefficient firm to produce zero. We relax this assumption: when $q_i = 0$, demand for product j is given by $q_j = 1 - p_j$.

[6]This differs from Singh and Vives (1984) original paper since we have normalised the own-quantity slope of the inverse demand function by setting their $\beta = 1$.

[7]The demand function is not well defined when $\gamma = 1$, see Singh and Vives (1984).

We assume that firm 1 is fully efficient and that $c_1 = 0$. Firm 2 is less efficient, i.e. $c_2 \geq 0$ and c_2 can therefore be interpreted as the cost difference between the firms. By assumption the cost difference is not drastic, meaning that the efficient firm cannot monopolize the market irrespective of the form of competition $(1 > c_2)$.

Our model is based on a collusive and one non-collusive state. In the non-collusive state, we assume Bertrand competition, i.e. firms compete by setting prices simultaneously. In the collusive state firms we assume that the efficient firm makes a take-it or leave-it offer to the inefficient firm. Collusion is sustained as a subgame perfect equilibrium where deviation is deterred by a grim trigger strategy that brings the market to the non-competitive equilibrium if deviation is detected. The Folk Theorem implies that any set of individually rational collusive payoffs can be sustained as the outcome of a subgame perfect quilibrium of an infinitely repeated game as long as the discount factor is sufficiently high (Fudenberg and Maskin 1986). In this paper, our prime focus is however not primarily to analyse the minimum discount factor that can sustain collusion, but rather to focus on the damage caused by the cartel.

3 Non-cooperative equilibrium - the counterfactual

To get the notation out we initially characterize the non-collusive Bertrand equilibria. We start with a standard non-constrained duopoly model in which both firms are active, but as the inefficient firm will not be able to survive in a highly competitive market, i.e. a market where the products are fairly homogenous, we also investigate two sets of non-cooperative equilibria in which the inefficient firm is not active on the market. The non-collusive equilibrium resembles the one derived by Zanchettin (2006).

The firms face the following profit function

$$\pi_i = (p_i - c_i)\left(\frac{1 - p_i - \gamma(1 - p_j)}{1 - \gamma^2}\right) \tag{4}$$

When both firms are active we get standard differentiated Bertrand results. However, due to the cost asymmetry between the firms, such an equilibrium will not always exist. When the cost difference between the firms is sufficiently high and the products are sufficiently close substitutes, the inefficient firm will not be active on the market. In this model, any firm that is forced out can re-enter the game at a later stage without incurring any costs, i.e. there are no entry or exit costs. The combination of inefficiency and product differentiation that forces the inefficient firm to zero production is given by[8]

$$\widehat{c}_2 \equiv 1 - \frac{\gamma}{2 - \gamma^2} \tag{5}$$

When $c_2 > \widehat{c}_2$, only the efficient firm is active. The condition implies that at higher degrees of substitutability between the products, the inefficient firm needs to be more efficient to stay on the market. Since $\frac{d\widehat{c}_2}{d\gamma}$ and $\frac{d^2\widehat{c}_2}{d\gamma} < 0$ it is clear that $\widehat{c}_2$ is strictly decreasing in γ at an increasing rate. Hence the efficiency requirement becomes stronger the more competitive the market is, and in the limit $(\gamma = 1)$, it needs to be fully efficient to remain active. This implies that there is a trade off between product differentiation and cost asymmetry that enables the inefficient firm to remain active if the products are sufficiently differentiated.

[8] All proofs are relegated to appendix.

Despite the inefficient firm not being active when $c_2 > \widehat{c}_{2,}$ it still restricts the pricing behaviour of the efficient firm, as the inefficient firm would enter should the efficient firm charge high enough prices. This potential entry restricts the pricing of the efficient firm until it can set monopoly prices without incurring entry, i.e. unless $q_2 = 0$ given $p_2 = c_2$ and $p_1 = p_1^M$. The critical cost difference is given by

$$\widetilde{c}_2 \equiv 1 - \frac{\gamma}{2}$$

When $c_2 > \widetilde{c}_2$ the efficient firm is unconstrained in its pricing and can therefore set monopoly prices without the inefficient firm entering. The critical level of inefficiency decreases with the level of product homogeneity $\left(\frac{d\widetilde{c}_2}{d\gamma} < 0\right)$ also in this case.

The degree of product differentiation and cost asymmetry define three regions of competition. These regions in the space $\{c_2, \gamma\}$, are is illustrated in Figure 1 below.

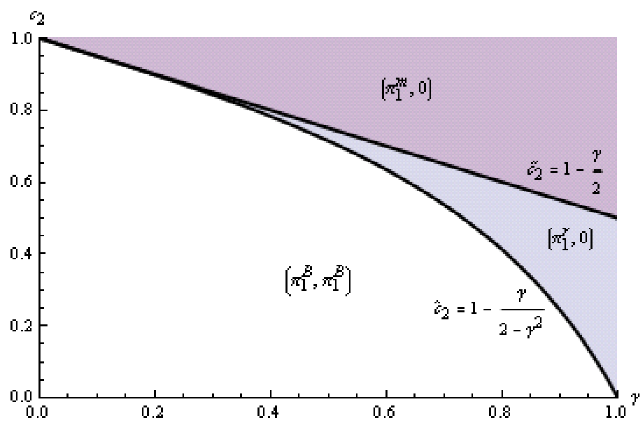

Figure1: Forms of competition

The area to the left in figure 1 is the Bertrand region. When products are fully differentiated the inefficient firm can be totally inefficient and still produce, since the markets are independent. But as soon as there is some substitutability between the products, there is a requirement on the efficiency level of the inefficient firm. The requirement monotonically increases for more substitutable products. The top area of figure 1 is the monopoly region. If $c_2 \geq \frac{1}{2}$ and products are homogenous, the efficient firm will be able to set monopoly prices ignoring the inefficient firm. For differentiated products the level of inefficiency has to be higher for this to hold. In the region between the monopoly and Bertrand areas, pricing is constrained. Hence, only the efficient firm is producing, but it sets a price below the monopoly level.

Depending on the degree of efficiency and level of product differentiation, there are thus three different sets of pure strategy equilibria in this game. One Bertrand equilibrium where both firms are active and two equilibria when only the efficient firm is active. In one of the latter equilibria the efficient firm is constrained in its pricing, in the other it sets monopoly price. This gives the following non-cooperative outcomes for the two firms[9]:

[9]All proofs and calculations are relegated to appendix.

Table 1: Non-cooperative equilibria

		Bertrand $c_2 < \widehat{c}_2$	Constrained $c_2 \in [\widehat{c}_2, \widetilde{c}_2]$	Unconstrained $c_2 > \widetilde{c}_2$
Efficient firm	$p_1 - c_1$	$\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}$	$\frac{c_2+\gamma-1}{\gamma}$	$\frac{1}{2}$
	q_1	$\frac{p_1-c_1}{1-\gamma^2}$	$\frac{1-c_2}{\gamma}$	$\frac{1}{2}$
	π_1	$\frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} + \frac{\gamma c_2}{4-\gamma^2}\right)^2$	$\frac{(1-c_2)(c_2-1+\gamma)}{\gamma^2}$	$\frac{1}{4}$
Inefficient firm	$p_2 - c_2$	$\frac{1-\gamma}{2-\gamma} - \frac{c_2\left(2-\gamma^2\right)}{4-\gamma^2}$	0	0
	q_2	$\frac{p_2-c_2}{1-\gamma^2}$	0	0
	π_2	$\frac{1}{1-\gamma^2}\left(\frac{1-\gamma}{2-\gamma} - \frac{c_2\left(2-\gamma^2\right)}{4-\gamma^2}\right)^2$	0	0
	$Q \equiv q_1 + q_2$	$\frac{p_1+p_2-c_1-c_2}{1-\gamma^2}$	$\frac{1-c_2}{\gamma}$	$\frac{1}{2}$

The first part of the Bertrand equilibrium markup determines the markup effects of product differentiation. At full differentiation ($\gamma = 0$) prices equal monopoly prices[10]. Markups and profits for both firms increase monotonically with product differentiation, as in the standard literature (Deneckere 1983). If $c_2 = 0$ and $\gamma = 1$ we get the standard Bertrand result, zero markup.

The second part of the Bertrand equilibrium markup determines the effect of cost differences. When the inefficiency (c_2) increases, the price margin increases for the efficient firm both in the constrained and in the Bertrand equilibria, but the price margin decreases for the inefficient firm in the Bertrand equilibrium and remains constant at zero in the other two cases. For all $c_2 > 0$, profits are higher for the efficient firm than for the inefficient firm. The cross-partial $\frac{d^2(p_i - c_i)}{d\gamma dc_2}$ from the Bertrand equilibrium reveals that the margin exhibits increasing and decreasing differences for the efficient and inefficient firm respectively. Thus, the positive effect from cost asymmetries on the price margin of the efficient firm is stronger for more substitutable products.

The two effects can be seen in figures 2 and 3 below.

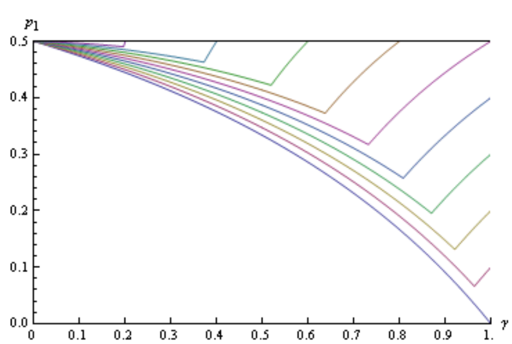

Figure 2: Bertrand price - Efficient firm

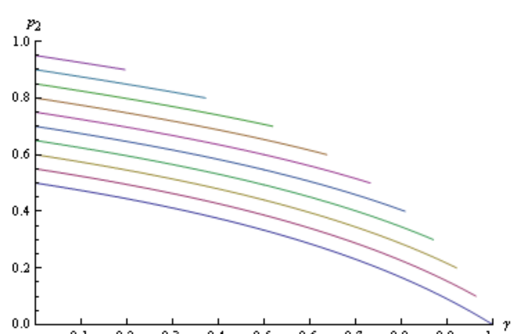

Figure 3: Bertrand price - Inefficient firm

[10]The monopolist's profit is $\pi_i = (p_i - c_i)(1 - p_i)$. So the monopoly price is $p_i = \frac{1+c_i}{2}$. For the efficient firm $p_1^M = \frac{1}{2}$ and for the inefficient firm $p_2^M = \frac{1+c_2}{2}$ and so $p_2^M - c_2 = \frac{1-c_2}{2}$ when $\gamma = 0$.

The lower lines in the two figures are the Bertrand prices when there are no cost asymmetries. Hence they are the same for the efficient and inefficient firms. In the curves above cost asymmetry is introduced with increments of 0.1. The curves become shorter for higher levels of cost asymmetry since the inefficient firm is forced to exit the market when $c_2 \geq \widehat{c}_2$. The reduction in prices for higher levels of γ is not only attributed to increased competition as products become more homogenous. The effect is reinforced by the love of variety property of the utility function that affects total market demand. Demand with homogenous products is only half compared to when products are independent and the demand reduction is monotonic in product substitutability. Since demand is lower, so is price.

In the constrained region cost asymmetry and product differentiation have the same effects on the efficient firm's price as in the Bertrand region. But, in the unconstrained region, when the efficient firm makes an independent pricing decision, prices are set at the monopoly level. In this case, prices, quantity and profit do not depend directly on the costs and degree of product differentiation. But $\widetilde{c}_2$ is a function of γ and c_2, and if the products are homogenous, the efficient firm can only set monopoly prices if $c_2 > \frac{1}{2}$. If on the other hand products are completely differentiated, it can always set monopoly prices.

From the three possible pure strategy non-cooperative equilibria, defined by γ and c_2, it is trivial to show that $\pi_1^M > \pi_1^{Constr} > \pi_1^{Bert}$. In the following we refer to the relevant pay-off from the non-cooperative equilibria in Table 1 as π^n.

4 Collusive equilibrium

In this section we analyze the cooperative equilibrium. We focus on subgame perfect collusion and will therefore, in line with most of the literature (see Miklos-Thal 2009 for a brief discussion), not allow for side-payments between firms.[11] In this model, collusion is only sustainable if the private gains from being in the cartel is larger than those obtained by chiseling. We first briefly describe the requirement for cartel stability to then turn the attention to the selection of collusive prices by members of the cartel.

4.1 Sustainability of collusion

Cartels are inherently instable as there is always a temptation to deviate from the agreement to make short run profits. The cartel is therefore only sustainable as long as all members find that the discounted value from staying in the cartel is higher than the value from deviating. Thus, high cartel profits and tough punishment of deviation will improve the sustainability of a cartel. We assume that deviation from the collusive price triggers a grim response, leading to the non-cooperative equilibrium ever after. It is therefore profitable for a firm to stay in the collusion if

$$\frac{1}{1-\delta}\pi_i^{Cart}\left(c_i, c_j, \gamma\right) \geq \pi_i^{Dev}\left(p, c_i, \gamma\right) + \frac{\delta}{1-\delta}\pi_i^n\left(c_i, c_j, \gamma\right), i \in \{1, 2\} \qquad (6)$$

Thus the lowest discount factor for collusion to be sustainable is defined by

[11] Side-payments exist in reality, in fact several cartels have been known to have elaborate transfer schemes (Levenstein and Suslow 2006), but as transfers cannot be contracted they represent a challenge to the sustainability of collusion (see Berg 2011) for furhter reasosns). The inability to contract side-payments may be an explanation for price wars.

$$\widehat{\delta}_i \equiv \frac{\pi_i^{Dev}(p, c_i, \gamma) - \pi_i^{Cart}(c_i, c_j, \gamma)}{\pi_i^{Dev}(p, c_i, \gamma) - \pi_i^{n}(c_i, c_j, \gamma)} \tag{7}$$

Our starting point is the situation in which an antitrust authority or a court has already established the existence of the cartel. At that point, the question is not if the cartel was sustainable or not, but rather what damages are inflicted upon customers and on society. For this reason, we de-emphasize sustainability in our analysis.

As shown by Bae (1987), Harrington (1991) and Berg(2011), asymmetric producers of homogenous products have to agree on a single price to ensure that they are all active in equilibrium. However, when products are differentiated, firms may charge different collusive prices. Before deciding on a price setting mechanism, we note that due to cost asymmetries and product differentiation, cartel members prefer to set individual prices rather than a common price[12]. By setting a higher price for the inefficient firm and a lower price for the efficient firm, collusive profits will increase and deviation profits will decrease (non-cooperative profits are unaffected), hence it will also lead to a lower required discount factor than when the cartel is forced to charge one price. The remaining question is which mechanism the firms should use to select their cartel prices.

4.2 Determination of cartel prices

When products are homogenous, a cartel needs to decide both on a price and on market shares for the individual firms (Tirole 1998, Cabral 2000). With differentiated products each firm has a unique demand function and there is therefore no need to decide on a market sharing rule. In fact, allocation of market shares between the firms is redundant once prices are determined. To some extent this makes the cartel's problem easier to solve as the firms only have to coordinate along one dimension, prices.

When firms are symmetric, all members have the same reaction functions and the cartel therefore sets a joint price for all members. It is often assumed that the price is set to give the Pareto optimal profit for the members, i.e. set at the monopoly price which is the same for all firms (irrespective of products being homogenous or differentiated). As a consequence, joint profit maximization is the most commonly used mechanism to select the cartel price. But, when there are cost asymmetries there is no one focal price on which the members coordinate (Scherer 1980): firms with lower costs prefer lower prices than those with high costs. In fact, joint profit maximization will not provide a stable equilibrium: for some combinations of c_2 and γ, the inefficient firm will need to leave the market and let the efficient firm produce everything. Without sidepayments this cannot be an equilibrium.[13] To see this in our framework, note that if prices were set by joint profit maximization, the inefficient firm would be forced to exit the market when $c_2 \geq \overline{c}_2$ where[14]

$$\overline{c}_2 \equiv 1 - \gamma$$

Since $\overline{c}_2 > \widehat{c}_2$, the restriction on efficiency is stricter when prices are set by joint profit maximization than with Bertrand competition. This implies that for $c_2 \geq \overline{c}_2$, the inefficient firm would be too inefficient to be part of a cartel, while it could make positive profits in a non-cooperative setting. This makes no sense and cannot be the equilibrium for a stable cartel without side payments. Accordingly, joint profit maximization is not a

[12] See appendix for proof.

[13] Bae (1987) combines joint profit maximization with Friedman's (1971) balanced temptation requirement but this is problematic, see Harrington (1991).

[14] Derivations are found in appendix.

good mechanism for determining cartel prices when there are cost asymmetries between the firms, but no side payments allowed. The reason for this is that without the possibility to distribute profits among the members, firms are interested in maximizing own, not total profits. Hence we need to turn to another mechanism for determining the cartel price; which one to use in this setting is not obvious.

One way to handle the problem of setting prices is to follow Harrington (1991) and let the firms bargain over prices using Nash bargaining. For any combination of c_2 and γ, the bargaining surplus for each firm is given by the difference of the profits from collusion minus the profits from the best outside non-cooperative option, in this case the Bertrand equilibrium. Since the efficient firm has a better outside option than the inefficient firm, prices will be closer to the monopoly price of the efficient firm. However they will not be set so low that the inefficient firm is forced inactive. Unfortunately the problem cannot be solved for a simple algebraic form when products are differentiated and costs are different.

4.3 Take-it or leave-it offer (TIOLI)

In this paper, we employ an extreme version of Nash Bargaining where the firm with the best bargaining position, the efficient firm, makes a take-it or leave–it offer to the inefficient firm and maximizes its own profits[15]. The lowest possible offer that the inefficient firm will accept, is an offer that makes it indifferent between collusion and the non-cooperative Bertrand equilibrium. The collusive solution is therefore a menu of prices (one for each firm) proposed by the efficient firm.

Since the efficient firm has more bargaining power, we assume that it will make the offer. The efficient firm's pricing problem can therefore be formulated as

$$Max_{p_1,p_2}\ \pi_1\ s.t.\ \pi_2^{Tioli} \geq \pi_2^n \tag{8}$$

where π_2^{Tioli} is defined by the general profit function in equation (2) and π_2^n is the relevant non-cooperative profit for the inefficient firm in table 1. The constraint can be solved to obtain the price, $\widetilde{p}_2$, that assures Bertrand profits to the inefficient firm.[16] It can be shown that $\frac{\partial \widetilde{p}_2}{\partial p_1} > 0$, which implies that prices are strategic complements as in the non-cooperative equilibrium.

The maximization problem for the efficient firm hence boils down to

$$\max_{p_1} p_1 \left(\frac{1 - p_1 - \gamma\,(1 - \widetilde{p}_2)}{1 - \gamma^2} \right) \text{ subject to } p_1 > p_1^n,$$

where the constraint is needed for incentive compatibility.[17] Despite a relatively simple functional form, the algebraic solution to the take-it or leave-it problem is too complex

[15] Since all bargaining power is given to the firm that prefers low prices, the general Nash bargaining solution will give higher collusive prices.

[16] In terms of sustainability of collusion, this would mean that $\widehat{\delta}_2 = 1$, i.e. that the inefficient firm needs to have a discount factor of at least one, see (7). Assume that this were not the case, i.e. that $\delta_2 < 1$. Then the TIOLI problem of the efficient firm would entail ensuring that the inefficient firm would receive cartel profits of $\pi_2^{Cart} = \pi_2^n + \overline{\pi}$ where $\overline{\pi}$ is a constant set such that $\delta_2 = \widehat{\delta}_2$ in accordance with (7). This would not change the results in the following qualitatively, but for the remainder of the paper, we assume that $\delta_2 = 1$ and $\overline{\pi} = 0$.

[17] For any prices requiring $p_1 < p_1^n$, the efficient firm would switch to the constrained Bertrand equilibrium or monopoly pricing. Collusion is therefore only an option as long as the inefficient firm would be active in the Bertrand equilibrium, i.e. when $c_2 < \widehat{c}_2$.

to show, thus we proceed numerically. By definition, the efficient firm's collusive price is always larger than the non-cooperative price, at any level of product differentiation and cost asymmetry. But we also find that its collusive price is higher than the efficient firm's monopoly price for most combinations of γ and c_2.

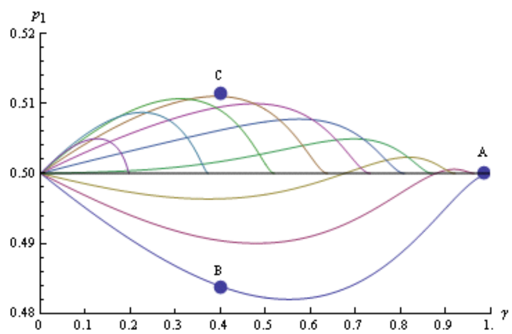

Figure 4: Collusive price - Efficient firm

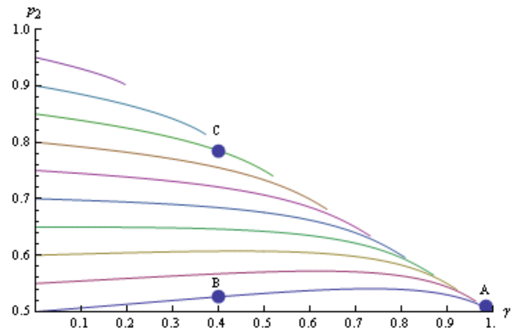

Figure 5: Collusive price - Inefficient firm

As a reference point we assume a model with homogenous products and no cost asymmetries, point A in the two figures above. When products are in reality differentiated and there are cost asymmetries, using such a simplified model can either under- or overestimate the efficient firm's price and will clearly underestimate the inefficient firms' price (compare points B and C to A). The estimation error is largest when the degree of product differentiation is at an intermediate range, which is unfortunate as this region covers most industries.[18] Only for independent or homogenous products is there no estimation error as prices are set at the monopoly level. Between these extremes, pricing is complex. Without cost differences, the lowest line in figures 4 and 5, the efficient firm's price (point B in figure 4) is lower than the monopoly level since the efficient firm increases profit by lowering price and stealing demand, the business stealing effect. To assure that the inefficient firm receives non-cooperative profits despite a lower market share, the inefficient firm's price is increased above its monopoly level (point B in figure 5).

When costs are asymmetric, the inefficient firm will only make positive non-cooperative profits if $c_2 < \widehat{c}_2$ so for large cost differentials and sufficiently substitutable products, there will be no cartel and the efficient firm will serve the market by itself charging constrained or monopoly prices. This is consistent with previous findings that cost asymmetry makes collusion less stable.[19] Higher costs for the inefficient firm leads to a higher collusive price and a lower non-cooperative profit. For small cost differences the efficient firm will steal market share by reducing price below the monopoly level, but the reduction is less than in the symmetric case, hence price is higher.

For sufficiently large cost asymmetry, the efficient firm needs to increase price above the monopoly level to assure that the inefficient firm's incentive constraint is satisfied (point C in figure 4). Non-cooperative profits falls with product substitutability, hence when the inefficient firm approaches the zero profit condition $c_2 = \widehat{c}_2$, the constraint is less binding and the efficient firm charges a price closer to its monopoly price. The inefficient

[18] Very few products are totally homogenous or independent from all other products.

[19] [Add references here].

firm's price increases monotonically with the level of cost asymmetry. Further, the level of cost asymmetry determines the effect of product differentiation on prices. For large cost differences the inefficient firm's price is monotonically decreasing in product substitutability. Compared to a standard model, the inefficient firm's price is underestimated unless products are totally independent.

As can be seen in figures 4 and 5, while the efficient firms collusive price is close to the monopoly price in all cases, it is a non-monotonic function of product differentiation. The degree of cost asymmetry determines whether the relation between product differentiation and collusive price is convex or concave. Without cost asymmetries the relation is convex as the efficient firm undercuts for highly differentiated products but increases prices towards the monopoly level as products become more similar. This contradicts the earlier findings by Deneckere (1982) that product differentiation has no effect on collusive prices and by Chang (1991) that $\frac{\partial p}{\partial \gamma} > 0$ and $\frac{\partial p}{\partial \gamma} < 0$ for low and high γ respectively. In fact we find the opposite. When there are sufficiently large cost differences and products are differentiated, the efficient firm sets a price above the monopoly level to assure that the inefficient firm receives non-cooperative profits. As the non-cooperative profits fall with product differentiation the constraint becomes less binding and the eficient firm lowers its price towards the monopoly level.

Product differentiation and cost asymmetries can affect cartel prices in both an upward and a downward direction but the efficient firm's cartel price does not change significantly with the degree of product differentiation or cost asymmetry and in the typical damage litigation, cartel prices are observed, not estimated. However, product differentiation does have a significant impact on the counterfactual, non-cooperative prices as seen in figures 2 and 3 so overcharges are vulnerable to misspecification. We now turn to the calculation of damages and relate this to consumer welfare.

5 Damages and consumer welfare

The ability to claim damages for cartel overcharges is the main driver for private litigation. Misspecification of the model in terms of failure to recognize cost asymmetries and product differentiation may give rise to incorrect estimation of cartel overcharges and damages. We investigate if standard models over or under reward the claimants and determine how damages reflect cost asymmetries and product differentiation. Furthermore, we compare the consumer surplus of those who buy (damages) to those who do not buy the product due to the cartel price (consumer deadweight loss).

5.1 Overcharges and damages to customers

Since actual prices are (more or less) observable, the most central element in overcharge estimations is determining the counterfactual price, i.e. what the price would have been "but for" the cartel.[20] The counterfactual is in most cases not a perfectly competitive market with marginal cost pricing, but an imperfect market where firms are likely to make profits in equilibrium.[21] Overcharges are therefore simply defined as the difference

[20] The importance of using counterfactuals when asessing effects of cartels was noted already in 1966 in Europe, when the Court of Justice declared that "The competition in question must be understood within the actual context in which it would occur in the absense of the agreement in dispute."Société Technique Minière, Case 56/65 1966.

[21] Most cartels are found in concentrated markets, see for example Levenstein and Suslow (2006). This may be attributed to the fact that it is easier to coordinate with fewer agents.

between the cartel price and the counterfactual price $\left(p_i^{Cart} - p_i^n\right)$ and the damages suffered by those who purchased the good are found by multiplying the overcharge by the quantity sold by the cartel member, q_i^{Cart}:

$$\text{Damage of firm } i = \left(p_i^{Cart} - p_i^n\right) q_i^{Cart}.$$

In this section, we calculate total damages for different degrees of product differentiation and cost asymmetry. In the last section it was shown that product differentiation and cost asymmetry affect the efficient firm's collusive price relatively little while the inefficient firm's collusive price always exceeds the monopoly price of the efficient firm (which would be the benchmark of an efficient cartel). The damages caused by the cartel are nevertheless significant. Figure 7 depicts total damages by the cartel and we find that damages are larger for lower levels of cost asymmetry and decrease with product differentiation (increase with γ). When conducting such a horizontal comparison, one should however remember that the total overcharges are mitigated by the love of variety effect embedded in the utility function. Since demand increases with product differentiation, horizontal comparison does not distinguish between love of variety and the pure price effect. The high overcharges from homogenous products are generated by a demand that is only half the size compared to fully differentiated, or independent products. For constant demand, the slopes in figure 6 are even steeper. Ignoring product differentiation and cost asymmetry will therefore overstate the overcharges caused by the cartel.

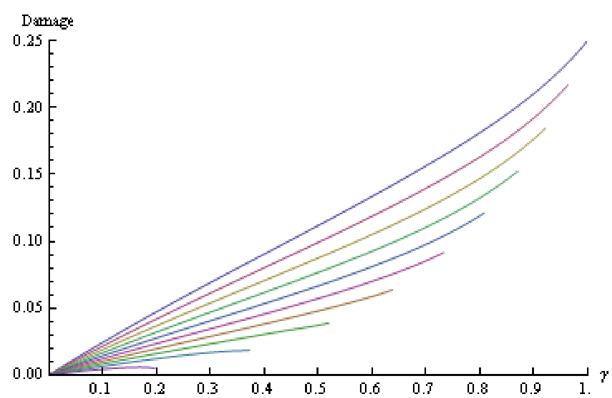

Figure 6: Total damages

The upper curve in figure 7 illustrates the damages caused by a cartel consisting of symmetric firms and the lower ones indicate higher degrees of cost asymmetry. The largest damages are thus caused by symmetric firms selling homogeneous products. If these two assumptions are not fulfilled, overcharges calculated with the simple model are excessive. The intutition for these findings is that neglecting cost asymmetries and product differentiation corresponds to an incorrect assumption of marginal cost pricing in the counterfactual, non-cooperative model. The correct counterfactual price is established by acknowledging that products are differentiated and costs asymmetric, but this price is higher than marginal costs and so the estimated overcharge is lower. Overcharges estimated with the standard assumptions are therefore too high unless products are homogeneous and firms symmetric.

The efficient firm's monopoly price is close to the monopoly level (see Figure 4), that is relatively unaffected by γ and c_2. The efficient firm's overcharges are therefore determined by the effect of product differentiation and cost asymmetry on counterfactual, non-cooperative prices, depicted in Figure 2. From Table 1 we conclude that the efficient firm's overcharges decrease with the degree of cost asymmetry and with product differentiaiton.

The overcharges from the inefficient firm are also decreasing in cost differences but they have a non-monotonic relation to product differentiation which stems from the fact that the inefficient firm produces less when products are substitutable. Hence overcharges decrease when product substitutability makes sales fall more than collusive mark-ups are increased.

[Decompose damages into those attributed to the efficient firm and those attributed to the inefficient firm, e.g. through a figure showing Damage of firm 1/(Damage of firm 1 + Damage of firm 2)].

5.2 Consumer welfare (Consumer dead weight loss)

Economists have traditionally not been too concerned with damages since they are just an allocation between two parties without any welfare effects. Economists have instead been more focused on the losses incurred by consumers that don't buy the good due to high cartel prices, the dead weight loss. However, antitrust damages are currently only awarded to those who suffered from overcharges, and the real damage to society, the welfare loss is not compensated for. In fact, in the US, damages to non-buyers has been found to bee too speculative to give rise to compensation, since it is impossible to know from whom the claimants wold have purchased, what quantity and at what price[22]. In the EU there are references to the legal and economic difficulties for non-buyers to prove injury (European Commission 2007). Below we illustrate how product differentiation and cost asymmetry combine to determine the effects of the cartel on consumer welfare, i.e. the difference between the consumer surplus with the cartel and the consumer surplus in the counterfactual situation without the cartel.[23] Consumer surplus is calculated as the net utility in equation (1) above.

From equation (1)) we know that $\frac{\partial U}{\partial p_i} < 0$ since higher prices reduces the number of products a consumer can purchase. As costs increase prices, net utility decreases with c_2 for the same reason. Utility however increases with product differentiation since the utility function exhibits love of variety. However, in the counterfactual, non-cooperative equilibrium, the partial effect of product differentiation on net utility is negative, i.e. $\frac{\partial U}{\partial \gamma} > 0$. This is explained by the finding in Table 1 that price increase with product differentiation, i.e. $\frac{\partial p_i}{\partial \gamma} < 0$. In the collusive equilibrium net utility increases with product differentiation (i.e. decreases with γ) since the average price does not change significantly.

[22] Montreal Trading Ltd v. Amax Inc, §§ 15-16.

[23] In the US a consumer welfare standard is applied, but it is still debated wether it in reality is a consumer or total welfare standard (Orbach, 2010). In Europe the Court of First Instances confirmed in the case GlaxoSmithKline (T-168/01 2006, para 118) that consumer welfare is the relevant standard.

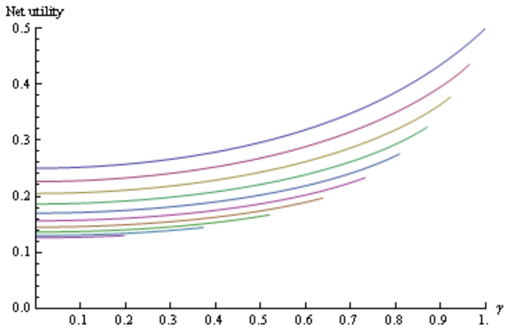

Figure 7: Net utility - non-cooperative

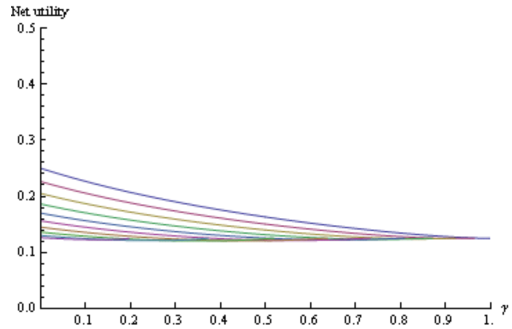

Figure 8: Net utility - collusion

The effect of collusion on welfare is defined as the difference in utility between the non-cooperative and the collusive states. As seen in figure 9 below, the negative welfare effects from collusion is largest when the cartel is operating on a market with homogenous products and firms are symmetric. Since cost asymmetries increase non-cooperative prices more than cartel prices, the difference in net utility between the non-cooperative and collusive states falls as cost asymmetries increase. The difference in net utility also decreases when products are differentiated.

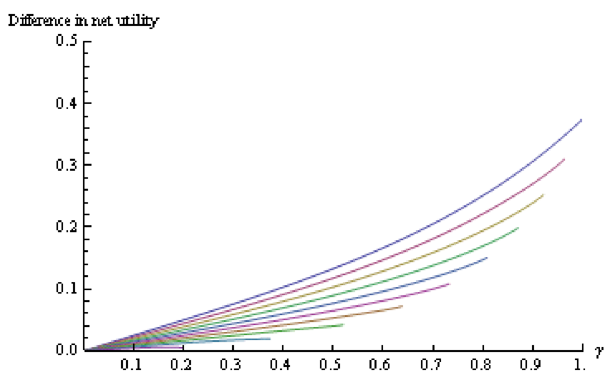

Figure 9: Difference in welfare

Not accounting for product differentiation and cost asymmetries, will therefore overestimate the welfare losses caused by collusion since the counterfactual, non-collusive state has lower net utility than estimated with standard models.

The relation between the damages and the loss of consumer surplus caused by the cartel depends on the degree of product differentiation and cost asymmetry. For highly differentiated products and high cost differences, damages awarded according to the model would compensate consumers fully; but for less differentiated products and smaller cost asymmetry, damages awarded according to the model would undercompensate consumers. The reason is that when goods are independent, the two firms are monopolists and a cartel between them do not make the situation worse for the consumers. On the other hand, when products would have competed in the counterfactual, then the cartel prices result in lower quantities: Figure 10 shows the fraction of the total loss of consumer surplus, consumers will get as compensaton for damages. Consumers are more undercompensated when products are more homogeneous and firms are more symmetric.

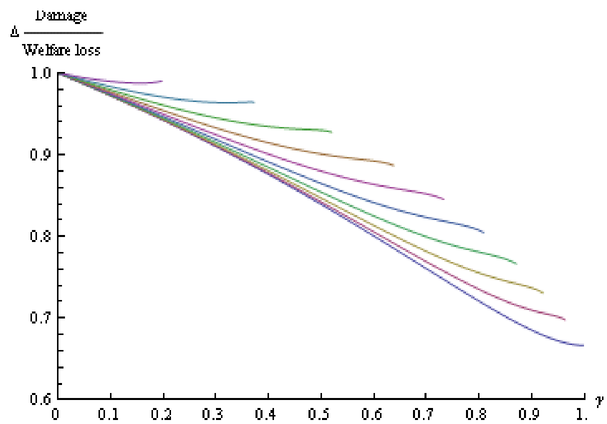

Figure 10: Change in ratio damage/welfare loss

In the US private damages are automatically trebled[24] to encourage private actions (ABA 1986). Treble damages (given that correctly calculated) will hence always exceed the welfare loss caused by a cartel and the damages and will therefore always over-reward claimants. The proposed European system with single damages will on the other hand leave consumers uncompensated for the loss in consumer surplus that results from their decision not to buy due to high cartel prices.

6 Conclusions

Collusion models are important tools to estimate the negative effect of cartels, but they need to be calibrated after the specific market at hand to give correct results. By incorporating two common market features, product differentiation and cost asymmetry, in a standard model, we find that overcharges are overestimated when the features are not accounted for. The estimation error can be as large as 20%. These results do not primarily stem from the collusive price being different from the standard models. Instead it arises as the misspecification on the model has large ramifications on the counterfactual, non-cooperative price.

When the cartel members are symmetric and products homogenous, customers have strong incentives to start a private litigation process since overcharges are high. Under these circumstances overcharges are high compared to the loss of consumer welfare, and only 2/3 of the total damages caused by the cartel can be recouped in single damages. When products are differentiated and firms asymmetric however, overcharges are lower.

[24] 15 U.S.C. § 15(a)

The analysis is based on a two-firm model. Extending it to $n > 2$ firms is a complicated task since, depending on the level of product differentiation and cost asymmetry, firms may prefer to form smaller cartels instead of one large. Berg (2011) deals with the the situation of three firms, two of which are efficient and extends this to a larger number of efficient firms.

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