An empirical inquiry into cartel overcharges and cartel fines including an assessment of the EU's guidelines on cartel fines and damages

Justus Haucap, Mehmet Karacuka & Hakan Inke

Article - Version of Record

Suggested Citation:
Haucap, J., Karaçuka, M., & Inke, H. (2025). An empirical inquiry into cartel overcharges and cartel fines including an assessment of the EU's guidelines on cartel fines and damages. European Journal of Law and Economics, 61(1–2), 151–180. https://doi.org/10.1007/s10657-025-09862-y

European Journal of Law and Economics (2026) 61:151–180
https://doi.org/10.1007/s10657-025-09862-y

An empirical inquiry into cartel overcharges and cartel fines including an assessment of the EU's guidelines on cartel fines and damages

Justus Haucap[1] · **Mehmet Karacuka**[1,2] · **Hakan Inke**[2]

Received: 7 October 2024 / Accepted: 11 November 2025 / Published online: 1 December 2025

Abstract
Utilizing Connor's International Cartel Database and employing difference-in-differences methodology, we find that market concentration, the number of buyers and cartel duration have significant impacts on cartel overcharges. We also find that the European Commission's 2006 guidelines on the method of setting fines for cartel infringements seem to have decreased cartel overcharges in the EU. In addition, the EU's cartel damages directive of 2014 (2014/104/EU) appears to have increased private damage payments. Overall, we find support that these two changes in EU competition policy have a reversing impact on the otherwise increasing trend of cartel overcharges, as these measures tend to make infringements more costly at least in the EU.

Keywords Cartel fines · Cartel damages · EU guidelines · Competition law · Antitrust

JEL Classification L41 · K21

✉ Justus Haucap
haucap@dice.hhu.de

✉ Mehmet Karacuka
mehmet.karacuka@ege.edu.tr; karacuka@dice.hhu.de

✉ Hakan Inke
hakan.inke@ege.edu.tr

[1] Heinrich Heine University Düsseldorf, Düsseldorf, Germany

[2] Ege University, Izmir, Turkey

1 Introduction

A key goal of antitrust policy is to deter cartels, so as to preserve market competition in order to ensure that markets foster efficiency and consumers get a fair deal (see, e.g., Motta, 2004, Feinberg, 2023, Haucap & Heldman, 2023). To accomplish this, competition authorities and policy makers must establish a deterrence framework that typically includes prohibitions and penalties and, at least for the last twenty years, increasingly also compensation for damages inflicted on buyers by anticompetitive conduct, or sellers in case of a buyer cartel (see, e.g., Block et al., 1981; Boulu-Reshef & Monnier, 2024; Auriol et al., 2023). According to the simplest economic theory, following Becker (1968), the optimal fine depends on the additional profit gained by the cartel members, the harm caused (i.e., the total deadweight loss caused by the misconduct), and the likelihood of detection. Several papers have elaborated on this simple analysis and included enforcement costs, the likelihood of private lawsuits, and several other factors (e.g., Polinsky & Shavell, 1979, 1984; Landes, 1983; Garoupa, 2001; Wils, 2006; Korsten & Samuel, 2023; Bento & Barros, 2025).

The United States and the European Union have antitrust policies that often serve as templates for competition authorities in other jurisdictions. Hence, analyzing the effectiveness of competition policy instruments used in the USA and the EU is of particular relevance also for other jurisdictions.

In the U.S., the Federal Sentencing Guidelines provide a framework for penalizing cartel offenses. Penalties depend, firstly, on the volume of commerce affected by the cartel, and secondly, on specific characteristics of the case and the particular behavior of the cartel and its members. More precisely, the process of setting the fines starts with establishing a base offense level for the individual or organization involved in the cartel. This base level is then increased based on the volume of commerce affected by the cartel activity. Consequently, the offense level is adjusted based on specific characteristics, such as (i) bid rigging, which increases the offense level, (ii) leadership roles, (iii) abuse of trust, as exploiting a position of trust can also lead to a higher offense level, (iv) leniency applications and other forms of cooperative or, in contrast, obstructive behavior during the cartel investigation. A key objective of cartel enforcement is, typically, to deter individuals and organizations from engaging in anti-competitive behavior through the threat of penalties.

The legal basis for cartel fines in the European Union is Article 102 of the TFEU and Council Regulation 1/2003. In 2006, the European Commission published new "Guidelines on the method of setting fines imposed pursuant to Article 23(2)(a) of Regulation No 1/2003". The guidelines set out the methodology used by the European Commission when setting fines on undertakings that infringe the EU's competition rules. These guidelines have been applied since September 2006 and aimed at improving transparency of how fines are determined. The base fine for EU competition law violations is set at up to 30% of the company's annual sales of the concerned product, based on the last full year of the violation, typically ranging from 15 to 20% for cartels, depending on factors such as the type of infringement, its geographic extent, among others. This percentage is multiplied by the duration of the infringement (in years and months) to account for the economic damage caused over time. The fine may be increased for aggravating factors, like repeated viola-

tions, or decreased for mitigating factors, such as limited participation. For cartels, an additional "entry-fee" penalty of 15 to 25% of one year's sales is imposed to discourage short-term infringements. The total fine is limited to 10% of the company's annual turnover (of all products). Leniency programs grant full immunity to the first company providing evidence or up to 50% reductions for others, while settlements offer a 10% fine reduction. In rare cases, fines may be lowered if they jeopardize a company's economic viability (European Commission, 2025).

The U.S. and EU antitrust regulations for cartel sanctions share similarities but differ in key aspects. Both calculate the base fine as a percentage of affected sales, but the U.S. sets a fixed rate of 20%, justified by an assumed average gain of 10% from price-fixing, while the EU allows a range of up to 30% (typically 15 to 20% for cartels) without linking to a specific gain. The U.S. accounts for cartel duration by aggregating sales across all years of the conspiracy, with each year weighted equally, whereas the EU multiplies the base fine (based on the last full year's sales) by the number of years, giving disproportionate weight to that final year. Consequently, EU fines can reach 45 to 55% of affected sales, and are thought to be significantly higher than the 20% rate in the USA. In addition, the impact of cartel duration on fines varies due to these calculation methods (also see Bolotova & Connor, 2008).

This paper firstly provides an empirical analysis of the main determinants of cartel charges. In addition, we will also shed light on the effects of the 2006 EU guidelines on fines as well as the 2014 EU guidelines for damages (Directive 2014/104/EU), which set out rules for individuals and businesses to seek compensation for harm caused by cartel and antitrust violations within the EU.

The next section gives a brief review of the empirical literature on the determinants of cartel overcharges and fines, before the third section introduces the by now famous International Cartel Database assembled by John Connor (Connor & Lande, 2005, 2006; Connor & Bolotova, 2006; Connor, 2024), which is by far the most extensive database on cartels. We also discuss some key statistical features of these cartels. Section 4 presents the empirical analysis on the determinants of cartel overcharges, fines and damage compensations, and interprets the main findings. Finally, we conclude in the last section.

2 A brief review of the literature on determinants of cartel fines and damages

Most antitrust regulations set maximum cartel fines either in absolute terms or as a percentage of affected sales or a firm's total revenues or both, without directly linking fines to the size of the damages caused. How effective these penalties are in deterring anticompetitive behavior is still a subject of intense discussion among policy makers, enforcers and academics alike (see, e.g., OECD, 2019).

One of the earliest studies to investigate the effectiveness of antitrust policies and the impact of potential fines on cartel formations goes back to Posner (1969) who provides a descriptive analysis of data on antitrust violations in the USA for the period 1890–1944. According to his analysis, the average duration for the conspiracy cases was between six and eleven years and almost half of the cases directly or indi-

rectly involved foreign trade (Posner, 1969; Bolotova & Connor, 2008). Gallo et al. (2000) also provide a descriptive analysis of US antitrust cases for the period between 1955 and 1997 and found that about half of the antitrust cases were related to horizontal conspiracies. The average duration was between three and eight years, and the share of international conspiracies was a bit more than 30%. Furthermore, Block et al. (1981), Cohen & Scheffman (1989–1990) and Wils (2007) provide some estimates of the ratio of fine to affected commerce (Bolotova & Connor, 2008).

As Connor and Lande (2006) point out, one of the approaches to evaluate the effectiveness of antitrust regulations is to analyze changes in the overcharge levels over time and across different antitrust jurisdictions. In the case that antitrust regulations are getting more effective, we would expect a decline in cartel overcharges over time. Bolotova (2006), using a subset of Connor's (2005, 2008) overcharge data, finds that stricter antitrust regimes correlate with lower cartel overcharges, with the 1991–2005 period showing the most significant reduction in overcharge levels. Additionally, overcharges are lower in regions with established antitrust regulations (e.g., USA, Canada, EU, and some European countries) compared to regions with newer or unenforced regulations (e.g., Asia, Latin America, and rest of the world).

Bolotova and Connor (2008) estimate the determinants of both government fines and private compensations for cartel damages separately, taking into account cartel overcharges, the volume of affected sales, cartel duration, and geographical locations, by using a Tobit maximum likelihood procedure to account for the censored nature of the data where the dependent variable has only positive values. Their findings show that cartel fines are negatively affected by the magnitude of cartel overcharge, contrasting with the theory that rather predicts a positive relationship. The authors argue that "more harmful cartels tend to pay smaller fines, on average, resulting in an adverse effect of the cartel guilty pleas and leniency programs leading to lower penalties actually paid versus higher levels of the imposed damages". The effect of affected sales volumes is positive which means that cartels with larger affected sales tend to pay larger fines than cartels with smaller sales volumes, holding all other effects constant. Similarly, they find a positive effect of cartel duration, i.e., longer lasting cartels tend to be sanctioned with larger fines-, cartel fines. Also according to their results, the European Union fined cartels more than the U.S. and the rest of the world, holding other factors constant. However, when all all monetary sanctions paid by cartel participants (i.e., government fines and compensations recovered by private parties), are considered, the U.S seems to be highest fining jurisdiction. A further result reported by this study is the insignificance of overcharge variable when it is used as a percentage of affected sales. According to these results, modern antitrust regulations fail to deter international cartels effectively, as sanctions, averaging 18.9% (median 4.9%) of affected sales, are lower than the average cartel overcharge of 27.8% (median 27%). The design of current antitrust regulations, which caps fines based on monetary units or a percentage of affected sales without adjusting for cartel duration, does not align fines with cartel overcharges, undermining deterrence. Contrary to the theory of optimal sanctions, which suggests, by and large, that fines should correspond to the harm caused, the study finds a negative relationship between cartel overcharges and fines, meaning cartels with higher overcharges face

smaller fines. Instead, fines correlate strongly with affected sales, with larger cartels paying higher fines, likely due to the perceived gravity of offenses in larger markets.

Bolotova (2009) finds that cartel duration, market characteristics and cartel organizations, antitrust law regimes, as well as geographical markets, play significant roles in determination of cartel overcharges in her empirical analysis based on 406 overcharge estimations. According to the regression results, cartels with high market shares, fewer participants, and greater size inequality among members tend to impose higher overcharges, with international cartels causing more significant price increases than domestic ones. Overcharges in the US and European markets are generally lower than those in Asian markets and other regions worldwide. Bolotova, Connor and Miller (2007), in a similar analysis, use overcharge estimates from 395 cartel episodes from the 18th to 21st century, and find an average overcharge of 19% and a median of 16% of the selling price, with food industry cartels imposing lower overcharges than domestic cartels, longer-lasting cartels generating higher overcharges, and cartels found or pleading guilty achieving similar overcharge levels as legal cartels. Connor (2008) also surveys economic research and court rulings, analyzing 1,040 quantitative estimates of overcharges from hard-core cartels, finding a median long-run overcharge of 18.8 to 25 % for domestic cartels and 31.0% for international cartels. The mean overcharge for successful cartels reaches 43.4% due to positively skewed data, with convicted and unpunished cartels equally effective at price increases, though bid-rigging cartels show slightly lower mark-ups than price-fixing ones, suggesting a need for higher monetary penalties to achieve optimal deterrence.

However, it should be noted that the overcharge numbers in the Connor dataset that are employed in the above mentioned studies are estimates obtained through different methodologies, sources and contexts rather than from direct observations. The sources of collected observations vary from official government reports and court and antitrust authorities' decisions to monograms, historical case studies, journal publications and working papers. Even though Connor and Bolotova (2006) find that duration, legal environment, and organizational characteristics of cartels explain the variation of overcharge rates to a greater extent than the type of publication or the method of overcharge analysis in a meta-analysis of overcharges from 395 cartel episodes, they also find that the robustness of overcharge estimates depend on the source of the estimates such as historical case studies and government reports calculate lower overcharges, whereas antitrust authorities arrive at relatively high rates. Therefore, these data are subject to model error, estimation error, endogeneity bias, and publication bias. Boyer and Kotchoni (2015) criticize this methodology as the estimates are potentially biased, and fitting a linear regression model without addressing these issues could lead to distorted results. They also perform a meta-analysis of cartel overcharge estimates, and arrive at bias-corrected mean and median overcharge estimates of 15.5% and 16%, respectively.

Smuda (2014) has examined cartel overcharges for European markets. To be more precise, the impact of different cartel characteristics and the market environment on the magnitude of cartel overcharges is analyzed, using a sample of 191 overcharge estimates and several parametric and semiparametric estimation procedures. Smuda (2014) found the mean and median overcharge rates to be 20.70% and 18.37% of the

selling price, with an average cartel duration is 8.35 years. Smuda (2014) concludes that from an ex-post perspective the fine levels have been insufficient for optimal cartel deterrence. It should be noted though that most of his case pre-date the 2006 reform and all pre-date the 2014 reform. Obviously, Smuda (2014) does not study the impact of these reforms.

In contrast to overcharge levels, cartel fines are generally less subject to empirical analysis. Mariuzzo et al. (2020) employ multiple methods to investigate the different roles of public sanctions (fines), which are imposed directly by an administrative body or the court, and reputational sanctions, which materializes indirectly through market mechanisms in deterring misconduct. Based on a sample of 339 listed cartel member firms, prosecuted by the European Commission between 1992 and 2015, they find that public and reputational sanctions act as substitutes. If there is a reputational penalty, increasing this penalty reduces the effect of the public sanction. However, the effect of the cartel fine steps in in the absence of a reputational punishment. Bolotova and Connor (2008) focus on cartel sanctions as well as overcharges and find that when compensations recovered by private parties are taken into account, the average cartel sanction is 18.9% (4.9%) of affected sales. Furthermore, they find a negative, statistically significant relationship between the level of cartel sanctions and the overcharge level and a positive and statistically significant relationship between the level of cartel sanctions and the volume of affected sales. They argue that cartel sanctions tend to be based on the volume of affected sales rather than on the overcharge level (i.e., damage).

Finally, Levenstein and Suslow (2011) have estimated the impact of cartel organizational features, as well as macroeconomic fluctuations and industry structure, on cartel duration. Their analysis indicates, among other things, that the probability of cartel death from any cause increased significantly after 1995, when competition authorities expanded enforcement efforts toward international cartels.

3 John Connor's international cartels data base

The Private International Cartels (PIC) data set, originally assembled by John Connor in the early 2000s (see Connor & Lande, 2005, 2006; Connor & Bolotova, 2006) and updated by Connor (2020, 2024), stands as the most comprehensive repository of legal and economic data on contemporary cartels. Covering the period from 1990 to 2017, this dataset covers 1,307 cartel cases. In order to determine the main determinants of cartel overcharges, we use this data set both aggregated and disaggregated to analyze various aspects of cartel structures, including industry-specific characteristics, the geographic distribution of firms penalized for cartel participation, the fines imposed, and the overcharge rates attributed to cartel activity. Due to some missing sector information in three cases, the final data includes 1,304 cases.

We focus on cartel structures by assessing the proportion of market supply controlled by cartelized firms (cartel market share) and the diversity of demand for their products. Connor (2020) notes that in some instances, certain cartels reported zero overcharge rates, a result he attributes to their inability to capture sufficient market share. The terms "many buyers," "mod buyers," and "few buyers," as defined in the

original dataset, refer to the products' demand in over 100 geographic markets, 30 to 99 markets, and fewer than 30 markets (typically between 5 and 10), respectively.

To better understand the scope and global influence of cartels, the geographic distribution of firms penalized for their participation is also examined. Overcharge rates, which quantify the additional costs imposed by cartels relative to competitive market prices, provide insight into both the excessive profits generated by cartels and the fines levied against them. Connor categorizes these overcharges under the heading "overcharges/competitive sales," reflecting the percentage of overcharges relative to competitive prices. Additionally, the dataset compares overcharge rates with affected sales volumes, facilitating a more nuanced understanding of the economic impact. Fines imposed for cartel activity are expressed both in total monetary terms and as a percentage of sales and overcharge rates. Finally, the variable duration measures the lifespan of a cartel in months, offering insights into the persistence and longevity of cartel operations.[1]

We analyze cartel structures across aggregated industries (see Table 1) and find that cartel activity is most prevalent in services and the construction sector, while the capital goods sector exhibits the lowest level of cartel activity. In terms of cartel market share (i.e., the market share controlled by the cartel), services and the construction sector also rank highest, while the raw materials sector exhibits the lowest cartel market shares. With respect to demand heterogeneity, the data reveal that the capital goods sector is characterized by a high degree of government procurement, with governments accounting for more than 50% of total demand in this sector. This observation aligns with the fact that this sector is dominated by a relatively small number of buyers. In contrast, most other sectors are found to face markets with a more dispersed demand base, typically serving a large number of buyers. A comparable sector to industrial capital goods, but with less government involvement as a major buyer, are generic final consumer goods.

Table 2 provides a comprehensive overview of cartel activity across various sectors, measured by the number of firms involved across regions and the average number of executives implicated in private suits. The services, including construction sector stands out as the most active, with the highest number of cases (538) and the largest average number of firms globally (12.10), particularly concentrated in Europe (8.21). This suggests that cartel activity in the services sector is both extensive and involves a substantial number of firms, particularly within Europe.

By contrast, the raw materials sector has the fewest reported cases (33) and the smallest average number of firms (6.07). Participation in this sector is relatively limited, with North America and Asia showing particularly low levels of involvement (0.70 and 0.55 firms, respectively). Interestingly, despite the smaller total number of cases (66), the industrial capital goods sector exhibits relatively high firm participation in Asia (1.80) and Latin America (2.15), indicating a stronger cartel presence in these regions. Meanwhile, cartel activity in the generic final consumer goods and differentiated consumer goods sectors is more moderate, with firms more evenly dis-

[1] For further reference, see: John M. Connor's Private International Cartels Full Data 2019 edition (Version 2.0), Purdue University Research Repository. doi:https://doi.org/10.4231/G5GZ-0505.

Table 1 Cartel structure and market characteristics across industries (Aggregated)

Industries		Cartel Structure								
Code	Industry list	Total Case	Avg. Duration	Avg. Cartel Share	Govt as major buyer (total)	Govt as major buyer (%)	Many Buyers (total)	Many Buyers (%)	Few Buyers (total)	Few Buyers (%)
R	Raw Material	33	2261.33	79.76	4	12.12	25	75.76	7	21.21
I	Ind. intermediate input	421	714.32	84.21	52	12.35	251	59.62	100	23.75
K	Ind. capital good	66	1191.74	86.71	35	53.03	19	28.79	37	56.06
G	Generic final consumer good	108	1177.89	88.09	30	27.78	55	50.93	32	29.63
D	Differentiated consumer	138	1108.61	84.43	20	14.50	113	81.88	23	16.67
S	Services, incl. construction	538	2093.52	90.66	112	20.82	384	71.38	132	24.54

tributed across regions, although Europe consistently accounts for the largest share of firms in these industries.

Table 3 provides valuable insights into the relationship between penalties and overcharges across different industries, highlighting significant variations in both the extent of cartel behavior and the effectiveness of enforcement. In the raw materials sector, while the number of cases is relatively low, the mean overcharges are notably high relative to competitive sales (38.21%). However, the disparity between the mean and median overcharge rates suggests that a few cases involve exceptionally high overcharges, skewing the overall data. The high penalty-to-overcharge ratio (292.67%) indicates that cartels, when detected, are penalized harshly. However, the much lower median value points towards inconsistencies in enforcement practices. In the industrial intermediate input sector, which accounts for the largest number of cases, overcharge behavior is more consistent, with a mean overcharge of 26.68% relative to affected sales and 75.44% relative to competitive sales. The relatively high penalty-to-sales ratio (mean of 11.35%) reflects an overall robust enforcement regime. However, the large gap between the mean and median penalty values suggests that many firms receive significantly lower fines, potentially indicating leniency in smaller cases. The penalty-to-overcharge ratio is also lower than in the raw materials sector, suggesting that while overcharges are substantial, penalties may not fully correspond to the economic harm caused.

The industrial capital goods sector, on the other hand, exhibits a relatively low penalty-to-overcharge ratio (21.41%), raising potential concerns about the adequacy of penalties in relation to the economic damage caused by cartels in this sector. Despite significant overcharges, firms appear to face relatively lenient penalties. This imbalance may point to regulatory gaps or enforcement challenges if firms engaging in cartel activity do not encounter sufficient financial deterrence. The generic final consumer goods sector stands out with exceptionally high overcharges relative to competitive sales, averaging 591.27%, the highest across all sectors. This suggests that cartels in this sectors have substantial pricing power, enabling them to manipulate prices significantly. Despite this, the penalty-to-overcharge ratio (252.59%) indicates that penalties are more proportionate to the overcharges in this sector. However, the substantial difference between mean and median values highlights wide variation in cartel behavior and the corresponding penalties, suggesting disparities in enforcement across cases.

Finally, services and the construction sector, which have the highest number of cases, demonstrate a pattern of concentrated penalties in a few high-profile cases, as evidenced by the stark contrast between the mean and median penalty-to-sales ratios (15.74% vs. 0.36%). The relatively high overcharges (90.47% over competitive sales) reflect significant cartel activity in this sector. However, the moderate penalty-to-overcharge ratio (67.18%) suggests that penalties may not fully align with the level of market distortion caused. This points to potential areas for improvement in enforcement mechanisms to ensure penalties effectively deter cartel behavior in the services sector.

In Table 4 we provide a broad analysis of cartel market shares, government affectedness as a major buyer, and buyer diversity across various industries. The construction sector is particularly noteworthy, with the highest average cartel market

Table 2 Number of firms and executive involvement across industries (Aggregated)

Industries		Firms									
Code	Industry list	Total Case	World (mean)	North Am (mean)	Europe (mean)	Africa (mean)	Asia (mean)	Latin Am. (mean)	ROW (mean)	Private Suits (mean)	Nb of Execs (mean)
R	Raw Material	33	6.07	0.70	2.31	0.88	0.55	0.58	1.14	0.58	0.10
I	industrial intermediate input	421	6.55	1.17	3.66	0.40	1.01	0.52	1.53	1.68	1.93
K	Industrial capital good	66	6.24	0.17	3.41	0	1.8	0.75	2.15	0.27	1.82
G	Generic final consumer good	108	7.12	0.56	3.63	0.35	1.09	0.61	1.85	0.66	0.69
D	Differentiated consumer	138	6.19	0.33	4.25	0.20	0.5	0.33	0.92	0.44	1.28
S	Services, incl. construction	538	12.10	1.42	8.21	0.26	0.90	0.61	1.57	0.72	1.32

share (97.76%) and significant government affectedness, with public procurement accounting for 74.32% of cases. This suggests that cartels in this sector control a substantial portion of the market, and government entities are significantly affected as primary purchasers. The combination of high cartel activity and significant government affectedness underscores the need for stronger regulatory oversight in public procurement processes to mitigate the risk of cartelization.

Similarly, the pharmaceuticals, medicines, and medical devices sector exhibits a high average cartel market share (90.12%), with government entities serving as major buyers in 70.73% of cases. Given the critical nature of this sector and its impact on public health budgets, these findings are particularly significant. Additionally, pay-for-delay cases within the pharmaceutical industry show comparably high cartel market shares, illustrating the persistent risks of anti-competitive practices in a sector with substantial demand from both public and private buyers. The dominance of a few large buyers in this industry (60.98% of cases) highlights the vulnerability of concentrated markets, where major buyers may be more easily targeted by cartels, thereby raising concerns about the potential for market distortion.

The transport services sector also demonstrates a high average cartel market share (87.53%), with 85% of cases involving a large number of buyers. While government entities play a less prominent role as major buyers in this sector (10%), the prevalence of cartels in markets with many buyers suggests that markets with little buyer power can also be susceptible to cartel activity, contrasting the regularly employed narrative (typically by cartel members) that cartels serve as a "defense" to counter significant buyer power.

Table 5 provides a detailed analysis of the average number of firms involved in cartel activities across various industries and regions, with insights into regional concentrations and participation in private suits. The construction sector emerges as particularly significant, with a global average of 25.62 firms, most of which are concentrated in Europe (23.00). This data underscores the dominant presence of cartel activity within Europe, while participation from other regions remains limited. Interestingly, despite the large number of firms, there is no recorded involvement in private suits, which could suggest underreporting or a lack of legal follow-up in this sector, raising questions about enforcement and regulatory oversight.

Similarly, the food and beverage manufacturing sector show considerable cartel activity globally, with an average of 9.81 firms. Once again, Europe leads with 7.20 firms, but there is also notable participation from Asia (0.96) and Latin America (0.33), indicating a broader geographic spread of cartel activity. The relatively high participation in private law suits (0.26 firms on average) and the involvement of a significant number of executives (1.61) highlight more active enforcement in this sector. In contrast, the pharmaceuticals, medicines, and medical devices sector presents a more globally distributed cartel structure, with an average of 4.51 firms involved worldwide. Government regulation may be playing a role in limiting cartel activities, as suggested by the lower participation levels across regions such as Africa and Latin America. Interestingly, within this sector, pay-for-delay cases involve fewer firms (2.84), reflecting the targeted and specific nature of these agreements. However, there is a notably higher involvement in private law suits (1.22 firms), which points to

Table 3 Penalties and overcharges across industries (Aggregated)

Industries		Total case	Penalties				Overcharges					
Code	Industry list		Avg. Monetary Penalties	Monetary Penalties (median)	Penalties/ Sales (Avg)	Penalties/Sales (median)	Overcharges/Affected Sales (Avg)	Overcharges/Affected Sales (median)	Overcharges/Comp. Sales (Avg)	Overcharges/Comp. Sales) (median)	Penalties/ Overcharges (Avg)	Penalties/ Overcharges (median)
R	Raw Material	33	115.77	9.78	7.23	1.43	16.62	7.34	38.21	7.92	292.67	39.66
I	industrial intermediate input	421	249.42	41.40	11.35	2.08	26.68	23.65	75.44	30.97	222.93	29.87
K	Industrial capital good	66	158.12	12.35	6.28	2.295	24.59	24.35	37.76	32.19	21.41	11.75
G	Generic final consumer good	108	86.01	12.04	53.88	2.05	52.22	55.47	591.27	143.65	252.59	13.97
D	Differentiated consumer	138	85.28	18.48	14.73	1.97	29.11	18.50	171.17	19.54	234.92	10.74
S	Services, incl. construction	538	226.49	9.65	15.74	0.36	26.21	18.49	90.47	23.49	67.18	17.25

strong legal scrutiny in this industry due to the critical importance of pharmaceuticals for public health.

The transport services sector stands out with a notably high number of firms involved globally, averaging 12.58. North America leads with 4.44 firms, followed closely by Europe (6.24), suggesting significant cartel activity in both regions. The large number of firms involved, combined with the sector's broad geographic distribution, highlights the potential for large-scale cartelization in transport services, which may have substantial negative implications for international trade and logistics. However, the relatively limited involvement in private law suits (0.83 firms) and the low number of implicated executives (1.13) suggest that enforcement may be less stringent in this sector, pointing to potential gaps in regulatory frameworks.

Finally, the finance, insurance, and banking sector exhibit moderate cartel activity globally, with an average of 8.03 firms involved. European firms dominate, averaging 3.74, followed by Asian firms (1.50). The relatively high number of private suits (1.89 firms) and executives implicated (1.29) reflect the sensitive nature of financial markets and the critical need for regulatory oversight. Cartel activity in this sector could have far-reaching implications for global financial stability, emphasizing the importance of continuous monitoring and stringent enforcement to safeguard the integrity of financial systems.

Table 6 provides a detailed overview of fines, overcharges, and fine-to-overcharge ratios across various sectors, highlighting significant disparities in cartel behavior and regulatory enforcement. The data show that some sectors face disproportionately higher fines or overcharges compared to others. In the following, the most notable sectors are examined in terms of fines, overcharges, and fine-to-overcharge ratios.

The agricultural raw materials sector stands out with one of the highest average fine-to-overcharge ratios at 554.39%. This is particularly notable given the average overcharge of 75.47%, suggesting that fines in this sector tend to be severe when cartels are detected. However, the much lower median value points towards an inconsistency in enforcement. The significant gap between the mean and median fines (154.37 vs. 7.15) suggests that a few large cases skewed the average, reflecting a lack of regularities in regulatory practices. In contrast, the construction sector combines high fines with substantial overcharges. With one of the highest average fines (179.23) and significant overcharges of 113.74%, cartel activity in this sector notably distorts market prices. The fine-to-overcharge ratio (102.49%) suggests that fines are proportional to the harm caused, but the difference between the mean and median fines (14.53) indicates that the largest penalties are concentrated in just a few cases.

The pharmaceuticals, medical devices, and drugs sector is notable for its extreme overcharges, averaging 614.27%, making it one of the most severely affected by cartel activity. Pay-for-delay cases are particularly severe in this sector, with an even higher average overcharge of 780.83%, reflecting significant market manipulation. Despite these high overcharges, the fine-to-overcharge ratio for pay-for-delay cases (115.53%) suggests that fines do not fully compensate for the economic damage caused. The wide gap between the mean and median fines (204.58 vs. 62.20) indicates variability in enforcement, pointing to the need for stricter, more consistent penalties, especially given the public health implications. In the oil and petroleum products sector, despite high overcharges of 154.42%, the fine-to-overcharge ratio is

Table 4 Cartel structure and market characteristics across industries (Detailed)

	Industry list	Total case	Cartel Share (mean)	Cartel Share (median)	Govt major buyer (total)	Govt major buyer (%)	Many Buyers (total)	Many Buyers (%)	Mod Buyers (total)	Mod Buyers (%)	Few Buyers (total)	Few Buyers (%)
1	Agricultural raw materials	16	83.22	80.00	1	6.25	13	81.25	0	0	3	18.75
2	Forestry, timber, roundwood	2	80.00	80.00	0	0.00	1	50	0	0	1	50.00
3	Mining: Minerals & metal ores	15	77.13	80.00	3	20.00	11	73.33333	1	6.666667	3	20.00
4	Construction	74	97.76	100.00	55	74.32	14	18.91892	2	2.702703	58	78.38
5	Food and beverage manufacturing	92	82.63	86.90	2	2.17	80	86.95652	4	4.347826	8	8.70
6	Tobacco manufacturing	2	46.00	46.00	0	0.00	2	100	0	0	0	0.00
7	Textiles	7	89.50	89.50	2	28.57	4	57.14286	0	0	3	42.86
8	Clothing	0			0		0		0		0	
9	Wood, lumber	8	87.50	87.50	0	0.00	8	100	0	0	0	0.00
10	Furniture	1			1	100.00	0	0	0	0	1	100.00
11	Paper, printing, publishing	44	80.13	88.00	3	6.82	39	88.63636	2	4.545455	3	6.82
12	Pharmaceuticals, medicines, medical devices	41	90.12	100.00	29	70.73	13	31.70732	3	7.317073	25	60.98
12.1	Pay-for-delay cases within pharmaceuticals	40	90.21	100.00	11	27.50	11	27.5	17	42.5	12	30.00
13	Organic chemicals, other than pharmaceuticals	69	83.00	89.50	4	5.80	57	82.6087	5	7.246377	7	10.14
14	Inorganic chemicals & fertilizers	25	84.27	82.00	2	8.00	18	72	2	8	5	20.00
15	Petroleum and Petroleum products	14	75.00	75.00	4	28.57	7	50	2	14.28571	5	35.71
16	Rubber and plastic	52	86.22	85.00	6	11.54	37	71.15385	4	7.692308	10	19.23
17	Stone, clay, graphite, glass products	82	85.26	90.00	15	18.29	56	68.29268	13	15.85366	13	15.85
18	Primary metals and alloys (bars, slabs, ingots, and similar forms)	9	100.00	100.00	0	0.00	7	77.77778	2	22.22222	0	0.00
19	Fabricated metal products	57	86.94	95.00	17	29.82	30	52.63158	10	17.54386	18	31.58
20	Machinery, including electrical and parts	124	84.97	88.50	33	26.61	31	25	24	19.35484	68	54.84
21	Electronic devices, including computers	31	85.50	96.50	4	12.90	9	29.03226	13	41.93548	9	29.03
22	Instruments, miscellaneous manufacturing	33	83.25	87.00	5	15.15	27	81.81818	1	3.030303	5	15.15
23	Transport services	80	87.53	90.00	8	10.00	68	85	5	6.25	7	8.75

Table 4 (continued)

	Industry list	Total case	Cartel Share (mean)	Cartel Share (median)	Govt major buyer (total)	Govt major buyer (%)	Many Buyers (total)	Many Buyers (%)	Mod Buyers (total)	Mod Buyers (%)	Few Buyers (total)	Few Buyers (%)
24	Communication services	34	93.29	100.00	1	2.94	33	97.05882	0	0	1	2.94
25	Wholesale, retail distribution	118	86.94	90.00	16	13.56	100	84.74576	4	3.389831	14	11.86
26	Finance, insurance, banking	120	89.46	90.00	3	2.50	98	81.66667	2	1.666667	20	16.67
27	Water and energy distribution ("utilities")	19	90.00	95.00	6	31.58	10	52.63158	2	10.52632	7	36.84
28	Other business & Govt services	51	94.77	100.00	20	39.22	24	47.05882	5	9.803922	22	43.14
29	Other consumer services	44	94.00	100.00	2	4.55	39	88.63636	2	4.545455	3	6.82

Table 5 Number of firms and executive involvement across industries (Detailed)

	Industry list	World (mean)	North Am (mean)	Europe (mean)	Africa (mean)	Asia (mean)	Latin Am. (mean)	ROW (mean)	Private Suits (mean)	Nb of Execs (mean)
1	Agricultural raw materials	6.71	1.25	2.88	1.00	0.86	0.00	1.21	0.75	0.00
2	Forestry, timber, roundwood	9.00	0.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Mining: Minerals & metal ores	5.43	0.20	0.71	0.87	1.14	1.27	2.00	0.47	0.21
4	Construction	25.62	0.86	23.00	0.38	0.26	0.88	1.38	0.00	3.06
5	Food and beverage manufacturing	9.81	0.28	7.20	0.55	0.96	0.33	1.70	0.26	1.61
6	Tobacco manufacturing	7.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Textiles	6.00	0.43	2.57	0.00	1.83	0.00	1.83	0.86	0.43
8	Clothing									
9	Wood, lumber	5.13	0.75	2.88	0.00	0.25	0.38	0.63	1.88	0.75
10	Furniture	4.00	0.00	0.00	0.00	4.00	0.00	4.00	0.00	4.00
11	Paper, printing, publishing	7.32	0.86	4.45	0.00	0.84	0.48	1.39	0.80	3.30
12	Pharmaceuticals, medicines, medical devices	4.51	0.95	1.79	0.29	0.37	0.95	1.29	0.38	0.68
12.1	Pay-for-delay cases within pharmaceuticals	2.84	0.66	0.59	0.08	0.05	0.33	0.15	1.22	0.10
13	Organic chemicals, other than pharmaceuticals	6.14	1.78	4.28	0.07	0.72	0.29	0.83	2.28	1.39
14	Inorganic chemicals & fertilizers	4.63	0.60	1.44	0.16	1.13	0.13	1.29	1.92	0.88
15	Petroleum and Petroleum products	5.25	0.00	2.71	1.07	0.62	0.14	1.77	0.00	0.00
16	Rubber and plastic	6.28	0.77	3.20	0.25	0.75	0.90	1.33	1.59	1.61
17	Stone, clay, graphite, glass products	7.95	0.68	4.78	0.43	1.44	0.53	1.63	0.93	1.85
18	Primary metals and alloys (bars, slabs, ingots, and similar forms)	7.88	0.00	2.38	4.67	0.22	0.00	4.89	0.00	0.56
19	Fabricated metal products	7.82	0.98	4.39	0.82	1.16	0.23	2.15	1.05	0.96
20	Machinery, including electrical and parts	5.51	1.04	2.93	0.07	1.33	0.61	1.52	1.33	2.14
21	Electronic devices, including computers	6.42	1.59	2.41	0.00	2.16	1.17	2.83	2.94	4.77
22	Instruments, miscellaneous manufacturing	5.06	0.30	1.82	0.00	0.94	0.97	1.79	1.09	0.64
23	Transport services	12.58	4.44	6.24	0.26	1.51	0.54	1.73	0.83	1.13
24	Communication services	4.63	0.00	1.47	1.00	1.52	0.32	2.73	0.00	0.00

Table 5 (continued)

	Industry list	World (mean)	North Am (mean)	Europe (mean)	Africa (mean)	Asia (mean)	Latin Am. (mean)	ROW (mean)	Private Suits (mean)	Nb of Execs (mean)
25	Wholesale, retail distribution	11.34	0.31	8.24	0.39	0.43	1.44	2.29	0.02	1.28
26	Finance, insurance, banking	8.03	0.84	3.74	0.08	1.50	0.34	1.45	1.89	1.29
27	Water and energy distribution ("utilities")	10.83	0.11	10.22	0.00	0.47	0.00	0.47	0.11	0.32
28	Other business & Govt services	13.28	3.42	8.25	0.06	0.34	0.00	0.37	0.70	1.29
29	Other consumer services	5.08	0.58	2.76	0.00	0.56	0.07	0.64	1.25	0.45

Table 6 Penalties and overcharges across industries (Detailed)

	Industry list	Avg. Monetary Penalties	Monetary Penalties (median)	Penalties/ Sales (Avg)	Penalties/Sales (median)	Overcharges/Affected Sales (Avg)	Overcharges/Affected Sales (median)	Overcharges/Comp. Sales (Avg)	Overcharges/Comp. Sales) (median)	Penalties/ Overcharges (Avg)	Penalties/ Overcharges (median)
1	Agricultural raw materials	154.37	7.15	10.58	2.57	26.95	9.00	75.47	9.89	554.39	131.86
2	Forestry, timber, roundwood	58.55	58.55	1.36	1.36						
3	Mining: Minerals & metal ores	67.40	11.50	4.34	0.96	8.88	6.71	10.27	7.19	96.37	29.61
4	Construction	179.23	14.53	41.71	2.90	22.16	15.67	113.74	19.09	102.49	24.52
5	Food and beverage manufacturing	65.98	19.00	4.65	1.02	21.53	14.67	47.62	17.42	39.39	10.35
6	Tobacco manufacturing	205.35	205.35	0.99	0.99						
7	Textiles	33.28	8.51	4.97	2.20	27.54	27.54	38.01	38.01	34.27	34.27
8	Clothing										
9	Wood, lumber	37.08	26.43	17.89	3.30						
10	Furniture	0.00	0.00	0.00	0.00						
11	Paper, printing, publishing	73.12	18.10	32.77	0.61	17.20	18.00	26.29	20.88	516.23	7.90
12	Pharmaceuticals, medicines, medical devices	35.78	5.98	136.37	4.50	67.75	64.17	614.27	179.24	500.58	16.44
12.1	Pay-for-delay cases within pharmaceuticals	204.58	62.20	20.67	7.10	63.27	74.97	780.83	299.60	115.53	11.57
13	Organic chemicals, other than pharmaceuticals	247.48	88.41	13.34	6.30	28.72	28.13	80.23	39.15	81.04	59.67
14	Inorganic chemicals & fertilizers	52.74	30.75	10.03	1.98	28.74	27.00	95.08	36.99	53.21	12.53
15	Petroleum and Petroleum products	112.28	35.40	6.70	0.78	42.41	27.20	154.42	37.36	72.00	2.04
16	Rubber and plastic	122.23	19.10	16.74	1.34	19.35	14.13	27.93	15.70	191.08	35.50
17	Stone, clay, graphite, glass products	151.48	22.41	8.12	2.08	28.05	24.61	82.66	32.65	46.00	17.45
18	Primary metals and alloys (bars, slabs, ingots, and similar forms)	76.43	72.72	2.65	1.85	17.50	17.50	21.32	21.32	12.45	12.45
19	Fabricated metal products	120.49	19.46	14.36	3.09	31.62	31.83	132.89	46.70	44.26	11.77

Table 6 (continued)

	Industry list	Avg. Monetary Penalties	Monetary Penalties (median)	Penalties/ Sales (Avg)	Penalties/Sales (median)	Overcharges/Affected Sales (Avg)	Overcharges/Affected Sales (median)	Overcharges/Comp. Sales (Avg)	Overcharges/Comp. Sales) (median)	Penalties/ Overcharges (Avg)	Penalties/ Overcharges (median)
20	Machinery, including electrical and parts	449.22	33.00	11.91	1.21	20.11	19.54	28.00	24.24	996.74	19.12
21	Electronic devices, including computers	516.85	89.30	11.83	3.39	18.76	18.51	26.87	22.72	103.01	35.42
22	Instruments, miscellaneous manufacturing	56.71	32.38	7.80	1.50	20.81	20.00	33.39	25.00	17.44	9.83
23	Transport services	148.97	12.10	2.66	0.37	25.35	15.68	65.48	18.60	32.42	7.48
24	Communication services	47.25	6.70	1.16	0.22	26.61	17.14	68.88	20.68	11.82	6.41
25	Wholesale, retail distribution	83.97	11.20	26.31	0.40	28.94	19.75	67.48	25.00	40.20	20.89
26	Finance, insurance, banking	618.89	18.01	4.45	0.02	29.06	23.63	68.85	33.54	110.06	15.51
27	Water and energy distribution ("utilities")	137.99	12.36	10.03	0.45	17.89	13.00	26.33	15.93	27.93	27.93
28	Other business & Govt services	45.02	5.00	11.29	1.89	11.34	0.69	29.10	1.92	64.78	50.70
29	Other consumer services	35.59	0.94	4.69	0.00	28.70	14.45	370.33	16.90	75.54	32.56

relatively low at 72.00%. This suggests that while cartels in this sector significantly inflate prices, the fines are relatively moderate compared to the damage caused. The gap between the mean and median fines (112.28 vs. 35.40) further highlights inconsistency in enforcement, with some cases receiving much heavier penalties than others. Given the global significance of this sector, lenient penalties could encourage the persistence of cartel behavior.

The rubber and plastics sector exhibits a similar pattern, with overcharges of 19.35% and a relatively high fine-to-overcharge ratio of 191.08%. This suggests that fines in this sector are more proportionate to the damage caused, reflecting stronger enforcement compared to the oil sector. Such proportional enforcement could serve as a model for other sectors with high levels of cartel activity. In a striking example, the machinery and electrical parts sector shows an extraordinarily high fine-to-overcharge ratio of 996.74%, indicating that even small overcharges result in extremely high fines. The average fine in this sector is also remarkably high (449.22), reflecting increased regulatory scrutiny. This aggressive enforcement could serve as a strong deterrent against even minor cartel activity.

Finally, the finance, insurance, and banking sector reports some of the highest average fines (618.89), reflecting the critical role of this sector in any economy. However, the fine-to-overcharge ratio (110.06%) is more moderate, indicating that fines are broadly in line with the economic harm caused. The significant gap between the mean and median fines (618.89 vs. 18.01) points to considerable variability in enforcement, suggesting that larger cases attract much more attention. In conclusion, enforcement and penalties vary widely across sectors. While sectors like agricultural raw materials and machinery face disproportionately high fines, sectors such as oil and pharmaceuticals experience severe market distortions but relatively moderate fines. This uneven enforcement highlights the need for a more consistent regulatory approach to ensure fair market practices and better deter cartel activity.

4 Empirical analysis of cartel overcharges

4.1 General analysis

The proper case selection within Connor's Private International Cartels (PIC) Data Set mostly depends on the empirical purposes. Although the overcharge variable is based on calculations and estimations of other researchers, this dataset has been utilized as a basis for many studies in the literature (Bolotova et al., 2009; Bolotova, 2009; Boyer & Kotchoni, 2015). Discrepancies between the arithmetic mean and median values raise concerns about the presence of outliers in the data. To address this, outliers were identified using z-scores, with values exceeding 3 excluded from the analysis. The focus of the study is the overcharges/competition sales dataset, and any cases lacking relevant data were similarly excluded, along with the identified outliers. This resulted in a final sample of 403 cases for analysis. The correlation coefficients are presented in Table 7, with the regression results detailed in Table 8, and the t-test statistics provided in Table 9.

Table 7 Correlation between cartel characteristics and overcharges

Variables		Correlation Coefficent
Cartel Shares	Overcharges/Competative Sales	0.1779
Firms Number	Overcharges/Competative Sales	−0.0306
Duration	Overcharges/Competative Sales	−0.0059

Table 8 Regression results for cartel characteristics and overcharges

Variables	Coefficent	Standard Error	t-stat	*p* value
Cartel Shares	2.5894	0.9862	2.6257	0.0093
Firms Number	−1.7889	1.0592	−1.6889	0.0920
Duration	−0.1953	0.1291	−1.5128	0.1311

Table 9 t-Test results for overcharges based on buyer characteristics

Government Major Buying		Mod Buyers (30–99 buyers)	
No	146.57	No	100.59
Yes	150.02	Yes	474.601
t-test (p value)	0.2858	t-test (p value)	0.0000
Many Buyers (>99 buyers)		Few Buyers (>30 buyers)	
No	82.68	No	144.869
Yes	270.218	Yes	155.728
t-test	0.0008	t-test	0.9502

As shown in Table 7, the correlation analysis explores the relationship between cartel characteristics and overcharges relative to competitive sales. Cartel shares exhibit a positive correlation of 0.1779 with overcharges, indicating a weak but notable association, where higher cartel shares tend to correspond with increased overcharges. On the other hand, the number of firms shows a negative correlation of −0.0306, suggesting a minimal inverse relationship between the number of firms in a cartel and overcharges. Similarly, duration has an almost negligible negative correlation of −0.0059, implying that the length of cartel operations has little to no impact on overcharges. Overall, while cartel market shares seem to have some effect, the number of firms and duration show minimal influence on overcharge levels.

In the empirical set up, we first analyzed causal relationships using one independent variable in each regression. As shown in Table 8, cartel shares have a significant positive effect on overcharges, with a coefficient of 2.5894 ($p=0.0093$) which suggests that larger cartel market shares are associated with higher overcharges, consistent with the expectation that greater market control allows cartels to impose greater mark-ups on prices. The number of firms is also significant and negatively associated with overcharges, with a coefficient of −1.7889. This indicates that, as the number of firms in the cartel increases, overcharges tend to decrease. This finding may appear counter-intuitive, as the difference between cartel prices and non-cartelized prices should be higher the more intense competition is without cartel and the level of competition typically increases in the number of market participants. However, the inverse relationship between effective cartel overcharge and number of participants may reflect the coordination difficulties that arise with a larger number of participants, reducing the cartel's ability to sustain inflated prices.

In contrast, cartel duration does not exhibit a significant effect on overcharges. The coefficient (−0.1953) suggests a negative but insignificant relationship, indicating that the length of cartel operation does not appear to have a consistent impact on the extent of overcharges in these individual regressions.

The data in Table 9 suggest that government involvement in major buying does not significantly influence overcharge rates, with a p-value of 0.2858 showing no notable difference between cases where government buying is present (150.02) and absent (146.57). In contrast, the number of buyers has a clear impact, particularly in the 30–99 buyers range, where the p-value of 0.0000 indicates a substantial increase in overcharges (474.601) compared to cases without this buyer group (100.59). For markets with over 99 buyers, there is a significant difference in overcharge rates, supported by a p-value of 0.0008. Overcharges are considerably higher with more than 99 buyers (270.218) compared to fewer buyers (82.68). However, when considering markets with over 30 buyers, the p-value of 0.9502 suggests no statistically significant difference in overcharges between the groups (144.869 vs. 155.728).

4.2 The impact of policy changes in the EU

The economic harm caused by cartels, particularly through overcharges defined as price increases above the competitive level, and the effectiveness of monetary sanctions imposed against such conduct are central to assessing the success of competition policy. In this context, the European Union (EU) has periodically introduced reforms aimed at strengthening the deterrence and punishment of cartel behavior, most notably in 2006 and 2014.

4.2.1 The impact of the European Commission's 2006 guidelines on fines

On 1 September 2006, the European Commission released updated guidelines outlining its approach to imposing fines on companies violating the competition rules in Articles 81 and 82 of the EC Treaty. Since revising these guidelines, the Commission has issued eight of its ten highest-ever cartel fines. This increase in penalties is not surprising, as the 2006 guidelines were designed to enhance deterrence, addressing concerns that earlier fines were insufficient for large firms, especially those involved in long-term cartels affecting large product volumes or repeat offenders. Higher fines raise the stakes for companies under investigation and provide a greater incentive to seek leniency (Hinloopen et al., 2023). The 2006 guidelines set fines based on the sales impacted (considering economic impact and the market shares of the conspiring firms) and the duration of the violation. The calculation starts with the annual revenue from the affected products, which can be increased by up to 30% for aggravating factors, such as being a ringleader. This amount is then multiplied by the duration of the infringement, measured in half-year increments. Additionally, the guidelines doubled the maximum penalty for repeat offenders from 50% to 100% and introduced an "entry fee" of 15% to 25% of annual sales for severe anticompetitive practices, such as price-fixing or market allocation.

4.2.2 The impact of the 2014 EU directive on antitrust damages

In 2014, the EU adopted the Damages Directive (2014/104/EU), which sought to remove obstacles preventing victims of anticompetitive practices from pursuing private damages claims. The aim of the Directive is to facilitate citizens and companies pursuing damages claims for breaches of EU competition law before national courts across the EU, and to simplify the process for individuals and businesses to seek compensation for violations of EU competition law in national courts throughout the EU. Although EU competition law's direct effect allows anyone harmed by anticompetitive practices, such as cartels or abuse of dominant market positions, to claim damages, varying national legal systems have created barriers to effective redress. Published in the Official Journal in early December 2014, the directive addressed these challenges by requiring Member States to amend their laws to make it easier for victims of antitrust infringements to obtain compensation. While follow-on damages claims were already prevalent in certain EU jurisdictions (e.g., Germany, the Netherlands, and the UK), the directive aimed to standardize and increase the frequency of such actions across all member states.

Although this directive did not directly alter the methodology for calculating administrative fines, it was expected to exert indirect effects on cartel deterrence by increasing the likelihood and financial consequences of follow-on litigation, thereby complementing the Commission's sanctioning regime and making the violations of EU competition law to result in significant financial penalties. Companies found guilty of breaching competition rules now face substantial fines and the financial and legal risks associated with such infringements are heightened.

In the following, we aim to analyze the effects of the 2006 and 2014 EU competition policy reforms. Based on the changes in the EU competition policy, we aim to test if the new regime in antitrust enforcement created an incentive to change the undertakings' behaviours regarding cartel damages/overcharges in the EU, as damages became a significant factor in the determination of cartel consequences. However, the new regime (consisting of the two directives) affects cartels and cartel formation through at least two channels.

First, the sum of increased fines and damage compensations should work to deter cartel formation. Secondly, cartel pricing may be affected by the risk of potential fines and damage payments, leading to either lower overcharges (to avoid high fines and damages) or higher overcharges (to compensate for the increased risk). Hence, we test both whether the new guidelines had an impact on fines as well as private sanctions. Specifically, we examine the impact of these reforms on overcharge rates, the ratio of imposed fines to cartel sales, and the level of administrative monetary penalties. The analysis is conducted using regression models based on the Difference-in-Differences (DiD) approach. This method makes it possible to assess whether the changes observed in cartel cases within the EU after the respective reforms are statistically significantly different from those in the control group outside the EU during the same period. The following section first presents a methodological framework on the role and application of the DiD approach in economic analyses and subsequently provides a detailed interpretation of the regression results in terms of coefficient magnitudes and statistical significance levels.

The Difference-in-Differences (DiD) method is a quasi-experimental design widely used in the social sciences that allows for the causal identification of policy effects. This approach seeks to isolate the causal impact of a policy or shock by comparing the differences in outcome variables over time between a "treatment group" and a "control group." The DiD framework addresses the limitations of pure time-series analysis (which only compares pre- and post-treatment differences) and pure cross-sectional analysis (which only compares treated and untreated groups at a given point in time). It relies on the assumption that, prior to the intervention, both groups display similar trends in the outcome variable; this is commonly referred to as the parallel trends assumption. The core idea is that, in the absence of the intervention, the treatment group would have experienced a change in outcomes parallel to that observed in the control group. If this assumption holds, the additional change observed in the treated group after the intervention can be attributed to the policy effect.

Cartel cases subject to EU competition regulations are defined as the "treatment group," while cartel cases in other jurisdictions serve as the "control group." In terms of time dimension, for each regulatory reform separately, pre- and post-intervention periods are considered. Specifically, the pre- and post-2006 periods are compared for the 2006 Guidelines, and the pre- and post-2014 periods for the 2014 Directive.

Econometrically, each DiD specification includes three main components: (i) the group indicator (here, the dummy variable Jur_EU, denoting whether the cartel case falls under EU jurisdiction), (ii) the time indicator (After dummy, capturing whether the cartel ended after the relevant reform; for instance, After2006 indicates whether the cartel terminated in or after 2006), and (iii) the interaction term (the product Jur_EU × $\text{After}_{\text{year}}$, which captures the DiD effect). The general form of the model can be expressed as follows:

$$Y_{ikt} = \beta_0 + \beta_1 Jur\_EU_i + \beta_2 After_t + \beta_3 (Jur_{EU\,i}\, x\, After_t) + X_{ikt}\Gamma + \epsilon_{ikt}$$

here, Y_{ikt} denotes the outcome variable of interest (the value observed for cartel *i* at time *t*; e.g., the overcharge rate). Jur_EU_i indicates whether the case falls under EU jurisdiction (treatment group = 1, otherwise 0), while $After$ captures whether the observation belongs to the post-reform period (treatment period = 1, pre-reform = 0). The interaction of these two variables constitutes the DiD term, which identifies the effect of the reform on EU cases. $X_{ikt}\Gamma$ denotes the vector of other control variables. In this study, the following controls are included:

MKT_CRn: Market concentration ratio (the degree of concentration in the market where the cartel operates, e.g., the market share of the top *n* firms),

FewBuy: Dummy variable indicating markets with few buyers (e.g., situations with one or a few large buyers),

BigRid: Dummy variable for cartels involving significant public procurement (e.g., large-scale bid-rigging cartels, as frequently referred to in the literature),

Duration: The length of the cartel (total duration of activity measured in months),

Trend: Period dummies defined by decades to capture time trends (e.g., 1990 s, 2000 s, etc.).

In this study, two separate DiD analyses are conducted: (i) models including the interaction Jur_EU × After2006 to measure the effect of the 2006 EU reform, and (ii)

models including the interaction Jur_EU × After2014 to capture the effect of the 2014 reform. In total, 12 regression models are estimated. Among these, Models 1, 5, and 9 serve as the baseline specifications for each outcome variable; they do not include DiD interactions and only show the relationship between the dependent variables and the control variables. Models 2, 6, and 10 incorporate the DiD effect for the 2006 reform (Jur_EU × After2006) but do not additionally control for general time trends. Models 3, 7, and 11 extend this by including the Trend variables, thereby accounting for temporal patterns and providing a stricter test of the 2006 reform's DiD effect. Finally, Models 4, 8, and 12 capture the DiD effect for the 2014 reform (Jur_EU × After2014) while also controlling for time trends.

The results are presented in Table 10. Overcharges represent the extent to which cartel prices exceed the competitive benchmark. This variable directly reflects the economic harm generated by cartels and, therefore, constitutes a key indicator for assessing the effectiveness of competition policy. Models 1–4 are specified with overcharge rates as the dependent variable. In the second group of models (Models 5–8), the dependent variable is defined as the ratio of cartel fines to the cartel's annual sales during the relevant period. This ratio measures the relative severity of sanctions in proportion to cartel size and serves as a useful benchmark for comparing penalty practices across jurisdictions. For instance, the European Commission's fining guidelines typically determine penalties as a percentage (generally between 0 and 30%) of the sales affected by the infringement. Accordingly, this ratio provides an indication of the deterrent strength of fines. In the third group of models (Models 9–12), the dependent variable is the absolute value of monetary fines imposed on cartels by competition authorities. This variable captures the total sanction in monetary terms (e.g., millions of euros), reflecting the combined effect of cartel size, economic impact, and the sanctioning authority's enforcement policy.

Model 1 serves as the baseline specification and includes only the control variables. Among these, the market concentration ratio (MKT_CRn) appears positive and statistically significant (0.258; $p<0.05$), suggesting that cartels in more concentrated markets are able to sustain higher overcharges. Likewise, the presence of fewer buyers (Few Buy) produces positive and highly significant coefficients, indicating that when the number of buyers is limited, cartel power is more easily transmitted to prices. In contrast, the variable capturing bid-rigging cartels in public procurement (Big Rid) turns out negative and statistically significant, implying that such cartels have a more limited ability to push prices above the competitive level.

Model 2 incorporates a DiD specification to capture the impact of the 2006 EU Fining Guidelines. The results show that the coefficient of After2006 is positive (11.297; $p<0.01$), whereas the coefficient of DiD2006 is negative and statistically significant (−21.385; $p<0.05$). This indicates that overcharges in the EU declined markedly after the reform. Model 3 adds a time trend to test the robustness of this effect. The trend variable is positive and significant (4.058; $p<0.10$), reflecting a general upward trajectory of cartel prices over time. Nevertheless, the DiD2006 coefficient remains negative and significant (−21.399; $p<0.05$), confirming that the downward effect of the 2006 reform on overcharges holds even after accounting for the underlying time trend.

Table 10 The impacts of 2006 and 2014 changes in the EU

	Overcharges				Penalties/Sales				Government Fines			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Cons.	2.296	16.421	14.435	**27.951*****	8.104	**8.202****	8.305	**9.094***	61.790	**72.117****	**68.381***	**66.710***
	(0.831)	*(0.112)*	*(0.192)*	*(0.000)*	*(0.123)*	*(0.044)*	*(0.122)*	*(0.091)*	*(0.111)*	*(0.040)*	*(0.094)*	*(0.081)*
MKT_CRn	**0.258****	**0.208***	**0.205***		0.001	0.018	0.018	0.016	−0.521	−0.476	−0.476	−0.457
	(0.021)	*(0.057)*	*(0.061)*		*(0.969)*	*(0.705)*	*(0.709)*	*(0.750)*	*(0.155)*	*(0.187)*	*(0.189)*	*(0.196)*
Few Buy	**17.243*****	**18.765*****	**18.752*****	**11.046*****	−1.294	−0.199	−0.200	−0.219	−6.744	−1.144	−1.129	−1.347
	(0.001)	*(0.000)*	*(0.000)*	*(0.002)*	*(0.224)*	*(0.849)*	*(0.848)*	*(0.831)*	*(0.386)*	*(0.892)*	*(0.893)*	*(0.873)*
Big Rid	**−13.406*****	**−15.040*****	**−15.315*****	**−5.871***	−2.077	−1.871	−1.865	−2.212	−6.943	−8.650	−8.872	−8.363
	(0.003)	*(0.001)*	*(0.001)*	*(0.062)*	*(0.118)*	*(0.151)*	*(0.156)*	*(0.106)*	*(0.362)*	*(0.304)*	*(0.284)*	*(0.295)*
Jur_EU		1.681	1.518	−2.903		**−8.452*****	**−8.530*****	**−5.388*****		**−22.734*****	**−23.207****	**−28.658*****
		(0.669)	*(0.701)*	*(0.292)*		*(0.001)*	*(0.003)*	*(0.000)*		*(0.006)*	*(0.010)*	*(0.000)*
Duration	0.0001	**−0.074*****	**−0.075*****	0.0003	**−0.0001*****	**−0.0001***	**−0.0001***	**−0.0001***	**−0.0005****	−0.0003	−0.0003	−0.0003
	(0.876)	*(0.006)*	*(0.005)*	*(0.321)*	*(0.005)*	*(0.099)*	*(0.081)*	*(0.051)*	*(0.011)*	*(0.159)*	*(0.176)*	*(0.142)*
Trend	**4.058***		1.643	0.500	**−2.03****		−0.071	**−2.040****	3.198		2.655	
	(0.078)		*(0.612)*	*(0.798)*	*(0.015)*		*(0.961)*	*(0.028)*	*(0.581)*		*(0.756)*	
After 2006		**11.297*****	**9.491***			**−6.915****	**−6.838***			6.690	3.748	
		(0.002)	*(0.064)*			*(0.011)*	*(0.072)*			*(0.668)*	*(0.852)*	
DiD2006		**−21.385****	**−21.399****			**6.331****	**6.317****			−12.181	−11.615	
		(0.039)	*(0.040)*			*(0.020)*	*(0.031)*			*(0.475)*	*(0.512)*	
After 2014				4.417				−2.004				−9.543
				(0.374)				*(0.308)*				*(0.690)*
DiD2014				0.299				**3.321***				−2.370
				(0.973)				*(0.060)*				*(0.911)*
Obs	210	210	210	210	416	416	416	416	423	423	423	423
Prob>F	0.000	0.000	0.000	0.062	0.015	0.001	0.001	0.008	0.009	0.011	0.001	0.001
R^2	0.102	0.118	0.119	0.107	0.020	0.065	0.065	0.048	0.012	0.035	0.035	0.035

Finally, Model 4 examines the impact of the 2014 Damages Directive. Although the coefficient of After2014 is positive, it is not statistically significant (4.417; $p=0.374$), and the DiD2014 coefficient also shows no meaningful effect (0.299; $p=0.973$). Therefore, the 2014 reform does not appear to have had a notable short-term impact on cartel overcharges.

When turning to Models 5–8, Model 5 -which includes only control variables- does not yield significant results. By contrast, the negative and highly significant coefficient of Jur_EU in Models 6 and 7 indicates that the fine-to-sales ratios in EU cases are structurally lower. Moreover, the negative and significant coefficient of the time trend confirms that fines have been on a long-term downward trajectory. Model 8 provides consistent evidence, showing that fine ratios in the EU remain relatively lower, though the results suggest that this structure may shift during regulatory periods.

In the models testing the 2006 reform (Models 6 and 7), the positive and significant coefficient of DiD2006 demonstrates that the adoption of the Fining Guidelines led to a substantial increase in fine-to-sales ratios applied within the EU. This effect remains robust when the time trend is controlled for, thereby strongly confirming the policy impact of the reform. Regarding the 2014 reform, Model 8 shows that the DiD2014 coefficient is positive and statistically significant, suggesting that the 2014 Damages Directive exerted an upward influence on fines.

When evaluating the results of Models 9–12 with respect to government-imposed fines, the first notable finding is the negative coefficient of Jur_EU. This indicates that cartels under EU jurisdiction are subject to comparatively lower sanctions at the government level than those outside the EU. In other words, government-based penalties in Europe appear relatively limited, which may imply that the primary weight of enforcement has shifted toward the substantial monetary fines imposed by the European Commission.

Furthermore, the post-2006 (After2006) and post-2014 (After2014) dummy variables are statistically insignificant in these models. This indicates that the regulatory reforms enacted in these years did not, by themselves, significantly alter government-level sanctions. Similarly, the interaction terms DiD2006 and DiD2014 are statistically insignificant, suggesting that these reforms did not generate a discernible differential effect on government fines within the EU. Taken together, these results imply that, while policy changes may have strengthened deterrence through private litigation or through fines imposed by the Commission, they did not translate into a corresponding shift in government-based sanctions.

When the findings are considered as a whole, it becomes evident that EU competition regulations have produced different impacts on sanctions imposed against cartels. With regard to overcharges, the analysis demonstrates that the 2006 Fining Guidelines significantly altered the pricing behavior of cartels within the EU. The negative and statistically significant DiD2006 coefficient indicates that the reform substantially reduced excessive pricing. By contrast, the 2014 Damages Directive did not exert a statistically significant short-term effect in this area. In terms of penalties relative to sales, the results reveal that cases under EU jurisdiction were structurally associated with lower sanction ratios, yet these ratios increased considerably following the 2006 reform. This underscores the reform's role in strengthening the deter-

rent effect of sanctions. Furthermore, the 2014 Directive is also shown to have had a positive and statistically significant impact on penalties relative to sales. On the other hand, when government fines are considered, neither the 2006 nor the 2014 reforms appear to have had a significant influence, indicating that policy changes primarily enhanced deterrence through Commission decisions and private enforcement rather than through government-imposed sanctions. Overall, these results suggest that the EU's anti-cartel policy instruments have been reinforced mainly through the actions of the European Commission and private litigation, while national government-based sanctions have remained relatively limited in scope.

5 Conclusion

This paper has provided an empirical examination of cartel overcharges and sanctions, using John Connor's International Cartel Database to study 1,304 cases worldwide and to evaluate the impact of major EU competition policy reforms in 2006 and 2014. We have first analyzed the determinants of cartel overcharges, showing that higher cartel market shares significantly increase overcharges, while a larger number of cartel participants tends to reduce them—likely reflecting coordination difficulties in larger cartels and the associate difficulty of keeping cartel discipline. Duration, by contrast, does not have a statistically significant effect. Overcharges are also substantially higher in markets with many buyers, suggesting that dispersed demand environments facilitate price increases, whereas government involvement as a large buyer does not systematically influence overcharges. Sectoral patterns reveal wide variation in both overcharges and penalties, with construction, pharmaceuticals, and services demonstrating high cartel shares and significant pricing distortions.

The paper's core contribution, however, lies in evaluating the EU's 2006 Fining Guidelines and the 2014 Damages Directive using a Difference-in-Differences approach. The results show that the 2006 reform significantly reduced cartel overcharges in the EU and led to higher fine-to-sales ratios, strengthening deterrence. The 2014 Damages Directive also increased the fine-to-sales ratio but did not deliver a statistically significant short-term reduction in overcharges. Interestingly, fines imposed by national authorities did not respond materially to either reform, suggesting that enforcement improvements stemmed primarily from European Commission fines and private damages actions rather than national authorities. Overall, the findings indicate that EU reforms—especially the 2006 guidelines—effectively strengthened the deterrence of cartels by raising sanctions and curbing price increases, while highlighting ongoing variation across sectors and jurisdictions in the severity and consistency of cartel penalties.

Acknowledgements We are very grateful to two anonymous referees and the editor for their enormously helpful comments. In addition, Mehmet Karacuka gratefully acknowledges financial support by the Meyer Struckmann Foundation.

Author contributions J.H., M.K. and H.I all wrote the main text. M.K. and H.I. conducted the regressions. J.H. reviewed the manuscript and gave advises.

Funding Open Access funding enabled and organized by Projekt DEAL.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

References

Auriol, E., Hjelmeng, E., & Søreide, T. (2023). Corporate criminals in a market context: Enforcement and optimal sanctions. *European Journal of Law and Economics*, *56*, 225–287. https://doi.org/10.1007/s10657-023-09773-w

Becker, G. (1968). Crime and punishment: An economic approach. *Journal of Political Economy*, *76*(2), 169–217.

Bento, R., & Barros, P. P. (2025). The larger the tip, the smaller the iceberg: Reassessing anti-cartel policy evaluation. *Journal of Industry, Competition and Trade, 25*, 1. https://doi.org/10.1007/s10842-024-00436-3

Block, M. K., Nold, F. C., & Sidak, J. G. (1981). The deterrent effect of antitrust enforcement. *Journal of Political Economy*, *89*(3), 429–445.

Bolotova, Y. V. (2006). *Three essays on the effectiveness of overt collusion: Cartel overcharges, cartel stability and cartel success* (Doctoral dissertation). Department of Agricultural Economics, Purdue University, West Lafayette, IN.

Bolotova, Y. V. (2009). Cartel overcharges: An empirical analysis. *Journal of Economic Behavior & Organization*, *70*(1–2), 321–341. https://doi.org/10.1016/j.jebo.2009.02.012

Bolotova, Y., & Connor, J. M. (2008). Cartel sanctions: An empirical analysis. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1116421

Bolotova, Y., Connor, J. M., & Miller, D. J. (2007). Factors influencing the magnitude of cartel overcharges: An empirical analysis of food-industry cartels. *Agribusiness*, *23*, 17–33. https://doi.org/10.1002/agr.20111

Bolotova, Y., Connor, J. M., & Miller, D. J. (2009). Factors influencing the magnitude of cartel overcharges: An empirical analysis of the U.S. market. *Journal of Competition Law and Economics, 5*(2), 361–381. https://doi.org/10.1093/joclec/nhn025

Boulu-Reshef, B., & Monnier, C. (2024). Punitive attitudes toward cartels: Evidence from an experimental study. *European Journal of Law and Economics*, *58*, 481–516. https://doi.org/10.1007/s10657-024-09824-w

Boyer, M., & Kotchoni, R. (2015). How much do cartels overcharge? *Review of Industrial Organization*, *47*(2), 119–153. https://doi.org/10.1007/s11151-015-9472-1

Cohen, M. A., & Scheffman, D. T. (1989–1990). The Antitrust Sentencing Guideline: Is the Punishment Worth the Costs? *American Criminal Law Review, 27*(2), 331–366.

Connor, J. M. (2005). Price-fixing overcharges: Legal and economic evidence (Staff Paper No. 04-17). Department of Agricultural Economics, Purdue University, West Lafayette IN. Retrieved from http://www.agecon.purdue.edu/staff/connor/papers/PRICE_FIXING_OVERCHARGES_APPENDIX_TABLES_8-05.pdf

Connor, J. M. (2008). Forensic economics: An introduction with special emphasis on price fixing. *Journal of Competition Law and Economics*, *4*(1), 31–59.
Connor, J. M. (2020). *The Private International Cartels (PIC) Data Set: Guide and Summary Statistics, 1990–2019.* https://doi.org/10.2139/ssrn.3682189
Connor, J. M. (2024). : Price-fixing overcharges: Revised 4th edition. Available at SSRN: https://ssrn.com/abstract=4906907.
Connor, J. M., & Bolotova, Y. (2006). Cartel overcharges: Survey and meta-analysis. *International Journal of Industrial Organization, 24*(6), 1109–1137. https://doi.org/10.1016/j.ijindorg.2006.07.003
Connor, J. M., & Lande, R. H. (2005). How high do cartels raise prices? Implications for optimal cartel fines. *Tulane Law Review, 80*(2), 513570.
Connor, J.M., & Lande, R. H. (2006). The size of cartel overcharges: Implications for U.S. and EU fining policies. *The Antitrust Bulletin*, *51*(4), 983–1022. https://doi.org/10.1177/0003603X0605100407
European Commission (2025). *Fines*. European Commission Competition Policy. Retrieved August 20, 2025, from https://competition-policy.ec.europa.eu/index/fines_en
Feinberg, R. M. (2023). Patterns and determinants of Canadian anti-cartel and antidumping policy: 1990–2019. *Journal of Industry, Competition, and Trade, 23*, 309–327. https://doi.org/10.1007/s10842-023-00406-1
Gallo, J. C., Dau-Schmidt, K., Craycraft, J. L., & Parker, C. J. (2000). Department of justice antitrust enforcement, 1955–1997: An empirical study. *Review of Industrial Organization, 17*(1), 75–133.
Garoupa, N. (2001). Optimal magnitude and probability of fines. *European Economic Review*, *45*(9), 1765–1771. https://doi.org/10.1016/S0014-2921(00)00084-2
Haucap, J., & Heldman, C. (2023). On the sociology of cartels. *European Journal of Law and Economics*, *56*, 289–323. https://doi.org/10.1007/s10657-023-09780-x
Hinloopen, J., Onderstal, S., & Soetevent, A. (2023). Corporate leniency programs for antitrust: Past, present, and future. *Review of Industrial Organization, 63*, 111–122. https://doi.org/10.1007/s11151-023-09913-1
Korsten, R., & Samuel, A. (2023). Cartel formation and detection: The role of information costs and disclosure. *European Journal of Law and Economics*, *56*, 117–153. https://doi.org/10.1007/s10657-023-09770-z
Landes, W. M. (1983). Optimal sanctions for antitrust violations. *University of Chicago Law Review*, *50*(2), Article 13.
Levenstein, M. C., & Suslow, V. Y. (2011). Breaking up is hard to do: Determinants of cartel duration. *Journal of Law and Economics*, *54*, 455–492.
Mariuzzo, F., Ormosi, P. L., & Majied, Z. (2020). Fines and reputational sanctions: The case of cartels. *International Journal of Industrial Organization, 69*, Article 102584. https://doi.org/10.1016/j.ijindorg.2019.102584
Motta, M. (2004). *Competition Policy Theory and Practices*. Cambridge University Press.
OECD. (2019). *Review of the 1998 OECD recommendation concerning effective action against hard-core cartels*. OECD. https://doi.org/10.1787/58c38ceb-en
Polinsky, A. M., & Shavell, S. (1979). The optimal tradeoff between the probability and magnitude of fines. *American Economic Review, 69*(5), 880–891.
Polinsky, A. M., & Shavell, S. (1984). The optimal use of fines and imprisonment. *Journal of Public Economics*, *24*(1), 89–99. https://doi.org/10.1016/0047-2727(84)90006-9
Posner, R. A. (1969). Oligopoly and the antitrust laws: A suggested approach. *Stanford Law Review*, *21*(6), 1562–1606.
Smuda, F. (2014). Cartel overcharges and the deterrent effect of EU competition law. *Journal of Competition Law & Economics*, *10*, 63–86. https://doi.org/10.1093/joclec/nht012
Wils, W. P. J. (2006). Optimal antitrust fines: Theory and practice. *World Competition, 29*(2), 183–208. https://doi.org/10.54648/woco2006014
Wils, W. P. J. (2007). The European Commission's 2006 guidelines on antitrust fines: A legal and economic analysis. *World Competition, 30*(2), 197–229.