

RESEARCH ARTICLE

Polycentric governance in collusive agreements

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Abstract

Collusive agreements in the form of corporate cartels are complex structures. The involved firms need to agree on terms that are legally not enforceable. However, the interplay between the involved firms in a collusive agreement, i.e., the governance dimension within a cartel, has received surprisingly low attention. Using a comprehensive OECD dataset of 191 cartels from 2012 to 2018, this paper empirically demonstrates how polycentric governance within a cartel may possibly contribute to understanding its stability. It may be beneficial for the duration and lower sanctions imposed by competition authorities, especially for large cartels. By that, the paper sheds new light on two aspects: the entangled governance structures of corporate cartels and the relevance of the concept of polycentricity beyond public administration.

Keywords: collusion; governance; illegal cartels; institutions; polycentricity

JEL Codes: A14; D02; D23; K42; L40; O17

Introduction

Corporate governance is a crucial driver of firm performance, value, innovation, and dividends paid (Acharya *et al.*, 2011; Ammann *et al.*, 2011; Bhagat and Bolton, 2008; Wu, 2008). There exist influential indices to measure it (see, e.g., Bebchuk and Cohen, 2005; Brown and Caylor, 2006; Gompers *et al.*, 2003). Even though well-established in management and finance literature, the impact of corporate governance plays only a minor role in industrial economics, particularly in studies on cartels and collusion.

Collusive agreements are concerted practices that increase profits but harm consumer welfare. Involved firms agree on sales quotas below the competitive equilibrium or prices above it. Another practice is assigning monopoly markets by geographical distinction: one cartel member is the sole distributor within a specific region, state, or country. While reliable statistics on cartels substantially suffer from the structural challenge that they are mostly illegal and hard to track, statistics exist on their disclosure. Between 2019 and 2023, the European Commission imposed fines amounting to 3.8 billion EUR.¹ The US Department of Justice imposed fines worth 1.3 billion USD in this period.² A remarkable case in the European Union has been the commercial truck cartel. For at least 14 years, DAF/Paccar, Daimler, Iveco, MAN, Scania and Volvo/Renault colluded on pricing and introducing new low-emission technologies. The cartel had a joint market share of 90% in Europe's medium and heavy truck market. As a consequence, the fines for this cartel alone make up for 3.8 billion EUR, imposed in 2016 and 2017.³

Even though complex governance structures within and between firms are predominant, in industrial economic research a common simplification of firms to abstract entities prevails. They often interact based

¹See https://web.archive.org/web/20231222184518/https://competition-policy.ec.europa.eu/system/files/2023-12/cartels_cases_statistics.pdf, last updated 7 December 2023; copy from the Internet Archive, copy date: 22 December 2023.

²See <https://www.justice.gov/atr/criminal-enforcement-fine-and-jail-charts>, last updated 24 October 2023.

³See the press releases of the European Commission on 19 July 2016, https://ec.europa.eu/commission/presscorner/detail/en/IP_16_2582 and 27 September 2017: https://ec.europa.eu/commission/presscorner/detail/en/IP_17_3502.

on the maximization of an infinite stream of expected profits (Schmal, 2022). Such an approach may neglect how entangled communication and coordination between firms in a corporate cartel can become.⁴ Put differently, focusing on firm profits addresses financial but not governance aspects of collusion. As cartels are illegal in most countries, the governance schemes of a cartel need to incorporate that collusive agreements cannot be legally enforced. Corporate governance *within* a firm is already an established subject of study. The same holds for market characteristics that foster or harm the formation and duration of cartels. This paper examines the layer between the two: governance among firms within a cartel. It aims to study how *polycentric* governance of cartels can serve as an additional explanation of their stability. It attempts to widen the perspective of how to study collusion, its emergence, and its collapse. Doing so aims to complement and expand the existing research programme on cartels.

The present paper introduces the concept of polycentricity to the mesolevel of firm interaction within a cartel.⁵ Using a comprehensive OECD dataset, I present correlational evidence pointing at the presence of polycentric structures, particularly among large cartels. I provide evidence that more cartel members do not co-occur with lower cartel duration. Furthermore, a concave relationship exists between the number of cartel members and the aggregate financial sentence for a disclosed cartel. Lastly, third parties involved, such as business associations, hardly increase cartel stability in the present dataset.

A few papers already address some governance-related topics within cartels: Dick (1996) and Hyytinen *et al.* (2019) study cartel contract design. However, both investigate *legal* cartels, which has implications for the organizational structure. Furthermore, both focus on the mechanics of the cartel – to which extent firms collude on prices or quantities and how they compensate each other. It leaves open questions regarding the overall governance structures. Haucap and Heldman (2023) descriptively investigate characteristics of the inner workings of German cartels. Haucap *et al.* (2024) experimentally demonstrate that gender can affect the willingness to collude. However, an institutional analysis of the governance dimension in a more general way (and following Aligica, 2015) is hitherto missing.

The concept of polycentricity in governance structures has lately been applied to various collectively organized structures aside from public administration. Aligica *et al.* (2019) propose a ‘polycentric stakeholder analysis’ to better understand corporate governance and social responsibility. Shortland (2018) applied the concept to extra-legal governance structures such as kidnapping, Shortland and Shortland (2020) to the not always law-abiding market for precious art. Lewis and Aligica (2024) outline how strongly Ostromian governance theory ties in with self-governance, which is present in illegal endeavours such as cartels. Enriching the interdisciplinary field of antitrust with methods of the (broader) public choice literature has been proposed lately by Shughart (2022). Doing so also tackles the decreasing heterogeneity in research on collusion (Schmal, 2023b). I study collective action issues *within* cartels – an up-to-now rather neglected topic.

The concept of polycentricity applied to cartels

The origins of the concept of polycentricity date back to botanical studies. They used mono- and polycentricity to distinguish the reproduction of plants. In the 1960s, it was adapted to study administrative structures (Stephan *et al.*, 2019). Ostrom *et al.* (1961) observed for US metropolitan areas many different governmental units that are not hierarchically organized but independent and partially overlapping. They defined polycentric structures as having more than one officially independent decision-making centre that may act independently or be interrelated with others.

Ostrom (2005, p. 283) subsumed the concept as such that ‘Each unit exercises considerable independence to make and enforce rules within a circumscribed domain of authority for a specified

⁴Parallels exist for merger or bargaining analysis; in general, all oligopoly analyses in industrial economics, see, e.g., Schmal (2023a). However, in all these cases, firms and their agents do *not* face the challenge of illegality but can communicate and coordinate more openly.

⁵A rare example of related earlier studies is the work of Schwalbe (2013) on cartel structures.

geographical area... some units are general-purpose governments while others may be highly specialized... These are nested in several levels of general-purpose governments'. This definition was suited to understanding governance structures in public administration. It requires adjustment for its use in industrial economics. Considering the case of different hierarchy levels joint with general and special purpose management roles, it is easily conceivable that this universal definition is also applicable to corporate cartels.

In their review, Aligica and Tarko (2012) suggest that polycentricity encompasses three building blocks: multiple decision centres, an institutional framework with over-lapping rules, and spontaneous order in terms of market entry and exit as well as information availability. McPhail and Tarko (2017) label these blocks as the 'structure', 'process' and 'outcome' of a polycentric governance system and add an evaluation loop as an iterative element.

Subsequently, I go through these three blocks and discuss how corporate cartels can be related to this concept. At that point, I define a sample cartel as a collusive agreement between two or more firms that want to optimize joint profits by illegally colluding on prices and quantities sold. They have several managerial levels, such as a board, top management and middle management, e.g., regional or product managers. For simplicity, I set aside more details on market characteristics and structure.

Multiplicity of decision centres

As Aligica and Tarko (2012) state, this criterion requires the 'active exercise of diverse opinions' as well as 'autonomous decision-making layers'. Last, there must be either common or individual goals. Sticking to the sketched situation, it is the case that colluding firms communicate their needs and opinions on how to behave given the joint maximization of profits. Plenty of evidence exists that people in cartels communicate (Haucap and Heldman, 2023). Harrington and Skrzypacz (2011) theoretically demonstrate that communicating its sales figures to fellow cartel members can be an equilibrium behaviour. Furthermore, sales and target profits are, to some extent, private knowledge, which requires communication if it is meant to be shared.

The last point relates to the autonomous decision-making layers. Various case studies of cartels in leading economics journals often describe in detail the mechanisms applied but not *how* these mechanisms have been concluded. An exception is the work of Igami and Sugaya (2022) on the global vitamin cartels in the 1990s. They mention that the agreements were developed on the firms' top-level boards but reviewed on lower levels by different agents at different meetings. It highlights that several vertically related decision centres may exist and have some autonomy over how to reach defined targets. However, a hierarchy continues to exist as it is hardly imaginable that middle managers possess the same authority to decide crucial issues as the top management. There may still be autonomy in the sense that the firms themselves constitute decision centres. Even if there exists some central entity organizing meetings or information exchange, every firm is independent as it autonomously decides whether to stick to the collusive agreement or to deviate. Plenty of research has shown that a firm's valuation of future profits is crucial to the stability of a cartel, and every cartel is only as stable as its 'weakest' member, i.e., the firm with the lowest future discount factor. It even assigns small firms much power over the stability of a cartel. Hence, the power distribution in cartels can be understood as '*primus inter pares*' ('first among equals') in the sense that larger firms may be leaders but among equals since every member can break up the cartel. Put differently, autonomy concerning cartels can be understood as 'mutually assured destruction'. Thus, polycentric power stems from the absence of legally binding contracts, given the illegality of such undertakings.

Institutional/cultural framework (overarching system of rules)

Regarding the institutional framework, Aligica and Tarko (2012) highlight the overlapping systems of rules present in a polycentric structure. It clearly applies to cartels. They name incentive compatibility, which is a cornerstone of cartels. Furthermore, often multiple jurisdictions exist – formal ones in the

countries where the firms are doing business as well as informal, moral jurisdictions, as cartels are, in general, illegal. The involved agents may feel the urge to justify their behaviour before themselves or bystanders who know about the illegal activities.

Third, the agents are directly involved in the rule design as they define the mechanisms of what to do in case some corporate targets are not met or when someone deviates from an agreement. The collective choice is highly involved as it depends on the specific cartel and whether there is a majority or consensus rule. Due to the '*primus inter pares*' situation the firms find themselves in, majority rules are risky in light of the option for everyone to deviate from the agreement or even to apply for lenience and disclose the whole cartel.

Spontaneous order

The third block of the polycentricity concept is spontaneous order and evolutionary competition. It comprises three aspects: entry, exit and information. All of them are crucial issues for corporate cartels. 'Entry' has two dimensions: the initial entry when forming the cartel. It is already an essential evolutionary and under-studied topic as it is unclear how firms contact each other to form a cartel, whether during association meetings or bilaterally, e.g., during fairs or privately. Once a cartel establishes itself, it is an open question how the cartel members deal with either left-out market participants or new market entrants. The global vitamin cartels highlight the endogeneity of the issue as the artificially high prices for vitamins triggered the emergence of new competitors (Igami and Sugaya, 2022).⁶

The opposite is true for any exit from a cartel. Two options exist. Either a cartel member deviates or contacts competition authorities (or both). Theoretically, a firm could also leave a collusive agreement without further action. Since the activities within a cartel remain illegal even after leaving it, approaching competition authorities and applying for full leniency appears to be a better protection against prosecution. However, it does not protect the firm from private damage claims. This additional threat can strengthen cartel stability and make 'silent exits' more attractive (Bodnar *et al.*, 2023). Last, there must be some information involved, either publicly or privately. It is certainly the case given the data on sales, production capacities, and, of course, the level of future orientation the cartel members have.

Polycentricity collapse

The three building blocks of polycentricity can also break down if they are no longer satisfied. For the *multiplicity of decision centres*, Aligica and Tarko (2012) point out three potential *breakages* for polycentric structures. Besides the trivial 'risk' that a cartel becomes meaningless because its purpose disappears, e.g., by a rapidly growing market, two issues are central: the exchange of opinions does not work anymore, or the structure becomes hierarchic. The latter case may occur especially if some members disrespect the *primus inter pares* principle and try to exert decision power on the other cartel members.

Related to the *institutional framework/system of rules*, the major risks for polycentricity in cartels emerge if the cartel members either dismiss the cartel's rules as beneficial for them or the members can no longer alter or enforce the self-imposed rules. In cartels, especially new board members or shareholders that want to change the conduct of their firm could be a cause for that.

Regarding a breakdown related to *spontaneous order*, the aspect of 'no entry' seems crucial as cartels generate super-normal profits that may attract other firms to enter the market. It can be vital for the cartel to incorporate the newcomers into their collusive agreement. The case of the vitamin cartels exemplifies how the inability to incorporate new members into an existing collusive agreement may

⁶The vitamin cartels were 16 cartels separated by the vitamins produced, namely vitamins A, E, B1, B2, B3, B5, B6, B12, C, D3, H, choline chloride, feed premix, folic acid, beta-carotene and corticoids (Connor, 2006). Some of the cartels collapsed independently. Others endured until the US Department of Justice or the European Commission shut them down (Igami and Sugaya, 2022). The market leaders and leading firms in the cartels were the European firms Roche, BASF and Rhone-Poulenc (now part of Sanofi) (European Commission, 2003).

lead to a collapse of this polycentric order. The other two points raised by Aligica and Tarko (2012) are also applicable: missing information to maintain the cartel is an issue that may occur and be particularly crucial in case cartel members withhold information because they mistrust each other. Last, there is the risk that the ‘constituency of the system is unclear’. It means ambiguity over who is part of the cartel. It also could apply to cartels in which the member firms are dispersed worldwide or in which only one or a few members communicate with other members. The risk is more relevant for decentral communication.

Mapping drivers of cartel failure and success

Plenty of research investigates disclosed cartels. Levenstein and Suslow have published important reviews of drivers of cartel success (2006) and their failure (2011). They define three crucial challenges for cartels: *coordination*, *cheating* and *entry* (Levenstein and Suslow, 2006, p. 85). In particular, they name coordination in response to an altered economic environment as well as the entry of new competitors as the two primary breakpoints of cartels.

Regarding coordination, Levenstein and Suslow (2011) find that cartels with compensation schemes are much more stable than those that punish their members for deviations from the collusive agreement.⁷ Related to the economic conditions, they find variations in firm-specific time discounting to be much more influential than exogenous variation in interest rates, which constitutes some generic future discounting. It does not only emphasize the role of individual discount factors (as outlined, e.g., by Schmal, 2022), but it also offers various relations to polycentricity analysis. The fragile balance created by the intra-cartel compensation and maintenance systems to explore the common pool resource of excess profits generated by *joint* profit maximization suits the definition of overlapping decision centres, at least for large companies, quite well. While the cartel *as such* is the overall body, it consists of the firms as entities that cooperate and compete simultaneously. Nested within these firms are the different managerial layers with their own ties and organizational rivalries, which are common, especially in multinational firms (see, e.g., Becker-Ritterspach and Dörrenbächer, 2011; Birkinshaw and Lingblad, 2005; Bouquet and Birkinshaw, 2008).

Relating to the vitamin cartels, one can see that firms took different roles within the organization of the collusive agreement: according to process files of the European Commission (2003), Roche representatives contacted the Japanese firm Eisai in 1989. Later on, Roche was the critical intermediary between Europe and Asia as only Roche held contact with Eisai and represented all three European firms (see paras 234–239, *ibid*). Hence, the outcome of a successful set-up of the cartel in Europe led Roche to extend the number of actors by involving Eisai as a non-European member. An apparent parallel existed in the Vitamin C cartel that consisted of the European members Roche, BASF and Merck. Again, it was Roche that contacted a Japanese firm, Takeda, and held a similar role as an intermediary between the European cartel members and Takeda, whose officials mostly met and communicated bilaterally with Roche officials: ‘Takeda refused to attend multilateral cartel meetings with BASF and Merck but held “one-to-one” meetings with Roche’ (European Commission, 2003, para 415). It hints at the presence of multiple decision centres.

As Aligica and Tarko (2012) note, polycentric orders collapse once they get hierarchical, and the multiplicity of decision centres disappears. This might be a reason why cartels using sophisticated compensation schemes are more resilient (Levenstein and Suslow, 2006). Even though such methods leave more traces and underline criminal intentions, such compensation schemes require maintenance and, by that, the involvement of more agents and decision centres. In contrast, very plain cartels that can be arranged solely by one decision layer or are managed by one leading firm are rather mono-centric. The same holds for incorporating a third party into the cartel governance, such as a business

⁷Such compensation schemes take into account that variation may occur in demand across firms that cannot be controlled by the cartel directly. Such schemes compensate cartel members disadvantaged by such fluctuations to avoid a cartel breakdown, for example, by internal purchases to level differences.

or trade association. These institutions may serve as essential clearing centres of information, such as actual prices and sales of the participants. However, they also centralize communication and decision-making, which may lead to monocentric governance structures within a cartel. This, in turn, would destabilize a cartel in the long run, according to polycentricity theory.

One should not ignore that such schemes may also raise stability and deter cheating as compensation schemes usually adjust for asymmetries between the cartel members in terms of future orientation, market shares or cost structures (Levenstein and Suslow, 2011). Furthermore, internal compensation schemes can foster trust among the participants, a core ingredient of cartels (Leslie, 2003) and collective action more generally (Ostrom, 1998).

Aside from coordination and cheating, the third sensitive topic for cartel stability is the entry of new competitors (Levenstein and Suslow, 2011). This threat always exists in markets but is particularly relevant for those with solid cartels operating in them. Overly high prices are an endogenous accelerator of market entry. Ostrom (1999, p. 59) stated that the ‘viability of the market as a polycentric ordering will depend upon whether individuals have incentives to organize firms that will be effective participants in such a market ... and whether such firms are free to enter the market and engage in trade’. While it is conceivable that new market participants are interested in participating in the incumbent cartel, the opposite may not hold. Cartels, as well as oligopoly markets, often engage in driving new entrants out of their market (see, e.g., Asker and Bar-Isaac, 2014; Lerner, 1995; Scott Morton, 1997).

On the other hand, cartels also try to approach existing or new competitors in their market to join them. Thus, entry is possible. Exit from a cartel is also conceivable but difficult: if a firm leaves a cartel, its former cartel partners may still possess compromising evidence of the period in which the leaving firm was active in the cartel (and so does the leaving firm). Also, a firm leaving a cartel may scare the other participating firms and managers, of whom one or more could use the often-offered leniency schemes to disclose the cartel to the authorities under the condition of impunity. Thus, an exit of a member is a moment of peak instability but generally imaginable.

Exploratory empirical evidence

By construction, analyses of corporate cartels and collusive agreements are troublesome as they usually operate illegally. Sample selection exists as only detected cartels can be studied.⁸ Switching to legal cartels, as, for example, Forsbacka *et al.* (2023) do, is not an alternative as such cartel agreements can rely on legal structures and enforcement mechanisms. It severely alters the setting in which the involved agents find themselves. Therefore, I rely on the scarce data on illegal but disclosed collusion cases.

I use the OECD cartel database that includes 191 unique cartels discovered between 2012 and 2018.⁹ It bears the advantage of including recent cartels and a comparatively large number of cases. But overall, there is still a relatively small number of observations, and I can only discuss correlational evidence.¹⁰ Given this endeavour’s novel and exploratory character, it may still be informative. Figure 1 depicts the number of corporate cartels per industry using the established ‘North American Industry Classification System’ (NAICS) to structure industries.

Figure 2 presents cartel duration and imposed sanctions separated by NAICS, and Table 1 presents further descriptive statistics.

⁸It is not clear whether this is a major distortion or to which extent disclosed cartels may be representative of the entirety of cartels (see, e.g., Harrington and Wei, 2017).

⁹See for more information https://web.archive.org/web/20231201001555/https://qdd.oecd.org/subject.aspx?Subject=OECD_HIC. Note that the OECD unpublished the original website before this paper was published, which is why I present a copy from the web archive. The underlying data are openly available in the corresponding Zenodo repository. The URL is provided in the data availability statement at the end of the paper.

¹⁰To ensure that my results are valid, I conduct jackknife estimations, which work via re-estimating the regression N times while leaving out each observation once. It is more conservative in estimating standard errors than bootstrapping and particularly applies to small samples (Efron, 1982). It reduces the impact of outliers in the data, i.e., that specific cartels drive the results.

Number of Cartels per Industry NAICS 2-digit code

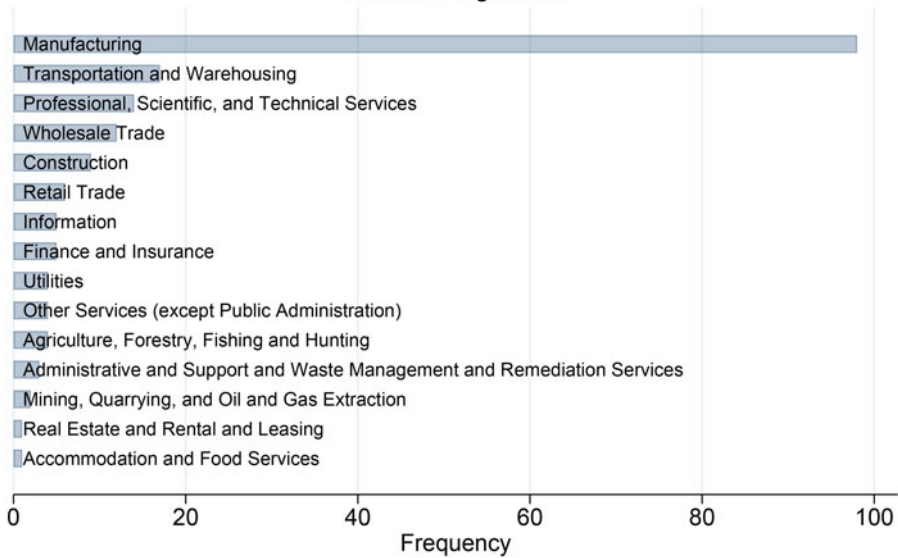


Figure 1. Number of cartels per industry sector.

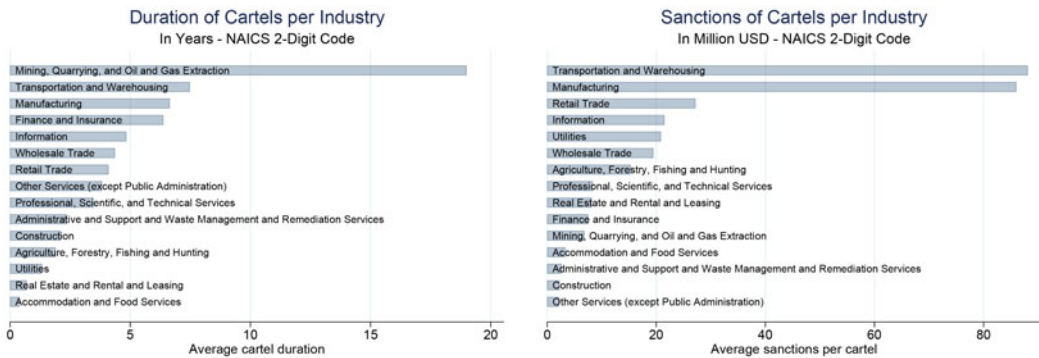


Figure 2. Duration and sanctions of cartels per industry sector.

Table 1. Descriptive statistics of the variables in the dataset

Variable	#Obs.	Mean	Std. Dev.	Min	Max
Cartel duration (years)	176	5.8210	4.9797	0	28
#Cartel members	181	7.2652	6.6505	2	38
¹ BidRigging	191	0.4607	0.4998	0	1
¹ ThirdParty	191	0.0785	0.2697	0	1
Sanctions (mio. USD)	191	56.9905	152.9816	0	1,165.85

Cartel members and duration

In the first step, I analyse the relationship between the number of members of a cartel and its duration.¹¹ Figure 3 provides a scatter plot and both a linear and quadratic fitted trend for the relationship between logarithmic cartel duration and members. One observes a very light upward trend but a large dispersion of observations. Table 2 shows the OLS coefficients for a linear and Table 3 for a quadratic specification. I use logarithmic values for all variables. Each table consists of five columns that implement different sets of time and industry fixed effects; column #1 does not include any.

The regression without fixed effects (col. #1) in Table 2 indicates an insignificant linear coefficient of +0.175 for the duration, which would imply for a 1% increase in cartel members an increase in duration by 0.175%. It is fully tentative as the coefficient does not differ statistically from zero. The same holds for the specifications with industry, time, industry and time, and, lastly, industry \times year fixed effects. Including the fixed effects implies looking at estimates within an industry and/or year. In the quadratic specification, both coefficients for the number of cartel members are statistically insignificant for any combination of fixed effects as well. This means that neither studying cartel cases across time or industry nor within them leads to a statistically significant relationship between cartel duration and the number of cartel members.

I intentionally chose the two fixed effects for time (year of discovery) and industry. Due to unobserved industry characteristics, cartel stability may substantially vary across industries. While general time trends in cartel detection and sanctioning may exist, which would already justify the inclusion of 'year' fixed effects, Marvão and Spagnolo (2023) detect what they call 'leniency inflation'. The term shall capture that in the European Union, an increasing number of former cartel members applied for some form of leniency in recent years.¹²

Especially industry heterogeneity can also be drawn from Figures 1 and 2. They emphasize stark differences between industries in the overall occurrence of (detected) cartels as well as their duration and sanctions. Including industry fixed effects is crucial to not simply pick up differences across industries. Of course, one has to remember that all results are still correlational and do not allow for causal interpretation. Furthermore, the regressions might fall prey to some omitted variable bias. Nevertheless, including time and industry fixed effects can already capture much statistical variation, as the increase in the measure R^2 highlights.

The absence of a statistically significant downward trend in cartel members is a surprising departure from the basic game theoretic modelling of cartels. The conventional wisdom suggests that more firms would 'destabilize' the cartel as the deviation profit increases in the number of cartel members relative to each participant's collusive profit. With more participants, one's own share decreases while the deviation profit remains approximately the same. Therefore, a significantly negative coefficient would be the expected result. The fact that this is not the case is a noteworthy finding that warrants further investigation.

In light of the polycentricity theory, the null effect makes sense. An increase in members could stabilize a cartel as more members allow for a more dispersed assignment of responsibilities as well as more mutual interdependencies. This positive effect could offset the undoubtedly increasing incentive to cheat on the other cartel members.

One data-driven objection to this finding is the potential risk that cartel duration is easy to measure at the end but not at the starting point. Here, the data rely on legal investigations and court decisions. However, investigators are not always able to prove the existence of a cartel years ago *judicially*, mainly

¹¹Figure F1, available in the online appendix, presents descriptive statistics on this variable. Overall, the average number of cartel members is 7.27, the median is 5, the 90th percentile is 15, the 99th percentile is 35, and the highest observation in this dataset is 38 members of a single collusion case, namely the modelling agency cartel in France, that was convicted of price fixing for fashion shootings and related services, see, e.g., <https://www.lexology.com/library/detail.aspx?g=0b6803af-fb95-41fe-ab6b-20422bfcc86e>.

¹²However, taking a closer look at the descriptive statistics the authors present, there exists substantial fluctuation but not a clear (visual) trend for the years 2012–2018 (except for the year 2016, in which fines were unusually high). Furthermore, this only addresses EU cases, but the OECD cartel database has a global scope. In any case, year fixed effects should capture intertemporal heterogeneity.

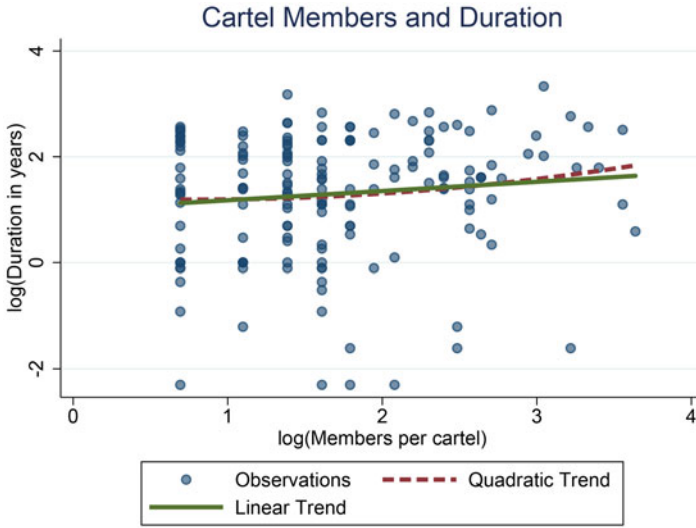


Figure 3. Scatter plot for the relation between cartel members and duration. Corresponding regression coefficients presented in column (1) of Tables 2 (linear fit) and 3 (quadratic fit).

Table 2. Linear relationship between the number of cartel members and cartel duration

Dependent variable: cartel duration in years					
<i>Linear specification</i>					
	(1)	(2)	(3)	(4)	(5)
log(#Cartelists)	0.175	0.170	0.123	0.119	0.033
	(0.12)	(0.13)	(0.13)	(0.13)	(0.17)
Constant	1.002***	0.985***	1.012***	1.059***	1.289***
	(0.23)	(0.31)	(0.28)	(0.32)	(0.23)
<i>Fixed effects</i>					
Year	-	✓	-	✓	-
Industry	-	-	✓	✓	-
Year × industry	-	-	-	-	✓
R ²	0.012	0.046	0.166	0.186	0.343
BIC	529.152	554.092	567.706	594.287	589.690
F-test	0.157	0.337	0.000	0.000	-
N	164	164	164	164	164

Estimation method: OLS. Dependent variable: logarithmic cartel sanctions in million USD. Heteroscedasticity-robust standard errors in brackets below. Significance levels: * $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$. Table B1 in the online appendix presents the results for the corresponding jackknife standard error computations.

if no clear records exist (see also Zhou, 2016). Thus, cartel duration could be, in reality, longer than in the data. As long as this left-truncation is idiosyncratic, it is acceptable. However, it may bias the dataset if the lack of evidence occurs more often among smaller cartels as they could be able to better hide and delete evidence than larger cartels.

A last objection to the analysis concerns the evolution of the size of a cartel. It could be the case that only very few firms initiated a cartel, but others joined over time. When detected, only one value for the number of cartel members is registered, and it is likely the number recorded at detection.

Table 3. Quadratic relationship between the number of cartel members and cartel duration

Dependent variable: cartel duration in years					
<i>Quadratic specification</i>					
	(1)	(2)	(3)	(4)	(5)
log(#Cartelists)	-0.126	-0.247	-0.006	-0.004	-0.265
	(0.58)	(0.57)	(0.62)	(0.60)	(0.76)
log(#Cartelists) ²	0.080	0.110	0.034	0.033	0.080
	(0.15)	(0.15)	(0.15)	(0.15)	(0.18)
Constant	1.239**	1.313**	1.118*	1.160*	1.550**
	(0.51)	(0.55)	(0.60)	(0.61)	(0.72)
<i>Fixed effects</i>					
Year	-	✓	-	✓	-
Industry	-	-	✓	✓	-
Year × industry	-	-	-	-	✓
R ²	0.014	0.049	0.166	0.186	0.345
BIC	533.944	558.606	572.746	599.333	594.471
F-test	0.307	0.417	0.000	0.000	-
N	164	164	164	164	164

Estimation method: OLS. Dependent variable: logarithmic cartel sanctions in million USD. Heteroscedasticity-robust standard errors in brackets below. Significance levels: * $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$. Table B2 in the online appendix presents the results for the corresponding jackknife standard error computations.

Empirically assuming that the value at the end equals the one at the beginning might distort the analysis. Even though I cannot resolve this issue with the given data, it is unlikely that *many* firms joined an existing cartel. It is more likely that only a few successfully joined over time (if at all) due to the complicated procedures of integrating a new member into grown governance and trust structures.

Cartel members and sanctions

Sanctions for detected cartels are a crucial tool for policymakers to fight collusion. After investigating the relationship between cartel members and duration, I will look at the correlation between sanctions and cartel members, as it can tell us a lot about how liable individual firms can be depending on cartel size and governance. In theory, more members may increase the fines imposed when a cartel is detected because bigger cartels are likely to cover a higher market share, which might cause higher welfare losses.

Besides this first-order effect, it is unclear in which direction any second-order effect points. A linear relation would be conceivable given that more participants also require a higher fine because every member needs to be punished. As the welfare losses caused by a cartel with a higher number of members should be greater than those of a cartel in the same market with fewer participants, even an increase in sanctions, which is larger than proportional, could be theoretically backed. In contrast, there is the regressive nature of the leniency regulation: as Connor (2012) notes, nearly all recent major cartel cases ended with full or partial leniency for at least one former cartel member. So, fines could also grow slower with a higher number of members if more of them file for leniency.

Tables 4 and 5 depict the actual relation found in the OECD database. Again, I provide both linear and quadratic specifications. The sanctions imposed on the cartel members increase in the number of

Table 4. Linear relationship between the number of cartel members and the amount of sanctions

Dependent variable: cartel sanctions in million USD					
<i>Linear specification</i>					
	(1)	(2)	(3)	(4)	(5)
log(#Cartelists)	0.673***	0.681***	0.653***	0.646***	0.471
	(0.23)	(0.23)	(0.23)	(0.24)	(0.31)
Constant	0.875**	1.351***	-1.081	-0.377	0.969**
	(0.43)	(0.47)	(1.09)	(0.91)	(0.43)
<i>Fixed effects</i>					
Year	-	✓	-	✓	-
Industry	-	-	✓	✓	-
Year × industry	-	-	-	-	✓
R ²	0.047	0.136	0.172	0.215	0.394
BIC	809.807	823.467	852.058	873.613	884.290
F-test	0.004	0.003	0.000	0.000	-
N	180	180	180	180	180

Estimation method: OLS. Dependent variable: logarithmic cartel sanctions in million USD. Heteroscedasticity-robust standard errors in brackets below. Significance levels: * $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$. Table B3 in the online appendix presents the results for the jackknife standard error computations.

participants. The positive linear coefficient in both specifications is evidence for that. However, the significant coefficient for the squared number of members emphasizes that it is not a linear increase alone but a *concave* relationship in which a negative quadratic effect offsets the positive linear effect. Again, this effect is stable regardless of the inclusion of fixed effects, as the columns (2)–(5) of Table 5 demonstrate.

Figure 4 illustrates the concave relationship between the number of cartel members and the total amount of sanctions. Given the distribution of the cartel member variable, it becomes clear that most cartels are in the area with a positive slope. However, several cartels with many participants received comparatively low sanctions.

The decrease *per firm* is also directly captured by the coefficient for ‘log(#cartelists)’ in the linear specification in Table 4. In the logarithmic setting, a 1% increase in the number of members corresponds only to an increase of 0.673% increase in the amount of sanctions. Put differently, sanctions are relatively inelastic to more participants in a collusive agreement. Again, this result also holds *within* industries, years, and industries and years combined. Thus, the concavity is not a statistical artefact driven by differences across industries or years of disclosure.

Again, polycentricity is a potential driver of this statistical artefact. The more participants a cartel has, the more dispersed its decision centres and layers can be.

Suppose a sufficient amount of spontaneous order coordination and overlapping decision centres exists. In that case, it may be more challenging for competition authorities to prove who was responsible for specific illegal activities or otherwise had ‘the last word’. While, for example, Martin and Schmal (2021) explain sophisticated cartel organization with its arguably beneficial impact on raising the future orientation of participating *firms*, it might also be reasoned by the sociological phenomenon of ‘shifting the blame’. As argued by Fiorina (1982, 1986) and Vaubel (1986), politicians have an interest in delegating unpleasant tasks and the responsibility for bad decisions to other agencies in the public body. A polycentric order of a collusive structure could reflect this behaviour in the context of firms.

Table 5. Quadratic relationship between the number of cartel members and the amount of sanctions

Dependent variable: cartel sanctions in million USD					
Quadratic specification					
	(1)	(2)	(3)	(4)	(5)
log(#Cartelists)	3.446***	3.275***	3.159***	3.084***	3.191***
	(0.97)	(0.94)	(0.96)	(0.97)	(1.21)
log(#Cartelists) ²	-0.737***	-0.688***	-0.668***	-0.648***	-0.726**
	(0.24)	(0.23)	(0.24)	(0.24)	(0.31)
Constant	-1.303	-0.666	-2.913**	-2.178**	-1.406
	(0.89)	(0.85)	(1.16)	(1.03)	(1.12)
Fixed effects					
Year	-	✓	-	✓	-
Industry	-	-	✓	✓	-
Year × industry	-	-	-	-	✓
R ²	0.088	0.170	0.202	0.242	0.420
BIC	807.117	821.407	850.585	872.410	881.408
F-test	0.001	0.000	0.000	0.000	-
N	180	180	180	180	180

Estimation method: OLS. Dependent variable: logarithmic cartel sanctions in million USD. Heteroscedasticity-robust standard errors in brackets. Significance levels: * $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$. Table B4 in the online appendix presents the results for the jackknife standard error computations.

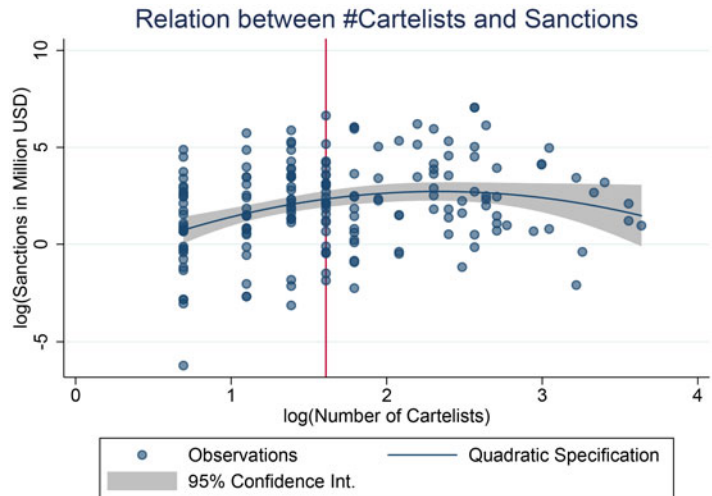


Figure 4. Relationship between cartel members and sanctions: quadratic specification. Red vertical line: median of the logarithmic number of cartel members: $1.609 \approx 5$ cartel members. Corresponding regression coefficients presented in Table 5, column (1).

A system of different decision layers might serve not only as a top-down delegation system but also as a sharing of responsibilities so granular that every participant considers themselves only as a small part of a larger system, which reduces the potential burden of doing something illegal as well as the actual ability of legal authorities to assign particular actions to specific entities. Polycentricity can serve as a protection against legal action since dispersed decision-making processes make it more difficult to assign accountability in a legally binding way.

Table 6. Relationship between cartel members and the presence of a third party

Dependent variable: presence of a third party					
<i>Linear specification</i>					
	(1)	(2)	(3)	(4)	(5)
log(#Cartelists)	0.750***	0.735***	0.853***	0.849***	0.771***
	(0.23)	(0.24)	(0.24)	(0.23)	(0.26)
Constant	-2.859***	-2.601***	-2.987***	-2.958***	-0.958
	(0.54)	(0.50)	(0.75)	(0.73)	(1.12)
<i>Fixed effects</i>					
Year	-	✓	-	✓	-
Industry	-	-	✓	✓	-
Year × industry	-	-	-	-	✓
BIC	96.720	113.171	102.331	117.423	101.398
F-test	0.001	0.035	0.000	0.001	0.028
N	181	159	136	121	94

Estimation method: Probit. Dependent variable: binary indicator for the presence of a third party. Heteroscedasticity-robust standard errors in brackets. Significance levels: * $P < 0.10$, ** $P < 0.05$, *** $P < 0.01$. Table B5 in the online appendix presents the results for the corresponding jackknife estimation, Table A1 the results for the quadratic specification.

The impact of third party involvement

In the last step, I examine the role of third parties in collusive structures. Frequent examples are industry associations that facilitate unobtrusive coordination. They also often allow their members to track other members' sales by collecting and aggregating information. By doing so, third parties are often considered a stabilizing element in cartels (see, e.g., Levenstein and Suslow, 2006). Such associations come with the advantage that membership is legal. Cartels also often hire retired officials, law or consulting firms to coordinate and/or monitor the activities of cartel members (Aways and Krishna, 2020; Jaspers, 2017).

From a polycentric governance perspective, the involvement of a third party does not necessarily need to stabilize a cartel. Centralizing communication and coordination by employing a third party may constitute a monocentric element within a cartel that actually *destabilizes* it. Of course, it depends on the specific governance structure of a cartel. It matters to which extent such a third party is involved in decision-making or whether its role is just information aggregation and provision. For the latter, the challenge of monocentricity is likely to be smaller. Empirical evidence using the OECD database hints at a null relation and only slightly towards a positive effect. However, only 14 cartels included a third party. The analysis, admittedly, suffers from low statistical power.

First, I look at the relationship between the number of cartel members and the presence of a third party. Unsurprisingly, the likelihood of a third party being present increases in the number of cartel participants, as Table 6 shows. Large cartels are more likely to require a third party to organize and coordinate information streams. Crucially, I cannot detect an effect of a third party on cartel duration. Figure 5 presents two boxplots for cartel duration for those cartels *with* and *without* an involved third party. Cartels with a third party (RHS) had a higher average cartel duration. However, both group averages are influenced by one stark outlier. It affects the much smaller group of cartels with a third party more severely than the group without.

To not only rely on visual inspection, Table 7 presents the results from a two-sample *t*-test and the *P*-value for the non-parametric Mann-Whitney *U*-test (MWU-test). While there exists a difference between the group averages, it is not statistically significant, as the *p*-values of 0.118 (*t*-test) and

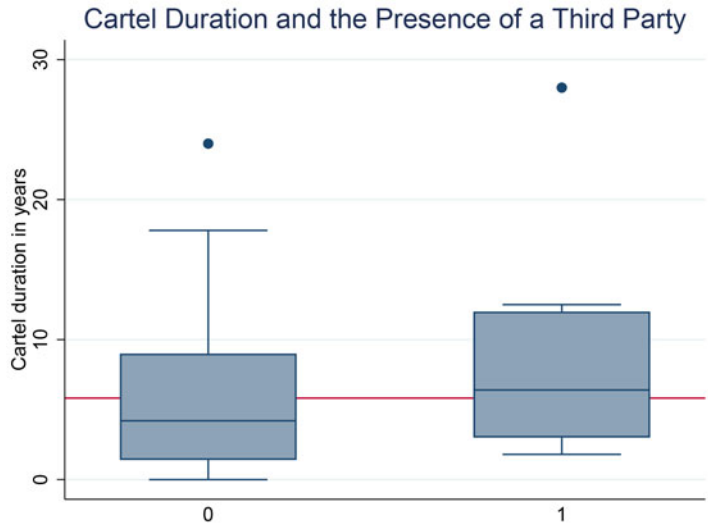


Figure 5. Boxplot for the duration of a cartel and the presence of a third party. The boxes (0) present the duration of cartels without (0) and with (1) an involved third party. The horizontal red line depicts the overall average cartel duration.

0.145 (MWU-test) indicate. Levenstein and Suslow (2011) detect in their analysis that third parties increase the risk of being caught but also stabilize a cartel. These two effects could offset each other. An up-to-now overlooked issue is that the implementation is a monocentric element in a cartel. It (consciously) centralizes communication and coordination. By that, it collides with the core principles of polycentricity, as presented in section ‘The concept of polycentricity applied to cartels’. The ‘multiplicity of decision centres’ vanishes when everything is centred around, e.g., meetings of a business association. It may differ in cases where a third party, such as a law firm, only serves as an information exchange. The risk of monocentricity would decrease.

In any case, third-party involvement undermines spontaneous order. A central organization collects large amounts of data that may serve as evidence for competition authorities if detected. Exiting a cartel that includes a business association raises doubts about whether the leaving member is still welcome there. Even if a firm leaves a cartel, it remains part of the industry and, probably, of a business or trade association, as such organizations tend to be monopolies in their respective branches. This monocentric organization implies that exit is only possible when the cartel as a whole breaks down. In turn, it incentivizes the firm willing to leave to file for leniency. Such a scheme, however, will destroy the cartel as a whole – a consequence that could be avoided if a participating firm could exit without facing such problems.

Common theory primarily discusses a third party as a monitoring device, which increases stability via increased transparency but decreases it via a greater risk of detection (see, e.g., Levenstein and Suslow, 2011). While the stabilizing factor addresses internal communication, the destabilizing factor is higher external detectability. A polycentric perspective adds the monocentric information-gathering issue as an additional governance element that may *internally* destabilize the whole endeavour.

I argue that monocentricity destabilizes cartels relying on a third party organizing communication and coordination. In general, polycentric governance may be a novel explanation for the question of why there exist so many cartels with a large number of participants, even though economic theory would suggest more instability for them.¹³ Previous research in this domain has focused on external factors, such as market characteristics, that may have led to relative stability despite the large size

¹³One objection to that hypothesis is the already discussed selection bias of the data. It could be the case that only a tiny fraction of small cartels has been disclosed and added to the OECD database, but, at the same time, a considerable fraction of the large cartels was listed. In that case, large cartels would be overrepresented in the sample, relative to their actual frequency of occurrence. Put differently, it could be that detection is not idiosyncratic. Nevertheless, among the disclosed cartels, the large ones also had a notable duration period, which implies at least some stability.

Table 7. Cartel duration and the presence of a third party: *t*-test/MWU-test

Variable of interest: cartel duration						
<i>Distinction by the presence of a third party</i>						
Group	Obs.	Mean	Std. Err.	Std. Dev.	90% Conf. Int.	
¹ Third Party = 0	161	5.476	0.356	4.518	4.887	6.065
¹ Third Party = 1	13	6.992	1.172	4.225	4.904	9.081
Combined	174	5.589	0.341	4.503	5.025	6.154
Difference		-1.517	1.225		-3.670	0.637
H_0 : diff = 0		Satterthwaite's degrees of freedom = 14.309				
H_{alt} : diff < 0		H_{alt} : diff \neq 0			H_{alt} : diff > 0	
$Pr(T < t) = 0.118$		$Pr(T > t) = 0.236$			$Pr(T > t) = 0.882$	

Two sample *t*-test with unequal variances to account for the variation in variance between cartels without and with an involved third party (see also Ruxton, 2006, on the 'unequal variance' *t*-test). Excluding two outliers with cartel duration of >20 years. The full sample test is presented in Table A2 in the online appendix. An alternative to the *t*-test is the nonparametric Mann-Whitney *U* test (1947). It requires less functional form assumptions than the *t*-test and leads to a test statistic of $z = -1.463$, which corresponds to a *p*-value of $p = 0.1435$ for the sample without outliers.

of cartels. The present paper contributes the governance dimension as an additional explanation. Nevertheless, cartel governance, especially the role of third parties, requires further research. It should avoid reducing the presence of a third party to a binary indicator as in the present OECD dataset.

Conclusion

Business scholar Deborah Spar inadvertently explained the necessity of the research question discussed here in the preface of her book 'The Cooperative Edge: The Internal Politics of International Cartels': 'Thus while the economics of cartels underlie this study, ... it is still not a book about the economics of cartels. Rather, this is a book about cooperation and about the internal forces that shape, constrain, and define the cooperative process' (Spar, 1994, p. X). In the past, industrial economic research often ignored the governance dimension and focused on different aspects of collusion. The present paper shall serve as a first step to change this. It theoretically introduces the concept of polycentricity to cartels and provides suggestive empirical evidence for its existence and role. Given the intertwined illegal situation firms and their managers find themselves in, it is reasonable to assume that corporate cartels have complex governance systems.

The concept of polycentric governance offers novel ways to understand coordination within a cartel. Applying it to an extensive OECD dataset of detected cartels, polycentricity sheds new light on several empirical phenomena. There seems to be no negative relationship between the number of cartel members and its duration. In addition, sanctions imposed on cartel participants follow a concave pattern. Fines increase less than proportionally with the rise in members. Lastly, although large cartels often involve third parties in their activities, such entities do not appear to substantially stabilize a cartel in terms of duration.

Polycentric governance can offer an explanation for all three empirical findings. By that, the paper shows how institutional theory can fruitfully enrich the understanding of industrial economic phenomena. I consider it the first step towards deeper integration of institutional, political, and public choice theory into industrial economics to better understand firm behaviour. More rigorous empirical evidence beyond my preliminary and correlational findings is needed to explain the governance dimension within cartels. This paper shall serve as a starting point and a proposal for a broader research agenda.

Supplementary material. The supplementary material for this article can be found at <https://doi.org/10.1017/S1744137424000274>.

Data and appendix availability. The appendix, as well as data and code replication files, is openly available on Zenodo: Schmal, W. B. (2024). Online Appendix and Replication package for the paper ‘Polycentric Governance in Collusive Agreements’. Zenodo: <https://doi.org/10.5281/zenodo.13312411>

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References

- Acharya V.V., Myers S.C. and Rajan R.G. (2011). The internal governance of firms. *The Journal of Finance* **66**(3), 689–720.
- Aligica P.D. (2015) Public administration, public choice and the Ostroms: The achievements, the failure, the promise. *Public Choice* **163**(1), 111–127.
- Aligica P.D. and Tarko V. (2012). Polycentricity: From Polanyi to Ostrom, and beyond. *Governance* **25**(2), 237–262.
- Aligica P.D., Boettke P.J. and Tarko V. (2019). Polycentric stakeholder analysis: corporate governance and corporate social responsibility. In *Public Governance and the Classical-Liberal Perspective: Political Economy Foundations*. New York, NY: Oxford University Press, pp. 189–208.
- Ammann M., Oesch D. and Schmid M.M. (2011). Corporate governance and firm value: International evidence. *Journal of Empirical Finance* **18**(1), 36–55.
- Asker J. and Bar-Isaac H. (2014). Raising retailers’ profits: On vertical practices and the exclusion of rivals. *American Economic Review* **104**(2), 672–686.
- Awaya Y. and Krishna V. (2020). Information exchange in cartels. *The RAND Journal of Economics* **51**(2), 421–446.
- Bebchuk L.A. and Cohen A. (2005). The costs of entrenched boards. *Journal of Financial Economics* **78**(2), 409–433.
- Becker-Ritterspach F. and Dörrenbächer C. (2011). An organizational politics perspective on intra-firm competition in multi-national corporations. *Management International Review* **51**(4), 533–559.
- Bhagat S. and Bolton B. (2008). Corporate governance and firm performance. *Journal of Corporate Finance* **14**(3), 257–273.
- Birkinshaw J. and Lingblad M. (2005). Intrafirm competition and charter evolution in the multibusiness firm. *Organization Science* **16**(6), 674–686.
- Bodnar O., Fremerey M., Normann H.-T. and Schad J. (2023). The effects of private damage claims on cartel activity: Experimental evidence. *The Journal of Law, Economics, and Organization* **39**(1), 27–76.
- Bouquet C. and Birkinshaw J. (2008). Weight versus voice: How foreign subsidiaries gain attention from corporate headquarters. *Academy of Management Journal* **51**(3), 577–601.
- Brown L.D. and Caylor M.L. (2006). Corporate governance and firm valuation. *Journal of Accounting and Public Policy* **25**(4), 409–434.
- Connor J.M. (2006). The great global vitamins conspiracy: Sanctions and deterrence. *American Antitrust Institute Working Paper* 06-02.
- Connor J.M. (2012). Cartel fine severity and the European commission: 2007–2011. *European Competition Law Review* **34**(2013), 58–77.
- Dick A.R. (1996). When are cartels stable contracts? *The Journal of Law and Economics* **39**(1), 241–283.
- Efron B. (1982). *The jackknife, the bootstrap and other resampling plans*. CBMS-NSF Regional Conference Series in Applied Mathematics. Philadelphia, PA: Society for industrial and applied mathematics (SIAM).
- European Commission (2003). Case COMP/E-1/37.512 – Vitamins. *Official Journal of the European Communities* **L6**, 1–87.
- Fiorina M.P. (1982). Legislative choice of regulatory forms: Legal process or administrative process? *Public Choice* **39**(1), 33–66.
- Fiorina M.P. (1986). Legislator uncertainty, legislative control, and the delegation of legislative power. *Journal of Law, Economics, and Organization* **2**(1), 33–51.
- Forsbacka T., Le Coq C. and Marvão C. (2023). Cartel birth and death dynamics: Empirical evidence. *International Journal of Industrial Organization* **89**, 102932.
- Gompers P., Ishii J. and Metrick A. (2003). Corporate governance and equity prices. *The Quarterly Journal of Economics* **118**(1), 107–156.
- Harrington J.E. and Skrzypacz A. (2011). Private monitoring and communication in cartels: Explaining recent collusive practices. *American Economic Review* **101**(6), 2425–2449.
- Harrington J.E. and Wei Y. (2017). What can the duration of discovered cartels tell us about the duration of all cartels? *Economic Journal* **127**(604), 1977–2005.

- Haucap J. and Heldman C. (2023). The sociology of cartels. *European Journal of Law and Economics* 56, 289–323.
- Haucap J., Heldman C. and Rau H.A. (2024). Gender and cooperation in the presence of negative externalities. *Games and Economic Behavior* 147, 148–169.
- Hyttinen A., Steen F. and Toivanen O. (2019). An anatomy of cartel contracts. *The Economic Journal* 129(621), 2155–2191.
- Igami M. and Sugaya T. (2022). Measuring the incentive to collude: The vitamin cartels, 1990–99. *The Review of Economic Studies* 89(3), 1460–1494.
- Jaspers J.D. (2017). Managing cartels: How cartel participants create stability in the absence of law. *European Journal on Criminal Policy and Research* 23(3), 319–335.
- Lerner J. (1995). Pricing and financial resources: An analysis of the disk drive industry, 1980–88. *The Review of Economics and Statistics* 77(4), 585–598.
- Leslie C.R. (2003). Trust, distrust, and antitrust. *Texas Law Review* 82, 515.
- Levenstein M.C. and Suslow V.Y. (2006). What determines cartel success? *Journal of Economic Literature* 44(1), 43–95.
- Levenstein M.C. and Suslow V.Y. (2011). Breaking up is hard to do: Determinants of cartel duration. *The Journal of Law and Economics* 54(2), 455–492.
- Lewis P. and Aligica P.D. (2024). The Ostros on self-governance: The importance of cybernetics. *Journal of Institutional Economics* 20, e23.
- Mann H.B. and Whitney D.R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics* 18(1), 50–60.
- Martin S. and Schmal W.B. (2021). Collusive compensation schemes aided by algorithms. *CESifo Working Paper* 9481.
- Marvão C. and Spagnolo G. (2023). Leniency inflation, cartel damages, and criminalization. *Review of Industrial Organization* 63(2), 155–186.
- McPhail E. and Tarko V. (2017). The evolution of governance structures in a polycentric system. In Altman M. (ed.), *Handbook of Behavioural Economics and Smart Decision-Making*. Cheltenham, UK: Edward Elgar Publishing, pp. 290–314.
- Ostrom E. (1998). A behavioral approach to the rational choice theory of collective action: Presidential address, American Political Science Association, 1997. *American Political Science Review* 92(1), 1–22.
- Ostrom V. (1999). Polycentricity (part 1). In McGinnis M.D. (ed.), *Polycentricity and Local Public Economies*. Ann Arbor, MI: University of Michigan Press, pp. 52–74.
- Ostrom E. (2005). Robust resource governance in polycentric institutions. In Ostrom E. (ed.), *Understanding Institutional Diversity*. Princeton, NJ: Princeton University Press, pp. 32–68.
- Ostrom V., Tiebout C.M. and Warren R. (1961). The organization of government in metropolitan areas: A theoretical inquiry. *American Political Science Review* 55(4), 831–842.
- Ruxton G.D. (2006). The unequal variance t-test is an underused alternative to Student's t-test and the Mann–Whitney U test. *Behavioral Ecology* 17(4), 688–690.
- Schmal W.B. (2022). *On Corporate Cartels as Common Pool Resources*. mimeo.
- Schmal W.B. (2023a). Downstream profit effects of horizontal mergers: Horn & Wolinsky and von Ungern-Sternberg revisited. *The B.E. Journal of Economic Analysis & Policy* 23(4), 981–1000.
- Schmal W.B. (2023b). Vice versa: The decoupling of content and topic heterogeneity in collusion research. *Journal of Economic Surveys*. Online publication. <https://doi.org/10.1111/joes.12600>.
- Schalbe U. (2013). Kronzeugenregelungen und die interne Struktur von Kartellen. In Dewenter R., Haucap J. and Kehder C. (eds), *Wettbewerb und Regulierung in Medien, Politik und Märkten*. Baden-Baden, Germany: Nomos Verlagsgesellschaft, pp. 415–440.
- Scott Morton F. (1997). Entry and predation: British shipping cartels 1879–1929. *Journal of Economics & Management Strategy* 6(4), 679–724.
- Shortland A. (2018). Governing criminal markets: The role of private insurers in kidnap for ransom. *Governance* 31(2), 341–358.
- Shortland A. and Shortland A. (2020). Governance under the shadow of the law: Trading high value fine art. *Public Choice* 184(1–2), 157–174.
- Shughart W.F. (2022). On the Virginia school of antitrust: Competition policy, law & economics and public choice. *Public Choice* 191(1), 1–19.
- Spar D.L. (1994). *The Cooperative Edge: The Internal Politics of International Cartels*. Ithaca, NY: Cornell University Press.
- Stephan M., Marshall G. and McGinnis M. (2019). An introduction to polycentricity and governance. In Thiel A., Blomquist W.A. and Garrick D.E. (eds), *Governing Complexity: Analyzing and Applying Polycentricity*. Cambridge, UK: Cambridge University Press, pp. 21–44.
- Vaubel R. (1986). A public choice approach to international organization. *Public Choice* 51(1), 39–57.
- Wu H.-L. (2008). When does internal governance make firms innovative? *Journal of Business Research* 61(2), 141–153.
- Zhou J. (2016). The rise and fall of cartels with multi-market colluders. *Review of Industrial Organization* 48, 381–403.