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Cartel Detection in Procurement Markets

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Non-technical summary

Cartel detection is usually viewed as a key task of either competition authorities or compliance officials in firms with an elevated risk of cartelization. We argue that customers of hard core cartels can have both incentives and possibilities to detect such agreements on their own initiative through the use of market-specific data sets. We apply a unique data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers and show that a price screen – if it had been available at the time – would have allowed particularly larger customers to detect the upstream cement cartel *before* the competition authority. The results not only suggest that monitoring procurement markets through screening tools has the potential of substantial cost reductions – thereby improving the competitive position of the respective user firms – but also allow the conclusion that competition authorities should view customers of potentially cartelized industries as important allies in their endeavour to fight hard core cartels.

Das Wichtigste in Kürze

Die Aufdeckung von Kartellen wird üblicherweise als Aufgabe von Wettbewerbsbehörden oder Unternehmen mit einer erhöhten Neigung zur Kartellbildung angesehen. In diesem Arbeitspapier argumentieren wir, dass Kunden von bestehenden Kartellen sowohl Anreize als auch Möglichkeiten haben können, erste Indizien für eine Aufdeckung solcher Absprachen zu sammeln und zwar unter Zuhilfenahme marktspezifischer Datensätze. Wir nutzen einen Datensatz bestehend aus rund 340.000 Rechnungspositionen von 36 größeren und kleineren Kunden deutscher Zementhersteller und zeigen, dass ein Preismonitoring-Instrument es insbesondere größeren Nachfragern – bei einer seinerzeitigen Verfügbarkeit der entsprechenden Daten und Methoden – erlaubt hätte, erste Indizien für das im Beschaffungsmarkt bestehende Kartell zu sammeln und zwar *vor* der öffentlichen Aufdeckung des Kartells durch die Wettbewerbsbehörde. Unsere Ergebnisse legen nicht nur ein signifikantes Kostensenkungspotential – verbunden mit den korrespondierenden Wettbewerbsvorteilen – durch die Beobachtung von Beschaffungsmärkten mit Hilfe von Preismonitoring-Instrumenten nahe, sondern erlauben auch die Schlussfolgerung, dass Wettbewerbsbehörden die Kunden von potentiell kartellierten Industrien als wichtige Alliierte im Kampf gegen Kartelle ansehen sollten.

CARTEL DETECTION IN PROCUREMENT MARKETS

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Abstract
Cartel detection is usually viewed as a key task of either competition authorities or compliance officials in firms with an elevated risk of cartelization. We argue that customers of hard core cartels can have both incentives and possibilities to detect such agreements on their own initiative through the use of market-specific data sets. We apply a unique data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers and show that a price screen would have allowed particularly larger customers to detect the upstream cement cartel *before* the competition authority. The results not only suggest that monitoring procurement markets through screening tools has the potential of substantial cost reductions – thereby improving the competitive position of the respective user firms – but also allow the conclusion that competition authorities should view customers of potentially cartelized industries as important allies in their endeavour to fight hard core cartels.

Keywords Business economics, procurement, antitrust policy, cartels, detection, screening

JEL Class D24, L41, L61, M11, M21, K21

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1 Introduction

There is no question that the fight against hard core cartels is ranked high on the agenda of competition authorities these days. The recent efforts of, e.g., the European Commission, are not only reflected in policy reforms such as new fining guidelines or the introduction of a leniency program but have already materialized in the form of an improved anti-cartel enforcement record. While the European Commission decided only 10 cartel cases in the 1995-1999 period, the number increased to 30 in the period from 2000-2004 and to 33 in the 2005-2009 period.[1] The enforcement records in other jurisdictions such as the United States or Germany show comparable developments.

Despite the identified significant increase in the number of detected hard core cartels, empirical evidence suggests that a large fraction of the existing hard core cartels remain undetected. Although admittedly difficult to estimate, studies by Combe, Monnier and Legal (2008) for the European Union and Bryant and Eckard (1991) for the United States come to the conclusion that the average annual probability of cartel detection lies between 12.9 percent and 15 percent. Although recent policy changes are likely to have a promoting effect, there is no clear indication that a substantial increase in these probabilities of detection has taken place in recent years.

From a firm perspective, these results immediately suggest that a substantial fraction of customers of undetected cartels face elevated cost levels in the sourcing of their input goods. Depending on firm-specific factors such as the cost share of the respective input good or the possibilities to pass-on cartel overcharges through higher downstream prices, firms can have *incentives* to detect cartels in procurement markets – not only due to a potential reduction of the costs of the respective input good but also due to a corresponding increase in their competitiveness in downstream markets. Furthermore, the availability of detailed transaction data together with a profound knowledge of the respective industry leaves customers of cartelized industries with *possibilities* to proactively detect such conspiracies.

Against this background, we develop a market screening approach that could be applied by customers of potentially cartelized industries to analyze procurement markets based on their own invoice information. In a first step, we apply structural break analysis to detect anomalies in the data. In a second step, we use multivariate pooled and static panel estimation approaches to investigate whether the observed structural breaks could be related to the existence of a cartel. We test the accuracy and effectiveness of the proposed screening tool by applying a unique data set of about 340,000 market transactions from 36 smaller and larger

customers of German cement producers.[2] We show that alternative screening approaches would have allowed particularly larger customers to detect the upstream cement cartel *before* the competition authority. The results not only suggest that monitoring procurement markets through screening tools has the potential of substantial cost reductions – thereby improving the competitive position of the respective user firms – but also allow the conclusion that competition authorities should view customers of potentially cartelized industries as important allies in their endeavour to fight hard core cartels.

The paper is organized as follows. The subsequent second section provides an overview of the existing literature with respect to the detection of hard core cartels. In addition to the activities of competition authorities, recent contributions on detection possibilities for firms with an elevated risk of cartelization (as part of their compliance programs) are summarized, complemented by a discussion of both incentives and possibilities of customers of cartels to proactively detect these conspiracies. The third section provides brief overviews of the cement market in general and the latest German cement cartel in particular. This industry knowledge is an important precondition for the presentation of our empirical analysis in the fourth section. Following an introduction to the applied public and private data sets, the section concentrates on the development, execution and discussion of our market screening approach consisting of (a) structural break analysis and (b) multivariate regression analysis. Section 5 concludes the paper with a review of the key results and the development of important conclusions for both business strategy and antitrust policy.

2 The detection of hard core cartels

Hard core cartels are typically defined as "… a group of firms who have agreed explicitly among themselves to coordinate their activities in order to raise market price – that is, they have entered into some form of price fixing agreement" (Pepall et al., 1999), p. 345). The types of agreement that typically lead to such an increase in market price include not only price fixing agreements in the literal sense but also bid-rigging, output restrictions and quotas, allocation of customers, suppliers, territories and lines of commerce. Hard core cartels typically cause harm in the form of allocative, productive, and dynamic inefficiencies and are therefore prohibited on a per-se basis by the competition laws in most countries, i.e. the competition authority only has to prove that the cartel agreement existed and must not show that the harm caused exceeded potential benefits for consumers or society.

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1 Data source: European Commission (2010), Cartel Statistics (situation as of 19 May 2010), available at http://ec.europa.eu/competition/cartels/statistics/statistics.pdf

2 Please note that 'smaller' and 'larger' customers are delineated on the basis of their respective demands of the cartelized input good and not by their absolute firm sizes.

The academic discussion on the detection[3] of hard core cartels is often restricted to competition authorities, recently complemented by first attempts to extent the detection task to firms with an elevated risk of cartelization. In the following we review the existing research for both groups complemented by the delineation of a third group which can have both incentives and possibilities to proactively detect cartels: customers of cartelized industries.

2.1 Competition authorities

It has long been recognized that competition authorities can make use of various methods to detect hard core cartels. Generally, these methods can be separated into reactive methods and proactive methods. According to the International Competition Network (2010), important reactive methods are complaints (filed, e.g., by competitors or employees), other external information (e.g., through whistleblowers or informants) and leniency applicants. Complementary to these reactive methods, several proactive methods can be applied to detect cartels. In addition to the general analysis of past cartel or other competition cases, competition authorities can, e.g., monitor press and internet or stay in regular contact with both industry representatives and foreign competition authorities to increase the probability of cartel detection. Last but not least, both researchers and authorities have recently joined in an intensive discussion on the potential role of an explicit use of economic insights and tools to proactively detect cartels. For example, economics can play a role in the form of the study of collusion factors across industries, the conduct of market/industry studies or the implementation of screening tools.

Although all reactive and proactive methods are of possible relevance for a competition authority, we restrict our review of the literature to the so-called screening tools. Generally, screening tools use "… data such as prices, costs, market shares, bids, transaction prices, spreads, volumes, and other data … [t]o identify patterns that are anomalous or highly improbable" (Abrantes-Metz et al. (2011), p. 3). Although a substantial variety of different screening approaches has been developed by academics and practitioners (see, e.g., Abrantes-Metz and Bajari (2009) or Harrington (2008)), they can roughly be subdivided into more general industry-based structural screening approaches and more specific market-based behavioral screening approaches. The former set of approaches differs from the latter through a preceding structural screening to identify industries with an elevated probability of

[3] Please note that we define 'detection' as the gathering of first significant evidence that a cartel agreement might exist. However, this evidence must be complemented by more concrete proofs obtained by, e.g., dawn raids of the competition authority to prove cartel existence in court.

cartelization.[4] In the second step, this set of suspicious industries is investigated further through the application of market-based behavioral screening approaches.

Generally, market-based behavioral screening approaches focus on the market impact of cartelization. Following Harrington (2006b, p. 3), "suspicions may emanate from the pattern of firms' prices or quantities or some other aspect of market behavior". The approaches aim at investigating whether the firms' (re)actions to the observable structural breaks (e.g., caused by cartel price wars) or exogenous shocks (e.g., caused by changes in input costs) are consistent with competitive behavior or whether it might better be explained by some kind of collusive model (see, e.g., de Roos, 2006).

In general, various different collusion markers can be applied to distinguish between collusive market behavior and competitive market behavior. For example, Harrington (2006a, 2006b) differentiates between price-related collusive markers and quantity-related collusive markers. Examples of the former group are either a series of steady price increases which are preceded by steep price declines or a higher list price combined with a reduced variation in prices across customers. An example of the latter group is highly stable market shares over a longer time period.

In the remainder of this section, we concentrate on one specific price-related collusive marker that recently gained importance: price variance. From a theoretical perspective, such a marker is justified by the expectation that price variance is reduced during a conspiracy because, for example, frequent adjustments of cartel agreements are costly and would complicate the detection of (individual firm) deviations from the cartel agreement. Hence, it can be expected that the transition from a cartel state to a non-cartel state is characterised by an increase in price variance (and vice versa).

Existing empirical research supports this general reasoning. Abrantes-Metz et al. (2006) (re)investigate price movements over time around the collapse of a bid-rigging conspiracy among seafood processors in the United States (with respect to supplying seafood to military installations). The authors find that in the case of frozen perch fillets, the average weekly price decreased by about 16% after the collapse of the cartel, while the standard deviation of price increased by 263%. Furthermore, Esposito and Ferrero (2006) investigate data of two Italian cartel cases with respect to the question whether a variance screen would have successfully detected the conspiracies. The authors conclude that in both cases – motor fuel and baby food products – such a screen would have detected the conspiracies. Finally,

[4] The practical implementation of structural screening approaches experienced substantial problems due to the use of highly aggregated industry data following Standard Industrial Classifications (SIC) which hardly have any relationship to antitrust markets.

Bolotova (2005) found for the lysine price-fixing conspiracy that the price variance decreased significantly during the cartel period.

Given this general description of proactive detection tools in general and (price variance) screening tools in particular, the discussion of the incentives and possibilities for competition authorities to detect cartels and to apply screening tools are straightforward. With respect to the *incentives*, the detection of hard core cartels is one of the key objectives and justification for the existence of competition authorities. Although theoretical research suggests that internal cartel stability is endangered by the deviation incentives of individual cartel members, empirical evidence shows that firms have been able to stabilize cartels over long time periods (see generally Levenstein and Suslow, 2006). As a consequence, competition authorities have to work on ways to reduce the number of existing cartels and to foreclose the formation of new cartels.

With respect to the *possibilities* to detect cartels, competition authorities have certain key advantages in gaining information on the alleged conspiracy. For example, authorities can set incentives for cartelists to report wrongdoings through leniency programs. Complementary, and even more important, competition authorities can make use of the instrument of dawn raids to gain further evidence on an alleged conspiracy and to therefore increase the probability that a court will later confirm the existence of the cartel (and impose the respective corporate fines).

2.2 Firms with an elevated risk of cartelization

Complementary to the detection of cartels by competition authorities, recent contributions discuss to what extent screening tools can be included in antitrust compliance programs of firms with an elevated risk of cartelization[5] (see especially Abrantes-Metz et al. (2010)). Focusing on the *incentives* to proactively detect cartels first, the key drivers are basically the consequences of cartels detected by competition authorities. Although there is substantial variation in the dimension of the various consequences between jurisdictions, the general categories include corporate fines, individual sanctions, damages, litigation costs and counsel fees, effects on stock prices and effects on firm reputation. By detecting hard core cartels in-house before the competition authority receives knowledge on the existence of the cartel leaves the firm the possibility to react by terminating the cartel and either (a) build on the hope that the competition authority will not detect it at a later point or (b) disclose the

[5] In practice, cartel agreements are often implemented by product managers rather than the general 'top' management. However, as the general management is held responsible for breaches of antitrust laws and the attached consequences, they typically have incentives to detect and deter in-house cartel formation through the introduction of compliance programs.

existence of the cartel to the authority and receive a reduction or exemption from (corporate) fines as part of a leniency program. Additionally, the implementation of proactive cartel detection methods as part of internal compliance programs has an additional deterrence effect on new cartel formation (as soon as internal managers have to expect punishments by their respective employers).

With respect to the *possibility* to proactively detect cartels, the first impression might be that firms have reduced possibilities to detect hard core cartels compared to competition authorities, e.g., given the absence of instruments such as the implementation of a leniency program or the execution of dawn raids. However, although this argument is certainly valid on a general level, a firm may ensure compliance with competition law in-house through both internal dawn raids and the implementation of internal leniency programs. Furthermore, and even more important, the availability of detailed transaction data and a profound knowledge of the respective industry leaves the firm with a substantial information advantage which increases both the probability to detect a cartel in general and the accuracy of screening tools in particular.

2.3 Customers of cartelized industries

Complementary to competition authorities and firms with an elevated risk of cartelization, a third group typically has both possibilities and incentives to detect cartels proactively: the customers of cartelized industries. The potential relevance of this third group for the detection of cartels has been discussed in the academic literature before, however, solely from the perspective of (public) procurement auctions (see generally Bajari and Summers, 2002). For example, Bajari and Ye (2003) develop an approach to identify and test for bid rigging and subsequently apply it to a data set of bidding by construction firms in the Midwest of the United States. Further seminal contributions include Porter and Zona (1993, 1998) or more generally OECD (1998).

Apart from the specific focus of detecting collusion in procurement auctions, the existing literature is silent on the more general possibilities and incentives for customers of cartelized industries to proactively detect these conspiracies. The *possibilities* of customers to proactively detect cartels in procurement markets generally and with an application of screening tools in particular depend on various factors. First, as already described in the preceding section, customers can not only be expected to have a profound knowledge of its procurement markets but especially have detailed transaction based data in the form of invoices available in their (cost) accounting systems. This data can be used to particularly apply screening tools such as variance screens described above. However, in anticipation of

our empirical analysis below, the accuracy and effectiveness of such tools typically depend on factors such as the time of entry in the respective procurement market, the frequency and size of purchases of the cartelized good and the behavior of the cartel. For example, a variance screen will struggle to detect a cartel if it was already existent at the time of entry in the procurement market and no type of deviation (causing a structural break in the data) occurs afterwards.

With respect to the *incentives* to proactively detect cartels in procurement markets, economic theory suggests the question why customers of a cartel do not immediately react to the formation of a cartel with the formation of a coalition which aims at prompting the cartel members to end their agreement. If such a reaction would work frictionless, all cartel activity would be deterred automatically. However, in a world with positive transaction costs and incomplete information, the incentives of customers to form such coalitions might be reduced significantly. For example, the larger the number of customers of a cartel the more diverse the respective interests and the more relevant are free-rider problems. Both arguments speak against the practicability of such proposals as an effective deterrent against cartelization (see, e.g., von Weizsäcker, 1995: 2736f.). In other words, the existence of transaction costs and incomplete information suggests that the stakes for customers must be high enough to start activities to proactively detect cartels. The size of the stakes is a direct function of factors such as the cost share of the respective cartelized input good, the size and frequency of purchases, the possibilities of firms to produce the respective input good in-house, the competitive situation in downstream markets (which determine pass-on possibilities) or, last but not least, the competitive position in the own market (which might be threatened, e.g., by direct competitors which are vertically integrated with members of the upstream cartel).

Even if several or all key drivers are present, one might still argue that it is sufficient for the private firm to wait for a competition authority to detect the respective cartel und to sue for damages in the aftermath of public enforcement. For several reasons, such a strategy is unlikely to be the optimal choice. First, damages trials take time and use substantial amounts of in-house resources which could be used in a more productive fashion otherwise. Second, and even more important, competition authorities only detect a fraction of existing cartels. Although admittedly difficult to estimate, studies by Combe, Monnier and Legal (2008) for the European Union and Bryant and Eckard (1991) for the United States come to the conclusion that the average annual probability of cartel detection lies between 12.9 percent and 15 percent. As a consequence, there surely is no certainty whatsoever that the competition authority will detect the cartel in the near future and the respective customers will have the

possibility to sue for damages. Last but not least, internal codes of conduct often force managers to handle the firms' resources with care. Therefore, managers might be obliged to follow a potential cost saving potential through the detection of cartels in procurement markets.

Given this review of the existing literature together with a discussion of the incentives and possibilities to proactively detect cartels, we contribute to the existing literature in two important ways. First, we show for the case of the German cement cartel, that if the screening tools had been available at the time, then the larger customers in particular, could have been able to detect the cartel through the application of screening tools *before* the competition authority. These results confirm the potential value of screening tools for firms if they are correctly applied to a rich data set. Second, our results more generally suggest that competition authorities should view customers of potentially cartelized industries as important allies in their endeavour to fight hard core cartels.

3 The cement market and the German cement cartel

An important precondition for a robust econometric analysis of the detection of a hard core cartel is a profound understanding of both the respective market in general and the cartel agreement in particular. As a consequence, this section concentrates on, first, an overview of the key economic characteristics of the cement market, and second, a characterization of the latest German cement cartel.

3.1 The cement market

Cement can broadly be defined as a substance that sets and hardens independently, and can bind other materials together. Cement used in construction is largely so-called hydraulic cement that hardens when the anhydrous cement powder is mixed with water. Although cement is usually seen as a homogenous product, the current European standard EN 197-1 for common cements defines no less than 27 different cement types. However, a large fraction of the cement sales in most European countries refer to the so-called CEM I cement which contains only Portland cement clinker and no other possible constituents such as blastfurnace slag, natural pozzolana, siliceous fly ash, burnt oil shale or limestone.

The cement production process can be subdivided into three main steps: the preparation of the raw mixture, the production of the clinker and the preparation of the cement. Cement producers tend to locate near the most important raw material source (which typically is lime). The production of the clinker through heating in a cement kiln is not only quite inflexible (in the sense that the costs per unit increase quickly with a reduction in capacity utilization) but is

also particularly energy-intensive (which is why cement producers have started to (partly) replace clinker by other constituents during the final step of the preparation of the cement). In general, production characteristics suggest that high start-up costs are incurred with entry into the cement market, e.g. due to the necessary access to lime resources or the installation of production plants and mills.

The most common use for cement is in the production of concrete. Concrete is especially used in the construction industry either through the factory production of pre-cast units (such as panels, beams or road furniture), or through so-called 'cast-in-place' concrete needed for the construction of building superstructures, roads or dams. Given the seasonality of the construction business (with peaks in the summer months and a reduced activity in the winter months) cement demand follows comparable trends in most European countries.

In the sale of cement, transportation costs are a significant fraction of overall costs. This might suggest that the relevant geographical markets are more local. However, various decisions in cartel and merger cases (e.g., by the European Commission) confirmed that cement is also profitably delivered over longer distances. The Commission concluded in this respect that the "relevant market is therefore Europe, made up of an overlapping pattern of interdependent markets."[6] Given such interdependence, cartel agreements are often intended to allocate the overall market. As a consequence, a largely local pattern of deliveries cannot necessarily be attributed to economic constraints to long distance deliveries.

The general tendency of cartelization of cement markets can be explained by the presence of various factors that ease the implementation and stability of collusive agreements. For example, cement markets are typically characterized by a low number of cement producers, a relatively homogenous product, high market entry barriers and a rather inflexible production process. Interestingly, the assumed vulnerability for cartelization is not only supported by theoretical arguments but also reflected in the cartel enforcement record. In addition to the detected German cement cartel characterized in the following section, cement cartels have been identified and punished on the European level (e.g. European Commission, 1994)[7] and on the national level, such as in Norway, Sweden, France, Poland, India or the United States of America to name only a few.

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[6] European Commission (1994), *Commission imposes fines on a cement producers' cartel*, Press release on 30 November 1994, available at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/94/1108&format=HTML&aged=1&language=EN&guiLanguage=en

[7] See European Commission decision of *Cembureau*.

3.2 The German cement cartel[8]

In summer 2002, the German Federal Cartel Office (FCO) announced the alleged existence of a hardcore cartel in the German cement market. In the course of the investigation, it was found that a large number of German cement producers divided up the German market by a quota system at least since the early 1990s. Following its detailed investigation, the FCO found substantial supra-competitive proceeds due to elevated cement prices and imposed overall fines of about EUR 702 million with EUR 606 million referring to the six largest German cement producers Dyckerhoff AG, HeidelbergCement AG, Lafarge Zement GmbH, Readymix AG, Schwenk Zement KG und Holcim (Deutschland) AG.

The existence of the cartel was disclosed to the FCO under the German leniency program by the cartel member Readymix AG. The Higher Regional Court in Düsseldorf confirmed the illegal cartel agreements in its decision of 26 June 2009, however, reduced the fine level to a sum of 329 million EUR due to partly insufficient data. Fines totaling € 70 million became effective prior to the decision of the Higher Regional Court, because some cartel members did not appeal the decisions relating to those fines.

The proved existence of the cartel suggests that customers paid elevated prices for cement and were therefore harmed substantially. This assumption is supported by the substantial drop in the public price index for cement shown in Figure 1.

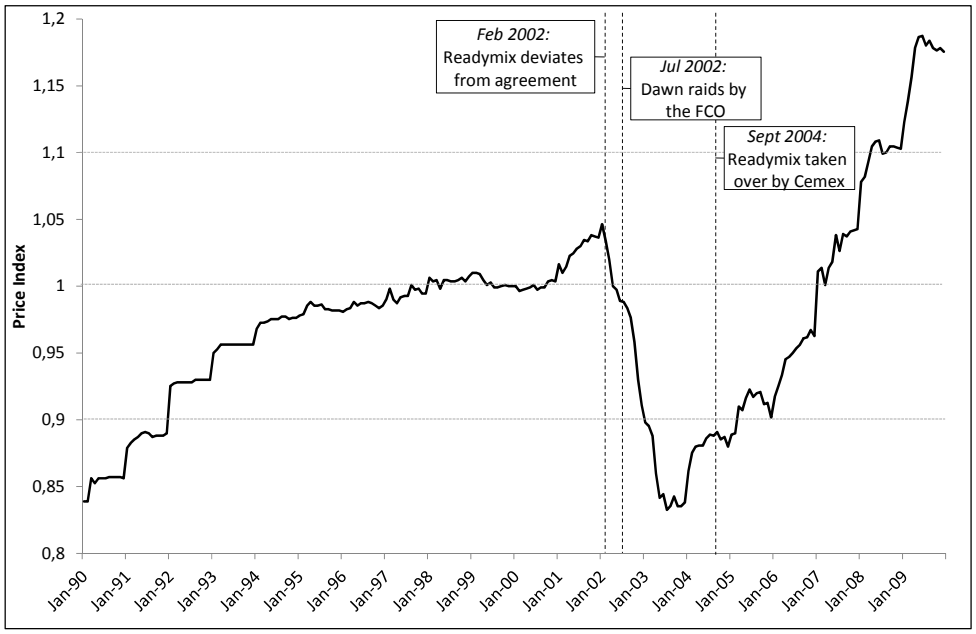

Figure 1: The public price index for cement from January 1990 to December 2009
Source: Own graph following Friederiszick and Röller (2010), p. 599

[8] This section largely follows Friederiszick and Röller (2010).

In addition to the general development of the public cement price index from January 1990 to December 2009, Figure 1 also marks key stages of the detection and prosecution of the cement cartel. The first indication of the cartel breakdown must be seen in the announcement of Readymix (in November 2001) to start replacing deliveries of other cartel members to its subsidiary concrete producers downstream with its own cement. The implementation of this announcement in February 2002 led to an increase in the (agreed) quotas for Readymix and was therefore interpreted as deviation from the agreement by the other cartel members. The official investigation of the alleged cement cartel started on 4 July 2002 with dawn raids by the FCO on the premises of 30 cement companies in Germany.[9]

During the hearings before the Higher Regional Court, it was heavily discussed how the substantial drop in the price index after the disclosure of the cartel must be interpreted. Although a price drop as such is naturally expected after a cartel breakdown, it was argued by the defendants that the price drop was partly caused by a price war, i.e., the observed price decrease cannot be interpreted as the competitive level but a level below that. Eventually, the court identified the acquisition of cartel breaker Readymix by Cemex as crucial event for the derivation of the but-for price, partly because the cement price index increased substantially in the aftermath of this event.[10]

Independent of the question how the competitive but-for price is derived, it is obvious that the cartel caused substantial harm among customers in the form of higher prices for cement. The business concept of Cartel Damage Claims (CDC) in this respect is to purchase damage claims of cement customers and to enforce them on its own against the cartel, using its economic and technical know-how. In order to be able to prove and quantify the harm, CDC has collected around 340.000 market transactions from 36 customers of cement companies. This data provides the basis of our empirical analysis described in the following section.

4 Empirical analysis

Cement markets have recently attracted significant empirical research from various innovative perspectives. For example, Röller and Steen (2006) study the workings of a Norwegian cement cartel and show that the cement cartel has been ineffective in the sense that the sharing rule induces ‘overproduction’ and exporting below marginal costs. Furthermore, Hortaçsu and Syverson (2007) use a rich data set of cement and ready-mixed concrete plants

[9] Source: Press release of the German Federal Cartel Office on 8 July 2002, ‘Searches conducted in companies in the cement sector’ available at www.bundeskartellamt.de/wEnglisch/News/Archiv/ArchivNews2002/2002_07 _08.php (last accessed on 12 September 2011).

in the United States to empirically investigate the possible market power effects of vertical integration. The authors find evidence that integrated producers' productivity advantage is tied to improved logistics coordination afforded by large local concrete operations. Interestingly, this benefit is not due to firms' vertical structures per se: non-vertical firms with large local concrete operations have similarly high productivity levels.

In this section, we aim to contribute to this cement-related empirical literature by adding a further innovative perspective: the possibilities of customers to use invoice data to detect cartels in procurement markets. After a brief description of the underlying public and private data sets in the following section, Section 4.2 concentrates on the development, execution and discussion of our market screening approach consisting of (a) structural break analysis and (b) multivariate regression analysis.

4.1 Description of the data sets

Firms typically have access to various sources of data which can potentially be used to detect collusive agreements. While public information often is available from statistical offices, industry associations or independent data trading companies regularly provide additional market information (partly based on publicly collected data). While public information is typically provided (almost) for free, it often faces the key disadvantage of a high level of aggregation which masks many potentially important market developments. Partially-public data partly solves this issue; however, the purchase of these data sets is often expensive (especially for smaller firms).

Besides these public or partially-public data sources, firms have access to private data from their own sourcing activities, such as invoice documents, contract offers or scheduled price information. Compared to public and partially-public data, this data has the two key advantages of (a) being very detailed, and (b) being readily available (at very low cost) due to the existing (cost) accounting systems. For the German cement market and the German cement cartel, we are in the unique position to have both public and private data sets described in the following. As public data has been repeatedly used in both academic studies and court investigations, we start with a comparison of public and private data to provide an intuition how both data sets relate to each other.

[10] It is important to note that the decision of the Higher Regional Court refers to public enforcement only (following criminal law standards), i.e. its decisions are not binding for the ongoing private enforcement lawsuit (following civil law standards).

4.1.1 Public data set

The public data set is continuously collected by the German Federal Statistical Office (FSO). Major German cement producers are provided with a standardized internet-based questionnaire and asked (on a voluntary basis) to provide overview information (including prices, quantities and qualities) on one representative CEM I sale activity close to the date of data collection (which is the 15th of a month). As this data collection approach is highly standardized and used across a larger number of (cartelized and non-cartelized) firms, it offers possibilities for strategic behavior, e.g., with respect to the choice of the invoice handed over by the addressed firms to the FSO. Furthermore, the FSO only collects gross price data that ignores factual price reductions through the granting of rebates.

4.1.2 Private data set

Besides public data, we are able to use private data collected by Cartel Damage Claims (CDC) based in Brussels. The raw data consists of about 340,000 market transactions from 36 smaller and larger customers of German cement producers, both cartelist and non-cartelist.[11] Market transactions include information on delivered quantities, cancellations, rebates, early payment discounts or free-off charge deliveries. Based on this raw data, the private data set was constructed which includes detailed information on gross prices, quantities, provider, trader, cement type or places of deliveries.

We especially used information on cement types, providers and places of deliveries for data adjustments and the aggregation procedure.[12] In particular, (gross) prices were adjusted to monthly average prices using alternative aggregation methods. Standard trucks are able to carry up to 30 tons of cement of a particular type. Due to transportation capacity restrictions we repeatedly find identical invoices within days which show that a particular place of delivery was provided with a larger quantity under the given price structure. In contrast, between-day comparisons show nearly no such consistencies. Based on these findings, our standard aggregation approach follows a two-step procedure where we first aggregate daily information based on cement type, place of delivery, provider and customer. Afterwards, we aggregate the resulting data to a monthly database depending on the required information for further analysis. When using absolute values we deflate prices before aggregation using a public lime index as it is highly correlated with the public cement index (99 percent for the observation period until the end of the cartel, 95 percent until 2008) but does not follow the downward trend after the cartel breakdown.

[11] For confidentiality reasons, data was aggregated and used in an anonymous form.

4.1.3 Comparison of public and private data sets

Given the description of the public and private data sets, Figure 2 provides a comparison of the public price index and the price index calculated from private data (upper graph) and month-by-month relative price changes (lower graph). The base period for all indices is January 2000.

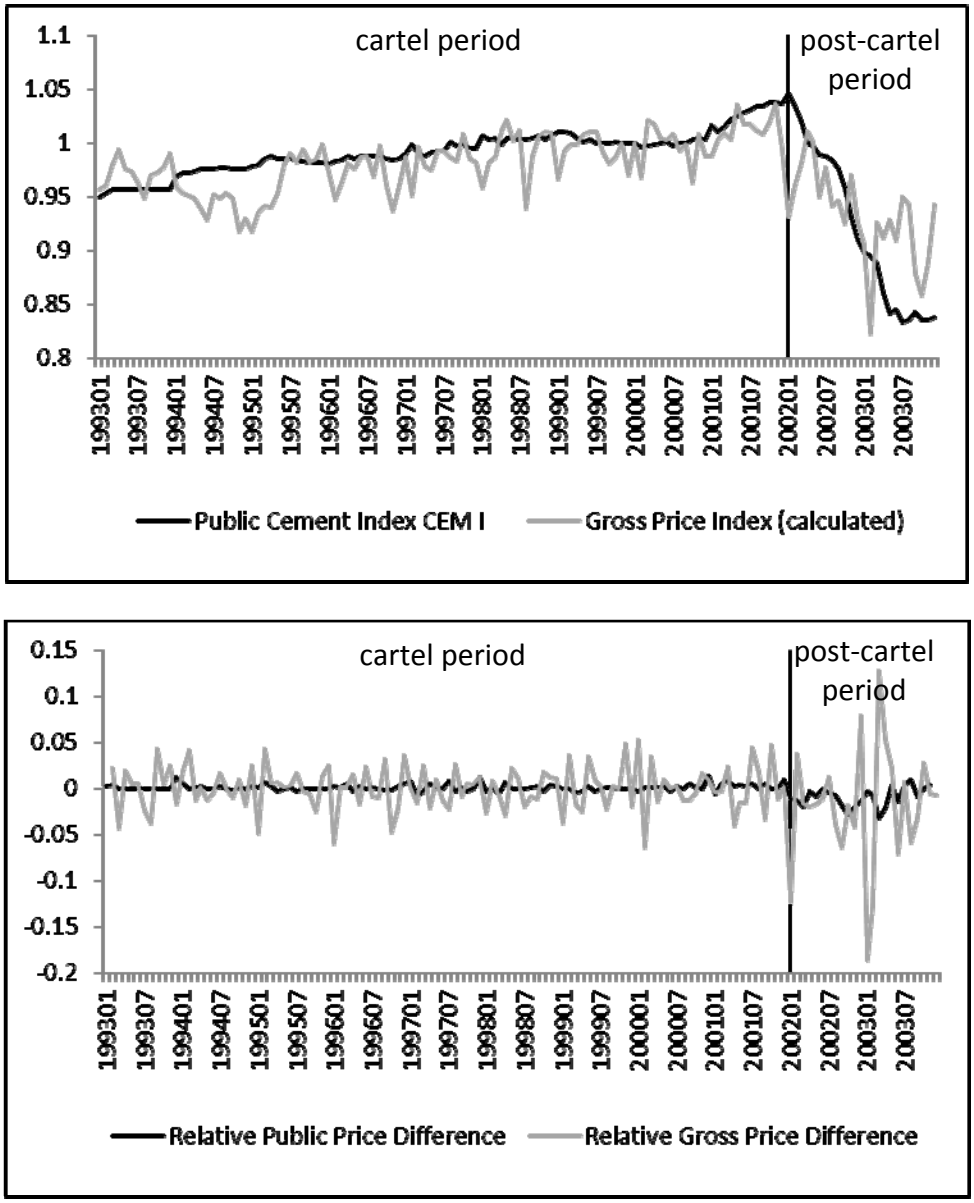

Figure 2: Comparison of public and private price indices

Source: Own calculations based on public and private price data; Base period: January 2000.[13]

As revealed by Figure 2, the upper graph shows a close relationship between the public and the private price indices. The moving-average development of the public index is highly

[12] We focus on CEM I cement as, first, substitution is hardly possible across different cement types and, second, CEM I makes up by far the largest share of total cement demand in the data set (about 73 percent).

[13] Please note that public price data is available only as an index. Therefore, private gross prices are also expressed in relative terms with the same base period.

correlated with the respective development of the private price index ($r = 0.87$), with a much higher absolute variation coefficient for 12-month moving-average mean deviation for private price data ($|vc| = 40.7$) than for public price data ($|vc| = 20.1$). Although both indices represent per-month data, the differences in the variation coefficients can be explained by, first, the number of companies and transactions used to derive the indices. While the public index requires 6 to 8 cement producers to provide information on one representative transaction per month, private information is the average of total daily average prices per month of 36 providers. Second, as about two-thirds of the German cement production is demanded by downstream subsidiaries of the cartel members, the price data collected by the FSO largely consists of internal transfer prices (which are likely to differ substantially from prices charged from independent customers of the cartel members).

4.2 Market screening approach

In this section, we develop and execute a two-step market screening approach to detect collusive agreements in procurement markets. We employ alternative screening measures using customers' prices to analyze whether customers (a) find a structural break as with public data and whether (b) this structural break could be related to the existence of the cartel. In particular, we start with a structural break analysis to detect the end of the cartel[14] for individual customers and use the findings of the structural break analysis in multivariate pooled and static panel estimation approaches. Finally, we extend the analyses to company-by-company estimations to consider whether individual companies would have been able to identify the existence of the cartel. Ceteris paribus, we expect that especially larger customers are able to specify more complex measures to identify collusive behavior in procurement markets, basically because their demand patterns are more continuous.

In general, our screening approach has two alternative application areas. First, as customers typically are familiar with standard trade parameters such as product price, quality and quantity conditions and also know how these parameters have developed over time, they are likely to notice deviations from standard supply-side habits. Based on the identification of such events, customers could start a screening procedure to investigate whether these changes can be attributed to a significant change in trading conditions or might rather be driven by some form of collusive agreement upstream. Second, a screening tool could also be implemented as part of a broader set of customers' standard market monitoring instruments. For example, by calibrating the screening tool to prevailing price volatilities known from the

past, the approach could be applied to flag significant changes (which could subsequently be investigated further by using more detailed information).

4.2.1 Step 1: Structural break analysis

Structural break analysis provides statistical evidence for changes in data structure over time. Its implementation to a particular data set requires an a-priori idea of a potential break between two points in time probably gained from market analysis (e.g. a change in production technology or a change in market structure), rumor (e.g. from industry association meetings) or, as in our case, changes in procurement parameters such as prices or offered quantities, whose statistical significance should be proved.

While structural break analysis is an adequate instrument for aggregated data, its usage becomes more difficult with individual data. By aggregating data, individual differences balance each other out, reduce volatility and, thus, provide a smoother index development. In contrast, individual data typically strongly depend on idiosyncratic influences with higher total volatility. Therefore, observed crucial changes result in a relatively weaker volatility compared to total volatility for individual data than for aggregated data.

We use structural break analysis around the date of the cartel breakdown starting six month before and ending six months after the period of the cartel breakdown. While knowing the date of the actual end of the cartel, as defined by the beginning of the price decrease in February 2002, the key question is whether customers experienced a significant change in prices due to the cartel breakdown. If not, a cartel-related price effect could not be identified.

We know from Figure 2 that a strong price reduction occurred after the end of the cartel period both in public data and also in private data. However, Figure 2 also provides evidence that volatility is higher with aggregated private data than with public data. To find out whether a significant change in prices occurred around the time of the cartel breakdown, we compare average prices and average variation coefficients 12 months before and 12 months after the period where the break is suspected. A significant change in prices takes place if the following t-value is significantly different from zero:

$$t = \frac{\widehat{p_c} - \widehat{p_{nc}}}{se(p_c, p_{nc})_{nc}} \qquad (1)$$

$\widehat{p_c}$ is the average price of the first period, $\widehat{p_{nc}}$ is the average price of the second period and $se(p_c, p_{nc})_{nc}$ is the corresponding standard error of the price differences. Additionally, we use

[14] Please note that we use the cartel breakdown and not the beginning of the cartel as we have no data on the beginning of the cartel period. However, this does not affect our general analysis (except that the sign of the

monthly variation coefficients instead of means to check whether volatility measures provide comparable results. Instead of variances or standard deviations, we use relative volatility measures, first, because levels differ between both sub-periods under scrutiny (see Figure 2) and, second, because prices differ across customer-provider trade relations. As prices in the non-cartel period are expected to be lower than prices in the cartel period, we also conduct one-sided t-tests expecting t to be significantly positive for prices. In contrast, we have seen volatility to increase after the cartel period. This is why we expect t to be significantly negative for variation coefficients and consider also one-sided t-tests.

Taking the end of the cartel period as the 'benchmark', we indeed find significantly positive t-values for the mean analysis both for the public and for the aggregated private data sets and significantly negative t-values for variation coefficients using the private data set. However, a priori, customers do not know the exact point of structural break which could also vary across customers. Moreover, as customers use private or public data in standardized market monitoring procedures to identify frictions in procurement markets, no information from public enforcement proceedings is available at that point in time. In consequence, they do not know exact dates which mark cartel existence.

However, is it relevant for customers to catch the point in time of the actual cartel breakdown? The primary interest of customers is to detect and, subsequently, analyze frictions in procurement markets, thus, to reduce own risks and related own costs. Even if customers cannot exactly define the dates and the duration of a cartel or – what is even more important from a customer's perspective – a period of damage, structural break analysis can still provide a statistically significant indication of a period to be further analyzed. In consequence, customers should follow an iterative procedure after having an economic idea of potential market frictions in the procurement market to detect a cartel as a one-shot consideration might not detect significant frictions in market data or even point to an economically insignificant price change.

Even knowing for sure that an important friction occurred in an industry at a particular point in time, comprehensive adjustments in company communication and strategies are not directly found in market data. Instead, complex changes e.g. in pricing strategies and corresponding contract adjustments need some time to be implemented. Therefore, we repeat the structural break analysis procedure six periods before and six periods after the end of the cartel to check whether it is a valid method even if the exact point of change is unknown.

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proposed measures is expected to change as soon as the beginning of the cartel is the point of interest).

To get a better understanding of the data and the iterative approach, t-values are plotted in Figure 3 for the period of the assumed structural break using public data and aggregated private price data and private monthly price variation coefficient data.

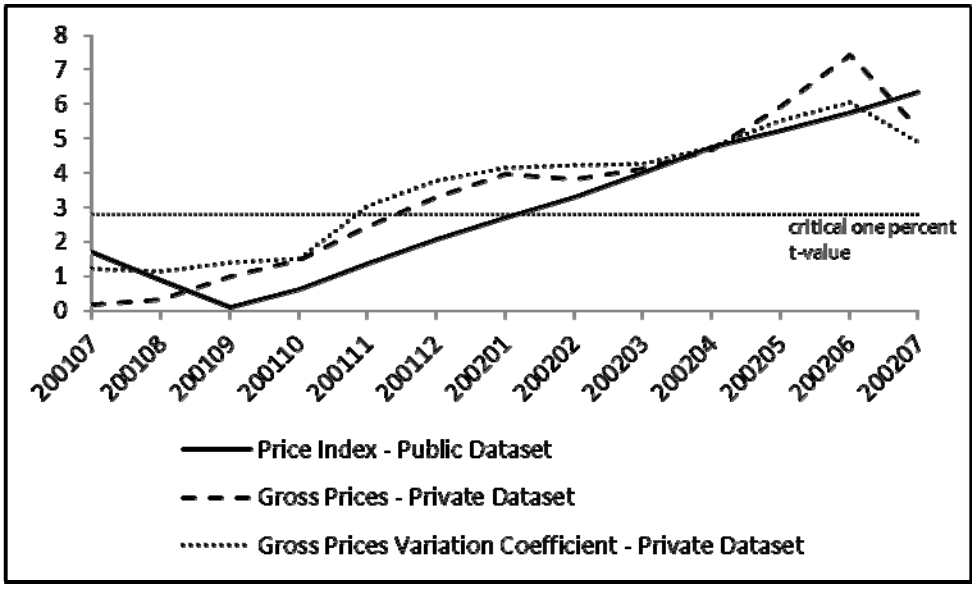

Figure 3: t-values for varying break points

Source: Own calculations based on public and private price data.

As shown in Figure 3, the significance of public and private data moves to a far extent in the same direction. The further the period of the assumed structural break is shifted to the actual non-cartel period, the more significant the t-values become. While public data provide significant evidence for a structural break not before January 2002, which coincides with the last month of the cartel period, aggregated private price data and also variation coefficients on prices result in a significant structural break already in November 2001 at the earliest (based on the 5-percent level).[15] This finding corresponds to the history of the cement cartel described in Section 3.2 above which found first signs of the cartel breakdown towards the end of the year 2001.[16] The growing t-values over time reflect the increase in the deviation of non-cartel prices from cartel prices as more non-cartel prices enter the index after January 2002. As average prices are closer together for the 12-month period before July 2001 and the 12-month period after July 2001 the index is not significantly different from zero for the assumed breakpoint. However, the larger the share of lower prices that enter the index (and

[15] Please note that these dates mark the first period where a significant difference between 12-month-before and 12-month-after prices is found. Thus, they are the earliest possible date for a change in the data structure but not the only date.

[16] It is important to remark at this point that the structural break analysis conducted here solely aims at gaining first indications on the possible existence of a cartel agreement. As a consequence, the results of the structural break analysis here might diverge from the results that should be used for a robust estimation of the cartel damages in court proceedings.

the larger the share of higher prices that drop out), the larger is the mean deviation around the end of the price maximum.

In a next step, the described procedure is repeated for individual price data. Such a step is crucial as we are particularly interested in answering the question whether individual firms are able to detect the upstream cartel. As individual data is much more volatile than aggregated data, significant structural breaks might occur much more often as, e.g., price trends are shorter due to unsteady provider relationships. To solve a potential problem of "false alarm" within individual customer data, a mechanism has to be implemented which separates sustainable from random findings. One possible solution in this respect is the identification of multiple structural breaks following one another, basically because these flag a sustainable change in the data structure (as mean deviation is not driven by a short-time outlier but by a switch to a significantly different series of price data). For this reason, we only classify such structural breaks as 'sustainable' which are found significant at the 1-percent level for at least 5 subsequent periods.[17] Applying this approach leads to the results reported in Table 1.

Table 1: Significant breaks in individual invoice data sets[18]

Price			Variation Coefficient		
Date	Share Customers	Cumulative Share	Date	Share Customers	Cumulative Share
200104	2.63	2.63	200101	2.63	2.63
200111	5.26	7.89	200110	2.63	5.26
200112	7.89	15.79	200205	5.26	10.53
200201	2.63	18.42	200207	2.63	13.16
200202	2.63	21.05	no sign. break	86.84	100.00
200203	2.63	23.68			
200205	2.63	26.32			
200206	5.26	31.58			
200207	5.26	36.84			
200208	5.26	42.11			
no sign. break	57.89	100.00			

Source: Own calculations based on private price data

In contrast to the joint analysis, a larger share of customers finds a structural break in prices after the actual date of the cartel breakdown (but before the competition authority announced the dawn raids in July 2002): For about one fifth of customers, the first significant change is identified at the point of the actual break or before whereas for nearly one fourth the first

[17] We have conducted robustness checks for shorter periods. However, no 3- or 4-period repetitions exist in the data set for the window around the actual cartel breakdown. Moreover, we cannot significantly extend the window due to the proximity of the upper end of the observation period.

[18] Please note that about 26 percent of the aggregated data, in particular volatility data, is excluded from individual analysis due to less than three periods of demand in the second period.

significant change occurs afterwards. While the joint consideration of individual data equally weights all customer data sets, aggregation dedicates more weight to data of larger customers due to higher demand. If, e.g., structural breaks in price data of larger customers take place at an earlier point in time, this is directly reflected in an earlier date of the structural break for the joint data set.

As shown further in Table 1, while mean price analysis provides evidence of a structural break around the date of the actual end of the cartel for nearly half of the customers, volatilities indicate significant changes only for about 13 percent of customers under scrutiny. Ceteris paribus, this result suggests that – for our data set – a ”mean price screen” provides better results than a ”price volatility screen”. Furthermore, more than half of the customers in our data set would not have found a structural break neither using own mean price nor using own price volatility data. Comparing these findings to average annual demand per customer shows that particularly smaller companies run into difficulties with structural break analysis due to more random demand patterns. Moreover, larger customers are more likely to purchase from several suppliers. This may enable them to have a more comprehensive overview of the market.

Combining the findings of both individual and joint customer data supports the view that the installation of a cartel or its breakdown must not necessarily be mirrored by an immediate reaction in the data which is shown, first, by the increasing t-values in the joint analysis and, second, the varying outcomes in the individual approaches. Several theoretical arguments can help to explain this observation. First, the adjustments of technology and production or market structure require some time for implementation. Thus, the beginning or the end of a cartel is characterized by a period of change. Second, a cartel need not be reflected in significantly higher prices or lower price volatility as in the counterfactual period. Instead, a cartel could also alleviate lower prices or higher price volatility which would have been in place without the cartel. Third, price changes in line with the implementation of a cartel or its breakdown might occur in a rather slow adjustment process. In consequence, standard structural break analysis might find no significant change in the data. Fourth, available prices are subject to strong volatilities or very weak volatilities which might drive cartel effects insignificant.

4.2.2 Step 2: Multivariate regression analysis

In the next step, we use the findings of structural break analysis to calibrate a model of multivariate price and volatility analysis with regard to the end of the cartel period. While structural break analysis provides information whether a change in price data took place,

multivariate regression analysis allows for both an estimate of the size of the difference between the two time series and information where the break actually comes from (by controlling for potential other drivers). As no information about the cartel existence is in place at the point in time when private price analysis is implemented, multivariate regression requires the prior step of finding a significant break in market or invoice data.

The key challenge with multivariate regression analysis is to find adequate measures for the subject under scrutiny. Before turning to separate data analysis, we use common approaches as these allow for controlling individual size differences and are more representative in particular for smaller customers. We control for customers' annual demand per provider as we expect quantity-based price differentiation. Invoice-based quantities are usually constrained by transportation facilities. Thus, the majority of deliveries found in the data set relate to nearly 30 tons which is the capacity constraint of average European cement trucks. In contrast, we expect quantity-related price reductions based on long-run demand as described above. As we use a data set which only partially covers the German cement market, we are not able to endogenously model size. As we expect production technology-based cost effects which stem from both access to lime and production volume (scale effects), we control for provider size. As cartelists cover about 80 percent of the cement market, this dummy corresponds to a cartelists-dummy but is independent from the cartel period.

Based on this discussion, the following equation is the baseline equation to be estimated in alternative specifications:

$$p_{ijt} = \alpha + \beta_c cartel_{it} + \beta_{cm} large\ provider_{ijt} + \beta_q \log(annual\ quantity_{ijt}) + \beta_i d\_i + \beta_t trend + \varepsilon_{ijt} \quad (2)$$

where p_{ijt} is the monthly average price of customer i for deliveries from provider j in period t, α is a constant, *cartel* is a dummy with value 1 for the first period identified by structural break analysis and 0 otherwise, *large provider* is a dummy with value 1 for deliveries from one of the six largest providers and 0 otherwise, log(*annual quantity*) represents the log of total annual demand, d_i is a customer dummy which controls for idiosyncratic effects in pooled estimations, *trend* is a time trend and ε_{it} is a normally distributed error term. βs are the corresponding coefficients. We use annual quantity in log-form as annual quantity is highly right skewed whereas the log-form is normally distributed. As cartelists are the major players in the market, a positive correlation between the dummy for large providers and the cartel dummy and between the dummy large providers and demanded quantity might bias estimates. Therefore, we compare results with and without the large-provider dummy to show whether its introduction significantly changes the coefficients of other variables.

4.2.2.1 Descriptive statistics

Before turning to the multivariate regression results and their discussion, variables are considered individually. Table 2 provides the descriptive statistics of the data set.

Table 2: Descriptive statistics

	Total Period				Cartel Period			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
large provider	0.488	0.500	0	1	0.481	0.500	0	1
price	98.047	18.855	34.526	231.699	100.741	15.189	60.995	231.699
vc price	3.496	5.060	0	53.576	3.308	4.450	0	47.125
log(*annual quantity*)	12.941	2.381	5.077	19.221	13.153	2.325	5.535	19.221

Non-Cartel Period			
Mean	Std. Dev.	Min	Max
0.522	0.500	0	1
84.097	27.757	34.526	135.429
4.940	8.232	0	53.576
11.842	2.363	5.077	18.927

Source: Own calculations based on private price data.

Invoices from cartel members comprise around half of the total data set.[19] Cartel prices are on average around EUR 17 above non-cartel prices with average price volatilities lower in the cartel period than in the non-cartel period. Annual quantities are on average higher in the cartel period than in the non-cartel period which is mainly due to the economic crisis starting in 2002.

4.2.2.2 Estimation results and discussion

In the following, we compare alternative model specifications to develop a detailed understanding of the results and to test their robustness. We start with a pooled estimation approach where the end of the cartel period is provided by the joint model presented in the previous section. While this model is based on data for all customers, individual structural break analysis provides alternating break points with a bulk of non-significant results. Thus, estimation approaches based on joint break point analysis are contrasted to estimation approaches based on individual break point analysis. We repeat the second estimation approach customer-by-customer and check to which extent results differ. This step especially allows us to get an impression of what individual companies could expect from an application of a market screening tool. Summary results are given for individual data analyses per

[19] With 40.5 percent of all invoices, the share of cartelists' invoices in non-aggregated data (not presented here) is comparable to the aggregated share.

customer. Mean price and volatility equations are first estimated with a pooled model using standard GLS with Huber-White-corrected standard errors where the panel data structure is ignored. Afterwards, results are compared to the findings of fixed-effects panel estimations.[20]

In Table 3, the results of the joint structural break analysis are shown. Columns (1) and (3) show the coefficients of the pooled estimations where the cartel-member dummy is neglected, whereas in columns (2) and (4) the dummy is included. Columns (5) and (6) show the panel estimation results. Please note that the cartel member dummy is excluded in the panel estimations as provider-customer relations are the panel variable.

Table 3: Price analysis (based on joint structural break analysis)

	Price	Price	VC Price	VC Price	Price	VC Price
	(1)	(2)	(3)	(4)	(5)	(6)
cartel	11.448 ***	12.078 ***	-0.030 ***	-0.032 ***	11.320 ***	-0.032 ***
	(0.844)	(0.825)	(0.005)	(0.004)	(0.637)	(0.003)
large provider		11.259 ***		-0.024 ***		
		(0.672)		(0.003)		
log(*annual quantity*)	3.263 ***	3.143 ***	0.005 ***	0.004 ***	2.765 ***	0.003 ***
	(0.222)	(0.214)	(0.001)	(0.001)	(0.149)	(0.001)
trend	0.035 ***	0.036 ***	-0.000 ***	-0.000 ***	0.017 **	-0.000 *
	(0.008)	(0.008)	(0.000)	(0.000)	(0.007)	(0.000)
constant	78.928 ***	68.209 ***	-0.003	0.027 ***	52.156 ***	0.033 ***
	(2.203)	(2.174)	(0.009)	(0.010)	(1.953)	(0.010)
customer dummies	customer dummies included				customer dummies not included	
F	162.25	175.44	61.44	63.48	395.13	47.69
R2	0.440	0.490	0.252	0.274	0.021	0.061
Observations	4899	4899	4405	4405	4899	4405

*Source: Own estimations based on private price data, *** p<0.01, ** 0.01<=p<0.05, *0.05<=p<0.1*

As idiosyncratic effects are controlled by customer dummies, all other variables are assumed to be independent of customer-related influences. Both cartel effects and quantity effects are only weakly affected by the provider type as the comparisons of columns (1) and (2) and columns (3) and (4) in Table 3 reveal. Based on the results of the pooled estimation approaches, customers had to pay significantly more for CEM I in the cartel period than afterwards, whereas monthly average price volatility measured by the variation coefficient is significantly lower in the cartel period.[21] Moreover, if an average customer buys cement from

[20] Hausman specification tests reject the null hypothesis of no significant difference between fixed and random effects estimations.

[21] Please note that these results are based on an highly simplistic estimation approach which provides only indications on price differences (as we only roughly control for other influences). This approach is suitable here as we aim at investigating only whether prices have changed over time when controlling for other easily accessible influences. These other variables cover part of the price difference between the damage period and the post-damage period prices as seen from the comparison of descriptive statistics and the multivariate

a large provider he has to pay EUR 11.26 more than for cement bought from small providers, however, larger providers' prices fluctuate on average 2.4 percentage points less than smaller providers' prices. Both of these findings strongly support well-known results from the existing cartel literature characterized in Section 2.1 above. However, our results here are different in the sense that they are derived from individual customer data which reflect individual customer-provider relationships.

Columns (5) and (6) in Table 3 show that the panel estimations strongly support the results of the pooled estimation approaches as the coefficients are in the same range. Minor differences only exist for quantities which might be due to additional customer-provider effects covered by this variable in the pooled estimation approach. Moreover, quantities have a significantly positive influence on prices. While this would be a striking result for market data, it is less of an issue for individual data given the fact that cement is produced on demand.

In the next step, the estimation results based on the joint structural break analysis are compared with the estimation results when taking into account individual differences along price series. The respective estimation results are provided in Table 4.

Table 4: Price analysis (based on individual structural break analysis)

	Price	Price	VC Price	VC Price	Price	VC Price
	(1)	(2)	(3)	(4)	(5)	(6)
cartel	16.122 ***	16.700 ***	-0.045 ***	-0.047 ***	20.504 ***	-0.050 ***
	(1.257)	(1.267)	(0.007)	(0.007)	(0.873)	(0.004)
large provider		11.439 ***		-0.034 ***		
		(0.824)		(0.004)		
log(*annual quantity*)	2.382 ***	2.781 ***	0.006 ***	0.004 ***	2.680 ***	0.004 ***
	(0.277)	(0.265)	(0.001)	(0.001)	(0.188)	(0.001)
trend	-0.001	0.013	-0.000	-0.000 *	0.050 ***	-0.000 *
	(0.010)	(0.010)	(0.000)	(0.000)	(0.009)	(0.000)
constant	28.709 ***	21.568 ***	0.015	0.071 ***	40.096 ***	0.033 ***
	(3.467)	(3.431)	(0.025)	(0.026)	(2.588)	(0.014)
customer dummies	customer dummies included				customer dummies not included	
F	135.84	143.58	57.41	75.24	453.82	61.36
R2	0.415	0.473	0.267	0.310	0.110	0.137
Observations	2540	2540	2332	2332	2540	2332

*Source: Own estimations based on private price data, *** p<0.01, ** 0.01<=p<0.05, *0.05<=p<0.1*

Table 4 provides estimation results for the same specification as Table 3 except for the specification of the structural break. While in Table 3 results are based on joint structural break analysis, estimations in Table 4 take into account differences in individual breaks in

approach. Nevertheless, a robust estimation of cartel overcharges would demand more sophisticated

price series. Consequently, the results in Table 4 refer to a lower number of observations as customers with no significant break in average price data are excluded. As a result, explanation power increases as variation from unaffected customers is excluded.

As shown in Table 4, estimation results strongly support the earlier results reported in Table 3. Moreover, price coefficients represent significantly higher cartel effects with significantly lower price volatility while the influence from the large-provider dummy remains nearly constant. As only data for those customers are considered who were able to detect a structural break, cartel-related price effects become even stronger in the smaller data set. Overall volatility during the cartel period is reduced relative to the non-cartel period. The quantity coefficient is smaller only for pooled estimations whereas it remains in the same range for the panel approach. Findings on quantity effects support the argument that in pooled estimations a fraction of the individual customer-provider effect is covered by the quantity variable. As quantity coefficients are close to those of the panel estimations, the customer-provider quantity effect found by comparing Table 4 to Table 3 shows that it is of particular importance for unaffected customers.

While both prior specifications are based on a joint multivariate estimation approach, it is of key interest for individual customers whether independent estimations would get to the same findings. Therefore, we estimate Equation (2) separately for each customer in our data set (for which a structural break has been identified in the first step). Summary results on cartel variables and large provider dummies are shown in Table 5.

Table 5: Summary of results of individual estimations

	Price (GLS)		VC Price (GLS)		Price (FE)	VC Price (FE)
	Cartel	Large Provider	Cartel	Large Provider	Cartel	Cartel
Significantly positive	*0.8*	*0.58*	0.06	0.18	*0.75*	0
Significantly negative	0.07	0.33	*0.44*	*0.27*	0.06	*0.5*
Not significant	0.2	0.08	0.5	0.55	0.19	0.5

Source: Own estimations based on private price data, significance based on the 10-percent level.

As revealed by Table 5, individual estimations on a customer-by-customer basis support the general outcome of the joint analyses, especially with respect to the price estimation results. Roughly speaking, four out of five firms would have been able to detect the upstream cement cartel by screening (gross) prices *before* the competition authority. However, the results for variation coefficients are less clear suggesting that only less than half of the customers would

regression approaches.

have detected the cartel with an application of the respective screen. Interestingly, even the more complex panel approach is unable to substantially improve screening performance.[22]

In a nutshell, comparing results based on joint structural break analysis with those based on differing structural breaks, on the one hand, provides evidence that taking into account differing structural breaks provides more precise results for actually affected customers. On the other hand, those customers for which no significant difference is found by individual structural break analysis benefit from the joint approach. Comparing the outcome of the joint estimation approach with those of the customer-by-customer approach shows that a bulk of customers could indeed identify the cartel not only as a change in data structure but would have been able to separate the cartel effect from other price drivers. However, volatility measures provide adequate results only for the joint analysis whereas results for the individual analysis diverge across customers.

Given this interpretation of our main results, it is important to remind that we deliberately chose a very general approach which provides as many degrees of freedom as possible. While a more specific approach with more control variables might increase explanatory power (particularly in individual customer estimations with a large number of price data), such an approach could hardly be implemented by customers with more erratic demand. Although our choice of a more general (but flexible) approach inevitably comes at the cost of a lower overall explanation power of the model (reflected in the relatively low R^2 for time series approaches), we are still able to find very robust evidence that especially large customers are not only able to identify cartels based on their own invoice data but that they are also able to isolate provider-based price effects.

5 Conclusion

Cartel detection is usually viewed as a key task of either competition authorities or compliance officials in firms with an elevated risk of cartelization. In this paper, we argue that customers of hard core cartels can have both incentives and possibilities to detect such agreements on their own initiative through the use of market-specific data sets. In addition to a general theoretical discussion, we use a unique data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers and show that

[22] It is important to note here that for several reasons the failure to identify a structural break in particular individual invoice data sets does not allow the conclusion that the respective firms were not affected by the cartel and its breakdown. First, our analysis focuses on gross prices rather than net prices. As a consequence, it can very well be the case that gross prices remain unchanged after the cartel breakdown while net prices were reduced substantially (see Hüschelrath and Veith, 2011, for empirical evidence). Second, post-cartel price adjustments on the basis on individual customers might not take place immediately but are subject to time lags of different sizes depending on factors such as individual demand patterns and general contract terms. This divergence of 'firm specific structural breaks' is clearly reflected in Table 1 discussed above.

especially price screens, if they had been available at the time, could have allowed the larger customers to detect the upstream cartel *before* the competition authority.

From a *business strategy perspective*, our results have several important implications. For larger customers, i.e., firms with a rather large and stable demand of the cartelized input good, it can be said that market screening tools have the clear potential to detect cartel agreements in procurement markets thereby announcing a significant reduction in the respective costs of the input good. Although data limitations in this paper forced us to focus on the detection of the end of the cartel agreement (caused by the deviation of a cartel member, *not* by the detection of the antitrust authority), our empirical approach could easily be applied to detect newly installed hard core cartels. However, the corresponding cost reduction potential can only be realized if (a) the firm uses the screening results to renegotiate prices for input goods with the supplier, or (b) decides to hand over the screening results to the competition authority who might decide to start an official investigation to collect further evidence on the potential cartel agreement. Furthermore, it is important to note that the successful application of a market screening tool crucially depends on a change in the behavior of the cartel (that causes a structural break in the data).

For smaller customers, i.e., firms with a rather small and less stable demand of the cartelized input good, it can be said that the possibilities (and incentives) for a successful application of screening tools are substantially reduced basically due to the more erratic demand patterns. Although it might be sufficient for smaller customers to free-ride (i.e., to build on the incentives of larger customers to detect the cartel[23]), an alternative solution would be to bundle the individually small demands of several customers to one larger demand, e.g., through the foundation of some form of purchasing cooperation. Although such cooperation not necessarily runs afoul of antitrust laws, potential antitrust concerns could possibly be circumvented by commissioning a third party to coordinate procurement activities and to also monitor the respective procurement market for collusive agreements.

From an *antitrust policy perspective*, our results suggest that competition authorities are well advised to view especially large customers of potentially cartelized industries as important allies in their fight against hard core cartels. Authorities can promote such interaction on the one hand by incremental innovation in the form of regular meetings with industry managers, the offering of screening training sessions for firm employees or extended

[23] Please note that such a free-riding strategy would only work if the large customers decide to hand over the screening evidence to the competition authority (and the authority subsequently starts an investigation). In case larger customers decide to renegotiate the input prices directly with the supplier, small customers are still likely to face the elevated cartel price.

(data based) cooperation as part of sector inquiries. In addition, competition authorities might even think about the promotion of more drastic innovation, e.g. by providing additional incentives for customers to report alleged collusive agreements in procurement markets. One possibility of providing such ”additional incentives” would be a financial reward paid for detailed information on an alleged conspiracy (which eventually turned out to be crucial in the subsequent detection and prosecution activities of the competition authority).

In a nutshell, our analysis has shown that the power of screens to detect hard core cartels can be increased substantially by simply enlarging the group of potential users rather than by further increases in the methodological complexity of the respective screens. Especially due to the typical richness of firm data, screening tools applied by customers of potentially cartelized industries can substantially promote the overall detection rate of hard core cartels thereby benefiting the respective firm through a reduction in input costs and a related increase in competitiveness and benefiting the consumers through a reduction in the number of harmful conspiracies among competitors.

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