An Anatomy of Cartel Contracts[*]

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Abstract

We study the contracts of 898 legal Finnish cartels. Cartels that exclusively allocate markets, either geographically or in the product/production space, are dominant in manufacturing. They are often bilateral and include a vertical dimension. Structural industry characteristics predict the type of a cartel; e.g., consistent with theory, quota cartels are more common in manufacturing and when buyers are primarily industrial. The contracts of quota cartels include more (governance) clauses. Pure pricing cartels are the dominant cartel type in non-manufacturing and are more common when demand is primarily from retail buyers. Pricing cartels are larger than other types of cartels.

JEL: L40, L41, K12

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1   Introduction

The theoretical modelling of cartels rests on limited empirical evidence, as many elementary questions still need to be answered: What is the most common type of cartel? For example, are cartels that (only) restrict pricing more typical than cartels that (only) allocate markets? Do structural industry characteristics, such as the nature of the product, fixed costs or variability of demand, predict the type of a cartel? Addressing questions such as these calls for detailed data on the agreements of a large number of cartels, operating in a shared environment. We have generated such a data set through archive work, using the Finnish Competition Authority's (FCA) archive of cartels. These data enable us to characterise an anatomy of cartel contracts (i.e., their stylised facts) in much more detail than has been possible before.[1]

Our analysis covers the period from the introduction of the first Finnish competition law of 1958, under which cartels continued to be legal, to the introduction of a modern competition law of 1993, which made cartels illegal. The archive contains quantitative information on the key contracting features of 898 manufacturing and non-manufacturing cartels. A noteworthy strength of our data set is that it contains rich information on cartels' price-fixing and market allocation schemes for a large number of cartels. We complement these data with further information on detailed contracting features for a subsample of 108 nationwide manufacturing cartels. For these cartels, we observe additional 14 contract clauses concerning internal stability of the cartel (e.g., monitoring); the organization of the cartel (e.g., number of meetings); the external threats faced by the cartel (e.g., entry); and production-related issues (e.g., sharing of technology).

The cartels that we study were legal but essentially self-policing. This feature is crucial for two reasons. First, there were no restrictions on communication or contracting. Unlike illegal cartels, legal cartels do not have to worry about the consequences of explicitly writing down their

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[1] We use the term "contract" in the meaning of (intended) "agreement", not in its strict formal legal meaning. In the same spirit, we use the term "clause" in the sense of the contract mentioning a practise or a dimension, such as price fixing, and not in the sense of formal (numbered) clauses in the actual agreement.

intentions and agreements. We can thus observe an "unobservable", i.e., what illegal cartels would like to write down if doing so were legal. Making cartels illegal leads to endogenously incomplete cartel contracts because the colluding parties have a strong incentive to hide their actions and to make unverifiable what might become observable.[2] Second, a legal cartel is self-policing if it is likely that it cannot rely on a court to enforce its cartel contract; we argue below that this is the case for the cartels in our data. A legal cartel therefore has an incentive to coordinate on actions and meet the incentive compatibility constraint, as illegal cartels would (Dick 1996a and Suslow 2005).

We make three main contributions. First, based on the available theory on collusion, we propose a typology of cartels distinguishing between pure price-fixing cartels, pure market allocation cartels, quota cartels and a mixed cartel type that simultaneously fixes prices and allocates markets. The typology illustrates which types of cartels are common and how cartel types are linked to the cartels' operating environment. In manufacturing, cartels that only allocate markets are dominant. Quota cartels are not as common as pure allocation or price-fixing cartels in manufacturing. Pure pricing cartels are dominant in non-manufacturing. Unlike prior work, we show that these sectoral differences also persist when we econometrically control for a number of structural industry characteristics, such as the source of demand (retail vs. industrial buyers), capital intensity, capacity utilisation and demand fluctuations around the time the cartels were registered.

Our second contribution is to provide evidence on how cartel type is associated with structural industry characteristics. Consistent with the theories on how observability of prices and quantities affects collusion (e.g., Stigler 1964, Harrington and Skrzypacz 2011), we find that when demand comes from retail buyers, pure pricing cartels are more common, and quota cartels are more rare. Cartels in high capital intensity industries are more likely to be of the mixed type, both

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[2] The detected illegal cartels are a selected sample of all illegal cartels, making inference problematic. Harrington and Wei (2016) study how to infer the duration of cartels from the observed duration of detected illegal cartels. Hyytinen, Steen and Toivanen (in press) provide a related empirical analysis, asking how common cartels would be were there no competition policy.

fixing prices and allocating markets, and less likely to be pure allocation cartels. We also document that the choice of cartel type depends on the prevailing and near-term demand conditions at the time of cartel formation. This suggests that initial conditions may shape the patterns of cartelization and behaviour of cartels more than the existing theory has considered.

Our third contribution is to use the typology to characterise how the different types of cartels look and how they try to ensure compliance (i.e., self-policing) in manufacturing. We provide novel evidence that pure allocation cartels are small, often bilateral and are more likely to have a vertical dimension. Pure pricing cartels are larger. Using pure pricing cartels as a benchmark, we find that manufacturing cartels that purely allocate markets more often have contractual clauses on entry and dispute resolution and deal with supply from sources external to the cartel. However, they rely less often than pricing cartels on a formal organizational structure (including a voting scheme) and rules on admitting new members. This result is in line with theory suggesting that pricing cartels need to be more inclusive. Further, quota cartels differ from pure pricing cartels, as they more often use more complex contracts for self-policing. For example, quota cartels often include clauses on monitoring, enforcement, fines, dispute resolution and dealing with supply from sources external to the cartel. These differences between cartel types are statistically significant, and the pattern is robust to controlling for the structural industry characteristics.

Our quantitative findings complement earlier case studies on the internal working of individual cartels (studied by, e.g., Porter 1983, Ellison 1994, Genesove and Mullin 2001, Röller and Steen 2006, and Clark and Houde 2013). We use the typology to show how representative these earlier case studies are. Our econometric findings also extend and complement earlier quantitative studies on cartel contracts. While insightful, a drawback of many earlier studies – surveyed by Levenstein and Suslow (2006) – is that they had relatively limited information on what the cartels tried to agree on and/or their economic environments. They also cover a heterogeneous set of episodes and institutional environments or refer only to international or prosecuted cartels. More recent work by Harrington (2006), Taylor (2007), Bouwens and Dankers (2010) and Levenstein

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and Suslow (2011) has only partially overcome these drawbacks (see Appendix A). A study similar to ours is Fink et al. (2017), which provides a descriptive analysis of 80 legally binding cartel agreements in Austria (80% of which are in manufacturing).

Section 2 describes the institutional environment and data sources. We analyse how cartels tried to raise profits in Section 3. Section 4 characterises the different types of cartels and how they maintained compliance. We discuss potential implications of our findings for both cartel theory and competition policy in the concluding section. Part of Appendix A and Appendices B-D are available in the Online Appendix.

2 The institutional environment and data

2.1 The institutional environment

The development of Finnish competition policy after the Second World War closely follows such developments in other European countries (Fellman 2016, Shanahan and Fellman 2016; see also Appendix B). There was no competition policy before the war. The first cartel law was implemented in 1958. The central idea was to collect information on cartels that operate in the domestic market rather than to deter collusive activities. For this purpose, a (predecessor of the) Finnish competition authority (CA) was set up and given the task to register cartels (Registry). Only bidding rings requiring express prebidding coordination were outlawed. Registration was initially contingent on the CA contacting the suspected cartel members. The Registry was relatively active in searching for and contacting (potential) cartels (Fellman 2016). In 1964 and 1973, the law was revised, leading to somewhat tighter registration requirements. In the 1980s, Finland finally edged towards a modern competition law, first via a new stricter law taking effect in 1988 and then cartels becoming illegal in 1993. As we have discussed elsewhere (Hyytinen, Toivanen and Steen, in press and in Appendix B), the cartels that we study here were actually harmful and not just harmless industry associations.

2.2 Legal vs. illegal cartels

Even though cartels in our sample were legal, they mostly had to rely on self-policing, in line with what was the case elsewhere; see, e.g., Dick (1996a,b) and Suslow (2005, p. 709), who writes: "[…] *although European law took a tolerant attitude towards cartels during this period, the legal tolerance did not translate into cartel enforceability; cartel contracts were still self-enforcing."* Supporting this view, a motivation for the law change in the 1980s was a lawsuit based on a cartel contract from the early 1980s that led to damages being awarded.[3] This incident suggests that there was – similar to the case of the US Sugar Institute (Genesove and Mullin 2001, pp. 385) – *ex ante* uncertainty as to the enforceability of these contracts in court. Taking your fellow cartel member to court seems to have carried the risk of affecting the legal environment.

While even legal cartels may find it difficult to work through and formalise all possible contingencies (Genesove and Mullin 2001), *illegal* cartels have an additional need to conceal their agreements, leading to the endogenous incompleteness of contracts. Participants of an illegal cartel have a strong incentive to strategically reduce the ability of a legal court to verify their concerted actions (Kvaløy and Olsen 2009 and Kaplow 2011a, pp. 758-765). The contracts we study are the type of contracts that illegal cartels might like to write, were there no legal consequences. The profit incentive and organizational issues that illegal cartels face, as well as issues relating to changes in the external environment, are likely similar to those faced by self-policing legal cartels (see also Dick 1996a).

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[3] We have interviewed people with a long working history in the Finnish Competition Authority, including people who worked with the Registry when it was still active. They could recall only one court case from the early 1980s. According to the Director General of the Finnish Competition Authority, Juhani Jokinen (private exchange), this case led to the law change in 1988 making sanctions in cartel contracts void. Note, however, that several of the cartel agreements provided that a potential dispute should be resolved by arbitration. The agreements stated, for example, that conflicts were to be solved by the parties meeting for the Finnish Chamber of Commerce (a form of private arbitration). Since these arbitrations are not known to the public, in retrospect, we do not know to which extent this option was used.

2.3   Data

We have (mostly manually) collected and matched data from three sources (see Appendix B): the Finnish CA archive of cartels (Registry), the database of the Research Institute of the Finnish Economy (ETLA) and Tiainen (1994).

All the data on the cartels and their contracts are based on the Registry's files and listings and on our archive work in the Registry (see Hyytinen, Steen and Toivanen 2007 and Appendix B). The Registry contains information on 898 cartels, of which the Registry maintained a listing. The Registry covers the years from 1959 to 1990, allowing us to identify whether a given cartel tried to collude by agreeing on prices and/or by allocating markets or by some other means. These data are available for all cartels and provide us with information on the main clauses of the registered cartel contracts.

We also have a set of variables characterising the cartels and their operating environment. The variables characterising the cartels were mostly obtained from the FCA's cartel listing and the associated documentation, and they include the number of members (available for most cartels), whether the cartel was nationwide, and whether the cartel contract had a vertical dimension. In addition, we collected more information on 108 nationwide manufacturing cartels by going through the Registry folders in detail, manually collecting information on 14 further contract clauses.

The variables characterising the operating environment of cartels are the sector of the cartel, the nature of demand (retail vs. industrial buyers), industry capital intensity, industry capacity utilisation, and measures of demand fluctuations. These data were collected from the database of the Research Institute of the Finnish Economy (ETLA) and Tiainen (1994). We also record the cohort of the cartel using the year the cartel entered the registry and code the changes in competition law. We explain how our variables are measured in the next section and in Appendix B.

3   How do cartels raise profits?

This section provides a typology for how cartels raise profits and characterises how the cartel types relate to structural industry characteristics. We answer questions such as the following: Are cartels that restrict pricing only more common than cartels that allocate markets in one way or another? To what extent does the primary type of cartelization depend on the environment in which the cartels operate?

3.1   Theory and prior evidence

3.1.1   Theory of cartelization

Building on Stigler (1964), Posner (1970), and Friedman (1971), a large number of theoretical papers have studied what makes for successful, stable cartels. While the models do not always make a clear distinction between implicit and explicit collusion (see, however, e.g., Athey and Bagwell 2001, 2008, Martin 2006, Awaya and Krishna 2016, and Garrod and Olczak 2018), the decision to collude always trades off the expectation of greater profits with the expected costs of keeping the collusion stable, such as monitoring and compliance costs and possible sanctions.

The three most important ways for cartels to influence market outcomes and coordinate behaviour is to agree on prices, to allocate markets and to set quotas (Stigler 1964, Motta 2004, Levenstein and Suslow 2006, Marshall and Marx 2012). Price-based cartels primarily aim at agreeing on prices but may sometimes also coordinate methods of payment and delivery in various ways. Market allocation-based cartels collude by dividing markets geographically, by assigning customers, or by coordinating product lines (e.g., Stigler 1964, Bernheim and Winston 1990, Belleflamme and Bloch 2004, Bond and Syropoulos 2008, Deltas, Salvo and Vasconcelos 2012, and Byford and Gans 2014). For example, the last three articles consider the incentives of cartels to adopt a home market principle, in which the colluding firms engage in mutual avoidance by allocating markets amongst themselves. Cartels using sales and production quotas aim at agreeing on the quantity that each cartel member is allowed to supply to or sell in the market (Stigler 1964, Harrington and Skrzypacz 2011).

Theory also suggests that at times, collusion calls for allocating markets and fixing prices simultaneously (e.g., Hörner and Jamison 2007) or setting quotas and fixing prices simultaneously (e.g., Stigler 1964, Harrington 2006, Harrington and Skrzypacz 2011, van den Berg and Bos 2017). The literature on semi-collusion similarly suggests that when there are many dimensions in which firms can deviate, colluding firms may need to contract on several dimensions simultaneously (e.g., Stigler 1964, 1968, Fershtman and Gandal 1994, Steen and Sørgard, 2009). The more choice variables firms have, the more complex the agreement because a more complete collusive agreement results in weakly higher profits (the default being the simpler semi-collusive agreement; van den Berg and Bos 2017). There is a tradeoff between more efficient collusion through a more complex agreement and the costs of both writing and monitoring such a contract (Levenstein and Suslow 2006, van den Berg and Bos 2017; see also Kaplow 2011a).

In sum, theory suggests that there are four broad types of cartels that differ in the way inter-firm rivalry is suppressed: pure price fixing cartels, pure market allocation cartels, quota cartels and mixed cartels, which have features of both price fixing and market allocation cartels.

3.1.2   *Structural industry characteristics*

Firms considering collusion anticipate their later incentives to deviate and try to construct their initial agreement accordingly (Stigler 1964). Despite the rich literature on collusion, economic theory offers relatively few precise predictions on the exact *type* of collusive agreement arising in different environments. Nonetheless, theory identifies features of the environments that are more conducive to pure price fixing than for market allocation-based cartels (or vice versa) or that may call for more complicated (mixed) arrangements.

Observability and nature of choice variables: The literature on imperfect monitoring suggests that the degree of observability of prices and quantities affects the type of cartel (Stigler 1964, Green and Porter 1984, Athey and Bagwell 2001, 2008, Harrington and Skrzypacz 2007, 2011). For example, when the product is a service as opposed to a physical good, inspection of

output is costly or ineffective (Stigler 1964). This implies that quantity-based allocation schemes, such as production quotas, are less feasible in the non-manufacturing sector. On the other hand, when posted prices are rare or when pricing practices are hard to monitor, both sales quota cartels (Harrington and Skrzypacz 2007) and market allocation-based cartels are more feasible. This suggests that when the demand comes from industrial buyers as opposed to retail buyers, price-based cartels are likely to be less common. When neither prices nor quantities are easily observable, mixed cartel types, which involve both market sharing and price fixing, can be expected (Hörner and Jamison 2007). In such an environment, cartels may, for example, need to coordinate both on price and to use quotas (and to use sales reporting and transfer payments; Harrington and Skrzypacz 2011).

The nature of the goods sold often differentiates manufacturing from non-manufacturing. While the prices of products sold to final consumers may be more easily monitored, such products are also more likely to be differentiated. Product differentiation reduces the price sensitivity of customers and thus the profitability of a secret price cut (Deneckere 1983), but it makes deviations in terms of quality and availability possible. When there is a risk of semi-collusion, firms are more likely to use mixed cartel types. In particular, when demand is inelastic (as is often the case with product differentiation), quotas may complete price fixing agreements (even with perfect monitoring; van den Berg and Bos 2017).

Fixed costs and entry conditions: Conditions that facilitate reaching a collusive agreement in the first place may also affect the choice of the type of collusive agreement. For example, the theoretical literature suggests that sizeable fixed costs (e.g., higher capital intensity) and entry barriers enhance collusion. The reason is that fixed costs tend to reduce entry and enhance concentration, making coordination easier, deviations less lucrative and inclusive collusive arrangements easier to achieve (e.g., Stigler 1964, Shapiro 1989; Friedman and Thisse 1994). An endogenously incomplete (pure) pricing cartel also benefits from reduced entry (and lower industry

capacity), as it has an incentive to be more inclusive and its stability requires that non-cartel members do not have enough capacity (see Bos and Harrington 2010). On the other hand, when firms can compete in several markets and have high fixed costs, market sharing agreements are predicted to be more typical than, e.g., production quotas (see Bernheim and Winston 1990, Belleflamme and Bloch 2004, 2008 and Roldan 2012). Other mechanisms may also induce cartels to adopt a home market principle (e.g., Byford and Gans 2014). It is thus theoretically ambiguous whether larger fixed costs and entry barriers foster certain types of collusion.

Capacity and demand fluctuations: Capacity constraints limit both the incentives of colluding firms to cheat and the likelihood of being punished (Brock and Scheinkman 1985, Benoit and Krishna 1987, Davidson and Deneckere 1990). Excess capacity may allow for a harsher punishment of deviations from both price-based and market allocation-based collusion. Endogenous capacity investments increase the risk of semi-collusion (Fershtman and Gandal 1994).[4] To manage this risk, cartels may need to resort to mixed cartel arrangements, which involve market sharing and price fixing simultaneously. Fluctuations in demand and business cycles are yet another source that may destabilise cartels. Green and Porter (1984) used a model of quantity competition with imperfect monitoring to show that an unanticipated demand shock may be destabilizing, as it can be misinterpreted as a deviation. Rotemberg and Saloner (1986) argue in turn that a pricing cartel's stability is compromised when the current demand is high. Using the same context but allowing the demand to have a predictable seasonal pattern, Haltiwanger and Harrington (1991) show that a pricing cartel becomes less stable when current demand is strong (making secret price cuts lucrative) and the anticipated near-term demand is weak (suggesting less scope for a harsh punishment). Gerlach (2009) argues that, in an infinitely repeated Bertrand game in which firms observe private signals of a common value demand shock, an inter-temporal market sharing arrangement may emerge and substitute for communication, especially in low demand periods. In

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[4] For example, the Norwegian cement cartel studied by Röller and Steen (2006) ran into trouble because of overinvestments in capacity, despite it having an explicit cartel agreement on prices.

sum, it is theoretically ambiguous how fluctuations of demand affect the formation of price-based and market allocating-based cartels, as well as their mixtures.

3.1.3   Prior evidence

Barring a few exceptions, it is difficult to infer from the prior studies how common the main cartel types are (see Appendix A); statistical tests for the differences do not exist. The descriptive statistics available from Bouwens and Dankers (2010) and Haucap et al. (2010) suggest that slightly more than a third of the manufacturing cartels in the Netherlands and Germany agree on prices, whereas from Hay and Kelley (1974), one can infer that the share of price-fixing cartels in the US non-manufacturing is roughly two thirds.[5] Fink et al.'s (2017) contemporary work shows that in Austria, manufacturing cartels account for 80% of the cartels, and approximately 36% are pure price/payment cartels. Moreover, the evidence for some identifiable types of cartels is quite mixed. For example, some studies report that quota cartels are common especially in manufacturing (Suslow 2005, Harrington 2006, Fink et al. 2017), whereas others suggest that they are rare (Posner 1970, Taylor 2007, Bouwens and Dankers 2010). Comparing numbers such as these with each other and to other prior work is difficult; classifications vary from study to study, are at times left implicit, or are based on incomplete typologies that consist of mutually non-exclusive and/or collectively non-exhaustive classifications (see Appendix A). A further complication is the unavailability of data on sectoral division. To our knowledge, no prior study has used large samples and quantitative methods to analyse how structural industry features facilitate the formation of certain types of cartels.[6]

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[5] In Bouwens and Dankers (2010), the share of pricing cartels in manufacturing is 34%, whereas in Haucap et al. (2010), the share of price-fixing cartels (excl. bidding agreements) is 31%. Using information from the appendix of Hay and Kelley (1974), we can calculate that 65% of the non-manufacturing cartels in their data agree on prices.

[6] The only study that briefly explores this is Taylor (2007). He shows that the use of production quotas by US cartels that registered their activities due to the National Industrial Recovery Act in the 1930s is not associated with industry characteristics.

## 3.2	Measurement

### 3.2.1	Main contract clauses

The Finnish CA collected information on how the cartels tried to raise profits and suppress inter-firm competition, i.e., the cartels' *main contract clauses* (see Appendix B). The CA recorded whether cartels agreed on prices or coordinated price-setting via *Pricing* clauses and whether they restricted the use of discount rules and/or rules of delivery and payment by having clauses for *Payment rules.* The data also reveal whether cartels agreed on sales or production quotas or market shares using a *Quota* clause; whether they had an explicit reference to a spatial distribution, such as exclusive territories, home market principle, or (local) assignment of customer base by having an *Area-based market allocation* clause; and whether they relied on a *Non-area-based market allocation* clause. According to the last of these clauses, the colluding members partitioned the production of goods in some way (e.g., specialisation via the sale of a production line or via a party ceasing production of certain variants of the goods in question) or in some cases, just by agreeing not to compete.[7]

### 3.2.2	A typology of cartels

Economic theory of collusion suggests that cartels attempt to raise profits by fixing prices, allocating markets, setting quotas, or using a mixture of these. Building on this characterization, we present a typology of cartels of four mutually exclusive and collectively exhaustive cartel types: *Pure pricing, Pure allocation*, *Quota*, and *Mixed price-allocation* cartels (see Appendix B for the more precise definitions and Appendix C for illustrative cases of each). We classify as *Pure pricing* cartels those that only use *Pricing* clauses and/or *Payment rules.* We view the suppression of competition in payment and delivery rules as closely related to direct price-fixing. *Pure allocation*

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[7] A closer look at the contracts of these cartels reveals that sometimes the collusive arrangement was based on the participating firms simply stipulating that they "specialise" in some dimension or "agree not to compete". While this may sound peculiar at first, similar cartel agreements and practices have been reported for the US (Posner 1970, Gallo et al. 2000), Germany (Audretsch 1989 and Haucap et al. 2010), the Netherlands (Bouwens and Dankers 2010) and cartels caught by the European Commission (Harrington 2006). See also Appendix C for examples of cartels using these clauses.

cartels use only *Area-based market allocation* and/or *Non-area-based market allocation* clauses. The remaining two types allow for a mixed use of clauses. In addition to a *Quota* clause, *Quota* cartels may also have *Pricing* clauses and/or *Payment rules,* whereas *Mixed price-allocation* cartels can, in addition to *Pricing* clauses and/or *Payment rules*, use *Area-based market allocation* and/or *Non-area-based market allocation* clauses, but they do not use *Quota*. This typology brings structure to the empirical analysis and, being mutually exclusive, provides a more transparent map from the relevant theoretical models to the empirics than what has been the case in most empirical work.

Table 1 displays the distribution of cartel contracts in terms of the five main contract clauses by sector and how each of the cartel contracts observed in our data map to the typology. Two key findings emerge. First, the use of main clauses is clustered. Out of the 32 theoretically possible combinations, the most popular contract accounts for 40% of all contracts in both sectors. The five most popular combinations of contract clauses account for 73% of all cartels in manufacturing and 82% in non-manufacturing.[8]

[Insert Table 1 here]

Second, we can map the typology of Table 1 to a number of insightful earlier case studies. Approximately 5% of the manufacturing cartels are quota cartels, such as the Joint Executive Committee (Porter 1983, Ellison 1994, Mariuzzo and Walsh 2013), which used market share allotments but allowed the colluding railroads to individually set prices. Cartels such as the Sugar Institute (Genesove and Mullin 2001), which neither fixed prices nor allocated markets but only standardised business practices, are not very common in our data, but they are not an anomaly either: approximately 4% of the manufacturing cartels have no main clauses in their contract, and

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[8] We provide a closer look at the joint use of the main clauses in Appendix D.

alternatively, 4% of them coordinate only discounts and terms of delivery.[9] Nearly 10% of the manufacturing cartels both agree on a sales quota and coordinate on some aspect of price, as the Lysine and citric acid cartels did (see, e.g., Harrington and Skrzypacz 2011) and as the Vitamin cartel did (Marshall, Marx and Raiff 2008, and Igami and Sugaya 2017). Approximately 3% of the manufacturing cartels fix prices and allocate markets either geographically or otherwise, as the Bromine cartel did (Levenstein 1997). The Norwegian cement cartel studied by Röller and Steen (2006) was another mixed price-allocation cartel, coordinating on prices and rebates, allocating local sales areas and sharing the total domestic quantity according to capacity. In light of our data, pricing cartels such as the Canadian retail gasoline cartel that primarily fixed prices using an asymmetric pricing cycle mechanism (Clark and Houde 2013) appear to be common in non-manufacturing, representing more than half of the cartels.[10]

3.3   Results

Table 2 takes a closer look at how the type of a cartel is related to the cartels' sector and to whether the demand comes primarily from retail (Business-to-customer, B2C) or industrial buyers (Business-to-business, B2B). The table shows that in manufacturing, 53% of the cartels are *Pure allocation* cartels that only allocate markets in some way. *Quota* cartels account for 16% of the manufacturing cartels, where they are more common than *Mixed price-market* cartels. In non-manufacturing, 62% of the cartels are *Pure pricing* cartels that agree only on prices. As expected, *Quota* cartels are rare in non-manufacturing, where *Mixed price-allocation* cartels are more common.

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[9] There are a number of reasons why we observe cartels without a main clause, as the contracts may have other horizontal-like restrictions besides those captured by our five main clauses. A common agreement like that is the joint purchase of one or more factors of production: approximately 40% of the cartels without a main clause had such a clause. Moreover, one-third of the cartels without a main clause were recorded as horizontal agreements due to some firms co-ordinating their sales or marketing efforts in some way. Finally, roughly one-fifth of the cartels without a main clause had their agreement classified as a miscellaneous competition restriction by the FCA.

[10] We cannot map some of the earlier cases studies, such as Porter and Zona (1993, 1999) and Pesendorfer (2000) and Asker (2010), to our data, as bidding rings were illegal during the sample period we study, and hence, none were registered.

All these differences are statistically significant within the sectors (p-values < 0.01), and the patterns hold if we condition further on whether the demand is primarily from retail or industrial buyers.

[Insert Table 2 here]

Table 3 reports the results from Linear Probability Models (LPM), in which the dependent variable is the type of cartel, i.e., an indicator for *Pure pricing*, *Pure allocation*, *Quota* or *Mixed price-allocation* cartel. We estimate the LPM models as a GMM system to test cross-equation restrictions. We cluster the standard errors by the year of a cartel's entry into the Registry.

In both panels of Table 3, the explanatory variables are a set of structural industry characteristics, characterising the operating environment of the cartels (see Appendix B for details). The first two characteristics are a *Manufacturing* indicator (= 1 for manufacturing and = 0 for non-manufacturing cartels) and a *B2C* indicator (= 1 when the primary source of demand is retail buyers; = 0 if industrial buyers). These measures mirror both the nature of demand and the transparency of price setting and quantity choices. Pricing cartels are likely to be more common when the demand comes from retail buyers (Harrington and Skrzypacz 2011), whereas quantity-based allocation schemes, such as production quotas, are more feasible when the product is a physical manufactured good (Stigler 1964). When neither prices nor quantities are easily observable, mixed cartel types, which involve market sharing and price fixing simultaneously, can be expected to be prevalent (Hörner and Jamison 2007, Harrington and Skrzypacz 2011).

The next two structural industry characteristics are a *Capital intensity high* indicator (= 1 when the ratio of net fixed capital stock to annual labour hours in a cartel's industry is in the highest third of the industry distribution; = 0 otherwise) and *Capacity utilisation low* indicator (= 1 when the capacity utilisation in a cartel's industry at the time of the cartel's entry into the Registry is in the lowest third of the distribution; = 0 otherwise). These variables mirror entry and capacity conditions that, according to theory, are important for cartel formation and stability in

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general even if their link to specific forms of collusion is ambiguous (e.g., Stigler 1964, Shapiro 1989; Fershtman and Gandal 1994, Bernheim and Winston 1990, Belleflamme and Bloch 2008).

Third, we include controls for demand fluctuations around the time the cartel was formed. To capture unanticipated demand changes (Green and Porter 1984), we use *Industry-growth slow* and *Industry-growth fast* indicators (= 1 when the deviation of the industry production in a cartel's industry from its Hodrick-Prescott trend around the time of the cartel's entry into the Registry is in the lowest/highest third of the distribution; = 0 otherwise). We measure predictable seasonal patterns in the current and near-term future demand (Rotemberg and Saloner 1986; Haltiwanger and Harrington 1991) using a *backward*-looking *Gdp-b-fast* indicator (= 1 when the Hodrick-Prescott smoothed GDP growth before and during the time of a cartel's entry into the Registry is in the highest third of the distribution; = 0 otherwise) and a *forward*-looking *Gdp-f-slow* indicator (= 1 when the Hodrick-Prescott smoothed GDP growth right after the time of a cartel's entry into the Registry is in the lowest third of the distribution; = 0 otherwise).

Finally, we use a *Year of registration* variable (*YoR*) to control for the year a cartel entered the Registry (normalised to be zero in 1959). This variable allows for a trend-like cohort effect in the types of cartels registered. We also include an interaction of *YoR* with the *Manufacturing* indicator, as a preliminary look at the data suggested that the cohort effects may be sector-specific (see Appendix B).

[Insert Table 3 here]

Four main findings emerge from Table 3. First, the structural industry characteristics matter for the formation of the different types of cartels. They are jointly significant at the 1% significance level in each equation. Bar two exceptions the cross-equation tests suggest that the effects of the characteristics are different across the types of cartels at the 5% significance level (see Table D5 in Appendix D). Consistent with this, the coefficients of determination (R^2) are relatively high,

indicating that the models predict quite well which type of a cartel is formed (Gronau 1998).[11] Second, as expected from theory, the formation of *Pure pricing* cartels is more likely in non-manufacturing and when the demand is from retail buyers, whereas the opposite holds for *Quota* cartels. Third, we see that high capital intensity is inversely related to the formation of *Pure allocation* cartels but directly related to the formation of *Mixed price-allocation* cartels. Finally, the demand conditions at the time of cartel formation also appear to matter. For example, if there is an unanticipated negative demand shock just before or during the year of registration, *Pure pricing* cartels are less likely to be observed.

We have evaluated the robustness of the results reported in Table 3 in three ways (see Appendix D). First, to exclude the possibility that our structural industry characteristics are capturing the effects of changes in competition law, we added indicators for the law cohorts to the models. The results remain intact. Second, to ensure that the method of estimation is not driving the results, we respecified the model as a Multinomial-logit model, where the outcome variable is a categorical variable, with values corresponding to the different types of cartels. Estimating the model using ML, we find results similar to those reported in Table 3. Finally, we used an alternative B2C indicator, based on a reclassification of some industries that were borderline calls in the original definition (not reported).

3.4   Discussion

We have proposed a theory-based typology of the main types of cartelization. The typology distinguishes explicitly *Pure pricing* and *Pure allocation* cartels from *Quota* cartels and from *Mixed price-allocation* cartels, which fix prices and allocate markets simultaneously. The typology produces results that confirm the existing empirical evidence and provides a number of novel insights.

While somewhat scattered (see Table A1 in Appendix A), the existing evidence suggests that the main type of cartelization depends on the sector. We confirm that this is indeed the case.

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[11] In an LPM-model, R2 measures the difference in the average predicted probability between those for whom Y = 1 and for whom Y = 0 (Gronau 1998). The larger the difference, the better is the predictive power of the model.

However, no earlier analysis has formally statistically tested and shown that manufacturing cartels fix prices less often than they allocate markets. This finding holds both for pure market allocation cartels and for quota cartels. The opposite holds in non-manufacturing, where pure price fixing cartels are clearly dominant. These results are robust to controlling for structural industry characteristics. The typology also illustrates how representative the particular cartels studied in a number of influential earlier case studies are.

We have also presented completely new evidence in line with the existing theory of explicit collusion. Our findings on how the structural industry factors are associated with the main type of cartelization are consistent with the general view, originally put forward by Stigler (1964), that colluding firms both take the observability of strategic choice variables into account and anticipate the later problems in constructing the initial agreement. In particular, our econometric results suggest that implementing quota-based market-share transfers is harder when the demand is primarily from retail buyers. This finding is consistent with, e.g., Harrington and Skrzypacz (2011) and with the view that in price-posting retail markets, colluding firms cannot as easily control where consumers buy. Moreover, consistent with theory, high capital intensity (entry barriers) predicts which type of cartel is formed. However, it is less clear why high capital intensity is associated negatively with pure allocation cartels but positively with the mixed cartels that fix prices and allocate markets simultaneously.

Finally, we have presented new evidence not captured by the existing theory of collusion. First, the popularity of *Pure allocation* cartels in manufacturing is to a large extent – but not solely – related to the use of *Non-area-based* clauses. These collusive arrangements form a broad category, often stipulating that the members are to specialise in one way or another or that the contracting parties simply agree to "not compete". They include, for instance, inter-cartel sales of production line(s) and some members ceasing production of certain goods. In a sense, these cartels adopt a home turf principle, in which the colluding firms engage in mutual avoidance by allocating

the product, production or some other space amongst themselves instead of allocating geographical markets or customers. Theory does not fully explain why these kinds of cartels should be dominant in manufacturing. The home turf principle can be seen as a substitute for a formal merger (Stigler 1964 and Verboven 1995) and is consistent with the observation that production and sales capacity are commonly transferred, relocated and/or sold when cartels are formed and when they dissolve (Röller and Steen 2006, Kumar et al. 2015, Marx and Zhou 2015 Dong et al. 2017; see also Motta 2004).

In addition, it seems that the structural industry factors that happen to be salient at the time a cartel is being formed, such as unanticipated industry-level demand shocks and business cycle conditions, are associated with the main type of cartelization. While, for example, Dick (1996a) and Symenonidis (2003) have shown that cartels are formed in industries where suppressing competition and subsequent enforcement are easier, our results suggest that the *type* of a cartel may also depend on the prevailing and near-term demand conditions. Consistent with Stinchcombe's (1965) early insights on organizational imprinting, our findings suggest that the environment at the time of establishment (initial conditions) may shape the patterns of cartelization and subsequent behaviour of cartels more than what the existing economic theory predicts.

4   How do cartels pursue compliance?

In this section, we first characterise what the cartels look like, using the typology we have introduced and the larger sample of 898 cartels. The aim of this analysis is to show how large and inclusive the different types of cartels were. We then explore which specific contracting features are used to pursue compliance and, especially, how their use depends on the type of cartel. To this end, we use information on a set of additional contract clauses that we collected for the subsample of 108 nationwide manufacturing cartels.

4.1 Theory and prior evidence

4.1.1 Characteristics of cartel types

While no theoretical study has formally compared how the size of cartels varies with the type of cartelization pursued, a number of models indirectly suggest that the size does matter. Basic price or quantity collusion is more likely to arise and be stable in markets with a few symmetric firms (e.g., Stigler 1964, Shapiro 1989; Friedman and Thisse 1994), even though the prediction may be reversed when explicit communication is allowed (Garrod and Olczak 2018). The capacity under the control of a pricing or quantity cartel is a determinant of its stability. Thus, these cartels typically have an incentive to be more inclusive, but they are not necessarily all-inclusive (e.g., Donsimoni, Economides, and Polemarchakis 1986, Bos and Harrington 2010, 2015). On the other hand, market sharing agreements may be easier to achieve among a smaller number of firms (e.g., Belleflamme and Bloch 2004, Bond and Syropoulos 2008, Deltas, Salvo and Vasconcelos 2012, and Byford and Gans 2014). Therefore, pure allocation cartels, in which firms refrain from entering each other's territory or poaching each other's customers, are likely to have fewer members.

At times, horizontal cartels have a vertical dimension (e.g., Jullien and Rey 2007, Piccolo and Reisinger 2011, Piccolo and Miklos-Thal 2012; see also Nocke and White 2007). For example, exchanging information in the market for inputs may make collusion in the market for final products easier to sustain. Cartels may also coordinate horizontally in a number of auxiliary dimensions, such as the members' sales, marketing and advertising efforts (Stigler 1964, 1968, Friedman 1983, Bagwell and Lee 2010).

These considerations suggest that a cartel's characteristics, such as its size, geographic coverage, or vertical inclusiveness, may be jointly determined by and vary with the type of the cartel and may depend on the environment in which the cartel operates. Beyond this, theory does not provide clear-cut predictions on how the above features are associated with the main type of cartelization.

4.1.2 Stability structures and governance of cartels

Both the early informal cartel literature (Stigler 1964) and the subsequent formal models with perfect (Friedman 1983) and imperfect price and sales monitoring (Green and Porter 1984, Sannikov and Skrzypacz 2007, Athey and Bagwell 2008, Harrington and Skrzypacz 2007, 2011), as well as with unobservable cost shocks (Athey et al. 2004, Athey and Bagwell 2001, 2008), have analyzed the stability and governance of cartels in various environments. This literature suggests that in addition to reaching either an explicit agreement or an implicit understanding of how to raise profits, the colluding firms have to determine a way to induce compliance (see also Harrington 2006, and Levenstein and Suslow 2006).

A number of predictions can be derived. For example, in face of external shocks and demand fluctuations, basic pricing cartels may need to more often make active decisions to change prices or update conditions for discounts and payments (e.g., Rotemberg and Saloner 1986; Haltiwanger and Harrington 1991). Stigler's (1964) arguments imply that a joint sales office might be a common way to organise such recurrent activities. When entry is possible, both pure pricing and quantity setting cartels may need procedures for accepting new members because of their need to make the cartel stable (i.e., sufficiently encompassing; see Donsimoni, Economides, and Polemarchakis 1986, Harrington and Bos 2010). When some communication may occur, and costs are stochastic, cost reporting should be prevalent in pricing cartels to ensure productive efficiency and be accompanied by transfer payments (see Cramton and Palfrey 1990, Athey and Bagwell 2001, 2008 Athey et al. 2004). On the other hand, when monitoring is imperfect, quota cartels should use sales reporting schemes and interfirm transfer sales (Harrington and Skrzypacz 2007 and 2011).

In sum, the literature suggests that especially explicit collusive arrangements should mirror how the colluding firms try to enhance their internal stability, solve organizational issues, prepare for external threats and secure a sufficient degree of productive efficiency. Many of the sharper predictions appear, however, to be quite context-specific.

4.1.3   Prior evidence

To the best of our knowledge, no prior study has used quantitative methods (econometric analyses or statistical tests) to analyse how the different *types* of cartels differ in terms of their observable characteristics or linked the differences to structural industry characteristics. The existing literature also provides limited evidence on the use of governance clauses on internal stability, organization of cartels, external threats and production-related issues (see Appendix A).

A notable exception is the contemporary study by Fink et al. (2017), who use data on 80 Austrian legally binding cartel contracts. They descriptively study how the orientation of cartels, cartel size, duration and length of cartel contracts vary by the type of cartel and provide descriptive statistics on cartel governance by type of cartel. They find that price and payment cartels often focus on preventing secret price cuts (e.g., via information provision and punishment clauses), that market allocation (specialisation) cartels rarely rely on reporting and punishment mechanisms and that in addition to using price clauses, quota cartels often rely on information exchange and compensation mechanisms. However, given the nature of the analysis of Fink et al. (2017), one cannot know whether the differences they report are statistically significant or robust when controlling for structural industry characteristics.

4.2   Measurement

We characterise the cartels using several measures, some of which we have for the whole sample and some of which we have only for the subsample of 108 cartels. For the larger sample, we have the following four measures: *Number of members* (available for most cartels), *Nationwide* indicator (= 1 if the cartel is nationwide; = 0 otherwise); *Vertical* indicator (= 1 if the cartel also had a vertical dimension; = 0 otherwise), and *Sales or marketing cooperation* indicator (= 1 if the cartel had a clause indicating shared sales, marketing or advertising efforts; = 0 otherwise). We regard all of these variables as being potentially jointly determined by the type of the cartel, as they mirror how large, geographically or vertically inclusive these cartels aimed to be.

Based on the cartel literature, we identify fourteen additional contract clauses that mirror the stability structures and governance of cartels and that we coded manually for the smaller sub-sample of 108 nationwide manufacturing cartels.[12] These governance clauses can be classified into four groups: (i) clauses that are related to *Internal stability* issues, aimed at providing incentives not to cheat or deviate from the cartel contract; (ii) clauses describing *Organisation* of cartels; (iii) clauses related to *External threats* that the cartels face; and finally, (iv) *Production-related* clauses. We use this grouping to organise our discussion (further details in Appendix B).

The first group consists of four clauses that have to do with the *Internal stability* of a cartel. *Monitoring* indicates whether the members monitor each other.[13] *Enforcement* refers to the contracts that stipulate how to handle situations where a member has deviated. Such instances include the mention of price wars, retaliation, and compensations.[14] If the cartel has rules on how to expel a member if rules are broken, this is captured by *Expel*. Similarly, for contracts including clauses on monetary fines for a company that violates the contract, *Fine* takes the value one. Fines were usually a percentage of some measurable activity such as sales; occasionally, a minimum monetary fine was defined.

The second group refers to five clauses that summarise cartels' *Organization*. The first of them, *Meeting,* identifies the contracts that stipulate whether, and if so, how often, the members are to meet. *Dispute resolution*, in turn, denotes whether the contract specifies a way in which disputes among members are to be resolved. Dispute resolution was primarily specified through either an internal or an external mechanism (e.g., arbitration). *Structure* indicates whether the cartel has a formal structure, such as an association or a limited liability company to organise

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[12] In an earlier version of this paper, we showed that these 108 cartels largely share the features of the manufacturing cartels in the larger sample (of which the 108 cartels are a subsample), except for being by definition always nation-wide and born earlier.

[13] As an example, the plywood cartel had a clause whereby "*all information on sales, deliveries and production must be given to the Association twice a month; twice a year a certified auditor's statement of the correctness of previous notifications is required*".

[14] An example is the clause used by the glass cartel: "*The delegation has the right to order production reductions or temporary closing of a plant. Compensation must then be paid*".

itself. *Vote* is an indicator for contracts that include a clause for a voting procedure.[15] Finally, *Sales office* refers to whether the cartel has formed a trade or a sales association.

The third group consists of three clauses that address *External threats*. The *New members* clause indicates whether the contract specifies a policy on how to accept new members. *Non-cartel supply* quantifies whether or not the cartel members have a clause on how to address supply from non-member rivals. Finally, *Entry* refers to a clause that stipulates how to react to entrants into the industry.

The fourth group consists of two *Production-related* clauses. *Technology* covers, e.g., sharing of technological knowledge, such as patents or blueprints.[16] *Efficiency* refers to contract clauses that aimed at achieving production or delivery efficiencies.[17]

4.3 Results

We first condition the four cartel characteristics on our cartel typology (see Appendix B for descriptive statistics). Table 4 reports regression results based on a quantile regression for the number of members and on LPM regressions for the rest of the outcome variables (*Nationwide*, *Vertical*, *Sales or marketing coop.*). We use the pure pricing cartels as the comparison group and condition on the same structural industry factors as those used in the regressions of Table 3.

Table 4 reveals a considerable amount of heterogeneity across the different types of cartels. Focusing on the differences that remain statistically significant after we condition on the structural industry characteristics, we see, first, that relative to the cartels that just fix prices (*Pure pricing*), cartels that allocate markets (*Pure allocation*) and *Quota* cartels have a smaller median number

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[15] Cartels using the *Vote* clause often also specify the voting rules to be used. Voting power is distributed according to (sales) quotas or sales (billing), using the 1-share-1-vote rule, as relative to wages paid, or as a function of the size of the members. As an example, the cardboard cartel used the following voting rule: "*Voting power is based on production (volume)*".

[16] As an example, the cartel for concrete reinforcement steel bars had a contract stipulating the "*sharing of information on raw materials, production techniques, etc.*"

[17] As an example of an *Efficiency* clause, the plastic pipe cartel's agreement stipulated that the member whose facility is closest to a given customer should deliver the goods (*"when dividing orders, the length of transport must be considered if possible"*).

of members. The mode of the number of members is four in *Pure pricing* cartels, and two in *Pure Allocation*, *Quota* and *Mixed price-allocation* cartels in both sectors (see Appendix B). Second, *Mixed price-allocation* cartels are less often nationwide. Third, *Pure allocation* and *Mixed price-allocation* cartels more often have a vertical dimension. Finally, *Quota* and *Mixed price-allocation* cartels often rely on sales or marketing cooperation.

[Insert Table 4 here]

Using the smaller sample, Table 5 displays the use of each of the 14 additional contract clauses, conditional on our cartel typology (Appendix B displays the descriptive statistics). We again use LPM regressions, set (pure) price-fixing cartels as the comparison group and condition on the same structural industry characteristics. The right-most column displays Poisson (count) model estimations with (lower panel) and without (upper panel) control variables, using the sum of the 14 additional contract clauses as the dependent variable.

[Insert Table 5 here]

Table 5 provides four main findings. First, as the individually significant coefficients and the joint tests indicate, there is a considerable degree of heterogeneity in the stability and governance structures of the different types of cartels even when the structural industry characteristics are controlled for. Second, we see from the right-most column that *Quota* cartels rely more often than other types of cartels on governance clauses. From the other columns, one can note that they often use *Internal Stability* clauses (except *Expel*), such as *Monitoring*, *Enforcement* and *Fine*. *Quota* cartels also pay attention to non-cartel sources of supply and production-related aspects more often than pure price-fixing cartels do. Third, relative to *Pure pricing* cartels, *Pure allocation* cartels less often use governance clauses, such as *New members*. In contrast, they often use clauses related to *Dispute resolution*, *Non-cartel supply*, *Entry*, and *Technology*. Finally, in light of existing theory, we note that *Pure pricing* cartels more often have clauses on new members but less often have clauses related to *Dispute resolution*.

We have explored the robustness of the results of Table 4 and 5 as follows: First, the differences between cartel types reported in Tables 4 and 5 would be similar but statistically stronger, had we *not* controlled for the structural industry characteristics (see Appendix B). Second, the results of both tables are robust to using our alternative B2C indicator (not reported). Finally, we have checked (see Appendix D) that the result of *Quota* cartels using more complex contracts – as documented in Table 5 – also applies in the larger sample of 898 cartels, using an alternative way of measuring complexity.

4.4   Discussion

This section has presented three types of findings: First, results that strengthen the existing empirical evidence. In particular, we confirm significant heterogeneity in what the different types of cartels look like, as has been documented in a number of detailed case studies of cartels (as reviewed by Levenstein and Suslow 2006; see also Ellison 1994, Genesove and Mullin 2001, and Clark and Houde 2013, 2014) and for some larger samples of cartels (e.g., Dick 1996a, Suslow 2005, and, more recently, Fink et al. 2017). Consistent with Fink et al. (2017), our typology reveals that relative to the cartels that just fix prices, both market allocation and quota cartels have a smaller median number of members. The larger size of pricing cartels is line with their need to be sufficiently inclusive to be stable (e.g., Donsimoni, Economides, and Polemarchakis 1986, Bos and Harrington 2010, 2015). What is novel is that we show that these size differences are statistically significant and that they also hold when structural industry factors (particularly entry costs) are held constant.

Second, we have presented novel evidence that supports specific theories of collusion. In our data, which also include regional and local cartels, the mode (and unconditional median) number of members in *Pure allocation* cartels is two. The cartels that resort to the home turf principle are often small and, indeed, bilateral, consistent with models of market sharing agreements (e.g., Belleflamme and Bloch 2004, Bond and Syropoulos 2008, Deltas, Salvo and Vasconcelos 2012, and Byford and Gans 2014). These agreements also often include specific governance clauses,

such as *Dispute resolution*, *Non-cartel supply*, *Entry*, and *Technology*. Furthermore, these pure allocation cartels more often have a vertical dimension, which supports the recent modelling of cartelization with a vertical dimension (e.g., Jullien and Rey 2007, Piccolo and Reisinger 2011, Piccolo and Miklos-Thal 2012).

Unlike prior empirical work, we have provided econometric evidence that *Quota* and *Mixed price-allocation* cartels often rely on sales or marketing cooperation, consistent with, e.g., Stigler (1964, 1968), Friedman (1983), and Bagwell and Lee (2010). Moreover, we have shown that heterogeneity in the stability and governance structures of the different types of cartels remains when the structural industry characteristics are controlled for. Many of these empirical regularities are in line with cartel theory. For example, *Quota* cartels, which in our data mostly operate in intermediate goods markets with hard-to-observe prices and quantities, often use *Monitoring, Enforcement, Fine*, and *Dispute Resolution* clauses. In the spirit of Stigler's (1964) conjecture and Harrington and Skrzypacz's (2011) model, these regularities suggest that *Quota* cartels need monitoring and side payments to function. However, *Quota* cartels also pay more attention than pure pricing cartels to non-cartel sources of supply and production and efficiency related issues, and they rely on a larger number of clauses than the other cartel types.

Earlier case studies (e.g., Genesove and Mullin 2001), experimental evidence (e.g., Cooper and Kühn 2014) and theory (e.g., Sannikov and Skrzypacz 2007, Rahman 2014, Awaya and Krishna 2016) suggest that (even unverifiable, non-binding) communication is important for a cartel's stability in certain environments. For example, a reinterpretation of the collusive agreement can prevent unjustified retaliations and an unraveling of the collusive arrangement (e.g., Genesove and Mullin 2001). However, subsequent communication may be only an imperfect substitute for a more complete initial cartel agreement. Consistent with this, initially reaching an informal consensus and making non-binding preplay threats and promises support subsequent cooperation (e.g., Harrington, Gonzalez and Kujal 2016, Dufwenberg, Servatka and Vadovic 2017). One interpretation of the more comprehensive use of clauses by *Quota* cartels is that, to start with, they require more *initial* communication ("more complete contracts") to be viable. Despite recent

advances (e.g., Harrington and Skrzypacz 2011), theory is still relatively silent on why that is so. More generally, there is much heterogeneity in the kinds of stability clauses used by the different cartel types. Existing theoretical models do not fully capture this aspect of the data.

5   Conclusions

This paper provides an anatomy of cartel contracts. The key elements of this anatomy are the following. In manufacturing, cartels often suppress competition by (just) allocating markets. This means adopting a home turf principle, whereby colluding firms engage in mutual avoidance by allocating the product, production, geographical or some other space amongst themselves. These cartels are often bilateral and use less complex contracts. Quota cartels are also relatively common in manufacturing and when demand is mostly from industrial buyers. They use more complex contracts. Manufacturing quota cartels rely frequently on clauses related to self-policing, such as monitoring, enforcement and fines. In non-manufacturing, cartels often suppress competition by (just) fixing prices. Holding the sector constant, pure price fixing cartels are also more common when demand is mostly from retail buyers. Mixed cartels, which both fix prices and allocate markets, also exist, especially in industries where capital intensity is high. These econometric findings are novel, as prior studies do not include quantitative analysis and have not linked cartel type to structural industry characteristics. These findings are largely consistent with the existing theory on how the observability of choice variables affects collusion and how the structural industry characteristics are associated with the formation of cartels.

We have also provided novel findings that are not predicted by the existing theories of explicit collusion. First, as documented in Section 3, the popularity of *Pure allocation* cartels in manufacturing is largely due to collusive arrangements that adopt a home turf principle, in which the colluding firms engage in mutual avoidance by allocating the product, production or some other space amongst themselves. Theory does not fully explain why these kinds of cartels should be dominant in manufacturing. Second, our econometric evidence suggests that which types of

cartels are formed depends on the prevailing and near-term demand conditions. This suggests that initial conditions may shape the patterns of cartelization and the behaviour of cartels more than what has been the focus in the existing theory. Finally, as documented in Section 4, the contracts of *Quota* cartels contain more clauses than those of the other types of cartels, beyond what is predicted by existing theory.

We want to make it clear that the patterns that we report do not establish causality. They are nonetheless useful for the development of cartel theory because a theoretical cartel model is arguably more useful if the equilibrium of the model is consistent with the patterns found in the data. For example, one could follow Harrington and Skrzypacz (2011) and build a model that in equilibrium delivers a cartel contract observed in our data under the assumption that there is no competition authority.[18] In the spirit of Bos and Harrington (2010, 2015), the environment could thereafter be changed (e.g., by introducing a competition authority) to study what type of an equilibrium cartel agreement arises in the new environment.

Regarding competition policy, our anatomy suggests specific empirical regularities in cartelization and illustrates what hardcore cartels would like to agree on were they not illegal. This kind of knowledge should ultimately increase the likelihood that authorities and courts make correct decisions in cartel cases. This is important because the boundaries for unlawful and harmful practices remain unclear (e.g., Harrington 2017, Kaplow 2011a,b). For example, were manufacturing cartels free to write collusive contracts, they would – by revealed preference – use relatively simple home turf allocation schemes whereby markets are divided spatially or by agreeing on the firms' positioning in the product/production space. Behaviour reminiscent of this kind of market allocation should be treated with a great deal of suspicion, especially in manufacturing. Quota cartels, on the other hand, call for much more complex contractual arrangements, suggesting that competition authorities should expect to find more evidence of communication for detected illegal

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[18] Harrington and Skrzypacz (2011; see also their 2007 paper) analysed the properties of an equilibrium that qualitatively match the key dimensions of observed cartel agreements in certain markets (quota cartel with monitoring) and showed under what conditions such an equilibrium exists.

quota cartels. While these observations provide suggestions for directing investigations, they do not provide direct criteria for detecting cartels: Prior work shows that many types of collusive strategies may be adopted even within narrowly defined markets (e.g., Conley and Decarolis 2016).

We conclude with a note about the external validity of our findings. We have reasons to believe that our data are relatively representative of the kinds of contracts cartels would like to write were there no harmful legal consequences. Our data suffer less from selection bias than, for example, data based on exposed illegal cartels (Harrington and Chang 2009, Harrington and Wei 2017, Hyytinen et al., in press). Moreover, like the Webb-Pomerene export cartels in the US (Dick 1996a,b) but unlike the legal Austrian cartels studied by Fink et al. (2017), for example, the legal cartels in our data were unlikely to be able to rely on legal enforcement and thus had to be self-policing, almost like illegal cartels. The following caveats about the external validity of our findings are nevertheless in order. First, some cartelization type may require activities and structures that are more easily detected. Participants in such a cartel have a strong incentive to strategically reduce the ability of a competition authority to detect and/or of a legal court to verify their actions. If so, then the distribution of cartelization types when cartels are illegal may differ from what it would be if cartels were legal. To sort out how the distributions can be expected to differ, we need more theoretical work in the spirit of Harrington and Chang (2009) and Harrington and Wei (2017). Second, we have used data from industries that at least once had a registered (discovered) cartel; our findings do not necessarily generalise to environments or industries where there is no detected cartel. A final caveat about the external validity of our findings is that new technologies (e.g., algorithmic collusion), global integration of economies and structural changes in the technological and economic environment may affect the types of collusion pursued and which factors predict them.

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Tables and Figures

Table 1: Combinations of main contract clauses and their mapping to cartel types

Panel A: Manufacturing *Combination of cartel clauses*	Count (N = 364)	Share	Cumulative share	Typology of cartel types
Non-area-based	152	0.42	0.42	A
Pricing + Payment rules	39	0.11	0.52	P
Pricing	33	0.09	0.62	P
Area-based	26	0.07	0.69	A
Pricing + Quota	18	0.05	0.74	Q
Pricing + Payment rules + Quota	15	0.04	0.78	Q
Area-based + Non-area-based	14	0.04	0.82	A
Quota	13	0.04	0.85	Q
Payment rules	13	0.04	0.89	P
Quota + Non-area-based	8	0.02	0.91	Q
Pricing + Payment rules + Non-area-based	5	0.01	0.92	PA
Payment rules + Non-area-based	3	0.01	0.93	PA
Pricing + Area-based	2	0.01	0.94	PA
Pricing + Payment rules + Area-based	2	0.01	0.94	PA
Pricing + Payment rules + Quota + Non-area-based	1	0.00	0.95	Q
Other combinations (each used by one cartel)	5	0.01	0.96	-
No main clause	15	0.04	1.00	-
Panel B: Non-manufacturing *Combination of cartel clauses*	Count (N = 534)	Share	Cumulative share	Typology of cartel types
Pricing	214	0.40	0.40	P
Pricing + Payment rules	66	0.12	0.52	P
Pricing + Non-area-based	65	0.12	0.65	PA
Payment rules	50	0.09	0.74	P
Non-area-based	43	0.08	0.82	A
Quota	6	0.01	0.83	Q
Pricing + Quota + Area-based	6	0.01	0.84	Q
Area-based	5	0.01	0.85	A
Pricing + Area-based	4	0.01	0.86	PA
Payment rules + Non-area-based	3	0.01	0.87	PA
Pricing + Area-based + Non-area-based	3	0.01	0.87	PA
Pricing + Payment rules + Area-based	3	0.01	0.88	PA
Area-based + Non-area-based	2	0.00	0.88	A
Other combinations (each used by one cartel)	5	0.01	0.89	-
No main clause	59	0.11	1.00	-

NOTES: Count is the number of cartels using a particular combination of the five main contract clauses. Share is the fraction of cartels doing so. The cartel types are: P = Pure price, A = Pure allocation, Q = Quota, PA = Mixed price-allocation.

Table 2: Cartel types by industry

	Count	Share of total	Cartel types				
			Pure pricing	Pure allocation	Quota	Mixed price-allocation	Difference (p-value)
Manufacturing	364	0.41	0.23	0.53	0.16	0.04	<0.01
… of which:							
Business-to-business (B2B)	224	0.25	0.19	0.54	0.21	0.04	<0.01
Business-to-customer (B2C)	140	0.16	0.30	0.51	0.09	0.04	<0.01
- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
Non-manufacturing	534	0.59	0.62	0.09	0.03	0.15	<0.01
… of which:							
Business-to-business (B2B)	257	0.29	0.47	0.09	0.06	0.27	<0.01
Business-to-customer (B2C)	277	0.31	0.75	0.10	0.00	0.04	<0.01
Total:	898	1.00	0.46	0.27	0.08	0.10	

NOTES: In the last column on the right, we report the p-values for a Chi2-test of the null hypothesis that the shares of different types of cartels are equal. The standard errors used in the test allow for clustering by the year of Registry entry. When summed over the cartel types, the shares do not sum to one because there are 74 cartels in the data that have none of the main clauses in the contract.

Table 3: LPM-regressions of the determinants of cartel types

Explanatory variable	Cartel types			
	Pure price	Pure allocation	Quota	Mixed price-allocation
Manufacturing	-0.253***	0.120**	0.186***	-0.012
	(0.068)	(0.058)	(0.047)	(0.037)
B2C	0.162***	0.006	-0.093***	-0.070***
	(0.032)	(0.025)	(0.021)	(0.024)
Capital intensity high	-0.011	-0.080***	-0.009	0.159***
	(0.037)	(0.031)	(0.034)	(0.042)
Capacity utilisation low	0.046	-0.066*	0.041	-0.054**
	(0.037)	(0.034)	(0.033)	(0.027)
Industry-growth slow	-0.109**	0.031	-0.007	0.073**
	(0.045)	(0.039)	(0.024)	(0.031)
Industry-growth fast	-0.062	0.038	0.014	0.036
	(0.043)	(0.030)	(0.026)	(0.030)
GDP-b-fast	-0.013	0.009	-0.044**	0.085***
	(0.036)	(0.029)	(0.019)	(0.026)
GDP-f-slow	-0.066	0.138***	-0.053*	-0.020
	(0.046)	(0.053)	(0.027)	(0.031)
Year of registration (YoR)	-0.011***	0.001	0.003	0.004*
	(0.004)	(0.003)	(0.002)	(0.003)
YoR*Manufacturing	-0.008*	0.021***	-0.006*	-0.004
	(0.004)	(0.004)	(0.003)	(0.002)
Constant	0.749***	0.057	0.068*	0.019
	(0.068)	(0.048)	(0.039)	(0.036)
R^2	0.289	0.379	0.099	0.171
Number of observations	898	898	898	898

NOTES: The method of estimation is a one-step system GMM. The standard errors allow for clustering by the year of Registry entry. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 4: Characteristics of cartels by cartel types

	Number of members	Nationwide	Vertical	Sales or marketing coop.
	Quantile	LPM	LPM	LPM
Cartel type:				
Pure allocation	-5.55***	0.01	0.12***	-0.10**
	(1.84)	(0.05)	(0.04)	(0.05)
Quota	-5.00**	-0.00	-0.00	0.22**
	(1.98)	(0.07)	(0.03)	(0.08)
Mixed price-allocation	-1.00	-0.22***	0.11**	0.31***
	(8.88)	(0.07)	(0.05)	(0.06)
Control variables	YES	YES	YES	YES
Observations (N)	520	898	898	898
R2	-	0.25	0.07	0.40
H0: "Pure pricing vs. other cartel types"	0.02	<0.01	<0.01	<0.01
H0: "Structural industry factors"	0.22	<0.01	<0.01	<0.01
Unconditional median / mean of dep. var. for Pure-pricing	16.5	0.63	0.05	0.16

NOTES: The number of members is not available for all cartels. Quantile (median) regression for the number of members (standard errors from 100 bootstrap replications); for the others, we use LPM-models (OLS, standard errors clustered at register year). Control variables are indicators from Manufacturing, B2C, Capital intensity high, Capacity utilisation low, Industry-growth slow, Industry-growth fast, GDP-b-fast, GDP-f-slow and Year of registration (YoR). In all models, a dummy for the cartels not having any of the five main clauses is included. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The joint tests are F-tests and the reported numbers are p-values.

Table 5: Use of additional governance contract clauses

Cartel type	Internal stability				External threats			Sum of all additional clauses
	Monitoring	Enforcement	Expel	Fine	New members	Non-cart. supply	Entry	
Pure allocation	0.09	-0.00	-0.27	-0.03	-0.43***	0.45**	0.24**	-0.14
	(0.13)	(0.07)	(0.22)	(0.09)	(0.13)	(0.17)	(0.11)	(0.14)
Quota	0.46***	0.54***	-0.27**	0.42***	-0.17	0.33***	-0.06	0.43***
	(0.13)	(0.11)	(0.10)	(0.12)	(0.13)	(0.10)	(0.04)	(0.12)
Mixed price-allocation	-0.07	-0.04	-0.56***	-0.07	-0.48**	0.19	-0.07	-0.44
	(0.10)	(0.07)	(0.14)	(0.11)	(0.18)	(0.28)	(0.07)	(0.36)
Control variables	YES	YES	YES	YES	YES	YES	YES	NO
Observations (N)	108	108	108	108	108	108	108	108
R2	0.28	0.42	0.28	0.24	0.35	0.44	0.39	-
H0: "Pure pricing vs. other cartel types"	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01
Mean for Pure-pricing	0.20	0.02	0.49	0.09	0.60	0.09	0.02	4.02

Cartel type	Organization					Production-related		Sum of all additional clauses
	Meeting	Disp. Resol.	Structure	Vote	Sales office	Technology	Efficiency	
Pure allocation	-0.21*	0.34***	-0.54***	-0.46***	-0.45***	0.40***	-0.12*	-0.26*
	(0.10)	(0.12)	(0.11)	(0.13)	(0.10)	(0.13)	(0.06)	(0.15)
Quota	-0.05	0.57***	-0.08	-0.03	0.05	0.21*	0.26**	0.43***
	(0.07)	(0.08)	(0.11)	(0.13)	(0.07)	(0.10)	(0.10)	(0.09)
Mixed price-allocation	-0.21**	0.33*	-0.65***	-0.51**	-0.36	0.06	0.04	-0.66**
	(0.09)	(0.19)	(0.18)	(0.20)	(0.25)	(0.11)	(0.08)	(0.33)
Control variables	YES	YES	YES	YES	YES	YES	YES	YES
Observations (N)	108	108	108	108	108	108	108	108
R2	0.21	0.40	0.34	0.21	0.47	0.44	0.36	-
H0: "Pure pricing vs. other cartel types"	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01
Mean for Pure-pricing	0.11	0.33	0.71	0.62	0.71	0.02	0	4.02

NOTES: The regressions are LPM models, except in the column on the right, where Poisson (count) model is used. The dependent variable in the column on the right is the sum of the 14 additional governance clauses, with the upper panel reporting the results without controls and the lower panel with controls. All standard errors are clustered by the year of the Registry entry. The control variables are B2C, Capital intensity high, Capacity utilisation low, Industry-growth slow, Industry-growth fast, GDP-b-fast, GDP-f-slow and Year of registration (YoR). In all models, a dummy for the cartels not having any of the five main clauses is included. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The joint tests of H0: "Pure pricing vs. other cartel types" are F-tests, and the numbers reported are p-values.

Appendix A: Prior empirical evidence

We summarise the studies using large samples of cartel contracts in Table A1. In addition to ours, the table lists thirteen studies, which rely on nine different data sources. Due to space limits, we comment on the table in greater detail in the Online Appendix, where Appendix A continues.

Table A1: Prior literature on cartel codes and contracts (excl. case / single industry studies)

	Posner (1970)	Hay & Kelley (1974)	Frass & Greer (1977)	Audretsch (1989)	Dick (1996)	Gallo et al. (2000)	Suslow (2005)	Taylor (2007)	Harrington (2006)	Bouw.&Dank. (2010)	Haucap et al. (2010)	Levenst.&Susl. (2011)	Fink et al. (2017)	Our paper
Period covered	1890-1969	1963-1972	1910-1972	1973-1986	1918-1965	1955-1997	1920-1939	1927-1937	2000-2004	1930-200	1958-2004	1971-2007	1976-2006	1959-1993
Legal regime	Illegal	Illegal	Illegal	Legal	Legal (export)	Illegal	Semi-legal	Legal	Illegal	Legal	Legal and illegal	Illegal	Legal	Legal
Coverage	M&NM	M&NM	M&NM	M&NM	M&NM	-	M	M	M&NM	M mostly	M&NM	M&NM	M&NM	M&NM
Country-/international	US	US	US	Germany	US	US	Internat.	US	EU / Internat.	Netherlands	Germany	Internat.	Austria	Finland
Nationwide	38 %	22 %	-	-	-	32 %	-	-	-	-	-	-	-	M:85% NM:55%
Sector-specific information on usage	NO	Data available, no statistics	NO	NO	NO	NO	Only manuf.	Only manuf.	NO	YES	NO	NO	YES	YES
Pricing*	100% (?)	-	-	-	-	-	-	-	100 %	34 %	-	-	51 %	M:23% NM:62%
Pricing	Deliver Pr.: 2%, Resale Pr.: 7%, Pr. Rules: 14%	65 %	Basing point system: 2%, RPM: 5%, Pr. discrim.: 7%	-	Price-setting and market allocation: 83%	-	-	Notificat./ filing Pr. changes: 34%	"Common to all" ≈ 100%	-	Illegal: 31% price-fixing, 23% bidding agreements	-	9% pure price cartels	M:9% NM:40%
Payment rules	-	14 %	Terms and conditions: 5%	Condition & rebate cartels: 21%	-	-	-	52 %	Some cartels	Rebates and exclusive: 5%	Condition/ rebate cart.: 17% (legal), 10% (illegal)	-	55%, whereof 30% pure payment cond.	M:4% NM:9%
Market allocation*	26 %	34%-35%	26 %	-	(see above)	-	-	-	-	33 %	-	80 %	79 %	M:58% NM10%
Quotas	2 %	-	-	-	-	-	40 %	11 %	> 50%	2 %	(see below)	-	46 %	M:4% NM:1%
Area-based	15 %	-	-	-	-	14 %	40 %	-	> 30%	13 %	Illegal: 4%	-	Specializ. on	M:7% NM:1%
Non-area -based	10 %	-	-	(see Panel B)	-	13 %	-	-	> 33%	Specializat.: 18%	(see Panel B)	-	products, custom, suppl. territor. 33%	M:42% NM:8%

NOTES: M = manufacturing, NM = Non-manufacturing; * = In many studies, it is unclear whether "price-fixing" refers to pure price cartels or whether they also coordinate in other dimensions. The same applies to "market allocation", which is not allways defined transparently. The numbers in the table present our interpretation of the available evidence.

	Posner	Hay & Kelley	Frass & Greer	Audretsch	Dick	Gallo et al.	Suslow	Taylor	Harrington	Bouw.&Dank.	Haucap et al.	Levenst.&Susl.	Fink et al.	Our paper
Internal stability	-	-	-	-	-	-	-	-	-	-		-	-	-
Monitoring	info: 6%	-	-	-	-	-	-	89 %	> 30%	-	-	79 %	58 %	24 %
Enforcement	-	-	-	-	-	-	-	-	Compens.: > 33%	-	-	Compens. 33% Punishm. 19%	Compens. 43% Punsishm. 74%	12 %
Expel	-	5%-6%	12 %	-	-	-	-	-	-	-	-	-	38 %	27 %
Fine	Fine+audits: 4%	-	-	-	-	-	Penalties: 30%	-	-	-	-	-	64 %	15 %
Organization	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meeting	-	-	-	-	-	-	-	-	> 65%	-	-	-	81 %	8 %
Dispute-resolution	-	-	-	-	-	-	-	-	-	-	-	-	80 %	62 %
Structure	-	-	-	-	-	-	-	-	> 39%	-	-	-	Staffed office: 56%	50 %
Vote	-	-	-	-	-	-	-	-	-	-	-	-	-	44 %
Sales office	Trade assoc. 36%, Sales agent: 6%	Trade association: 31%	Trade assoc. 36%, Sales agent: 3%	-	Foreign sales office/agent: 57%	Intra-ind. organization: 23%	Central sales agency: 30%	-	Some cartels	-	-	Trade association: 31%	Joint sales company 15%	52 %
External threats	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New members	-	-	-	-	-	-	-	-	-	-	-	-	-	38 %
Non-cartel supply	-	-	-	-	-	-	-	-	> 21%	-	-	36 %	-	41 %
Entry	-	-	-	-	-	-	-	-	Some cartels	-	-	-	50 %	15 %
Production-related	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Efficiency	-	-	-	-	Engineering: 17%	-	-	-	-	-	-	-	-	8 %
Technology	10 %	-	10 %	-	-	-	Patent/cross lic.: 20%	-	-	-	-	-	Joint R&D: 14%	28 %
Comment	Nearly all fix prices?, 989 cases	Overlaps Posner data, 62 cases	Overlaps Posner data, 606 cases	Numbers are averages 1983 and 1986; 321 cartels in 1986	Fractions pertain to 23 cartels, 111 cartel episodes	Same source as Posner, 688 cases	18% terminated due to antitrust; 71 cartel episodes	No price fixing in NIRA; at most 62 cartels (66 ind. obs.)	Qualitative descr. 23 EC decisions. The data refer to "practices"	Data here refers to 1980	863/95 legal/ illegal cartels	81 cartels in US, EC or both	80 Austrian horizontal cartels, 80% manufactur.	898 cartels, M: 364, NM: 534 (108 for stability clauses)

NOTES: In many studies, the statistics reported here are not allways clearly displayed. Nor can they be allways inferred without making some subjective judgement.

Online Appendix

This is an online appendix to paper Hyytinen, Steen and Toivanen (An anatomy of cartel contracts). In Appendix A, which is partly in the paper in a table form, we summarise the prior empirical evidence. We present our conclusions of the summary of the prior literature here. Appendix B describes the institutional environment and our data sources, measurement choices and variable definitions. Appendix C reports examples of the cartels in our data. Finally, in Appendix D, we present a number of auxiliary analyses and robustness tests.

Appendix A: Prior empirical evidence (continued)

The survey of Levenstein and Suslow (2006) covers a number of earlier papers, including a large number of case studies. We summarise the studies using large samples on cartel contracts in Table A1, which is in the paper: We have been able to identify thirteen earlier studies, which rely on nine different data sources. Four early papers study detected US cartels, one studies legal US export cartels and another legal US cartels from the 1930s National Industrial Recovery Act. Two papers study legal and illegal German cartels, again with overlap in the data, and one explores Dutch legal cartels. There are three studies of (mostly) detected international cartels, all using different data. One paper uses data on 80 legal Austrian cartels.

Our review of the available literature (and Table A1) suggests three conclusions: First, while the literature has provided a number of important insights, many earlier studies had relatively limited information on what the cartels tried to agree on and, especially, on their economic environments. Second, they also cover a heterogeneous set of episodes and institutional environments, or refer to international or prosecuted cartels. The differences in the studies'

institutional environments, data sources, definitions of key variables and findings make systematic comparisons difficult, possibly misleading, error-prone, and at times impossible. Finally, three aspects are clearly missing: i) There is no consensus on how to classify cartels. In particular, there is no consistent, mutually exclusive classification of the main cartel types; ii) no earlier study has presented statistical tests when evaluating which cartels types are more or less common; and iii) no earlier study has linked the formation of different types of cartels to their external environment. The only study that briefly explores this is Taylor (2007). He finds that the use of production quotas by US cartels due to NIRA in the 1930s is not associated with the number of firms in industry, industry size, measure of entry conditions, homogenous goods indicator, and availability of substitutes. Taylor does not analyze other cartel types.

Appendix B: Institutional Environment and Data

This appendix gives further details on the institutional environment (partly based on Hyytinen et al. in press) and describes in detail our data sources and variable definitions.

The institutional environment

The development of Finnish competition policy after the Second World War follows closely developments in other European countries. There was no competition policy before the war (see Fellman 2008, 2010). The first cartel law was implemented in 1958. The central idea was to collect information on cartels that operate in the domestic market rather than to deter collusive activities. For this purpose, a (predecessor of the) Finnish competition authority (CA) was set up and given the task to register cartels (called Registry in what follows). Only bidding rings requiring express pre-bidding coordination were outlawed.

In this regard Finland followed Norway, Denmark and Sweden, which set up similar registers in 1920, 1937 and 1946 (Shanahan and Fellman 2016). Also several other countries, among them Germany, India, Israel, Japan, the Netherlands, New Zealand, South Korea, Spain, and the UK had legal cartels in the post-WWII era, and registries similar to the Finnish one (see Shanahan and Fellman 2016).

As we have documented in more detail in Hyytinen, Toivanen and Steen (in press), the CA began registrations in March 1959. Despite its limited resources, the Registry was active and started systematic investigations concerning individual firms, specific branches (= industries) and trade associations already in 1958. By 1962, 9 539 inquiries had been sent, 235 industry investigations had been conducted and 310 cartels had been registered (Fellman 2016, Table 6.2). Registration was contingent on the CA contacting the suspected cartel members. Contacted firms had an obligation to inform the Registry of competition restrictions. In 1964 the law was revised: Cartels with a formal organization (such as an association) now had to register on their own and failing to register could result in a (small) fine. In 1973 the registration

requirements were again somewhat tightened. In the 1980s Finland finally edged towards a modern competition law, as the work of a committee established in 1985 resulted in a new law taking effect in 1988, with cartels becoming illegal in 1993.

The Registry was comprehensive but incomplete. Based on conversations and written accounts, the costs of registering were minor. It also seems that there were some benefits. The former and current Director Generals of the Finnish CA (Purasjoki and Jokinen, 2001) sum up the environment concerning those collusive practices that were legal: "*Time was such that there seemed no need to intervene even in clear-cut cases, especially if they had been registered. Registration had been transformed into a sign of acceptability of the [cartel] agreement, at least for the parties involved [in the cartel]*".

The cartels that we study were actually harmful and not just harmless industry associations (see also Hyytinen, Toivanen and Steen, in press). One piece of evidence supporting this view is that the various associations of manufacturing industries opposed the introduction of the original law and its subsequent adjustments to e.g. expand the obligation to register. Similarly, consumer organizations supported the law and suggestions to tighten it further. The available contemporary written documents, such as various committee reports, draft proposals for new legislation or writings of the contemporary economists, provide little support for the view that the registered cartels would have been harmless (Fellman 2010, 2016). For example, when the cartels eventually became illegal by the early 1990s, the FCA initiated (around 1988) a special, large-scale project that targeted the registered cartels. The aim of the project was to ensure that the cartels in the Registry would cease to exist by the time the new law forbidding them became effective. Had the authorities thought that the registered cartels were harmless and not real competition restrictions, launching such a project with the limited resources of the CA would not have been necessary. In Hyytinen, Toivanen and Steen (in press) we also find that for a subsample of the cartels studied here that the more likely an industry is to have a

cartel, the higher its price-cost margin. This finding is consistent with the legal cartels having impacted prices.

Data sources and variable definitions

Our data come from three sources: Finnish CA' archive of cartels (Registry), the database of the Research Institute of the Finnish Economy (ETLA) and Tiainen (1994). The collection and matching of these three datasets are based on a considerable amount of manual work.

Archive work: All the data on the cartels and their contracts is based on our archive work in the Registry and on the information available therein. The Registry contains in total 898 cartels. For each registered cartel, the Registry established a folder, and gave a running identification (registration) number. The folder contains a concise, quite standardized written description of the cartel, drafted by the civil servants who worked for the Registry, and all the correspondence between the Registry and the cartel. The standardized descriptions contains a fair bit of information on all the cartels, including information on what they mainly agreed on (i.e., on how they tried to raise profits). The Registry also always asked for the actual cartel contract, which is in the folder, if one was submitted by the cartel. The Registry also maintained a listing of cartels and their primary activities and basic features, based on the standardized descriptions and the correspondence between the Registry and the cartel. The listing covered all of the registered cartels, and covers years from 1959 to 1990. Once a cartel was registered, basic information on it was published in the Official Journal of the Finnish government.

We treat each identification number in the data available to us as a cartel, but it should be noted that there are some cases in which a previously registered cartel was later given a new identification number. The reason for this is not explicitly spelled out. In some cases, the earlier cartel (with a smaller identification number) has been removed from the database. Our reading of the standardized descriptions of the selected cases that remain in the data suggest that giving a new identification number may e.g. due to the cases representing separate cartel episodes,

or due to the contract changing so much that a new identification was warranted. We also note that sometimes there are two adjacent identification numbers, which are registered at about the same time, for two similar-looking cartel arrangements. This can be due to the colluding members being different (but partially overlapping), and the product and/or the contract being different. Systematic linking of the possibly related cases is unfortunately not possible, because doing so would call for us going manually through all the folders of the Registry.

Data on main contract clauses: The cartel listing allows us to identify whether a given cartel tried to collude by agreeing on prices, by allocating markets in one way or another, using quotas, or by doing a combination of these. Bar one exception, these data are available for all the cartels in our data.[1]

Panel A Table B1 displays cartels' main contract clauses {*Pricing, Payment rules, Quota, Area-based market allocation, Non-area-based market allocation*} and gives their definitions. Panel B presents the typology of cartel types which we use throughout our empirical analysis. The typology allows for four mutually exclusive and collectively exhaustive types of cartels {*Pure pricing, Pure allocation, Quota, Mixed price-allocation*}.[2]

[Table B1 about here]

We acknowledge that Stigler (1964) initially proposed that a collusive arrangement consists of pricing, allocation and enforcement structures (see also Marshall and Marx 2012). Pricing structure is primarily about the implementation of price increases, price discrimination or quan-

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[1] There were some minor inconsistencies in the listing and folders. There is one cartel, which we identified when we collected more detailed information for the nationwide manufacturing cartels that does not appear in the cartel listing that is the primary source of data in this paper. We decided to drop this cartel from the analysis, so as to obtain a consistent estimation sample. All our results hold if this cartel is included.

[2] A small number of cartels that have a *Quota* main clause also have an *Area-based* market allocation and/or *Non-area-based* market allocation clause. We label them as *Quota* cartels in our typology. Stigler (1964, pp. 46) asserts that quotas are the most efficient way of organizing cartels, especially if efficient monitoring of output and side-payments can be organized.

tity reductions. Allocation structure refers to market share, geographic and customer allocations. They are a means to divide surplus, to minimise risk of (unintentional) deviations and also to suppress competition. Enforcement structures are about monitoring and punishing (intentional) deviations. Our typology combines pricing and allocation structures to the extent that they are primarily about suppressing interfirm competition. We consider the allocation structures that mostly have implications for stability in Section 4 of the main paper, where the governance and enforcement of cartels are discussed.

We also point out that our typology differs from the categorization of the collusion methods used in the contemporary work by Fink et al. (2017) in three ways. First, their categorization is not mutually exclusive. Second, in line with Stigler's (1964) views on pricing structures, our typology combines cartels that fix prices with those that fix discount rules and/or rules of delivery and payment. Third, to allow for the more complex cartel types predicted by the recent theory, we explicitly allow for a distinct mixed category.

Figures B1 and B2 display show how the registering of the different types of cartels varies by decade and by sector. They show that in both sectors, the share of *Pure pricing* cartels has decreased, whereas that of the *Pure allocation* cartels has increased.

[Figure B1 and B2 about here]

Data on other cartel characteristics: Besides assigning each cartel to manufacturing or non-manufacturing, we use information in the cartel listing to classify whether a cartel was nationwide or not, whether it had a vertical dimension or not, and whether its contract included mentions or remarks about joint sales, marketing or advertising efforts. Finally, information on the number of members was scattered and not consistently available for all cartels. We searched for it from the cartel listing, from the folders and from the cartel contracts. We coded this information manually to obtain a proxy for the number of members, and were able to infer it for as many as 520 cartels. The main reason these data were not available appears to be that

the Registry corresponded with an industry association or equivalent, which was either a part of the cartel's organization or which acted on the behalf of the cartel.

Table B2 displays the descriptive statistics for the cartel characteristics, conditional on cartel type and sector.

[Table B2 about here]

Data on additional contract clauses: In order to understand better what cartels contract on, we collected more detailed information on nationwide manufacturing cartels, and chose to include the first cartel(s) in a given 3-digit industry. We concentrate on the first cartel in each industry, because early on, the general attitude and, to an extent, law were somewhat more lenient than during the last years of our sample on what one could contract on, suggesting that the richest contracts were written for these first cartels. This resulted in us going through the folders of 108 cartels in a very detailed manner.[3] For this, we used a semi-structured approach to collect information on 14 further contract clauses.[4] After initial discussions on how to interpret contracts, we first randomly chose eight cartels and had four researchers go through each of them independently. We then checked for any differences in interpretation, and decided on a common approach. We thereafter followed a written protocol with the 108 cartel contracts. We collected the information on the contract that was in force at the time of registration. It is worth noting that in terms of the form (template) of the contracts, there is no clear pattern. Thus, unlike in Austria (private correspondence with Konrad Stahl and Christine Zulehner), registrations were not done through law firms, nor was a standard template used. Table B3 displays the definitions of these 14 additional clauses and Table B4 gives their means, conditional on cartel type and sector.

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[3] Initially, we coded data on 109 cartels, as explained in footnote 1.

[4] See Hyytinen, Steen Toivanen (2007) for details of the coding of contract clauses.

Data on industry/macroeconomic variables: Except for the sector of the cartel, our industry and macroeconomic data come from the database of the Research Institute of the Finnish Economy (ETLA) and Tiainen (1994). We use ETLA's data on industry level characteristics whenever we can, but these data are only available from 1960 to 1990. The data are not consistently available at the 2-digit or 3-digit SIC code -level, so for many cartels we have to use industry data that are aggregated at a higher level (than the 3-digit level, to which the cartels were assigned by the Registry). We use Tiainen's (more aggregated) industry series to chain the ETLA data backwards, until 1955 (i.e., four years before the first cartel was registered). In the final estimation sample, we can distinguish 34 industries, but even at this level, the same aggregate level industry data are used for some industries, especially prior to 1960. The matching of these datasets required a considerable amount of manual work and case-by-case checking. The data on capacity utilisation are available from Tiainen (1994).

The structural industry characteristics are measured and defined as follows:

i)   The *Manufacturing* -indicator is set to one when the cartel's sector is manufacturing and to zero if it is non-manufacturing. The source of the data on the industry classification is the FCA's Registry, which assigned a 3-digit SIC code to each cartel.

ii)   The *B2C* -indicator is set to one when a cartel's industry is such that the primary source of demand is likely to be retail buyers and to zero if the demand comes from industrial buyers. This variable is a crude proxy, but it is similar in spirit to the indicators for the nature of product used by Dick (1996a) and Symeonidis (2018). The indicator is based on our reading of both the descriptions of industry classifications of Statistics Finland and, in some cases, the short case descriptions in the cartel listing of the Registry. We

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have explored the robustness of our key findings to us reclassifying certain industries (cartels) when forming this indicator.

iii) The *Capital intensity high* -indicator is set to one if the long-term capital intensity of a cartel's industry is high relative to the other cartels' industries and is set to zero otherwise. Here we follow Acemoglu and Guerrieri (2008), who classify 18 US industries into two sectors based on the industries' long-term capital intensity. We operationalise our classi-fication by ranking the industries in terms of their long-run capital intensity and by char-acterising as highly capital intensive those industries that are in the top third tail of the distribution. The long-term capital intensity refers to the ratio of an industry's net fixed capital stock to its annual labour hours, measured as an average from 1955 to 1990. We checked that taking such a long-term average is warranted by calculating the capital in-tensity separately for 1955-1970 and 1971-1990 and then checking how correlated the two rankings of the industries are. The correlation between the industry rankings of these two periods is 0.93 (p-value < 0.01). We also checked that the income share of capital (= value added minus total labour compensation divided by value added) is, on average, higher among the industries we treat as capital intensive as compared to those we treat as less capital intensive. In the data available to us, the unweighted average income share of capital over 1955-1990 is 0.59 among the capital intensive industries and 0.48 among the rest. The corresponding medians are 0.61 and 0.45, respectively.

iv) The *Capacity utilisation low* -indicator is set to one when the capacity utilisation of a cartel's industry is low relative to that of the other cartels' industries at the time when the cartels were registered by the Registry. We characterise an industry as having low capac-ity utilisation if it is in the lowest third of the distribution. Capacity utilisation is measured as a five-year average for each cartel's industry, with the measurement window including the year the cartel was registered and the four years preceding it. The raw data for this

variable comes directly from Tiainen (1994, pp. 208). The data were initially available for 1955-1985, but we imputed the missing values for 1986-1990 using dynamic predictions from industry-specific ARMA-regressions.

v) *Industry-growth slow* (*Industry-growth fast*) is set to one when the unexpected industry-growth in a cartel's industry is low (high) relative to that of the other cartels' industries at the time when the cartels' were registered by the Registry. When constructing this variable, we follow Dick (1996b) and Levenstein and Suslow (2011). We characterise as having low (high) unexpected growth those industries that are in the lowest (highest) third of the variable's distribution. The unexpected industry-growth is measured for each industry as a two-year average of the annual deviations of each industry's production from its Hodrick-Prescott -trend (we set the smoothing parameter to 6.25, as recommended by Ravn and Uhlig 2002 for annual data). The measurement window over which the average is calculated includes the year the cartel was registered and the year preceding it.

vi) *GDP-b-fast* (*GDP-f-slow*) is set to one when one when the current anticipated GDP growth is high (low) at the time when a cartel was registered by the Registry. When constructing this variable, we follow Levenstein and Suslow (2011). We characterize a given year as having high (low) current (anticipated) growth if it is in the highest (lowest) third of the variable's distribution. The current GDP growth is measured as a two-year average of a fitted Hodrick-Prescott -trend of the annual GDP growth (we again set the smoothing parameter to 6.25; see Ravn and Uhlig 2002). The measurement window over which the average is calculated includes the year the cartel was registered and the year preceding it. The anticipated near-term GDP growth is measured similarly as a two-year average, but the measurement window over which this average is calculated includes the two years after the cartel was registered.

The other variables, which refer to measurement at the time around the registration, are the following: Year of registration (*YoR*) records the year the cartel was registered. We normalize it to be zero in 1959. This variable allows for a trend-like cohort effect in the types of cartels registered. We also use *Law regime* (initial condition) -variable, which codes in a numerical form the changes in competition law. The variable is a stepwise indicator which grows by one each time the law was changed (towards stringer registration requirements).

Table B5 reports descriptive statistics for the structural industry characteristics.

[Table B5 about here]

Additional References (cited only in the Appendix)

Acemoglu, Daron and Guerrieri, Veronica (2008). Capital Deepening and Non-Balanced Economic Growth, *Journal of Political Economy*, 116(3), pp. 467-498.

Purasjoki, Martti and Jokinen, Juhani, 2001, Expectations, Achievements, and Challenges of Competition Policy, Borenius & Kemppinen 90-anniversary publication [in Finnish].

Ravn, Morten O. and Uhlig, Harald 2002 On Adjusting The Hodrick-Prescott Filter For The Frequency of Observations, *Review of Economics and Statistics*, 84(2): pp. 371–380

Symeonidis, George (2018). Collusion, profitability and welfare: Theory and evidence, *Journal of Economic Behavior & Organization*, 145, pp. 530–545

Tables and Figures to Appendix B

Table B1: Main cartel clauses and classification of cartel types

Panel A: Main clauses in the data	Descriptions of contract clauses
Pricing	= 1 if the contract refers to prices and/or pricing rules.
Payment rules	= 1 if the contract refers to discount rules and/or rules of delivery and payment.
Quota	= 1 if the contract refers to sales or production quotas or market shares.
Area-based	= 1 if the contract refers to exclusive territories, to a home market principle, or local allocation of customers
Non-area -based	= 1 if the contract stipulates that the members are to specialize in one way or the other (e.g. in product space), or agree to "not compete" .
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Panel B: Typology of cartel types	**Classification rule**
Pure pricing (P)	= 1 if (Pricing = 1 and/or Payment rules = 1) and Quota = 0 and Area-based = 0 and Non-area -based = 0
Pure allocation (A)	= 1 if (Area-based = 1 and/or Non-area -based = 1) and Pricing = 0 and Payment rules = 0 and Quota = 0 and
Quota (Q)	= 1 if Quota = 1
Mixed price-allocation (PA)	= 1 if (Pricing = 1 and/or Payment rules = 1) and (Area-based = 1 and/or Non-area -based = 1) and Quota = 0

NOTES: The definitions of the clauses in Panel A are meant to be descriptive of the broad content of each clause. The data contain also other wordings but those have a meaning that is economically similar to what is described in this table. We use term "contract clause" in the meaning of intended or agreed "practice" or dimension in an agreement, not in its strict formal legal meaning.

Table B2: Characteristics of cartels by cartel types

Descriptive statistics

	Number of members		Nationwide	Vertical	Sales or marketing cooperation
Manufacturing cartels	Mode	Median	Share	Share	Share
Pure pricing	4	7	0.94	0.04	0.14
Pure allocation	2	2	0.84	0.13	0.02
Quota	2	3	0.81	0.02	0.52
Mixed price-allocation	2	2	0.79	0.21	0.21
H0: "Cartel types do not differ" (p-value)	-	<0.01	<0.01	<0.01	<0.01
Sample median/means: All manufacturing	-	2	0.85	0.10	0.15
Observations (N)	296	296	364	364	364
Non-manufacturing cartels	Mode	Median	Share	Share	Share
Pure pricing	4	25	0.56	0.05	0.17
Pure allocation	2	2	0.84	0.26	0.04
Quota	2	5	0.73	0.07	0.13
Mixed price-allocation	2	41	0.19	0.10	0.76
H0: "Cartel types do not differ" (p-value)	-	<0.01	<0.01	<0.01	<0.01
Sample median/means: All non-manufacturing	-	18	0.55	0.09	0.25
Observations (N)	224	224	534	534	534

NOTES: The number of members is not available for all cartels. We implement the joint test using a quantile (median) regression for the number of members (standard errors from 100 bootstrap replications); for the others, we use LPM-models (OLS, standard errors clustered at register year). In all models, a dummy for the cartels not having any of the five main clauses is included. The joint tests are F-tests and the reported numbers are p-values.

Table B3: Additional contract clauses

Clause descriptions

Internal stability

Monitoring	= 1 if the contract has a clause on how the members monitor each other.
Enforcement	= 1 if the contract stipulates how to handle situations where a member has deviated or mentions price wars, retaliation, etc.
Expel	= 1 if the contract includes rules on how to expel (exclude) a member if rules are broken.
Fine	= 1 if the contract includes clauses on monetary fines for a company that violates the contract.

Organization

Meeting	= 1 if the contract stipulates whether, and if so, how often, the members are to meet.
Dispute-resolution	= 1 if the contract specifies a way in which disputes among members are to be resolved.
Structure	= 1 if the cartel has a formal structure, such as an association, a limited liability company or other form to organize itself.
Vote	= 1 if the contract specifies a voting procedure.
Sales office	= 1 if the cartel has formed either a trade or a sales association.

External threats

New members	= 1 if the contract specifies a policy on how to accept new members.
Non-cartel supply	= 1 if the contract specifies how to deal with supply from non-member rivals.
Entry	= 1 if the contract stipulates how to react to entrants into the industry.

Production-related

Efficiency	= 1 if the contract stipulates, e.g., that sales and/or production should be allocated according to efficiency.
Technology	= 1 if the contract refers to sharing of technological knowledge such as patents or blueprints.

NOTES: The definitions of the clauses are meant to be descriptive of the broad content of each clause. The data contain also other wordings but those have a meaning that is economically similar to what is described in this table. We use term "contract clause" in the meaning of "intended or agreed practice in an agreement", not in its strict formal legal meaning.

Table B4: Use of additional governance contract clauses

Descriptive statistics

Cartel type	Count	Internal stability				External threats		
		Monitoring	Enforcement	Expel	Fine	New members	Non-cart. supply	Entry
Pure pricing	45	0.20	0.02	0.49	0.09	0.60	0.09	0.02
Pure allocation	34	0.12	0.00	0.09	0.06	0.06	0.79	0.41
Quota	19	0.63	0.53	0.16	0.47	0.37	0.47	0.00
Mixed price-allocation	6	0.00	0.00	0.00	0.00	0.20	0.40	0.00
Nationwide manufacturing cartels (N = 108)		0.24	0.12	0.27	0.15	0.38	0.41	0.15
H0: "Cartel types do not differ" (p-value)		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Observations (N)		108	108	108	108	108	108	108

Cartel type	Count	Organization					Production-related	
		Meeting	Disp. Resol.	Structure	Vote	Sales office	Technology	Efficiency
Pure pricing	45	0.11	0.33	0.71	0.62	0.71	0.02	0.00
Pure allocation	34	0.06	0.76	0.18	0.18	0.09	0.65	0.06
Quota	19	0.11	0.89	0.63	0.58	0.74	0.26	0.32
Mixed price-allocation	6	0.00	0.80	0.20	0.20	0.40	0.20	0.20
Nationwide manufacturing cartels (N = 108)		0.08	0.62	0.50	0.44	0.52	0.28	0.08
H0: "Cartel types do not differ" (p-value)		0.03	<0.01	<0.01	<0.01	<0.01	<0.01	0.06
Observations (N)		108	108	108	108	108	108	108

NOTES: The joint tests are from LPM models, with standard errors clustered by the year of the Registry entry. In all models, a dummy for the cartels not having any of the five main clauses is included. The joint tests of H0: "Pure pricing vs. other cartel types" are F-tests, and the numbers reported are p-values.

Table B5: Descriptive statistics

Structural industry characteristics (initial conditions)	Obs	Mean	Std. Dev.	Min	Max
Manufacturing	898	0.41	0.49	0	1
B2C	898	0.46	0.50	0	1
Capital intensity high	898	0.26	0.44	0	1
Capacity utilisation low	898	0.33	0.47	0	1
Industry-growth slow	898	0.33	0.47	0	1
Industry-growth fast	898	0.36	0.48	0	1
GDP-b-fast	898	0.34	0.48	0	1
GDP-f-slow	898	0.32	0.47	0	1
Year of registration (YoR)	898	13.21	8.51	0	31
Law regime	898	2.24	0.76	1	3

NOTES: This table reports descriptive statistics for the structural industry characteristics, that were measured at the time of registration.

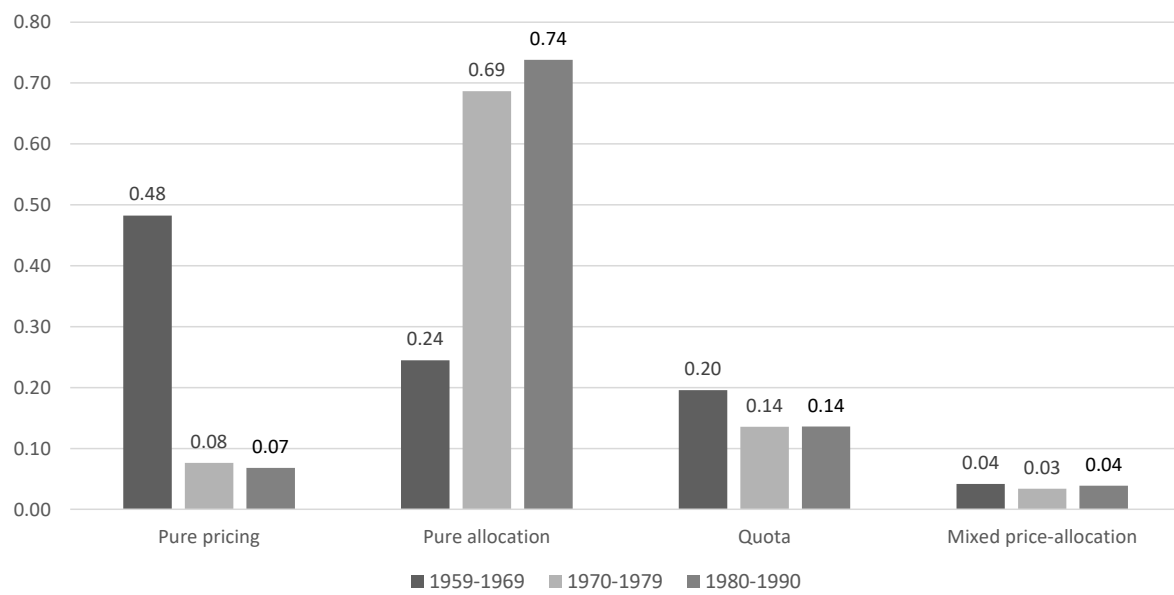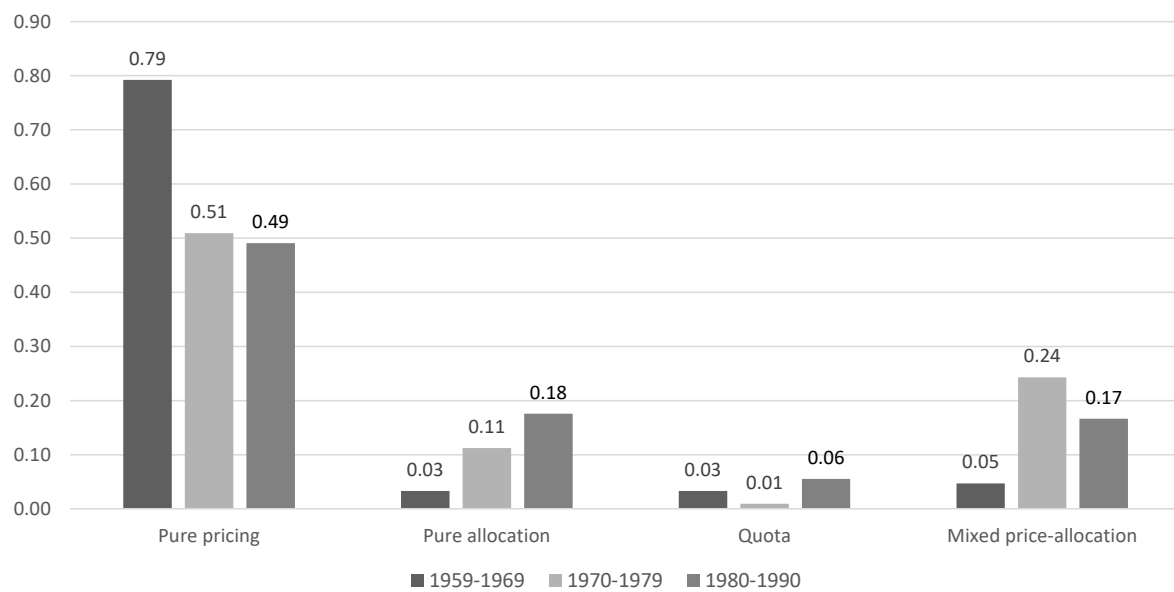**Figure B1**: Types of cartels registered over time in manufacturing

Figure B2: Types of cartels registered over time in non-manufacturing

Appendix C: Examples of cartels

In this appendix, we illustrate the nature of the manufacturing cartels that we have in our data and provide examples of each cartel type in our typology. Table C1 lists the examples and shows which main clauses they have. We give a short description of each below.

[Table C1 here]

Pure pricing cartels

Case #1: The soft drinks and brewing cartel: This cartel was founded in 1944 and registered in 1957. At the time of registration had more than 60 breweries and drink manufacturers as members, located all over Finland (except from Northern Finland). This cartel had a list of recommended prices, which was distributed to members. The list included the sale prices of certain clearly identified soft drinks, sparkling waters, and juices (*Pricing* = 1). Interestingly, some but not all of the members of this cartel were also members of another, related, collusive arrangement, which had fewer members and which coordinated the pricing of brewed drinks and beers. This other arrangement was registered in 1958. The other arrangement included both coordinated price-setting (*Pricing* = 1) and terms of delivery (*Payment rules* = 1). In 1962, the Registry was informed that the price-setting of certain other types of soft drinks and beers was coordinated, too. Apparently, this restriction augmented the earlier two agreements. It moreover seems that in 1978, these separate agreements were in some sense merged, because of the consolidation process in the industry and in the associated industry associations. In 1978, the Registry was informed that the cartel had an oral agreement on practices towards retailers. This arrangement included both prices at the level of cases of bottles and (standardized) bottles (*Pricing* = 1), and rebate tables, terms of delivery and the treatment of transport costs (*Payment rules* = 1).

Case #2: The match producers' cartel: The Finnish match producers' cartel was formed as early as 1927. The cartel was organized around a pricing-committee, which apparently covered almost the entire industry. At the time the cartel was registered in 1961, it had five members. Later also other independent match producers joined it. The cartel agreed on prices, on discounts to both wholesale customers and on cash purchases (*Pricing* = 1). It also agreed on prices of different labels on the boxes and the size of match boxes (*Payment rules* = 1). Thus, even within this relatively homogenous industry, the cartel made an effort to avoid competition in other dimensions than price. As a case in point, the match producers' cartel announced some changes to the earlier agreement that had to do with the pricing of different labels. There also was another, related agreement, which provided a framework for collaboration in the industry and which had almost the same members as those who were involved with the pricing committee. The pricing committee was abolished in 1971, and a new kind of collusive arrangement was introduced. This new arrangement was registered in 1973 and it too focused on coordinating both price-setting and methods of payment and delivery.

Case #3: The book publishing and printing cartel: This cartel was registered in 1967 and it had more than 30 publishers as its members, located mostly in the large cities in Southern Finland. It coordinated the pricing, sales and distribution of Finnish literature and books. While the arrangement had some elements of spatial allocation of sales areas, it explicitly coordinated price-setting of certain types of books (*Pricing* = 1) and restricted allowed rebates and payment and delivery rules, such as cash-discounts, quantity discounts, rates of interest on late payments, allowed methods of delivery, and return policies (*Payment rules* = 1).

Pure allocation cartels

Case #4: The cement cartel: This cartel operated in a homogenous goods market, had two members and was registered in 1959. The cartel has the simplest contract observed by us, as the two cement producers only agreed on geography-based market allocation (*Area-based* =

1): The firms announced that they had agreed to divide Finland geographically, with the smaller firm (whose market share was 35%) concentrating on an area that in the South was round the capital Helsinki, and extended to the North. Both to West and East of this area, as well as North of it was the designated area of the larger member. The reason for this split of the market was the location of production facilities, which allowed each of the two firms to serve easily their own dedicated areas (due to the associated opportunities for lake and sea transportation) but not those of its rival. The production facility of the smaller member was, at the time of registration, located West of Helsinki (in the town of Lohja). The larger competitor had (in 1959) a production facility in the South-eastern town of Lappeenranta, which allowed it to service Eastern Finland with the lowest possible transportation costs (as lake transport was readily available). The other production facility of the larger member was at the time in the South-west town of Parainen on the coast. This location allowed relatively cheap sea transport to the northern port of Oulu and thereby northern Finland was allocated to this member (as the other was not located on the coast).[1] These features of the agreement suggest that in the cement industry, geographic competition is limited. Further correspondence between the Registry and the cartel indicated that the spatially determined market shares remained stable over time. The larger cartel member stated in one of its letters that "*the marketing areas of cement are determined by customer choices, driven largely by transport costs*". It turns out that in separate contracts, given different identification numbers by the Registry, the two firms agreed, in addition, on discounts with their downstream retailers. In effect, they ensured a price-cost margin to their retailers through these contracts without agreeing on a final price for their products.

Case #5: The plywood box cartel: In this cartel, two manufacturers made an agreement whereby one of them ceased the production of plywood boxes altogether (*Non-area based =*

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[1] The firms also produced quicklime with 1959 market shares of 20-50% for the larger firm and 20-40% for the smaller, depending on the type of quicklime.

1). It also committed not to re-enter the business for 15 years, and to neither sell nor allow the use of its machinery. Further, it committed to not reveal its production know-how to any domestic competitor. As compensation the firm continuing production promised to pay a royalty on its plywood box revenues to the firm ceasing production. This arrangement had a flavour of monopoly, as in their correspondence with the Registry, the firms explicitly wanted to state that this agreement did not result in a monopoly in plywood box production.

Case #6: The metal pipes cartel: This cartel was bilateral, involving one Finnish and one Swedish producer. The two members agreed that one of the members ceased the production of some very specific welded stainless steel pipe products (*Non-area based* = 1), and the two firms cooperated in the manufacturing of other products via an arrangement that involved some kind of allocation of geographic operating areas (*Area-based* =1). To support the arrangement, the cartel had an external dispute resolution mechanism (private arbitration). The contract also stipulated restrictions on the cartel members regarding the sale of third parties' products.

Quota cartels

Case #7: The wooden houses cartel: This cartel was founded in 1955 and registered in 1962. It coordinated the manufacturing and sales of houses and other buildings made of wood and closely related materials. It had initially 13 members and each was allocated a quota. The quotas were set separately for exports and the domestic market. The number of members declined for various reasons to 4 by 1971 and then to 3 by 1975, and the quotas were reset accordingly.

Case #8: The pulp cartel: This cartel coordinated the manufacturing and sales of pulp. At the time of registration in 1964, the cartel was one of the larger quota cartels and had 22 members. Each members was allocated a production quota, according to a verbally described rule (*Quota* = 1). The cartel also utilised a sales organization (association), through which sales and pricing to domestic and export markets was apparently coordinated (*Pricing* = 1).

Case #9: The steel furniture cartel: In the steel furniture cartel two producers agreed to specialise by product line (*Non-area-based* = 1) and committed to a quota-like scheme (*Quota* = 1). To this end, the firms agreed to organise sales through a joint sales office (owned by one of the firms; the other firm got a seat on the board of the sales office), and the contract involved mentions on how sales will be allocated. The firms also agreed that the joint sales office would not sell products of third parties. In addition, the firms agreed that they would share blueprints and even patents (the receiving party is not allowed to disseminate the information further).

Mixed price-allocation cartel

Case #10: The cellulose and paper –machines cartel: In this cartel, three manufacturers of pulp and paper machines agreed in 1969 to permanently specialise in manufacturing certain types of paper, paperboard and pulp machines (*Non-area-based* = 1). The members agreed, in addition, that they subcontract from each other as much as possible when one of the members obtains an order, to utilise the collective manufacturing capacity of the members. The prices for these large and expensive machines are a result of long negotiations and complex contracting process. It remains somewhat unclear specifically how and to what extent pricing was co-ordinated in this agreement, but the contract mentions price setting in several occasions (*Pricing* = 1). The contract also includes mentions about the members sharing their technological information.

Table C1: Examples of cartel types

Cartel type	Case	Pricing	Payment rule	Quota	Area-based	Non-area-based
Pure pricing						
Soft drinks and brewing	#1	1	0	0	0	0
Match producers	#2	1	1	0	0	0
Book publishing and printing	#3	1	1	0	0	0
Pure allocation						
Cement	#4	0	0	0	1	0
Plywood box	#5	0	0	0	0	1
Metal pipes	#6	0	0	0	1	1
Quota						
Wooden houses	#7	0	0	1	0	0
Pulp	#8	1	0	1	0	0
Steel furniture	#9	0	0	1	0	1
Mixed price-allocation						
Cellulose and paper -machines	#10	1	0	0	0	1

NOTES: This table reports the five main clauses for the example cases of manufacturing cartels in our data. All the cartels listed in this table are in manufacturing.

Appendix D: Auxiliary analyses and robustness tests

In this appendix, we present a number of additional analyses.

Joint use of main clauses

Table D1 and D2 take a closer look at the joint use of the five main clauses. The tables show that the (correlation) patterns in the joint use are stronger in manufacturing. For example, Table D1 shows that conditional on there being a *Payment Rule* -clause, 80% of the manufacturing cartels have a *Pricing* clause. In line with this, *Pricing* and *Payment Rules* -clauses are positively correlated with each other in manufacturing, with p-value less than 1%. Second, *Area-based* and *Non-area-based* clauses are negatively correlated with the other clauses, especially in manufacturing. As an example, only 2% of the cartels that have an *Area-based* clause have a quota clause. We find much weaker correlations and a couple of very different patterns in

non-manufacturing: For instance, *Pricing* and *Payment rule*s are negatively correlated with each other in non-manufacturing.

[Insert Table D1 and D2 here]

Auxiliary results related to Table 3

Tables D3 and D4 report robustness results for Table 3, whereas Table D5 reports the joint tests mentioned in the main text. For Table D3, we add two law cohort indicators in the models of Table 3. In Table D4, we present results from a Multinomial-logit model. Both tables show that the results are similar to what we report in the main text.

[Insert Table D3, D4, and D5 here]

Auxiliary results related to Table 5

We report in Table 5 of the main text that *Quota* cartels use more complex contracts. In this section, we show that the result also applies in the larger sample of 898 cartels when an alternative way of measuring complexity is used. To this end, we use auxiliary information from the cartel listing which allows us to calculate how many "specific other clauses" the contract had. Here, the other clauses refer for example to mentions and remarks in the contracts about purchase cooperation in the markets for inputs, production cooperation, commitments to be selective in to whom or which products (brands) are sold, sales and marketing cooperation, and other similar (but not so well-defined) forms of interfirm cooperation.

We calculate the following proxies for the complexity of the contract: *Number of main clauses* (= sum of the main clauses displayed in Table 1 of the main text); *Number of other clauses* (= sum of a set of other specific contract features and clauses which the FCA recorded for the entire population of the registered cartels), and *Total number of clauses* (= sum of the main and the other clauses). Panel A of Table D6 reports the unconditional descriptive statistics, whereas Panel B of the table reports the regressions in which we control for the structural industry characteristics (i.e., for the same control variables as those used in Table 5). The table

shows that both conditionally and unconditionally, *Quota* and *Mixed price-allocation* cartels use more complex contracts than *Pure pricing* (or *Pure allocation*) cartels. The number of main clauses is (almost) by design larger for the *Quota* and *Mixed price-allocation* cartels, but as the table shows, the result is obtained also when the number of other clauses is used as the outcome variable.

[Insert Table D6 here]

Tables and Figures to Appendix D

Table D1: Joint use of main contract clauses

Panel A: Manufacturing		Pricing	Payment Rules	Quota	Area-based	Non-area - based
	Mean	0.33	0.22	0.16	0.13	0.52
	95%-CI	[0.22 - 0.43]	[0.14 - 0.30]	[0.11 - 0.21]	[0.06 - 0.19]	[0.38 - 0.66]
	N	119	79	58	46	189
Pricing		-	0.53	0.30	0.04	0.09
H0: Different from the clause mean		-	<0.01	<0.01	<0.01	<0.01
Payment Rules		0.80	-	0.22	0.03	0.14
H0: Different from the clause mean		<0.01	-	0.27	<0.01	<0.01
Quota		0.62	0.29	-	0.02	0.21
H0: Different from the clause mean		<0.01	0.221	-	<0.01	<0.01
Area-based		0.11	0.04	0.02	-	0.37
H0: Different from the clause mean		<0.01	<0.01	<0.01	-	0.06
Non-area-based		0.06	0.06	0.06	0.09	-
H0: Different from the clause mean		<0.01	<0.01	<0.01	0.166	-
Panel B: Non-manufacturing		**Pricing**	**Payment Rules**	**Quota**	**Area-based**	**Non-area - based**
	Mean	0.68	0.23	0.03	0.05	0.22
	95%-CI	[0.59 - 0.78]	[0.15 - 0.32]	[0.01 - 0.05]	[0.02 - 0.08]	[0.14 - 0.30]
	N	365	125	15	26	118
Pricing		-	0.19	0.02	0.05	0.19
H0: Different from the clause mean		-	0.40	0.79	0.97	0.63
Payment Rules		0.57	-	0.01	0.04	0.03
H0: Different from the clause mean		0.04	-	0.02	0.57	<0.01
Quota		0.60	0.07	-	0.53	0.07
H0: Different from the clause mean		0.65	0.05	-	0.02	0.05
Area-based		0.69	0.19	0.31	-	0.23
H0: Different from the clause mean		0.93	0.60	0.05	-	0.93
Non-area-based		0.59	0.03	0.01	0.05	-
H0: Different from the clause mean		0.50	<0.01	0.03	0.95	-

NOTES: This table provides an analysis of the joint use of main contract clauses by sector. The first line of each panel reports the unconditional mean of the clause mentioned in the column and the second and third rows the associated 95% confidence intervals and the number of cartels having the main clause indicated in the column. The last ten rows of both panels report the conditional means: The reported value is the mean of the column clause, conditonal on the row clause being present in the contract. The p-values associated with "H0: Different from the clause mean" refers to the tests of the null hypothesis that the reported conditional mean is different from the sample mean of the column clause (reported in the first row of each panel).

Table D2: Pairwise correlations of main contract clauses

Panel A:Manufacturing (N = 364)

Clause	Count	Pricing	Payment Rules	Quota	Area-based	Non-area-based
Pricing	119	1	-	-	-	-
Payment Rules	79	0.53***	1	-	-	-
Quota	58	0.27***	0.08	1	-	-
Area-based	46	-0.18***	-0.16***	-0.14***	1	-
Non-area-based	189	-0.59***	-0.40***	-0.27***	-0.11**	1

Panel B: Large sample, non-manufacturing (N = 534)

Clause	Count	Pricing	Payment Rules	Quota	Area-based	Non-area-based
Pricing	365	1	-	-	-	-
Payment Rules	125	-0.14***	1	-	-	-
Quota	15	-0.03	-0.06	1	-	-
Area-based	26	0.00	-0.02	0.38***	1	-
Non-area-based	118	-0.10**	-0.25***	-0.06	0.01	1

NOTES: Panel A refers to manufacturing cartels and Panel B to non-manufacturing cartels. The clauses are not mutually exclusive, as a cartel may use many of them simultaneously. The first column in both panels reports the number of cartels using the main clause mentioned on the row. The matrices present pairwise correlation coefficients for the contract clauses. *** = significant at 1% level; ** = significant at 5% , * = significant at 10% level.

Table D3: LPM-regressions of the determinants of cartel types

Explanatory variable	Pure price	Pure allocation	Quota	Mixed price-allocation
		Cartel types		
Manufacturing	-0.236***	0.115*	0.184***	-0.010
	(0.070)	(0.058)	(0.049)	(0.037)
B2C	0.156***	0.001	-0.089***	-0.068***
	(0.032)	(0.024)	(0.021)	(0.024)
Capital intensity high	-0.021	-0.062**	-0.014	0.154***
	(0.039)	(0.029)	(0.036)	(0.042)
Capacity utilisation low	-0.002	-0.071**	0.053	-0.050*
	(0.035)	(0.034)	(0.040)	(0.029)
Industry-growth slow	-0.103**	0.032	-0.009	0.073**
	(0.049)	(0.039)	(0.025)	(0.032)
Industry-growth fast	-0.043	0.030	0.013	0.037
	(0.042)	(0.032)	(0.027)	(0.031)
GDP-b-fast	-0.042	0.044	-0.051**	0.075**
	(0.044)	(0.037)	(0.021)	(0.028)
GDP-f-slow	-0.056	0.068	-0.028	0.004
	(0.046)	(0.060)	(0.031)	(0.032)
Year of registration (YoR)	0.001	-0.011*	0.004	0.008**
	(0.005)	(0.006)	(0.004)	(0.004)
YoR*Manufacturing	-0.008*	0.021***	-0.006*	-0.004
	(0.004)	(0.004)	(0.003)	(0.002)
Law_regime_64_72	-0.211***	0.084	0.013	-0.019
	(0.057)	(0.056)	(0.031)	(0.039)
Law_regime_73_90	-0.352***	0.327**	-0.050	-0.095
	(0.101)	(0.126)	(0.067)	(0.063)
Constant	0.837***	0.048	0.053	0.018
	(0.082)	(0.040)	(0.042)	(0.041)
R2	0.302	0.391	0.101	0.173
Number of observations	898	898	898	898
Joint Chi2-test (within equation, p-values)				
#1 H0: All industry characteristics = 0	<0.01	0.155	<0.01	0.023
#2 H0: All included explanatory variables = 0	0.862	0.030	0.396	<0.01

NOTES: The method of estimation is OLS. The standard errors allow for clustering by the year of registry entry ("year of birth"). Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table D4: Multinomial-logit estimations

	Marginal effect	Std. Err.	z-statistic	p-value
Manufacturing				
Pure pricing	-0.11	0.07	-1.51	0.13
Pure allocation	0.12	0.07	1.67	0.10
Quota	0.13	0.06	2.15	0.03
Mixed price-allocation	-0.06	0.05	-1.11	0.27
B2C				
Pure pricing	0.17	0.03	5.61	0.00
Pure allocation	0.01	0.02	0.58	0.56
Quota	-0.11	0.02	-4.83	0.00
Mixed price-allocation	-0.08	0.03	-2.61	0.01
Capital intensity high				
Pure pricing	0.03	0.04	0.84	0.40
Pure allocation	-0.08	0.04	-2.23	0.03
Quota	0.00	0.02	-0.11	0.91
Mixed price-allocation	0.10	0.02	4.68	0.00
Capacity utilization low				
Pure pricing	0.04	0.04	1.10	0.27
Pure allocation	-0.06	0.03	-1.80	0.07
Quota	0.03	0.02	1.35	0.18
Mixed price-allocation	-0.06	0.03	-2.17	0.03
Industry-slow				
Pure pricing	-0.11	0.05	-2.31	0.02
Pure allocation	0.02	0.04	0.63	0.53
Quota	0.02	0.03	0.87	0.39
Mixed price-allocation	0.05	0.03	1.60	0.11
Industry-fast				
Pure pricing	-0.06	0.04	-1.48	0.14
Pure allocation	0.03	0.03	1.07	0.29
Quota	0.04	0.03	1.62	0.11
Mixed price-allocation	0.02	0.03	0.61	0.54
GPD-b-fast				
Pure pricing	0.01	0.03	0.45	0.66
Pure allocation	0.00	0.03	0.04	0.97
Quota	-0.04	0.02	-1.90	0.06
Mixed price-allocation	0.06	0.02	2.51	0.01
GPD-f-slow				
Pure pricing	-0.09	0.05	-1.94	0.05
Pure allocation	0.11	0.04	2.78	0.01
Quota	-0.04	0.02	-1.88	0.06
Mixed price-allocation	0.02	0.03	0.65	0.51

NOTES: This table reports results from a multinomial logit estimation, estimated by ML. The standard errors are clustered by the year of Registry entry. Log pseudolikelihood = -881.06, and Pseudo R2 = 0.28.

Table D5: Joint tests for Table 3

	Pure price	Pure allocation	Quota	Mixed price-allocation
Joint Chi2-test (within equation, p-values)				
#1 H0: All industry characteristics = 0	<0.01	<0.01	<0.01	<0.01
#2 H0: All included explanatory variables = 0	<0.01	<0.01	<0.01	<0.01
Joint Chi2-test (cross-equation, p-values)				
#1 H0: Manufacturing = 0		<0.01		
#2 H0: B2C = 0		<0.01		
#3 H0: Capital intensity high = 0		<0.01		
#4 H0: Capacity utilization low = 0		0.022		
#5 H0: Industry-growth slow = 0		0.064		
#6 H0: Industry-growth fast = 0		<0.01		
#7 H0: GDP-f-slow = 0		<0.01		
#8 H0: GDP-b-fast = 0		0.107		

NOTES: This table reports joint tests for Table 3, estimated by GMM.

Table D6: Characteristics of cartels by cartel types

Panel A. Descriptive statistics			
	# of main clauses	# of other clauses	Total # of clauses
Manufacturing cartels	Mean	Mean	Mean
Pure pricing	1.46	0.34	1.80
Pure allocation	1.07	0.36	1.44
Quota	2.14	0.84	2.98
Mixed price-allocation	2.64	0.71	3.36
H0: "Cartel types do not differ" (p-value)	<0.01	<0.01	<0.01
Sample median/means: All manufacturing	1.35	0.49	1.84
Observations (N)	364	364	364
Non-manufacturing cartels	Mean	Mean	Mean
Pure pricing	1.20	0.30	1.50
Pure allocation	1.04	0.56	1.60
Quota	2.27	0.87	3.13
Mixed price-allocation	2.09	0.91	3.00
H0: "Cartel types do not differ" (p-value)	<0.01	<0.01	<0.01
Sample median/means: All non-manufacturing	1.22	0.55	1.77
Observations (N)	534	534	534

NOTES: We implement the joint test using LPM-models (OLS, standard errors clustered at register year). In all models, a dummy for the cartels not having any of the five main clauses is included. The joint tests are F-tests and the reported numbers are p-values.

Table D6: (continued)

Panel B: Regression results

	# of main clauses	# of other clauses	Total # of clauses
	LPM	LPM	LPM
Cartel type:			
Pure allocation	-0.22***	0.13	-0.09
	(0.04)	(0.10)	(0.11)
Quota	0.86***	0.51***	1.37***
	(0.14)	(0.12)	(0.16)
Mixed price-allocation	1.02***	0.47***	1.48***
	(0.05)	(0.12)	(0.15)
Control variables	YES	YES	YES
Observations (N)	898	898	898
R2	0.64	0.23	0.38
H0: "Pure pricing vs. other cartel types"	<0.01	<0.01	<0.01
H0: "Structural industry factors"	0.01	0.44	0.39
Unconditional median / mean of dep. var. for Pure-pricing	1.25	0.31	1.56

NOTES: LPM-models are estimated by OLS, with the standard errors clustered by Registry year. Control variables are indicators from Manufacturing, B2C, Capital intensity high, Capacity utilisation low, Industry-growth slow, Industry-growth fast, GDP-b-fast, GDP-f-slow and Year of registration (YoR). In all models, a dummy for the cartels not having any of the five main clauses is included. Statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The joint tests are F-tests and the reported numbers are p-values.