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"How Much Do Cartels Overcharge?"

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How Much Do Cartels Overcharge?*

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Abstract

The estimation of cartel overcharges lies at the heart of antitrust policy on cartel prosecution as it constitutes a key element in the determination of fines. Connor and Lande (2008) conducted a survey of cartels and found a mean overcharge estimate in the range of 31% to 49%. By examining more sources, Connor (2010) finds a mean of 50.4% for successful cartels. However, the data used in those studies are estimates obtained from different methodologies, sources and contexts rather than by direct observations. Therefore, these data are subject to model error, estimation error and publication bias. A quick examination of the Connor database reveals that the universe of overcharge estimate is asymmetric, heterogenous and contains a number of influential observations. Beside the fact that overcharge estimate are potentially biased, fitting a linear regression model to the data without providing a carefull treatment of the problems raised above may produce distorted results. We conduct a meta-analysis of cartel overcharge estimate in the spirit of Connor and Bolotova (2006) while providing a sound treatment of these matters. We find a bias-corrected mean and median overcharge estimate of 15.76% and 16.43%. Clearly, our results have significant antitrust policy implications.

Keywords: Antitrust, Cartel overcharges, Heckman, Meta-analysis

Résumé

L'estimation des surprix des cartels est au cœur de la politique de lutte aux cartels car elle est un élément clé de la détermination des pénalités. Connor et Lande (2008) survolent la litérature sur les majorations de prix des cartels et concluent à une augmentation moyenne variant entre 31% et 49%. Considérant un échantillon plus grand, Connor (2010) trouve une moyenne de 50,4% pour les cartels réussis. Cependant, les échantillons utilisés dans ces études sont constitués d'estimations venant de différentes études ou cas et non pas d'observations directes. De ce fait, ces échantillons héritent possiblement d'erreurs de modélisation et d'estimation, ainsi que d'un biais de publication. Une analyse sommaire des surprix dans l'échantillon de Connor révèle une distribution asymétrique, de l'hétérogénéité et la présence d'observations aberrantes. Ainsi, au-delà du fait que les estimations des surprix sont potentiellement biaisées, l'estimation d'un modèle de régression linéaire avec de telles donnée sans un traitement adéquat des problèmes ci-dessus pourait produire des distortions dans les résultats. Nous présentons une méta-analyse dans l'esprit de Connor and Bolotova (2006), mais qui tient compte adéquatement des problèmes mentionnés ci-dessus. Après correction du biais d'estimation, nos résultats suggèrent que la moyenne et la médiane des majorations de prix est de l'ordre de 15,76% avec une médiane de 16.43%. Nos résultats débouchent sur des enjeux importants en politique de la concurrence.

Mots-clés : Politique de la concurrence, Surprix de cartel, Heckman, Meta-analyse

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1. Introduction

A cartel is a group of independent firms which collectively agree to coordinate their supply, pricing or other marketing policies in order to generate higher profits than when "natural competition" prevails. Depending on the market of interest, the natural competition can be pure and perfect, oligopolistic or monopolistic. The price that would prevail absent the cartel conspiracy is called the "but-for price", and the amount charged by the cartel in excess of the but-for price is the "cartel overcharge". For a cartel to be successful, the cumulated overcharges paid by consumers who are willing and able to pay the higher price must be large enough to cover the losses stemming from the reduction in sales following the price increase. In addition to the welfare loss incurred by the latter consumers, the surplus that accrues to consumers who are unwilling or unable to incur the price increase is a deadweight loss for society.[1] Most advanced economies consider cartels illegal and are endowed with legislations aimed at deterring their formation.[2]

Tacit collusion can also cause the collective behavior of a group of firms to deviate from natural competition and ressemble more that of a single dominant firm (Ivaldi and al., 2003). For that reason, it is difficult to disentangle the impact of tacit collusion on observed prices from that of genuine cartel. From the viewpoint of antitrust laws, tacit collusion is legal although anticompetitive whilst overt collusion is prohibited.

The United States Sentencing Guidelines (USSG) recommends a base fine of 10% of the affected volume of commerce to a firm convicted of cartel collusion, plus another 10% for the harms "*inflicted upon consumers who are unable or for other reasons do not buy the product at the higher price*". This yields a fine of 20%, subject to further adjustments for aggravating and mitigating factors. The observed total financial fines generally fall in a range from 15% to 80% of affected sales. Moreover, there is a possibility of incarceration for the individuals involved in the collusion. For fiscal years 2010-2013, the prosecution of cartels resulted in over US$3.23 billion in criminal fines (270 cases filed) and more than 270 years of jail time (121 convicted individuals).

In the European Union, the antitrust policy is implemented by the European Competition Commission. The determination of fines takes into account the severity of the damages inflicted

[1] Other costs are inflicted on the economy in terms of distorted resource allocation. Indeed, the harm caused to society is equal to the cartel overcharge, which being a transfer from buyers to sellers may not appear as an efficiency loss or harm, plus additional social costs, namely the deadweight losses and the resources devoted to antitrust authorities for fighting cartels, plus other effects such as the impact on investment and employment, on entry and exit dynamics, on innovation and learning curve, etc.

[2] See http://www.justice.gov/atr/public/criminal/264101.html; http://ec.europa.eu/competition/cartels/statistics/statistics.pdf; http://www.gibsondunn.com/publications/Pages/2013-Mid-Year-Criminal-Antitrust-Update.aspx; and http://www.gibsondunn.com/publications/Pages/2013-Year-End-Criminal-Antitrust-and-Competition-Law-Update.aspx

upon consumers, suppliers and clients as well as aggravating and mitigating factors. The basic fine is set in a range of 0% to 30% of affected commerce times the cartel longevity (in years) plus 15% to 25% as an additional dissuasive measure all function of the gravity of the harm caused by the cartel. However, the total fine must not exceed 10% of the overall turnover or global sales of the firm. Between 2010 and 2013 (partial), the prosecution of cartels resulted in over €7.48 billion in criminal fines (139 cases filed. This amount includes the highest fines in history, namely €1.57 billion for the TV and computer monitor tubes (2012) cartel and €1.35 billion for the car glass (2008) cartel.

Connor and Lande (2008) examined a large number of cartel overcharge estimates (OE) from the literature and found an average OE in the range 31% to 49% and a median in the range 22% to 25%. Based on this, they concluded that *"the current Sentencing Commission presumption that cartels overcharge on average by 10% is much too low, and the current levels of cartel penalties should be increased significantly"*. A similar study conducted by Connor (2010) concludes that *"...penalty guidelines aimed at optimally deterring cartels ought to be increased"*. Combe and Monnier (2011, 2013) performed an analysis of 64 cartels prosecuted by the European Commission and arrived at the conclusion that *"fines imposed against cartels by the European Commission are overall sub optimal"*. In criticizing the Canadian Competition Bureau approach, Kearney (2009) writes: "*The assumption of an average overcharge of 10 percent also has been put into question by economic survey evidence which suggests that the median long-run overcharge is much greater than 10 percent. Research conducted by Professor John Connor indicates 'that the median long-run overcharge for all types of cartels over all time periods is 25.0 percent …" Accordingly, an assessment of economic harm based on an estimated overcharge of 10 percent is not supported by the empirical evidence*."

Cohen and Scheffman (1989) argued that an increase of 1% of a price above its natural competition level usually results in a reduction of sales of more than 1%. Based on this, they concluded with respect to USSG guidelines that *"at least in price-fixing cases involving a large volume of commerce, ten percent is almost certainly too high"*. Adler and Laing (1997) and Denger (2003) also judged that the fines imposed by the US Department of Justice are "astronomical" or "excessive" (Connor and Bolotova 2006, p. 1112). Allain, Boyer and Ponssard (2011) develop a dynamic model of cartel behavior and conclude that the Combe and Monnier (2011) results are indeed due to a misinterpretation of the Becker-Landes rule.[3] They concluded that "the fines imposed by the European Commission in the 64 cartels analysed by Combe and Monnier are on averagre above the proper deterrence level." Considering a different database, Allain, Boyer,

[3] Becker, G. (1968) and Landes, W. H. (1983). See references for details.

Kotchoni and Ponssard (2013) conclude that "a clear majority of fines imposed by the European Commission over the period 2005-2010 are above the deterrence level."[4]

Hence, there is disagreement among specialists about the magnitude of cartel overcharges and thus, about the optimal fines. The central issue of our paper is to determine the order of magnitude of the average cartel overcharge. The sample used for our study is an extended version of the database used in Connor (2010). Each OE in the sample is obtained from a previous study. Therefore, the OE data are potentially subject to model errors, estimation errors and sample selection. The sample is quite heterogenous and contains a few number of influential observations. The minimum OE is 0% while the maximum is 1800%. Two groups of variables describe the cartels. The first group (denoted Y) consists of variables that explain the true overcharge (e.g. the characteristics of the cartel) while the second group (denoted Z) consists of factors that captures potential estimation biases (e.g. the estimation method and the publication source).

One way to verify if the OE are biased is to perform a meta-analysis, as in the seminal paper of Connor and Bolotova (2006). In the meta-analysis, OE are regressed on the Y and Z variables mentioned above. Connor and Bolotova (2006) provide evidence that part of the variability of OE is indeed due to the Z variables, namely, the estimation methods and publication sources. In Boyer and Kotchoni (2011), we conduct a meta-analysis by introducing three refinements with respect to Connor and Bolotova (2006). In a first step, we remove all cartels with initial OE larger than or equal to 50% as well as zero OE. Second, we use a K-means analysis to separate the sample into four "homogenous" clusters. And third, we model the logarithm of overcharges as a linear function of the explanatory variables mentioned above while assuming that the coefficients of the Z variables vary across the clusters. The log-linear specification appears to be less subject to distortions caused by influential observations, and explains the variance of the overcharge estimates to a greater extent than a linear specification. A Heckman correction is used to control for potential sample selection biases. Our results confirm that the OE are biased as they depend on the Z variables. We obtain an average bias-corrected OE of 13.62% for the subsample of cartels with initial estimates between 0% and 50%, and of 17.52% for all cartels.

The analysis conducted in Boyer and Kotchoni (2011) can be criticized on at least three grounds. First, the trimming of the sample at 50% has not been well-motivated, and there are claim that trimming the sample at a bound higher than 50% may lead to a higher average bias-corrected OE. Second, the regressors used for the meta-analysis include the indicators of the clusters identified in a prior K-means analysis on the same data. Third, the Heckit procedure used in Boyer and Kotchoni (2011) assumes that the latent variable that drives the occurrence of zeros OE and OE above 50%

[4] Boyer (2013) discusses this recent literature.

are the same. Boyer and Kotchoni (2012) provides a partial response to these critics by performing further K-mean analyses showing that the subsample of cartels with initial OE in the range (0%,50%) is quite representative of the universe of cartels (70% of the sample). The current paper is aimed at providing more complete answers to the previous critics.

Our first objective is to design a empirical framework in which the upper bound retained for data trimming is less arbitrary. To this end, we use a Kullback-Leibler divergence to compare the probability of an OE being larger than θ conditional on Y to the same probability conditional on (Y,Z). We find that the two probabilities more or less agree for $\theta \in [0\%, 65\%]$ but diverge for $\theta > 65\%$. This is suggestive that OE above 65% are significantly biased and should be discarded.

Next, we perform log-linear regressions of OE on subsamples of type $(0, \theta]$ using Y and Z as regressors. We include an inverse Mills ratio (IMR) inferred from the Probit for the indicator of $OE \in (0, \theta]$ in the regressions in order to control for the sample selection bias. If the OE data were unbiased, the average bias-corrected OE for the subsample of cartels with $OE \in (0, \theta]$ must be lower than the average bias-corrected OE inferred for the subsample of successful cartels. We find this condition to be satisfied only for $\theta \leq 49\%$. Thus, our final results are derived from a Heckit that infers bias-corrected overcharges for the whole sample from the subsample of $OE \in (0\%, 49\%]$.

Note that this framework does not involve any prior K-means analysis. Also, we assume that the zero raw OE are unbiased and feed the Heckit procedure with only the data on cartels with strictly positive raw OE. The IMR included in the Heckit only controls for the truncation of the right tail of the OE distribution. The Heckit model is used to predict bias-corrected OE for the subsample of effective cartels (i.e., cartels with OE>0). The zeros are included back unaltered in the sample for the purpose of making predictions for the whole sample. Having done this, we obtain a mean and median bias-corrected OE of 16.92% and 16.65% for the subsample of effective cartels and a mean and median of 15.76% and 16.43% for the whole sample.[5] These numbers are significanltly lower than the means and medians of the raw OE while remaining close to the findings of Boyer and Kotchoni (2011, 2012). The comparison of mean and median bias-corrected OE reveals also a fairly homogenous behavior of cartels accross different types, geographical locations and periods, which is rather reassuring.

The rest of the paper is organized as follows. In Section 2, we briefly review the overcharge estimation methods commonly used in the literature. Section 3 presents the raw OE and discusses

[5] In Boyer and Kotchoni (2011, 2012), we contrasted the results for the subsample of cartels with raw OE in the range (0%, 50%) with those obtained for the whole sample. Here, it sounds more natural to contrast the results for the subsample of effective cartels with the results for the whole sample.

the data problems. Section 4 shows the importance of correctly characterizing the but-for world and illustrates the danger of converting Lerner indices into OE by ignoring the competitive mark-ups. Sections 5 and 6 presents the empirical framework on which our meta-analysis rests and the methodology used for bias-correcting the raw OE. Section 7 presents the determinants of cartel overcharge unveiled by our best meta-analysis model. Section 8 presents some summary statistics for the bias-corrected OE. Section 9 concludes. Appendix A contains summary statistics of the database.

2. The Overcharge Estimation Methods

Let $\tilde{p}$ be the price imposed by the cartel and p the but-for price, i.e. the price that would prevail absent the cartel. The cartel overcharge expressed as a percentage of the but-for price is given by $\delta = (\tilde{p} - p)/p$. While the cartel price $\tilde{p}$ is observed, the but-for price p needs to be estimated. Many authors acknowledge that overcharges represent the bulk of the damages caused by cartels. This explains why the largest body of the economic literature on cartels is devoted to the price effects. The methods often used by academic and forensic economists to estimate the cartel overcharge can be summarized into five groups:

The "Before-and-after" Method: This method is based on the comparison of the price during the alleged cartel period with the price before and/or after the cartel. Its main drawback is that it tends not to control for external factors. For that reason, Connor (2010) warns that *"Shifts in buyer preferences, appearance or the disappearance of substitutes, or changes in the cost of production of the cartelized product during the affected period can cause overstatement or understatement of the overcharge."* This lack of robustness is also pointed out by Finkelstein and Levenback (1983): *"[...] This estimate, however, meets the immediate objection that it is likely to be incorrect because changes in factors affecting price other than the conspiracy would have produced changes in competitive prices if there had been competition during the conspiracy period."* More recently, Boyer, Lasserre and Moreaux (2012) show that over the dynamic development of an industry, episodes of tacit collusion investments and prices may follow episodes of more intensely competitive investments and prices and vice versa, raising doubts on the validity of the "before and after" method.

The "Price during a price war" Method: This method uses the price during a price war or lack of collusion to proxy the but-for price. This method is basically an instance of the before-and-after method and thus suffers from the same limitations.

The "Yardstick" Method: This method compares the prices during the conspiracy period with comparable, or yardstick, assumed competitive, firms, product or markets. The yardstick method should be used with caution because an increase in price due to domestic market cartelization can

cause a partial demand shift toward nearby markets. Similar domestic firms that are not participating in the collusion will tend to follow the cartel price (umbrella effect).

The "Cost-Based" Method: This method is based on the observation that changes in price should reflect changes in costs. The direct way to apply this method is to estimate the production costs by using the (accounting) information on firms involved in the cartel. In the lysine cartel case for example, prosecutors introduced confidential production and sales records of ADM as exhibits, now publicly available (See Connor, 2001). However, economic experts do not usually have access to such confidential information. Typically, the overcharge is thus approximated by subtracting a *"reasonable margin"* from the actual cartel profit and dividing by the production volume.

"Econometric" Methods: This denomination gathers all methods using more or less sophisticated econometric models to assess the but-for price. Econometric methods can be used to simulate an oligopolistic competition (Cournot, Bertrand), to predict the Lerner index of market power, or to estimate a demand and cost function that account for dynamic market conditions. The econometric approach can be structural or reduced form. See Appelbaum (1979) Froeb, Koyak and Werden (1993) and more recently Nieberding (2006).

Any well-designed estimation method is expected to produce reasonable estimates when used wisely. One of the goals here is to detect whether there are biases associated with the estimation methods and to remove these biases from raw OE.

3. The Connor Database

The sample used for the study is an extended version of the one used in Connor (2010).[6] The raw database consists of 1178 cartels,[7] from which 59 are discarded for missing information. This leaves us with a sample of 1119 cartels with OE ranging from 0% to 1800%. The mean OE is 45.5% on the whole sample and 49% for the subsample of strictly positive OE. The mean is 20.5% for the cartels with OE lying strictly between 0% and 49%, representing 69.8% of the sample. Estimates that are larger than 49% represent 22.9% of the sample and the average OE for this subsample is 137.3%. However, the sample means of 45.5% and 49% are influenced by a small number of outliers. Roughly 1% of OE are larger than 400% and when the 5% largest observations are left out of the sample, the average OE drops from 49% to 32%.

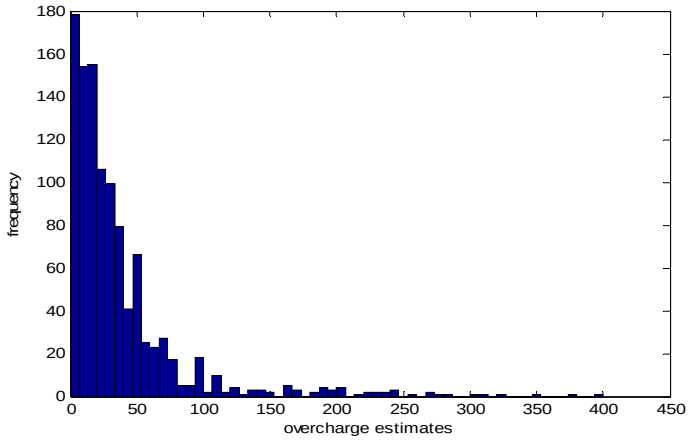
Connor (2010) found that the long run median overcharge for all types of cartels over all periods is 23.3% while the mean overcharge for successful cartels is 50.4%. The difference between the means and medians is due to the skewness of the distribution.[8] Figures 1 confirms that the large

[6] We sincerely thank Professor John Connor for generously making his database available to us.
[7] The sample actually describes cartel episodes. Each episode is treated as an independent cartel.
[8] This skewness problem is pointed out by Connor and Lande (2008) and Connor (2010).

magnitude of the empirical mean is due to a small number of outliers.[9] These outliers should be treated carefully when using econometric methods that are sensitive to their presence (e.g., OLS regressions).

The overcharge data consists of estimates previously published by different analysts and researchers. Therefore, they are potentially subject to model errors, estimation errors and sample selection. Model errors come from inconsistencies between the nature of the estimation problem and the choice of estimation method; estimation error stems from the randomness of the data used as input while sample selection refers to the extent to which the sample used is representative of the whole population.

Figure 1
OE: Distribution skewed to the right.
Overcharges larger than 400% (1% of the sample) are not shown on this figure.



The raw overcharge data are quite heterogenous across regions, scope (domestic vs international), and time periods (see Table 1). Such heterogeneity raises aggregation problems. Indeed, the average overcharge obtained for the whole sample is meaningful only if the conditions that determine the but-for price are the same across time and markets. Levenstein and Suslow (2003) illustrate this point: *"The reported price increases vary widely by industry and by source. At the low end, for example, we have a reported price increase of ten percent for the thermal fax paper cartel, which was formed as the industry was declining and lasted for less than a year. At the high end there is the stainless steel cartel, which reportedly almost doubled prices. This cartel lasted slightly more than one year (from January 1994 to March 1995) and involved six European steel companies."*

[9] It should be emphasized that Connor has been conservative in recording some of the OE, notably by tagging and excluding peak estimates from the sample (see Connor, 2010, pp. 48 and following).

Table 1
Means and medians of raw OE per location and types of cartels.
The prop. are percentages of the total Connor sample (1119 cartels).

		All Cartels	OE>0%	0%<OE≤49%	OE>49%	Cartels Before 1973	Cartels After 1973
All locations	Mean	45,47	49,01	20,46	135,89	61,98	38,89
	Median	23,00	25,00	18,30	73,00	29,00	21,40
	prop.	100.00	92.77	69.82	22.94	28.48	71.52
US	Mean	38,15	42,03	19,44	123,82	47,79	33,58
	Median	20,50	23,50	17,30	69,20	30,50	16,80
	prop.	30.00	27.23	21.34	5.89	9.64	20.36
EU	Mean	42,65	45,57	19,07	113,01	43,83	41,86
	Median	23,00	25,00	16,05	75,00	24,75	20,40
	prop.	33.48	31.34	22.50	8.84	13.39	20.09
Domestic	Mean	33,60	36,91	18,43	137,58	35,42	32,79
	Median	17,05	19,00	16,10	69,70	20,50	16,45
	prop.	46.79	42.59	35.98	6.60	14.46	32.32
International	Mean	55,90	59,28	22,62	135,21	89,38	43,93
	Median	30,00	31,88	22,00	74,40	37,00	27,50
	prop.	53.21	50.18	33.83	16.33	14.02	39.20

The following variables are listed in the Connor database:

$\hat{\theta}$ - the overcharge esimates, which is described in Table 1.

Y_1 – Duration: equals 1 if duration is less than 5 years, 2 if duration is from 6 to 10 years, 3 if duration is from 11 to 15 years, and 4 if duration is 16 years or more.

Y_2- Scope: equals 1 if domestic and 0 if international.

Y_3- Bid rigging: equals 1 if Yes and 0 if No.

Y_4- Found guilty or pleads guilty: equals 1 if Yes and 0 if No.

Y_5- Geographic market: five dummy variables for US, EU, ASIA, ROW including Latin America, and WORLD cartels that cannot be associated to a head region.

Y_6- Antitrust law regime: six dummy variables for P1 (1770-1890), P2 (1891-1919), P3 (1920-1945), P4 (1945-1973), P5 (1974-1990), and P6 (1991-2004).

Z_1- Overcharge estimation method: dummy variables for Price before conspiracy, Price war, Price after conspiracy, Yardstick, Cost based or normal profit, Econometric modeling, Historical case study with no method specified, legal decisions and Other.

Z_2- Type of publication: dummy variables for Peer reviewed journal, Chapters in a book, Monograph or book, Government report, Court or antitrust authority source, Working paper, and Speech or conference presentation.

The candidates explanatory variables listed above can be separated into two groups. The first group consists of variables that describe the cartel (i.e, the Y-variables) and has the potential the to explain the size of the true overcharge. The second group of variables (i.e., the Z-variables) describes the subjective factors that can cause the OE to be biased.

4. The Proper Characterization of the But-for Price

One of the most important cause of bias in OE resided in the difficulties raised by the proper characterization of the but-for world. In fact, the observed time series of prices are resultant of several causes. For example, an inelastic demand may grant a firm with a significant market power that translate into high mark-ups. Homogenous products may be perceived as differentiated by consumers due to the positioning of the product by the firm's advertisement policy. The product differentiation in turn can cause a previously pure competitive market to behave as an oligopolistic or a monopolistically competitive one. But typically, oligopolistic markets have margins over *MC* that are significantly above zero, as illustrated by the following citation from Morrison (1990): *"The empirical results suggest that mark-ups in most U.S. manufacturing firms have increased over time, and tend to be countercyclical."* In Morrison (1990), one further reads*:"...Robert Hall [ref.], [...] reported both significant increasing returns and mark-ups of price over marginal cost in various U.S. industries. Hall also finds that economic profits are approximately normal, suggesting an industrial structure along the classic lines of monopolistic competition."*

The proper but-for price should thus be the one that characterizes the natural competition equilibrium for the targeted market. More precisely, the but-for price is equal to the marginal cost plus a margin over marginal cost. In pure and perfect competition, this margin is low and close to zero. The accurate assessment of this marging is quite important when concerting Lerner indices into cartel overcharges.[10] The Lerner index of market power is defined as:

$$\mathrm{L} = \frac{\mathrm{p}-\mathrm{c}}{\mathrm{p}} \qquad (1)$$

where p is the market price and c is the marginal cost (MC). In a perfectly competitive market, $p = c$ so that $L = 0$. If the condition that would prevail in the absence of cartels is pure and perfect

[10] An overcharge calculation approach based on the Lerner index can fall within the family of econometric methods or cost-based methods depending on how this index is estimated.

competition, then the but-for price is given by $p = c$. The Lerner index for the cartelized market is then given by $\mathrm{L} = \frac{\tilde{\mathrm{p}}-\mathrm{c}}{\tilde{\mathrm{p}}}$ and the true overcharge is:

$$\delta = \frac{\tilde{\mathrm{p}}-\mathrm{p}}{\mathrm{p}} = \frac{\tilde{\mathrm{p}}-\mathrm{c}}{\mathrm{c}} \Leftrightarrow \delta = \frac{\mathrm{L}}{1-\mathrm{L}} \quad (2)$$

where $p = c$ is the but-for price in this case. Hence the formula above permits to retrieve the overcharge from the Lerner index if the but-for world is assumed to be characterized by pure and perfect competition.

In a natural competition (real life) context, the price is generally equal to the MC (c) plus a margin over MC (m). The but-for price is then given by $p = c + m$. The Lerner index in the cartelized market is:

$$\mathrm{L} \equiv \frac{\tilde{\mathrm{p}}-\mathrm{c}}{\tilde{\mathrm{p}}} = \frac{\tilde{\mathrm{m}}}{\mathrm{c}+\tilde{\mathrm{m}}} \quad (3)$$

where $\tilde{p} = c + \tilde{m}$ is the price in the cartelized market. Hence the (true) overcharge by the cartel over the natural competition price becomes:

$$\delta \equiv \frac{\tilde{\mathrm{p}}-\mathrm{p}}{\mathrm{p}} = \frac{\tilde{\mathrm{m}}-\mathrm{m}}{\mathrm{c}+\mathrm{m}} \quad (4)$$

However, the overcharge that would be inferred from the Lerner index (wrongly) assuming perfect competition as benchmark is:

$$\tilde{\delta} \equiv \frac{\mathrm{L}}{1-\mathrm{L}} = \frac{\tilde{\mathrm{m}}}{\mathrm{c}} = \delta + \frac{\mathrm{m}}{\mathrm{c}}(\delta + 1) \quad (5)$$

Table 2 illustrates the danger of converting Lerner indices into OE by ignoring the existence of competitive mark-ups that already in the but-for world. A number of OE used in Connor (2010) have been obtained from conversion of Lerner indices into overcharges.[11] These conversions are usually done assuming that the situation that would prevail absent the cartel conspiracy is pure and perfect competition. However, the natural competition for some markets might be oligopolistic. Oligopolistic competition mark-ups typically range from 10% to 30%, and sometimes more (Morrison 1990, 1993). If the true overcharge is $\delta = 10\%$ and $\frac{m}{c} = 20\%$, then the Lerner index delivers the biased estimate $\tilde{\delta} = 32\%$, i.e. more than three times the true value. Note that the bias

[11] Table 2 of the appendix to Connor 2010 ("price-fixing overcharge") provides a "*Summary of Price-Fixing Damages, Social-Science Studies*". The table presents 280 cartels, their OE and a description of the estimation method. Of the 280 OE, 51 have been obtained by conversion of a Learner index (which represents 17% of this subsample). Unfortunately, we do not know the exact proportion of the overcharges obtained by this method for the whole sample.

is increasing in both the true δ and the natural competition mark-up to marginal cost ratio $\frac{m}{c}$. If the unit cost c is small, the bias $\frac{m}{c}(\delta + 1)$ will tend to be large, no matter how small the true δ is.

Table 2
Pitfall in the Conversion a Lerner Index Into an OE: Constant overcharge, constant margin, and bias increasing as the marginal cost decreases.

Parameters	Values				
δ	10%	10%	10%	10%	10%
m	0.02	0.02	0.02	0.02	0.02
c	0.20	0.1625	0.1250	0.0875	0.05
$\frac{m}{c}$	10%	12.3 %	16%	22.9%	40%
$\text{Bias} = \frac{\text{m}}{\text{c}}(\delta + 1)$	11%	14%	18%	25%	44%
$\tilde{\delta} = \delta + Bias$	21%	24%	28%	35%	54%
$\frac{\text{Bias}}{\delta}$	52.4%	58.3%	64.3%	71.4%	81.5%

The other overcharge estimation methods (e.g., before-and-after methods) are not necessarily exempt of biases. In the ADM-lysine case for example (see Connor, 1997), the approach advocated by Connor in estimating the overcharge as well as what he considers as the effective conspiracy period remains an area of disagreement. For example, White (2001) wrote:*"Connor [...] has claimed that the trebled damages to lysine purchasers were an order of magnitude larger [than the 45 million settlement proposed by ADM]. Crucial to Connor's conclusions are his assumptions as to the time period during which the conspiracy had an effect on prices and the but-for price that otherwise would have prevailed in the absence of the conspiracy. This paper will argue that Connor substantially over-estimated the period of the conspiracy and under-estimated the but-for price."*

In the following citation from Levenstein and Suslow (2002), White further expressed his doubts about the quality of the estimates of Connor:*"White [...] argues that the lysine industry, absent cooperation, would not have operated as a perfectly competitive industry. It was a four-firm oligopoly that would have likely been able to engage in some form of implicit coordination if there had been no explicit meetings. Recognition of this possibility, White argues, causes us to " enter the world of oligopoly speculation." Perhaps ADM would have operated as a dominant firm. Or, perhaps the firms would have adopted Cournot behavior. [...] He concludes that " though the conspiracy surely did have harmful effects on the purchasers of lysine, those effects were less extensive and less severe than was claimed."*

In summary, some of the methods that have been used in the literature to estimate the overcharge are rather simplistic in regard of the complexity of proper characterization of the but-for world.[12]

5. A Formal Assessment of the Quality of the OE Data

Let us consider assessing the effectiveness profile of cartels from the overcharge data available to us, where the effectiveness profile is defined as the probability of the true overcharge being strictly larger than a given thresold θ, for $\theta \geq 0$:

$$\Pr(\theta_i > \theta | Y_i) = \Phi(a + Y_i b) \quad (6)$$

where θ_i is the cartel overcharge and Y_i contains variables that determine the overcharge.

Unfortunately, we do not observe θ_i. Instead, we observe an estimate $\hat{\theta}_i$ which is potentially influenced by some bias factors Z_i. Thus, we can reasonably assume that:

$$\Pr(\hat{\theta}_i > \theta | Y_i, Z_i) = \Phi(\tilde{a} + Y_i \tilde{b} + Z_i \tilde{c}) \quad (7)$$

If $\hat{\theta}_i$ were unaffected by the bias factors Z_i, then it would be an unbiased estimator of θ_i and $\tilde{c}$ should be equal to zero in Equation (7). We would then have:

$$\Pr(\hat{\theta}_i > \theta | Y_i) = \Pr(\hat{\theta}_i > \theta | Y_i, Z_i) \cong \Pr(\theta_i > \theta | Y_i)$$

Otherwise, $\Pr(\hat{\theta}_i > \theta | Y_i)$ can be very different from both $\Pr(\theta_i > 0 | Y_i)$ and $\Pr(\hat{\theta}_i > \theta | Y_i, Z_i)$. Thus, the impact of Z_i on OE can be detected by examining the following Kullback-Leibler divergence:

$$\Delta(\theta) = \frac{1}{n} \sum_{i=1}^{n} \log \Pr(\hat{\theta}_i > \theta | Y_i) \left[\log \Pr(\hat{\theta}_i > \theta | Y_i) - \log \Pr(\hat{\theta}_i > \theta | Y_i, Z_i) \right] \quad (8)$$

where $\Pr(\hat{\theta}_i > \theta | Y_i)$ and $\Pr(\hat{\theta}_i > \theta | Y_i, Z_i)$ are estimated by Probit. The Kullback-Leibler information criterion (see Kullback and Leibler, 1954) tells how dissimilar two distributions are. If f(u) denotes a true probability distribution function of interest, the Kullback-Leibler distance between a "false" probability distribution function g(x) and f(x) is given by:

$$\int \left(\log \frac{f(u)}{g(u)} \right) f(u) du$$

[12] Related to this issue, Katsoulacos and Ulph (2013) conducted a theoretical analysis that accounts for the timing of antitrust authorities' decision and found that the optimal cartel fine is approximately 75% of the amount implied by the conventional formula.

The expression of $\Delta(\theta)$ given by Equation (8) is an empirical counterpart of the Kullback-Leibler distance adapted to conditional distributions.

Figure 2 plots the values of $\Delta(\theta)$ on the y-axis against θ on the x-axis. We note that $\Pr(\hat{\theta}_i > \theta|Y_i)$ and $\Pr(\hat{\theta}_i > \theta|Y_i, Z_i)$ agree to a large extent when θ lies between 0 and 65. However, the divergence between $\Pr(\hat{\theta}_i > \theta|Y_i)$ and $\Pr(\hat{\theta}_i > \theta|Y_i, Z_i)$ increases dramatically as soon as $\theta \geq 65\%$, which suggests that the OE above this thresold are quite biased. Given these results, the subsample of cartels with raw OE strictly larger than 65% (14.29% of the sample) should be treated with caution. Subsequently, our investigation strategy will thus consist of estimating a meta-analysis model on a subsample of cartels with OE lying strictly above 0% and below 65% and using the results to infer the average overcharge for the whole sample.

Figure 2

Detecting the impact of the bias factors via the Kullback-Leibler divergence:
$\Delta(\theta)$ is on the y-axis and θ on the x-axis.

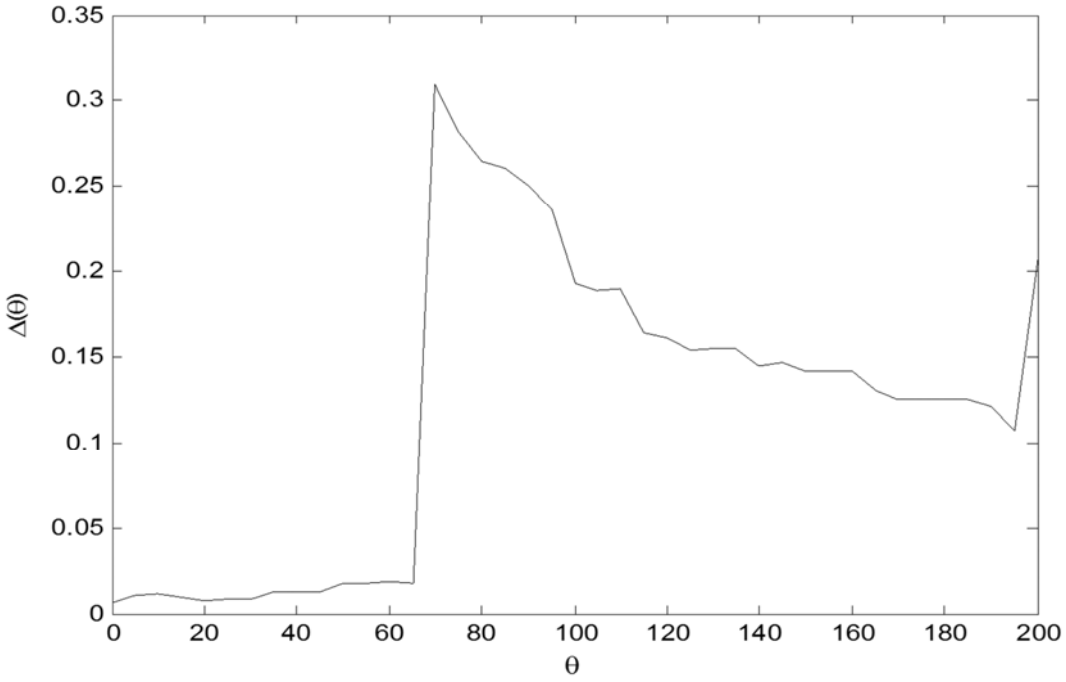


Table 3 shows the Probit estimation results for the probability of a cartel being successful at raising its price above the competitive equilibrium level. There is a positive link between the duration of a cartel and its probability of being successful. Domestic cartels tend to be less successful than international cartels while bid-rigging tends to be more successful than other forms of cartels. US cartels are less effective than EU cartels while recent cartels are less effective than cartels of the period P2 (1891-1919).

Table 3

Probit model for the probability of a cartel being successful: $\Pr(\hat{\theta}_i > 0 | Y_i, Z_i)$

Estimation is done using the whole sample (1119 cartels)

	Coefficients	Student-t[13]	Marginal effect at the median
Constant	1,73	3,94	0,15
Duration	0,14	2,08	0,01
Domestic	-0,29	-1,64	-0,03
BidRig	0,71	3,10	0,06
Guilty	0,37	2,26	0,03
US	-0,33	-1,43	-0,03
EU	0,03	0,15	0,00
ASIA	-0,12	-0,38	-0,01
ROW	-0,31	-0,82	-0,03
P1	15,74	0,00	1,35
P3	-0,89	-2,65	-0,08
P4	-0,22	-0,57	-0,02
P5	-0,68	-1,92	-0,06
P6	-0,49	-1,43	-0,04
OTHER	-0,84	-3,08	-0,07
HISTOR	-1,58	-4,31	-0,14
PBEFOR	0,16	0,68	0,01
PWAR	-0,04	-0,08	0,00
PAFTER	0,08	0,34	0,01
COST	0,00	0,00	0,00
YARDST	0,16	0,60	0,01
LEGAL	0,68	1,87	0,06
JOURNAL	-0,44	-1,61	-0,04
MONOGR	0,32	1,21	0,03
EDBOOK	-0,03	-0,10	0,00
COURT	-0,02	-0,06	0,00
WORKP	0,48	1,32	0,04
SPEECH	15,19	0,00	1,31

[13] A coefficient is significant in a one sided 10% level test if the corresponding student-t is larger than 1.28 in absolute value.

Curiously enough, there are more zero OE found in "*historical case study with no method specified*" than in studies that specify an estimation method. Also, more zero OE are published in "peer reviewed journal" than in "working papers" and legal proceedings. Despite the fact that the Z-variables explains the probability of cartel success, it is interesting to note that $\Pr(\hat{\theta}_i > 0|Y_i, Z_i)$ is not very different from $\Pr(\hat{\theta}_i > 0|Y_i)$, as shown by the value of divergence $\Delta(0)$ on Figure 2. This suggests that the information content of the raw OE data is accurate as long as our objective is to identify the set of effective cartels but unreliable when it comes to tell the true values of the OE.

6. A Meta-Analysis of the Cartel OE

Meta-analyses are used in experimental fields to summarize the findings of studies on a particular topic. They may also be used to verify if the conditions of experiments impact their results. In his preface to the second edition of Hunter and Schmidt (2004), F. Schmidt wrote: "*[...] In our view, the purpose of meta-analysis is to estimate what the results would have been had all the studies been conducted without methodological limitations and flaws*". The meta-analysis conducted in this paper is consistent with this statement.

It is reasonable to expect that the true overcharge depends on the conspiracy period, the duration of the cartel, the characteristics of the firm involved in the collusion and factors alike. However, we do not observe the true overcharge. Instead, we observe an estimate of it that is equal to the actual overcharge plus a bias. This bias can be positive, null or negative. Hence in addition to factors that affect the true overcharge, we can expect the estimate to be sensitive to subjective factors that cause the bias, namely the estimation method, the source of publication and other factors "posterior" to the occurrence of the conspiracy period. Formally, the bias is defined as the influence of factors that affect the OE, but not the true overcharge values themselves.

We consider estimating a log-linear meta-analysis model on subsamples of $OE \in (0, \theta]$. The model estimated is:

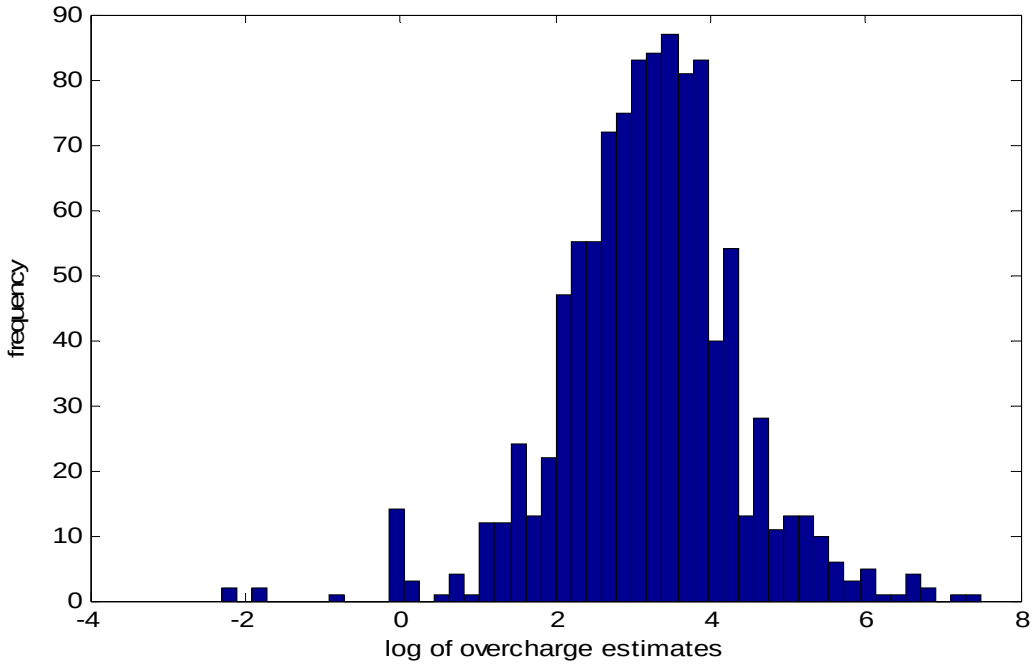
$$\log\hat{\theta}_i = \alpha + Y_i\beta + Z_i\gamma + \widehat{imr}_i\delta + e_i \qquad (9)$$

where $\hat{\theta}_i \in (0, \theta]$ and $\widehat{imr}_i$ is the inverse Mills ratio (IMR) associated with a preliminary Probit model for the indicator of $\hat{\theta}_i \in (0, \theta]$ (i.e., the selection variable). Here, we are employing the well-known two-step Heckit procedure where an IMR estimated in a first step is included in as extra regressor in the second step in order to control for sample selection biases. We have preferred the Heckit procedure to a right censored Tobit because the former model is less restrictive than the latter while the OE are noisy and potentially biased versions of the true overcharges of interest. We focus on modeling the log of OE because their distribution is more symmetric (See Figure 3).

The Heckit procedure requires that some regressors be included in the first step Probit from which the IMR is estimated and excluded from the second step regression. Such regressors are known as exclusion variables and they ensure the identifiability of the parameters that are estimated at the second step. An ideal exclusion variable should explain the probability of an OE belonging to the range (0%, 65%] while having no direct influence of the true OE. Unfortunately, such variables are clearly not available to us.

Figure 3

Logarithm of positive OE (92.7% of the sample)



To circumvent this difficulty, we consider shrinking the information set repesented by the bias factors (Z-variables) in the second set estimation. More precisely, we use the Y-variables as regressors along with the following dummy variables in the first step probit:

Z_1- Overcharge estimation method: Price before conspiracy, Price war, Price after conspiracy, Yardstick, Cost based or normal profit, Econometric modeling, Historical case study with no method specified, legal decisions and "Other."

Z_2- Type of publication: Peer reviewed journal, Chapters in a book, Monograph or book, Government report, Court or antitrust authority source, Working paper, and Speech or conference presentation.

This amounts to a total of 14 dummy variables. In the second step, we shrink the information set above as follows. Regarding the overcharge estimation method, Historical case studies with no method specified, legal decisions and "Other" are merged into a single category. Regarding the type of publication, peer reviewed journals and working papers are merged under one group while book chapters and monographs are merged into another group. All the other categories are kept unchanged so that the bias factors are represented by 10 dummy variables in the second step regression. This shinkage in information set plays as exclusion restrictions. Note that it would not be possible to employ this identification strategy if we have adopted a right censored Tobit model. Indeed the Z-variables affect the distribution of the OE and not the true overcharge. Thus, playing with the Z-variables ensures us that the bias-corrected OE obtained at the second step are not distorted too much.

After estimating Equation (9), we compute the bias-corrected OE conditional on $\hat{\theta}_i \in (0, \theta]$:

$$\hat{\theta}_{bc1,i}(\theta) = \exp\left(\hat{\alpha} + Y_i\hat{\beta} + \widehat{imr}_i\hat{\delta} + \frac{\hat{\sigma}_e^2}{2}\right), \hat{\theta}_i \in (0, \theta] \quad (10)$$

We also compute the bias-corrected estimates unconditionally by removing the IMR from the equation above:

$$\hat{\theta}_{bc2,i}(\theta) = \exp\left(\hat{\alpha} + Y_i\hat{\beta} + \frac{\hat{\sigma}_e^2}{2}\right), \hat{\theta}_i > 0 \quad (11)$$

Note that the Probit (from which the IMR is inferred) is feeded with the subsample of cartels with strictly positive OE (1038 cartels), $\hat{\theta}_{bc1,i}(\theta)$ is computed for cartels with OE lying between 0 and θ while $\hat{\theta}_{bc2,i}(\theta)$ is computed for the subsample of successful cartels.

Given that the subsample used for estimation is truncated from the right, the Heckit should predict a larger average bias-corrected OE on the whole sample than in the subsample, that is:

$$\bar{\theta}_{bc1}(\theta) = \frac{1}{n(\theta)}\sum_{\hat{\theta}_i \in [0,\theta]} \hat{\theta}_{bc1,i}(\theta) \leq \frac{1}{n}\sum_{i=1}^{n} \hat{\theta}_{bc2,i}(\theta) = \bar{\theta}_{bc2}(\theta) \quad (12)$$

where $n(\theta)$ is the size of the subsample used for estimation. Furthermore, $\bar{\theta}_{bc1}(\theta)$ should be an increasing function of θ over the valid range of overcharges. A violation of any of these two rules is suggestive of the presence of severe biases in the raw OE.

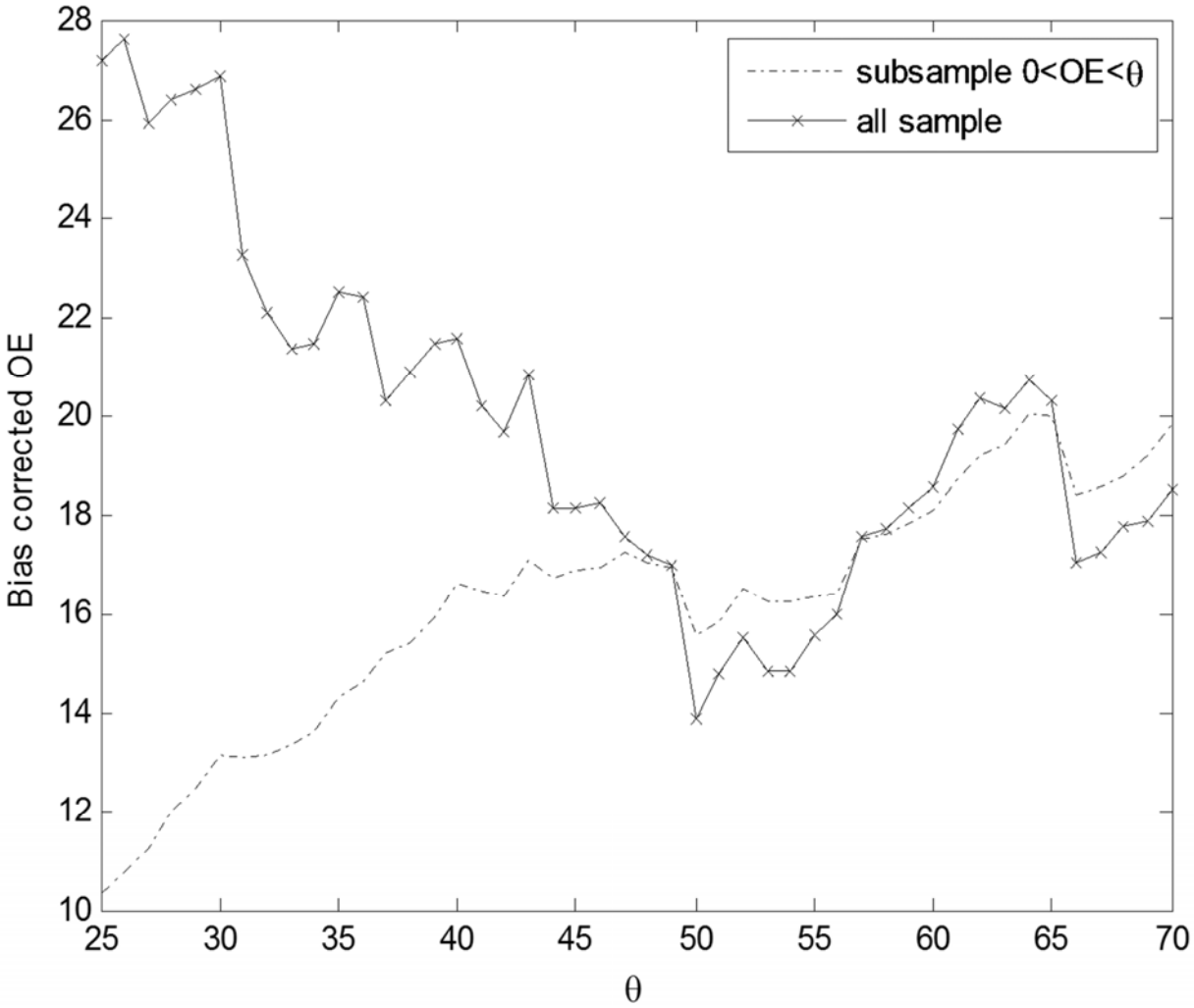
Figure 4 plots $\bar{\theta}_{bc1}(\theta)$ and $\bar{\theta}_{bc2}(\theta)$ on the y-axis against θ on the x-axis. We see that $\bar{\theta}_{bc2}(\theta)$ remains above $\bar{\theta}_{bc1}(\theta)$ as long as $\theta \leq 49\%$. As θ increases from 49% to 50%, $\bar{\theta}_{bc2}(\theta)$ drop from 16.99% to 13.89% while $\bar{\theta}_{bc1}(\theta)$ decreases from 16.90% to 15.53%. The predictions for the whole sample remain below those for the subsample as θ varies between 49% and 57%. $\bar{\theta}_{bc1}(\theta)$ is more or less monotocally increasing on $\theta \leq 49\%$. Unfortunately, the same cannot be said on $\theta > 49\%$.

These results suggests that the raw OE data above 49% are not reliable. It is glaring to see on Figure 4 how trimming at 49% and at 50% lead to substantially different bias-corrected OE. This is another signature of the bias contaminating the OE data.

As zero overcharges have been excluded from the analysis of this section, it should be emphasized that the bias-corrected overcharges showed on Figure 4 pertains to effective cartels only. The inclusion of the IMR in the estimating equations only controls for the truncation of the right tail of the distribution of strictly positive OE.

Figure 4

Average bias-corrected OE inferred from the subsample $\hat{\theta}_i \in [0, \theta]$
Dotted line: average bias-corrected OE $\bar{\theta}_{bc1}(\theta)$ on the subsample used for estimation
Solid line: average bias-corrected OE $\bar{\theta}_{bc2}(\theta)$ on whole sample



7. The Determinants of Cartel Overcharge

The results of Sections 5 lead us to restrict the analysis of Section 6 to cartel OE that are lower than 65%. The analysis of Section 6 further convinced us to truncate the sample at 49%. The current section is devoted to the discussion on the estimated coefficients when the sample is trimmed at 49%.

Let us first describe the sample used for estimation. Appendix A presents summary statistics for the subsample of cartels with zero OE, the subsample with OE between 0% and 49%, and the subsample with OE above 49%. Table 4 presents the Probit estimation results for the selection variable, i.e. $\Pr(\hat{\theta}_i \leq 49|Y_i, Z_i)$. Among others, we note that domestic cartels are more selected into the sample use at the second step than international cartels. Likewise, bid rigging cases are more selected into the sample than standard cartels. US, EU and ASIA cartels are more discarded than cartels of the reference group WORLD. However, cartels of the category ROW are less excluded into the sample than those of the reference group. Cartels that operated under the antitrust law regimes P3, P4 and P6 are more selected than those of the groups P1, P2 and P5. We also note that the Z-variables are significantly correlated with the selection variable. Indeed, OE obtained by econometric methods are less excluded than those obtained by other estimation methods. Also, OE published in government reports are more excluded than those published in other media.

Table 5 presents the estimated coefficients of the meta-regression. The results suggest that the ability of a cartel to raise its price increases with its duration (approximately 0.05% per quinquennium). Cartels resolved with a guilty plea charge approximately 0.28% more than the other cartels. Cartels of the EU charge 0.25% less than cartels of other georgraphical location. The anti-trust law regime does not seem to influence the size of the overcharge. The OE obtained by a "price war" method are significantly larger than those obtained by all other estimation methods. On the other hand, OE published in peer reviewed academic journals or working paper and in court decisions are on average higher than those published in other media.

Table 4

Probit model for the probability of a cartel being successful: $\Pr(\hat{\theta}_i \leq 49 | Y_i, Z_i)$
The sample used consists of strictly positive OE only (1038 cartels).

	Coefficients	Student-t[14]	Marginal effect at the median
Constant	0,16	0,51	0,05
Duration	-0,04	-0,83	-0,01
Domestic	**0,82**	**6,50**	**0,27**
BidRig	**0,34**	**2,39**	**0,11**
Guilty	0,06	0,45	0,02
US	**-0,43**	**-2,75**	**-0,14**
EU	**-0,16**	**-1,23**	**-0,05**
ASIA	**-0,68**	**-3,28**	**-0,22**
ROW	**0,45**	**1,39**	**0,15**
P1	0,16	0,30	0,05
P3	**0,35**	**1,59**	**0,12**
P4	**0,34**	**1,55**	**0,11**
P5	0,22	0,95	0,07
P6	**0,46**	**2,08**	**0,15**
OTHER	**-0,64**	**-2,70**	**-0,21**
HISTOR	-0,59	-1,12	-0,19
PBEFOR	**-0,33**	**-1,91**	**-0,11**
PWAR	**-0,77**	**-2,35**	**-0,25**
PAFTER	**-0,37**	**-1,90**	**-0,12**
COST	**-0,53**	**-2,17**	**-0,17**
YARDST	**-0,55**	**-2,88**	**-0,18**
LEGAL	-0,09	-0,42	-0,03
JOURNAL	**0,41**	**1,92**	**0,13**
MONOGR	**0,28**	**1,46**	**0,09**
EDBOOK	0,07	0,27	0,02
COURT	**0,33**	**1,54**	**0,11**
WORKP	**0,74**	**3,20**	**0,24**
SPEECH	**1,08**	**1,52**	**0,35**

[14] A coefficient is significant in a one sided 10% level test if the corresponding student-t is larger than 1.28 in absolute value.

Table 5

Meta-Analysis of cartel OE

The sample used is for estimation is $0\% < \hat{\theta}_i \leq 49\%$ (782 cartels). An IMR is included to control the right truncation. Therefore, the estimation results concern effective cartels only.

	Coefficients	1b(90)	ub(90)
Constant	2,5231	1,8473	3,1989
Duration	**0,0550**	**0,0030**	**0,1070**
Domestic	-0,2275	-0,5237	0,0687
BidRig	-0,0131	-0,1683	0,1421
Guilty	**0,2841**	**0,1321**	**0,4361**
US	-0,1216	-0,3586	0,1155
EU	**-0,2499**	**-0,4268**	**-0,0730**
ASIA	0,0440	-0,2854	0,3734
ROW	-0,1114	-0,4078	0,1849
P1	0,2586	-0,3702	0,8875
P3	-0,1781	-0,4894	0,1331
P4	-0,2475	-0,5485	0,0535
P5	-0,0500	-0,3358	0,2357
P6	-0,1609	-0,4609	0,1390
OTHER+HISTOR+LEGAL	-0,0019	-0,7454	0,7417
PBEFOR	-0,0118	-0,1973	0,1737
PWAR	**0,2303**	**0,0447**	**0,4159**
PAFTER	0,4431	-0,0271	0,9133
COST	0,1371	-0,0751	0,3493
YARDST	0,0942	-0,2210	0,4094
JOURNAL+WORKP	**0,2630**	**0,0148**	**0,5111**
MONOGR+EDBOOK	0,1167	-0,2041	0,4376
COURT	**0,4173**	**0,1459**	**0,6887**
SPEECH	0,1084	-0,1857	0,4025

Connor and Bolotova (2006) performed a meta-analysis of cartel OE in which they modelled the OE as a linear function of Y and Z.

$$\hat{\theta}_i = \alpha + Y_i\beta + Z_i\gamma + \varepsilon_i \qquad (13)$$

In an effort to improve the data quality before estimating their model, Connor and Bolotova (2006) did several types of data trimming. First, they eliminated peak estimates from the sample. Second, they eliminated low ends of ranges in episodic overcharges. Third, they removed all but the lowest of multiple estimates for the same episodes. And fourth, they took out observations more than several standard deviations from the estimated regression function. They estimated different

restrictions of the full model. Consider the estimation results for the full model (column [7] of Table 6 in their paper), they found that the OE is positively related to the duration, but does not depend on whether the firm is "guilty" or not; it is lower for domestic cartels and for cartels that have operated in the EU; it is neither higher nor lower for bid-rigging cases contrary to what is claimed by Cohen and Scheffman (1989); and that the size of overcharges has declined over time. Connor and Bolotova attribute the latter result to the increased severity of antitrust regulation.

Interestingly, they also found that the Z variables have significant impacts on OE. For example, they found the "yardstick" method to produce estimates that are at least 10% higher than the "after the conspiracy" method. For the publication sources, they found that "government reports" and "court reports" produce estimates that are respectively 22% lower and 15% higher than "monograph or book". The fact that the Z variables show significant effects in the regression suggests that the raw OE are indeed biased.

Our results differ in at least two ways from those of Connor and Bolotova (2006). First, we find that cartels who pleaded guilty have higher overcharge on average. Second, we find that the anti-trust law regime has no impact on the overcharge.

8. Bias-corrected OE

This section presents summary statistics of the bias-corrected OE obtained from the meta-analysis results discussed in Section 6. As noted earlier, we have applied our bias-correction formulas only to cartels with strictly positive OE, leaving the initial 0% OE unchanged. Table 6 replicates Table 1 with bias-corrected OE as input. For the subsample with initial estimates lying in the range 0% to 49%, we find a mean overcharge of 16.92% with a median of 16.65%. For the whole sample (including the zeros), the predicted mean is 15.76% while the median is 16.43%. For the subsample of strictly positive OE, the mean is 16.99 while the median is 16.65. For US cartels, we find a mean bias-corrected OE of 16.04% (with a median of 15.72%) for the subsample used for estimation and 14.44% (with a median of 15.08%) for the whole sample. For EU cartels, the corresponding figures are 14.49% (14.08%) and 13.75% (14.01%). Moreover, we find a mean bias-corrected OE of 17.78 (with a median of 18.60) for international cartels and 13.47 (with a median of 14.34) for domestic cartels. Finally, we find that post-1973 cartels achieved higher bias-corrected overcharge than pre-1973 cartels.

Overall, mean and median bias-corrected OE suggest a more homogenous behaviour of cartels accross different types, geographical locations and periods than suggested by the raw data of Table 1. Indeed, the but-for price reflects the market power of firms under natural competition. If the cartel overcharge were expressed in dollar, it would also reflects the initial market power granted

to firms by nature, strategy and other market conditions. However, as shown by Table 6, the overcharge displays a quite homogenous behavior across markets, time and geographical location and scope. Hence, *a cartel is a cartel is a cartel.*

Table 6
Means and medians of Bias-corrected OE per location and types of cartels.
The prop.% are fractions of the total Connor sample (1119 cartels)

		All Cartels	OE>0%	0%<OE≤49%	OE>49%	Cartels Before 1973	Cartels After 1973
All locations	Mean	15,76	16,99	16,92	17,22	13,67	16,59
	Median	16,43	16,65	16,65	16,65	13,83	17,36
	prop.	100.00	92.77	69.82	22.94	28.48	71.52
US	Mean	14,44	15,91	16,04	15,42	13,73	14,77
	Median	15,08	15,72	15,72	15,08	14,25	15,72
	prop.	30.00	27.23	21.34	5.89	9.64	20.36
EU	Mean	13,75	14,69	14,49	15,21	12,73	14,43
	Median	14,01	14,34	14,08	14,78	13,04	16,33
	prop.	33.48	31.34	22.50	8.84	13.39	20.09
Domestic	Mean	13,47	14,79	14,81	14,73	12,90	13,72
	Median	14,34	14,88	14,88	14,25	13,24	14,99
	prop.	46.79	42.59	35.98	6.60	14.46	32.32
International	Mean	17,78	18,86	19,16	18,23	14,46	18,97
	Median	18,60	18,80	19,74	17,59	14,76	21,12
	prop.	53.21	50.18	33.83	16.33	14.02	39.20

Table 7 presents the *mean* bias-corrected OE for different categories of cartels according to whether they are domestic or international, in bid-rigging cases of not, and/or were found or pleaded guilty or not. Table 8 presents *median* bias-corrected OE for the same subgroups. The differences between the raw OE (Table 1 and the left-hand side of Tables 7 and 8) and the bias-corrected ones (Table 6 and the right-hand side of Tables 7 and 8) are striking, both in terms of levels and in terms of orderings. The medians of the subgroups do not change very much as one moves from the whole sample to the trimmed sample. This suggests that the subsample used for estimation is quite representative of the whole universe of cartels.

Table 7
Raw versus Bias-corrected *mean* OE.
"n.a." means that the corresponding category of cartels is not represented in the subsample of interest.

Cartel characteristics			Raw OE					Bias-Corrected OE				
domestic	bidrig	Guilty	US	EU	ASIA	ROW	WORLD	US	EU	ASIA	ROW	WORLD
Subsample with OE>0%												
Yes	Yes	Yes	27,61	18,41	29,47	17,40	18,70	16,10	13,99	18,17	15,46	18,18
No	Yes	No	NaN	430,00	NaN	NaN	NaN	NaN	12,37	NaN	NaN	NaN
Yes	No	No	50,62	25,79	89,33	18,67	NaN	13,30	11,65	14,60	10,83	NaN
No	No	Yes	29,51	53,30	37,60	28,57	72,27	20,00	17,25	22,45	19,78	22,34
Yes	Yes	No	21,18	16,67	4,88	14,50	NaN	11,87	10,17	13,22	13,35	NaN
No	Yes	Yes	38,05	34,27	35,40	28,73	20,18	19,09	17,11	22,05	20,22	24,15
Yes	No	Yes	52,54	20,92	57,64	11,41	NaN	16,60	14,14	18,21	15,40	NaN
No	No	No	59,59	76,71	29,00	50,00	43,48	15,01	13,71	16,82	14,39	17,52
Whole sample												
Yes	Yes	Yes	26,73	17,38	29,47	17,40	18,70	15,59	13,22	18,17	15,46	18,18
No	Yes	No	NaN	430,00	NaN	NaN	NaN	NaN	12,37	NaN	NaN	NaN
Yes	No	No	46,72	20,15	77,15	17,12	NaN	12,28	9,10	12,61	9,93	NaN
No	No	Yes	27,67	52,78	37,60	24,49	71,89	18,75	17,09	22,45	16,95	22,23
Yes	Yes	No	21,18	16,67	4,88	14,50	NaN	11,87	10,17	13,22	13,35	NaN
No	Yes	Yes	38,05	32,89	35,40	28,73	20,18	19,09	16,43	22,05	20,22	24,15
Yes	No	Yes	44,51	20,52	51,24	11,41	NaN	14,06	13,87	16,19	15,40	NaN
No	No	No	46,56	72,20	29,00	50,00	34,29	11,73	12,90	16,82	14,39	13,82

Table 8
Raw versus Bias-corrected *median* OE.
"n.a." means that the corresponding category of cartels is not represented in the subsample of interest.

Cartel characteristics			Raw Median Estimates					Bias-Corrected Median Estimates				
domestic	bidrig	Guilty	US	EU	ASIA	ROW	WORLD	US	EU	ASIA	ROW	WORLD
Subsample with OE>0%												
Yes	Yes	Yes	18,30	12,40	29,00	17,40	18,70	15,72	13,83	17,56	15,46	18,18
No	Yes	No	NaN	430,00	NaN	NaN	NaN	NaN	12,37	NaN	NaN	NaN
Yes	No	No	26,05	18,40	30,00	17,50	NaN	13,33	11,65	14,95	10,51	NaN
No	No	Yes	31,80	29,00	17,50	24,50	29,60	20,00	16,65	22,34	19,86	22,59
Yes	Yes	No	14,50	17,00	4,83	14,50	NaN	11,52	10,04	13,22	13,35	NaN
No	Yes	Yes	25,75	21,00	29,80	30,55	13,45	18,69	16,90	22,05	19,94	23,85
Yes	No	Yes	16,80	16,00	24,55	10,00	NaN	15,93	13,26	17,79	15,23	NaN
No	No	No	50,00	50,00	29,00	50,00	31,25	14,59	13,55	16,82	14,39	17,40
Whole sample												
Yes	Yes	Yes	18,05	12,15	29,00	17,40	18,70	15,72	13,83	17,56	15,46	18,18
No	Yes	No	NaN	430,00	NaN	NaN	NaN	NaN	12,37	NaN	NaN	NaN
Yes	No	No	24,70	13,50	24,50	13,60	NaN	13,33	11,15	14,15	10,51	NaN
No	No	Yes	27,80	29,00	17,50	21,65	29,48	20,00	16,65	22,34	19,72	22,39
Yes	Yes	No	14,50	17,00	4,83	14,50	NaN	11,52	10,04	13,22	13,35	NaN
No	Yes	Yes	25,75	17,00	29,80	30,55	13,45	18,69	16,43	22,05	19,94	23,85
Yes	No	Yes	14,90	15,95	23,25	10,00	NaN	15,08	13,26	17,79	15,23	NaN
No	No	No	36,50	50,00	29,00	50,00	25,00	14,13	13,55	16,82	14,39	16,09

9. Conclusion

Our study identifies the mean and median overcharges of cartels by performing a meta-analysis on an extended version of the database used in Connor (2010). Each observation in the sample is a potentially biased OE obtained from a previous study. The sample is quite heterogenous and contains a few number of influential observations. Two groups of variables describe the cartels. The first group (Y) consists of variables that explain the true overcharge while the second group (Z) consists of factors that captures potential estimation biases.

In order to assess the quality of the data, we use a Kullback-Leibler divergence to compare the probability of an OE being larger than θ conditional on Y to the same probability conditional on (Y,Z). The two probabilities more or less agree for $\theta \in [0\%, 65\%]$ but diverge significantly for $\theta > 65\%$. This suggests OE above 65% are quite biased.

We pursued our empirical investigations by estimating log-linear models for OE on subsamples of type $(0, \theta]$, using Y and Z as regressors. We control for sample selection biases by including an inverse Mills ratio inferred from the Probit for the indicator of $OE \in (0, \theta]$ as regressor. If the OE data were unbiased, the average bias-corrected OE for the subsample of cartels with $OE \in (0, \theta]$ must be lower than the average bias-corrected OE inferred for the subsample of all successful cartels. We find this condition to be satisfied only for $\theta \leq 49\%$.

Acting on this result, we estimate our final meta-analysis model on the subsample of $OE \in (0\%, 49\%]$. We employ a Heckit procedure in order to control for sample selection biases and infer the bias-corrected overcharge of all successful cartels. The raw OE that are equal to zero are included back unaltered in the sample used for prediction.

Our meta-analysis delivers a mean and median bias-corrected OE of 16.92% and 16.65% for the subsample of effective cartels and a mean and median of 15.76% and 16.43% for the whole sample. These results differ significantly from the mean and median of the raw figures while being close to our previous findings in Boyer and Kotchoni (2011, 2012). The comparison of mean and median bias-corrected OE reveals also a fairly homogenous behavior of cartels accross different types, geographical locations and periods.

Our results have significant implications for antitrust policy. Indeed, a major element in the prosecution of cartel is their capacity to exert upward pressures on prices. Allain et alii (2013a) have used our bias-corrected OE to conduct a study on the optimal fining of cartels by the European Court and found that there is no need to increase the level of fines as the current level is optimal on average. The US and Canadian guidelines are based on the presumption of an average overcharge of 10%, which is closer to our results than to the 45.47% suggested by the average of the raw figures. Our

meta-analysis speaks of mean and median of a cartel drawn at random from the whole universe of cartels. In a specific cartel case, nothing can replace the specific data available on that cartel.

Unfortunately, the data set available for our analysis does not include variables that describe the industry characteristics (sector, concentration, etc) or the elasticity of demand. Thus, the type of analysis conducted in this paper could be improved if more data on cartels become available.

Appendix A: Summary statistics of the database

Table A1. Whole Sample

	mean	std	min	max
OE	45.47	102.86	0,00	1800,00
Duration	9.25	11.86	1	109
duration (discrete)	1.86	1.06	1	4
Domestic	0.47	0.50	0	1
BidRig	0.20	0.40	0	1
Guilty	0.66	0.48	0	1
US	0.30	0.46	0	1
EU	0.33	0.47	0	1
ASIA	0.09	0.28	0	1
ROW	0.04	0.19	0	1
WORLD	0.24	0.43	0	1
P1	0.01	0.08	0	1
P2	0.10	0.30	0	1
P3	0.11	0.31	0	1
P4	0.15	0.35	0	1
P5	0.57	0.50	0	1
P6	0.07	0.25	0	1
OTHER	0.06	0.24	0	1
HISTOR	0.02	0.13	0	1
PBEFOR	0.27	0.44	0	1
PWAR	0.02	0.14	0	1
PAFTER	0.13	0.34	0	1
COST	0.05	0.21	0	1
YARDST	0.14	0.35	0	1
ECON	0.14	0.34	0	1
LEGAL	0.18	0.38	0	1
JOURNAL	0.22	0.41	0	1
MONOGR	0.23	0.42	0	1
EDBOOK	0.06	0.24	0	1
GOVREP	0.23	0.42	0	1
COURT	0.18	0.38	0	1
WORKP	0.01	0.07	0	1
SPEECH	0.07	0.25	0	1
Sample size		1119		

Table A2. Cartels with Raw OE in the interval (0%, 49%]

	mean	std	min	max
OE	20,46	12,20	0,1	49
Duration	9,29	11,97	1	98
duration (discrete)	1,84	1,05	1	4
Domestic	0,52	0,50	0	1
BidRig	0,24	0,43	0	1
Guilty	0,71	0,45	0	1
US	0,31	0,46	0	1
EU	0,32	0,47	0	1
ASIA	0,09	0,28	0	1
ROW	0,04	0,20	0	1
WORLD	0,24	0,43	0	1
P1	0,01	0,09	0	1
P2	0,09	0,28	0	1
P3	0,10	0,30	0	1
P4	0,13	0,34	0	1
P5	0,62	0,49	0	1
P6	0,05	0,23	0	1
OTHER	0,05	0,21	0	1
HISTOR	0,01	0,08	0	1
PBEFOR	0,27	0,44	0	1
PWAR	0,02	0,13	0	1
PAFTER	0,13	0,34	0	1
COST	0,04	0,20	0	1
YARDST	0,13	0,34	0	1
ECON	0,16	0,37	0	1
LEGAL	0,19	0,39	0	1
JOURNAL	0,21	0,41	0	1
MONOGR	0,21	0,41	0	1
EDBOOK	0,05	0,22	0	1
GOVREP	0,25	0,43	0	1
COURT	0,22	0,41	0	1
WORKP	0,01	0,08	0	1
SPEECH	0,05	0,22	0	1
Sample size		782		

Table A3. Cartels with Raw OE of 0%

	mean	std	min	max
OE	0	0	0	0
Duration	9.38	12.27	1	72
duration (discrete)	1.86	1.10	1	4
Domestic	0.58	0.50	0	1
BidRig	0.07	0.26	0	1
Guilty	0.37	0.49	0	1
US	0.38	0.49	0	1
EU	0.30	0.46	0	1
ASIA	0.09	0.28	0	1
ROW	0.04	0.19	0	1
WORLD	0.20	0.40	0	1
P1	0.00	0.00	0	0
P2	0.19	0.39	0	1
P3	0.05	0.22	0	1
P4	0.25	0.43	0	1
P5	0.47	0.50	0	1
P6	0.05	0.22	0	1
OTHER	0.16	0.37	0	1
HISTOR	0.14	0.34	0	1
PBEFOR	0.20	0.40	0	1
PWAR	0.01	0.11	0	1
PAFTER	0.11	0.32	0	1
COST	0.04	0.19	0	1
YARDST	0.09	0.28	0	1
ECON	0.02	0.16	0	1
LEGAL	0.23	0.43	0	1
JOURNAL	0.44	0.50	0	1
MONOGR	0.21	0.41	0	1
EDBOOK	0.10	0.30	0	1
GOVREP	0.09	0.28	0	1
COURT	0.05	0.22	0	1
WORKP	0.00	0.00	0	0
SPEECH	0.11	0.32	0	1
Sample size		81		

Table A4. Cartels with Raw OE >49%

	mean	std	min	max
OE	135,89	187,13	49,2	1800
duration	9,09	11,43	1	109
duration (discrete)	1,92	1,08	1	4
domestic	0,29	0,45	0	1
BidRig	0,11	0,31	0	1
Guilty	0,57	0,50	0	1
US	0,26	0,44	0	1
EU	0,39	0,49	0	1
ASIA	0,09	0,28	0	1
ROW	0,02	0,12	0	1
WORLD	0,26	0,44	0	1
P1	0,01	0,09	0	1
P2	0,13	0,34	0	1
P3	0,14	0,35	0	1
P4	0,16	0,37	0	1
P5	0,45	0,50	0	1
P6	0,11	0,31	0	1
OTHER	0,08	0,27	0	1
HISTOR	0,01	0,09	0	1
PBEFOR	0,29	0,45	0	1
PWAR	0,03	0,17	0	1
PAFTER	0,14	0,35	0	1
COST	0,06	0,23	0	1
YARDST	0,20	0,40	0	1
ECON	0,09	0,28	0	1
LEGAL	0,11	0,31	0	1
JOURNAL	0,16	0,37	0	1
MONOGR	0,30	0,46	0	1
EDBOOK	0,10	0,30	0	1
GOVREP	0,23	0,42	0	1
COURT	0,11	0,31	0	1
WORKP	0,00	0,06	0	1
SPEECH	0,11	0,31	0	1
Sample size		257		

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