Discussion Paper No. 12-036

Estimating Damages from Price-Fixing
The Value of Transaction Data

Kai Hüschelrath, Kathrin Müller and Tobias Veith

Zentrum für Europäische
Wirtschaftsforschung GmbH

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Non-technical summary

According to the European Court of Justice, any citizen or business who suffered harm as a result of a breach of the antitrust rules of the European Union (EU) should be able to obtain compensation from the party who caused the harm. Despite this clear and undisputed right of compensation, the current state of antitrust damage actions in the EU has frequently been classified as 'ineffective' regularly leaving the victims of antitrust infringements without any compensation for the harm suffered (see European Commission, 2011).

Since 2004, the European Commission (EC) has taken a number of steps to develop a legal framework that allows victims of EU antitrust infringements to obtain compensation. In its Green Paper on damages actions for breach of antitrust rules, the EC (2005) concluded that the robust quantification of the caused damage is one of the key barriers to a further promotion of antitrust damage actions. Consequently, in the subsequent White Paper – published in 2008 – the EC announced the plan to derive a coherent economic framework which provides pragmatic, non-binding guidance on the quantification of harm. A first draft of this Guidance Paper was published in June 2011.

Although the public and academic discourse on the various methods and models to estimate damages certainly is a necessary step in the process of strengthening antitrust damages actions, the challenges of applying them in actual cases with real-world data are often ignored. Against this background, we use a unique private data set of about 340,000 invoice positions from 36 smaller and larger customers of German cement producers to study the value of such transaction data for an estimation of cartel damages. In particular, we investigate, first, how structural break analysis can be used to identify the exact end of the cartel agreement and, second, how an application of before-and-after approaches to estimate the price overcharge can benefit from such rich data sets. We conclude that transaction data allows such a detailed assessment of the cartel and its impact on direct customers that its regular application in private antitrust cases is desired as long as data collection and preparation procedures are not prohibitively expensive.

Das Wichtigste in Kürze

Gemäß der Rechtsprechung des Europäischen Gerichtshofs (EuGH) muss jedem Geschädigten ein Anspruch auf Ersatz des Schadens eingeräumt werden, der ihm durch einen Wettbewerbsverstoß entsteht. Trotz dieser klaren Vorgaben des EuGH wird das aktuell bestehende System der privatrechtlichen Durchsetzung des Kartellrechts oftmals als ineffektiv bezeichnet; unter anderem weil vielen geschädigten Parteien eine entsprechende Kompensation verwehrt bleibt (siehe Europäische Kommission, 2011).

Seit dem Jahr 2004 hat die Europäische Kommission eine Reihe von Schritten unternommen, einen rechtlichen Rahmen zu entwickeln, der es durch Wettbewerbsverstöße geschädigten Parteien erlaubt, eine entsprechende Kompensation zu erhalten. So veröffentlichte die Kommission beispielsweise im Jahr 2005 ein Grünbuch zur privatrechtlichen Durchsetzung des Kartellrechts, in dem sie insbesondere die vielfältigen Probleme einer Quantifizierung des entstehenden Schadens als eine große Hürde in der Umsetzung identifizierte. Im sich anschließenden Weißbuch, das im Jahre 2008 veröffentlicht wurde, kündigte die Kommission dann die Entwicklung von umfassenden, aber unverbindlichen Richtlinien zur Schadensermittlung an. Ein erster Entwurf dieser Richtlinien wurde im Juni 2011 publiziert.

Obwohl die aktuell stattfindende öffentliche wie wissenschaftliche Diskussion der verschiedenen Methoden und Modelle der Schadensermittlung ein wichtiger und notwendiger Schritt zur Stärkung der privatrechtlichen Durchsetzung des Kartellrechts ist, kommt die Würdigung der Herausforderungen einer praktischen Umsetzung der entsprechenden Methoden oftmals zu kurz. Vor diesem Hintergrund verwenden wir einen einmaligen Datensatz, bestehend aus ungefähr 340.000 Rechnungspositionen von 36 größeren und kleineren Kunden deutscher Zementproduzenten, zur Untersuchung des Wertes solcher Transaktionsdaten für die Abschätzung von Kartellschäden. Im Besonderen untersuchen wir zum einen, wie Strukturbruchanalysen bei der Identifikation des exakten Endes der Kartellabsprache helfen können. Zum anderen betrachten wir, wie eine Anwendung des zeitlichen Vergleichsmarktkonzepts zur Abschätzung der Kartellschadenshöhe von solch reichhaltigen Datensätzen profitieren kann. Wir stellen abschließend fest, dass Transaktionsdaten eine sehr viel detaillierte Untersuchung des Kartells und seines Einflusses auf die direkten Kunden erlauben, sodass sie regelmäßig in privatrechtlichen Verfahren zum Einsatz kommen sollten, solange die Datensammel- und -aufbereitungstätigkeiten nicht prohibitiv hohe Kosten verursachen.

ESTIMATING DAMAGES FROM PRICE-FIXING
THE VALUE OF TRANSACTION DATA

Kai Hüschelrath[*], Kathrin Müller[♣] and Tobias Veith[#]

May 2012

Abstract
We use a unique private data set of about 340,000 invoice positions from 36 smaller and larger customers of German cement producers to study the value of such transaction data for an estimation of cartel damages. In particular, we investigate, first, how structural break analysis can be used to identify the exact end of the cartel agreement and, second, how an application of before-and-after approaches to estimate the price overcharge can benefit from such rich data sets. We conclude that transaction data allows such a detailed assessment of the cartel and its impact on direct customers that its regular application in private antitrust cases is desired as long as data collection and preparation procedures are not prohibitively expensive.

Keywords Antitrust policy, private enforcement, cartels, overcharge, damages, cement

JEL Class L41, L61, K21

[*] *Head*, Competition and Regulation Research Group, ZEW Centre for European Economic Research, P.O. Box 10 34 43, D-68034 Mannheim, Germany, E-mail: hueschelrath@zew.de; *Coordinator*, MaCCI Mannheim Centre for Competition and Innovation; *Assistant Professor* for Industrial Organization and Competitive Strategy, WHU Otto Beisheim School of Management, Burgplatz 2, 56179 Vallendar, Germany. Parts of the paper refer to a study on cartel damage estimations which was financially supported by Cartel Damage Claims (CDC), Brussels. The study is published in German language (see Hüschelrath et al., 2012). We are especially indebted to Jakob Rüggeberg (CDC) for valuable comments on previous versions of the paper.

[♣] *Researcher*, Competition and Regulation Research Group, ZEW Centre for European Economic Research and MaCCI Mannheim Centre for Competition and Innovation, P.O. Box 10 34 43, D-68034 Mannheim, Germany, E-mail: kathrin.mueller@zew.de.

[#] *Researcher*, Department for Industrial Economics and International Management, ZEW Centre for European Economic Research, P.O. Box 10 34 43, 68034 Mannheim, Germany, E-mail: veith@zew.de.

1 Introduction

According to the European Court of Justice, any citizen or business who suffered harm as a result of a breach of the antitrust rules of the European Union (EU) should be able to obtain compensation from the party who caused the harm.[1] Despite this clear and undisputed right of compensation, the current state of antitrust damage actions in the EU has frequently been classified as 'ineffective', regularly leaving the victims of antitrust infringements without any compensation for the harm suffered (see generally European Commission, 2011).

Since 2004, the European Commission (EC) has taken a number of steps to develop a legal framework that allows victims of EU antitrust infringements to obtain compensation. In its Green Paper on damages actions for breach of antitrust rules, the EC (2005) concluded that the robust quantification of the caused damage is one of the key barriers to a further promotion of antitrust damages actions. Consequently, in the subsequent White Paper – published in 2008 – the EC announced the plan to derive a coherent economic framework which provides pragmatic, non-binding guidance on the quantification of harm. A first draft of this Guidance Paper was published in June 2011.

Although the public and academic discourse on the various methods and models to estimate damages certainly is a necessary step in the process of strengthening antitrust damages actions, the challenges of applying them in actual cases with real-world data are often ignored. Against this background, we use a unique private data set of about 340,000 invoice positions from 36 smaller and larger customers of German cement producers to study the value of such transaction data for an estimation of cartel damages. In particular, we investigate, first, how structural break analysis can be used to identify the exact end of the cartel agreement and, second, how an application of before-and-after approaches to estimate the price overcharge can benefit from such rich data sets. We conclude that transaction data allows such a detailed assessment of the cartel and its impact on direct customers that its regular application in private antitrust cases is desired as long as data collection and preparation procedures are not prohibitively expensive.

The article is structured as follows. Section 2 gives a general introduction into the identification and quantification of hardcore cartel damages and particularly discusses the importance of cartel length and cartel height. The subsequent Section 3 provides brief overviews of the German cement industry in general and the latest German cement cartel in

[1] See Case C-453/99 *Courage* [2001] ECR I-6297, paragraph 26; Joined Cases C-295/04 to C-298/04 *Manfredi* [2006] ECR I-6619, paragraph 60.

particular. This industry knowledge is an important precondition for the presentation of our empirical analysis in the fourth section. Section 4.1 gives a brief introduction into the data set and presents the descriptive statistics. The subsequent section 4.2 applies structural break analysis to gain additional insights on the particular end of the cartel agreement, followed by the estimation of different models aiming at quantifying the price overcharge realized by the cement cartel. In Section 4.3, we rerun all regressions for the aggregated data set in order to check the robustness of our results. Section 4.4 provides a brief discussion of the major insights of our empirical analysis. Section 5 concludes the paper with a review of the key results and a discussion of future research avenues.

2 The identification and quantification of hardcore cartel damages

In the modern industrial organization literature, a *hardcore cartel* is 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., 2001), p. 345). A perfectly functioning hardcore cartel – involving all firms in the market and referring to substitutive products – is expected to raise market price up to the monopoly level thereby harming overall and consumer welfare substantially. As hardcore cartels usually do not create any kind of benefits to society which could be traded-off against the anticompetitive effects, hardcore cartels are a prime example for a per se prohibition reflected in many antitrust legislations around the world.

An answer to the subsequent question after the design of an antitrust enforcement system for anti-cartel rules must refer to two different strands: public enforcement and private enforcement. *Public enforcement* basically means that antitrust rules are enforced by state authorities. Through the imposition of a threat of civil, administrative or criminal sanctions for violations of the respective laws and regulations, policy makers aim to alter the cost-benefit assessment for forms of anticompetitive behavior on the firm's side sufficiently to make compliance to the dominant strategy.

By contrast, *private enforcement* is based on the actions of private parties – such as competitors, suppliers, customers or consumers – who can bring antitrust lawsuits based on the private damages caused by forms of anticompetitive behavior. Unlike the fines in public enforcement – which are imposed for reasons of deterrence and punishment – monetary payments in private enforcement are generally motivated by the pursuit of corrective justice through compensation (see Wils, 2009). However, although these private damages actions aim at compensation, they typically also have a reinforcing effect on the deterrence of hardcore cartels.

From an economic perspective, a system of private antitrust enforcement must be based on a sound theory of harm and must address particularly two issues: identifying damaged parties and determining the amount of damages. In the remainder of this paper, we concentrate on the damage of direct purchasers[2] of a cartelized product and specifically investigate the key determinants of the final damage value and how transaction data can help to improve the respective estimations.

In general, the damage caused by a hardcore cartel is a function of the demanded quantities of the cartelized product and the cartel-induced increase in price above the competitive level. As a consequence, any analyst aiming at estimating cartel damages has to come to robust conclusions on both the length of the cartel, i.e., the time frame over which the cartel was active and charged excessive prices, and the height of the cartel, i.e., the price overcharge achieved by the cartel members. The total damage estimate is then basically derived by multiplying cartel length with the cartel height. Figure 1 below sketches these two dimensions of cartel damages graphically.

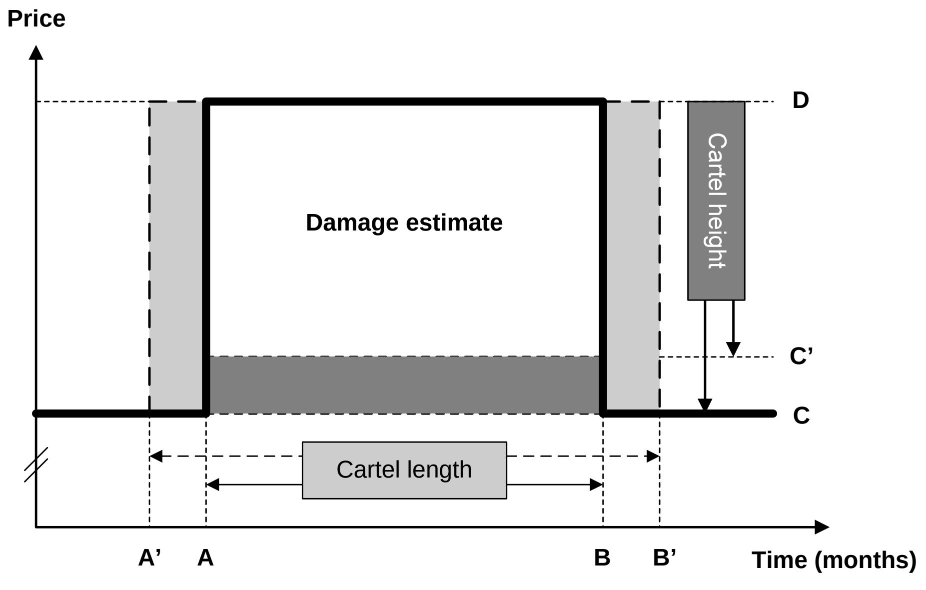

Figure 1: Cartel length, cartel height and the estimation of damages
Source: own graph

In order to derive an estimate of the final damage, the determination of *cartel length* is the first compulsory dimension. For example, if the cartel agreement was referring to a product sold via medium- and long-term contracts, it is likely that the breakdown of the cartel did not

[2] Other potentially damaged parties include indirect purchasers downstream, input suppliers upstream, non-cartel members or suppliers of complementary products (and their downstream customers).

cause an immediate drop in market price to the competitive level. As a consequence, the correct cartel length in the sense of the correct period in which harm was caused, might be longer than B, e.g., B' in Figure 1. The same general argument might apply vice versa for the time around the foundation of the cartel (A vs. A' in Figure 1).

The second dimension of the final damage value is *cartel height*. As the excessive cartel price (marked D in Figure 1) can be observed easily, the key challenge for an analyst is the estimation of the but-for price, i.e., the price that would have existed absent the cartel (marked C in Figure 1). The difference between the cartel price and the but-for price determines the so-called price overcharge. As sketched in Figure 1, the final damage value is reduced with increasing but-for prices (e.g., from C to C' in Figure 1).

2.1.1 Identification of cartel length

The identification of the length of a cartel is a compulsory step in the estimation of cartel damages[3] (see, e.g., van Dijk and Verboven, 2008; Davis and Garcés, 2010; ABA, 2010). Although most private damage cases are follow-on actions and are therefore able to use the cartel length determined in the public trial, different enforcement standards between public and private trials might suggest separate activities to identify the true cartel length. Moreover, the public trial considers overall welfare damage caused by the cartel. In contrast, damaged companies searching for compensation need not cover all damaged companies. Therefore, regional effects, long-term relations between the damaged and cartel firm or other influences might drive individual cartel damage claims. Furthermore, it is reasonable to assume that the breakdown of a cartel agreement does not lead to an immediate drop of the market price to the competitive level but – for several reasons – is rather followed by a transition period from the cartel to the non-cartel state. First, even after cartel detection, forms of tacit collusion might still have some impact leading to a lagged price decline down to the competitive level. Second, in many upstream product markets, medium- and long-term contracts may lead to certain price persistence even after the cartel breakdown. Third, price rigidities can play a more general role, e.g., in the sense that cost changes are not reflected immediately in respective price changes.

The likely existence of a transition period from the cartel to the non-cartel period demands a consideration in the damage calculation. As the transition period is caused by the cartel agreement, the smaller but still elevated prices in the transition period must be included into

3 In this paper, we abstract from the problem that cartels might temporarily break down for reasons such as dispute among the cartel members or new market entry (but get reinstated afterwards). From an economic perspective, such 'price war' periods must be included into the total damage estimation.

the price overcharge estimation and the subsequent calculation of damages. If only aggregated public data is available, the actual transition process is difficult to identify and an econometric model has to consider simplified assumptions on the transition period.[4]

The availability of transaction data allows a much more detailed investigation of the transition period. An econometric tool which can help to identify individual cartel length is structural break analysis. This method formalizes the intuition that the beginning and the end of the cartel is reflected in breaks in the time series. One possibility to implement such an analysis is to define several dummy variables reflecting different assumptions on the cartel beginning and cartel end (see Davis and Garcés, 2010). As shown in Section 4 below, the availability of detailed transaction data increases the value of such analyses substantially.

2.1.2 Identification of cartel height

Cartel height, i.e., the difference between the excessive cartel price and the competitive 'but-for' price, is the second key determinant of the final damage value. Economic research has developed several classifications of methods to estimate price overcharges (see, e.g., van Dijk und Verboven (2008), CEPS et al. (2007) and Oxera (2009)). For example, the seminal contribution by Oxera (2009) differentiates between three broad groups of methods: comparator-based, financial-performance-based, and market-structure-based. *Comparator-based approaches* use external data to estimate the price overcharge by a) cross-sectional comparisons (comparing different geographic or product markets); b) time-series comparisons (analyzing prices before, during and/or after an infringement); and c) combining approaches a) and b) in a so-called 'difference-in-differences' model (e.g., analyzing the change in price for a cartelized market over time, and comparing this change against the change in price in a non-cartelized market over the same time period).

Financial-analysis-based approaches use financial information on comparator firms and industries, benchmarks for rates of return, and cost information on defendants and claimants to estimate the counterfactual. Examples for techniques in this category are the examination of financial performance such as profitability or bottom-up costing of the cartelized product to derive the 'but-for' price.

4 For example, one possibility for the modeling of the price development in the transition period is to assume a linear price development by introducing an indicator variable with the value '1' at the end of the cartel period and the value '0' at the end of the transition period. Although indicator variables by definition have two specifications, a graduation can be implemented quite easily. A value of '1' of the indicator variable basically means that the price at this particular point in time contains the full price overcharge of the cartel. If the indicator variable reaches a value of '0.5' after the breakdown of the cartel, the respective price still contains half of the price overcharge of the cartel.

Market-structure-based approaches use a combination of theoretical models, assumptions and empirical estimations to derive a counterfactual estimate. Applying such an approach demands in a first step the identification of a theoretical model that fits best to the relevant market (e.g., a Cournot oligopoly model). Such a model should help in understanding how competition works in the respective market and how a reasonable 'but-for' price can look like. In a second step, the respective model can be calibrated using standard econometric techniques.

The different methods to estimate 'but-for' prices differ significantly with respect to their input requirements, conceptual complexity, technical complexity and underlying assumptions. Given these differences and the diverse characteristics of real-world cartels, Oxera (2008) among others argues that there is no one-size-fits-all approach. To the contrary, it is not only necessary to identify the most suitable methods on a case-by-case basis, but it is also advisable to apply several methods in parallel in order to cross-check (or even pool) the results to arrive at a robust and reliable estimate of the 'but-for'-price. E.g., in our empirical analysis below, data constraints only allow the application of a before-and-after approach.

3 The cement market and the German cement cartel

An important precondition for a robust econometric analysis of the damage caused by a hardcore cartel is a profound understanding of both the respective market in general and the cartel agreement in particular. Therefore, 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 refers to the so-called CEM I cement which contains only Portland cement clinker and no other possible constituents such as blast furnace 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 Portland 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."[5] 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)[6] and

5 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 (last accessed on 12 May 2012).

6 See European Commission decision of *Cembureau*.

on the national level, such as in Norway, Sweden, France, Poland, India or the United States of America to name only a few.

3.2 The German cement cartel

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 EUR 329 million due to partly insufficient data. Fines totaling EUR 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 2.

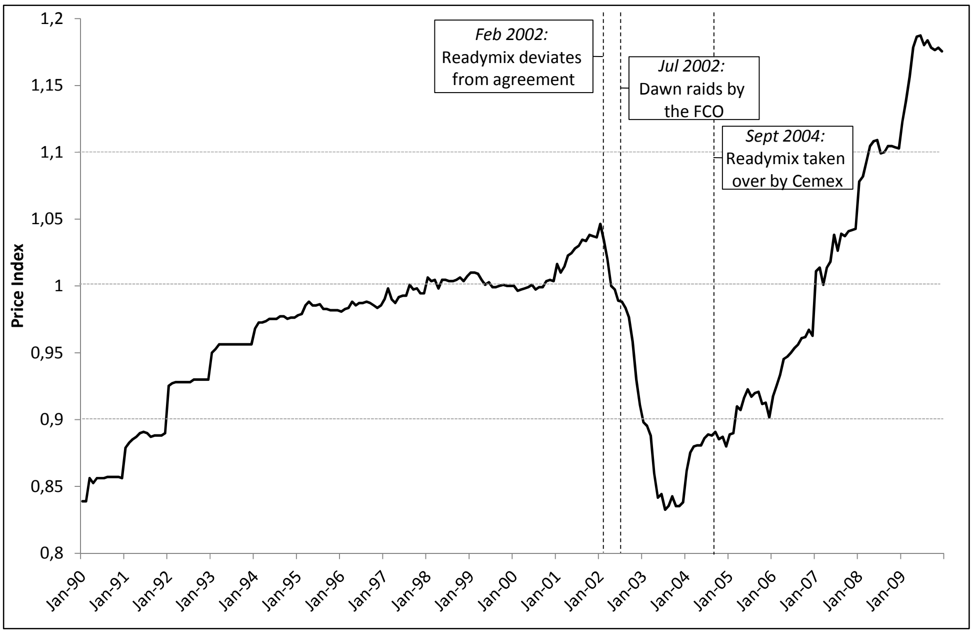

Figure 2: The public price index for cement from January 1990 to December 2009
Source: Own graph following Friederiszick and Röller (2010), p. 599

In addition to the general development of the public cement price index from January 1990 to December 2009, Figure 2 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.[7]

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 bottom price 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 deriving the but-for price, partly, because the cement price index increased substantially in the aftermath of this event.[8]

4 Empirical analysis

In this section, we use private transaction data to investigate the ‘length’ and the ‘height’ of the German cement cartel. Section 4.1 gives a brief introduction into the data set and presents the descriptive statistics. The subsequent section 4.2 applies structural break analysis to gain additional insights on particularly the end of the cartel agreement, followed by the estimation of different models aiming at quantifying the price overcharge realized by the cement cartel. In Section 4.3, we rerun all regressions for the aggregated data set in order to check the robustness of our results. Section 4.4 provides a brief discussion of the major insights of our empirical analysis.

4.1. Data set and descriptive statistics

In our empirical analysis, we use invoice data collected by CDC Cartel Damage Claims based in Brussels. The raw data consists of about 340,000 market transactions from 36 smaller and

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7 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 May 2012).

8 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).

larger customers of German cement producers, both cartelist and non-cartelist.[9] Market transactions include information on delivered quantities, gross prices, 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 and net prices, quantities, providers, traders, cement type or places of deliveries. Technically, the transaction data used for our analysis is an unbalanced panel data set. The descriptive statistics for the entire data set is shown in Table 1.

Table 1: Descriptive statistics (entire data set)

Variable		Unit	Mean	Std. Dev.	Min.	Max.
Deflated Price	p	Euro	74.81	15.04	1.30	231.20
Deflated Price North		Euro	83.57	16.92	18.40	228.41
Deflated Price South		Euro	80.22	14.52	14.79	178.71
Deflated Price West		Euro	75.07	14.15	1.55	231.20
Deflated Price East		Euro	66.81	11.91	1.30	210.51
Deflated Price Strength 32.5		Euro	68.45	14.18	1.30	228.41
Deflated Price Strength 42.5		Euro	77.28	14.00	1.55	231.20
Deflated Price Strength 52.5		Euro	85.88	18.55	8.31	130.14
Index of Production Precast Concrete Units (Detrended)	Pcu		138.366	12.767	107.900	161.700
Yearly Demand	Yd	1000 t	91.564	96.831	0.084	368.644
Share East Imports	$Eastimp$		0.041	0.199	0	1
Share Unloading Point North			0.073	0.260	0	1
Share Unloading Point South	$South$		0.314	0.464	0	1
Share Unloading Point West	$West$		0.310	0.463	0	1
Share Unloading Point East	$East$		0.303	0.459	0	1
Share Strength 32.5	$F32.5$		0.322	0.467	0	1
Share Strength 42.5	$F42.5$		0.635	0.481	0	1
Share Strength 52.5			0.043	0.203	0	1

Source: Own calculations based on transaction data

Due to the key role of market price for our empirical analysis, we differentiate this variable further by *market region* and *strength of CEM I cement.*[10] As revealed by Table 1, first, the regions North and South face on average higher prices than the regions West and East. Second, average prices increase with an increase in the strength of CEM I cement.

Due to the fact that cement demand typically follows cyclical trends, we include the variable *index of production precast concrete units* into our analysis. The index is detrended so that it does not exhibit seasonal fluctuations. The inclusion of the variable *yearly demand* reflects cement demand on a customer-by-customer basis throughout an entire year. The

9 Please note that our empirical analysis only refers to (a large part of) the transactions of the 36 customers of cement companies that enter our data set. In sum, these quantities cover less than 10 percent of the entire German demand for cement.

10 We concentrate on this type of cement for the remainder of the article. CEM I cement represents about 73 percent of the entire cement demand in the data set.

analysis of the direct impact of the transaction-based demand on prices ignores that the respective invoice-related demand is constrained by the size of the means of transportation. Furthermore, alternative measures such as demanded quantity per unloading point or supplier face serious flaws.[11]

The variable *Share East Imports* reflects the share of transactions which refer to imports of cement from Poland or the Czech Republic. Table 1 shows a small share of deliveries from both countries. We abstain from quantity-weighted measures due to the fact that most imports from these countries took place by rail (which is able to transport large quantities of cement at once).

Complementary to the presentation of the descriptive statistics of the entire data set, a split of the entire data set into the cartel period and the consecutive non-cartel period can provide additional insights. Table 2 shows the descriptive statistics under the assumption that the cartel period lasted from January 1992 (the beginning of our data set) to January 2002 (the last full month of the cartel agreement according to the public trial) and a consecutive non-cartel period lasted from February 2002 to December 2003 (the end of the data set, not the non-cartel period).

[11] With respect to the 'demanded quantity per unloading point' measure, the data base contains both transportation companies who deliver to different unloading points and companies who use cement as input good for the production of other goods such as paving stones or railroad ties. As a consequence, a differentiation by unloading point would underestimate the significance of transportation companies. Furthermore, no suitable approximation measures are available for the supplied quantity per unloading point. On the one hand, price should be explained by quantity. On the other hand, we can expect that – especially for transportation companies – price has an inverse impact on the ordered quantity per supplier leading to a simultaneity problem between price and quantity, i.e., a mutual influence between price and quantity on an unloading-point basis. The second alternative measure – demanded quantity per supplier – also faces serious flaws. For example, while the price might be reduced in the non-cartel period through rebates, the quantity cannot be corrected for, e.g., free-of-charge deliveries.

Table 2: Descriptive statistics (divided into cartel and non-cartel periods)

Variable	Unit	Cartel Period	Non-Cartel Period
Deflated Price	Euro	76.42	57.47
Deflated Price North	Euro	85.05	59.48
Deflated Price South	Euro	82.03	64.85
Deflated Price West	Euro	76.86	56.04
Deflated Price East	Euro	68.28	47.38
Deflated Price Strength 32.5	Euro	70.11	50.01
Deflated Price Strength 42.5	Euro	78.72	60.89
Deflated Price Strength 52.5	Euro	90.76	60.69
Index of production Precast Concrete Units (Detrended)		140.942	110.699
Yearly Demand	1000 t	92.082	85.992
Share East Imports		0.044	0.019
Share Unloading Point North		0.075	0.049
Share Unloading Point South		0.307	0.388
Share Unloading Point West		0.310	0.313
Share Unloading Point East		0.308	0.249
Share Strength 32.5		0.323	0.313
Share Strength 42.5		0.638	0.605
Share Strength 52.5		0.040	0.082

Source: Own calculations based on transaction data

As shown in Table 2, all four unloading point regions show a substantial price decrease in the non-cartel period. Comparable results are found for the different strengths of CEM I cement, although the price decrease for a strength of 52.5 N/mm^2 is the most significant. The index of production precast concrete units shows a downward trend of cement demand over time which can be explained by the general economic downturn in the observation period. With respect to the unloading points, the descriptive statistics show an adjustment from the regions North and East to the region South. However, this adjustment is not triggered by market-related changes but can simply be explained by changes in the available data. The strength shares show an increase in demand for cement with higher strengths while especially the demand for medium-strength cement experienced a significant reduction.

The substantial value of the transaction data at hand can best be exemplified by briefly comparing it to publicly available data. For example, the estimations used in the public trial (see Section 3 above) were largely based on a time-series of a cement price index. The index is calculated on a monthly basis 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 firms to the FSO. Furthermore, the FSO only collects gross price data for entire Germany and therefore does not allow any closer investigation of the role of gross-net price differences, geographical differences or variation in cement types.

4.2. Empirical assessment of cartel length[12]

In this section, we investigate how transaction data might help to gain additional insights on the length of the German cement cartel. Referring to the general discussion on the relevance of cartel length for robust damage estimation in Section 2.1.1 above, we conduct structural break analysis to particularly investigate the end of the cement cartel as reflected in invoice data.[13]

In general, structural break analysis provides statistical evidence for changes in data structure over time. While such an 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. 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 and at which point in time customers experienced a significant change in prices due to the cartel breakdown.

To investigate this issue, in a first step, we compare average prices and average variation coefficients 12 months before and 12 months after the period where the break is suspected (i.e., the official detection of the cartel by the Federal Cartel Office in February 2002). A significant change in prices takes place if the following t-value is significantly different from zero:

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

[12] This section largely follows the analysis in Hüschelrath and Veith (2011).
[13] Unfortunately, data limitations do not allow us to investigate the beginning of the cartel.

$\widehat{p_c}$ 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 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 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. Descriptive statistics suggest 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.

In a second step, we iteratively repeat the structural break analysis procedure six periods before and six periods after the end of the cartel to check whether transaction data suggests a different end of the cartel agreement. Figure 3 below shows the t-values for the period of the assumed structural break using public data and aggregated private price data and private monthly price variation coefficient data.

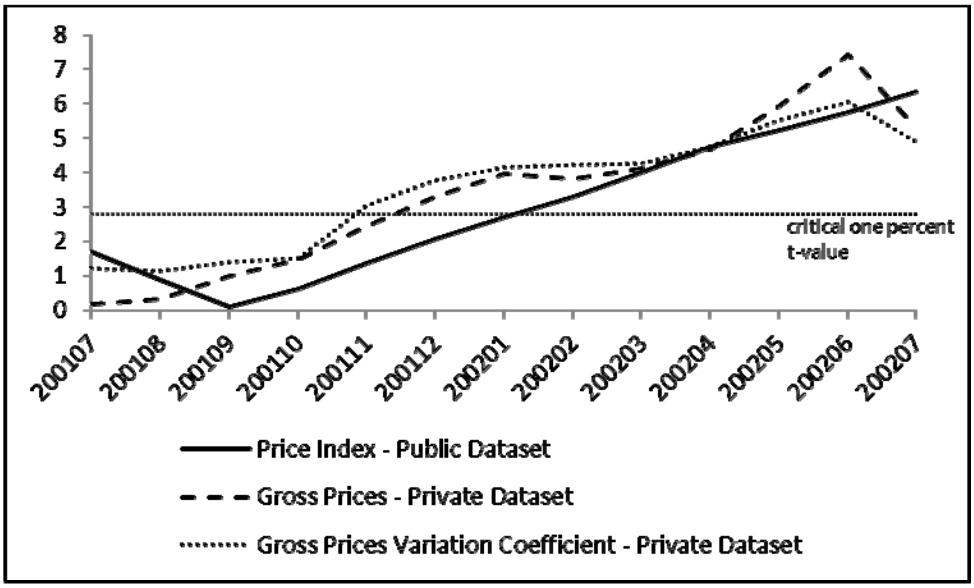

Figure 3: t-values for varying break points
Source: Hüschelrath and Veith (2011)

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 (based on the 5-percent level).[14] This finding corresponds to the history of the cement cartel described in Section 3.2 above which found first signs of the cartel breakdown – caused by the deviation of a cartel member *not* the detection of the competition authority – towards the end of the year 2001.[15] 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 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 nutshell, aggregated transaction data provides an indication that some (large) customers of the cartelists experienced lower prices due to the end of the cartel agreement in November 2001 already. In addition to the aggregate use of transaction data conducted here, it is also possible to conduct such an analysis on an individual firm level, i.e., structural breaks are investigated on the level of individual customers. On the one hand, such an analysis might create additional value as contract terms might differ substantially between customers. On the other hand, it complicates analysis especially due to substantial variation in the purchasing patterns and purchasing quantities across customers (see Hüschelrath and Veith, 2011, for a detailed assessment in a cartel detection context).

4.3. Empirical assessment of cartel height

Following the empirical assessment of cartel length as one key determinant of the amount of damages, this section focuses on the second key determinant: cartel height, i.e., the size of the cartel overcharge. Based on the transaction data set described above, we develop and estimate two different models. While model 1 belongs to the group of so-called 'pooled models' and differentiates between level and log-linear specifications, model 2 makes full use of the panel data structure and estimates random-effects and fixed-effects models.

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[14] 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.

[15] 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.

Due to data limitations, we will concentrate on the application of one particular comparator-based approach to estimate the price overcharge: the before-and-after approach. This method basically compares the price during the cartel period with the price in the same market before and/or after the cartel period. The 'before-and-after' approach has certain key advantages that explain its frequent application in overcharge estimations. First, data requirements are limited to time series of the respected cartelized product. Second, the economic concept behind the approach is quite straightforward thereby easing its application in court proceedings. Third, an estimation of the overcharge is technically relatively easy to implement and therefore suitable for implementation in a relatively short time window. Fourth, it is not necessary to make any assumptions on industry conduct absent the cartel.

These various advantages of the method have to be traded off against several potential disadvantages or challenges. In general, the performance of the ‚before-and-after' approach depends on the degree to which prices before/after the cartel provide a good approximation of the competitive prices in the long-run equilibrium. It is therefore crucial to closely investigate industry and market conditions before and after the cartel (see ABA, 2010). If the post-cartel period is chosen as comparator, overcharges might on the one hand be underestimated due to a possible continuation of (possibly tacit) collusion among the former cartel members (see, e.g., Harrington, 2004a, 2004b). On the other hand, an overestimation is possible if the former cartel members reduce prices below the competitive level, either to calm down angry customers (see Connor, 2008), or due to a price war that might follow the breakdown of the cartel (see de Coninck, 2010).

4.3.1. Pooled models

In general, the richness of transaction data allows a much more detailed analysis of specific aspects of the cement market and the cement cartel. For example, it is possible to control for differences between the four German sub-markets (North, South, West, East) and between different strengths of CEM I cement through the inclusion of dummy variables. In this section, we estimate the following equation by applying pooled models:

$$\begin{aligned} p_i = {} & \alpha + \beta_C Cartel + \beta_{Pcu} Pcu + \beta_{Yd} Yd_i + \beta_{Eastimp} Eastimp \\ & + \beta_{South} South + \beta_{West} West + \beta_{East} East + \beta_{F32.5} F32.5 + \beta_{F42.5} F42.5 + \varepsilon_i \end{aligned} \qquad (2)$$

Equation (2) basically explains the deflated price p_i per transaction i by a *Cartel* variable and several further right-hand side variables defined above. We follow the standard procedure in the econometrics literature and estimate two specifications of this model: in absolute terms (model 1a) and in logarithms (model 1b). Given this general characterization of our model approach, Table 3 shows the estimation results.

Table 3: Estimation of the price equation (models 1a and 1b)

Dependent Variable	Price		Log(Price)	
	Coefficient (Std. error) (1a)	Sign. Level	Coefficient (Std. error) (1b)	Sign. level
Cartel Period	17.024 (2.468)	***	0.325 (0.059)	***
Index of Production Precast Concrete Units (detrended)	0.112 (0.050)	**	0.001 (0.001)	**
Yearly demand (in '000/log.)	-0.036 (0.006)	***	-0.050 (0.007)	***
East Imports	-0.442 (2.397)		-0.013 (0.033)	
Unloading Point South	1.572 (2.751)		0.025 (0.028)	
Unloading Point West	-8.038 (2.530)	***	-0.098 (0.030)	***
Unloading Point East	-11.254 (2.379)	***	-0.140 (0.027)	***
Strength 32.5	-15.825 (2.583)	***	-0.170 (0.056)	***
Strength 42.5	-9.981 (2.629)	***	-0.087 (0.056)	*
Constant	63.809 (5.309)	***	4.518 (0.122)	***
Adj. R^2	0.427		0.382	
F(9, 201)	62.71***		87.14***	
RMS error	11.392		0.190	
Number of observations	245,477			

*Remarks: Significance level: *** 0 – <0.01, ** 0.01 – < 0.05, * 0.05 – < 0.1*
Source: Own estimations based on transaction data

Column (1) in Table 3 shows the estimation results for the level specification (model 1a) while column (2) reports the results for the log-linear specification (model 1b). An initial comparison of both sets of results reveals that both the coefficient of determination *adj.* R^2 and the F-test are quite similar for both specifications. This is not too surprising given the fact that the second specification only implements a linear transformation of selected variables.

At first sight, the level of the *adj.* R^2 seems relatively low for both specifications compared to the usual values observed in, e.g., time series analysis. However, it must be reminded that our analysis is based on individual transaction data which is expected to have higher standard deviations than more aggregated data sets (for which the aggregation procedure takes away part of the idiosyncratic variation).

Turning to an interpretation of the variables, the *Cartel* coefficient is highly significant in both regressions and leads to a price overcharge of 17.024 EUR/t for the level specification and of 21.077 EUR/t for the log-linear specification. *Total market demand* has a significantly positive influence on market price while a negative relationship is shown for *individual firm demand*. For example, following the results for model 1a, if a certain customer increases its yearly demand by 1,000 tons, the average price to be paid by this firm drops by on average 3.6 Cents. In other words, customers with a large cement demand pay a lower price than customers with a small demand.

As further shown in Table 3, the *East Imports* variable is insignificant in both specifications. Several explanations can be provided for this observation. First, parallel to the German cement cartel, a cement cartel in Poland existed (which lasted at least from 1998 to 2009).[16] Due to a large overlap of the cartel participants in both countries, a similar market conduct can be expected. Second, it is established that the Polish cartel implemented some kind of foreclosure strategy to hinder cement imports from Eastern European countries. The substantial investments of Germany-based cement producers in Eastern Europe together with a strategy to close down a significant fraction of production capacities are an indication for such objectives. Third, as the share of invoices relating to deliveries from Eastern Europe lies at only about 5 percent, it is possible that this share is simply too small to lead to a significant effect. Last but not least, the model specification must be considered as a fourth explanation for the observed results. Due to data limitations, we were forced to include East Imports as a dummy variable into the econometric model. As soon as further information on supply relationships or ownership interdependences become available, a more complete picture of the role of East imports could possibly be drawn.

The *unloading points* have to be interpreted in relation to the region North. Focusing on the results of model 1a, while no statistically significant price difference can be found between North and South, the average prices for West and East are EUR 8.04 and EUR 11.25 below the average value of the high-price regions. Finally, the results for the different *strengths* of CEM I cement have to be interpreted in relation to the strength class 52.5 N/mm^2.

[16] According to paragraph 512 of the decision of the Polish Competition Authority, the non-leniency applicants denied having taken part in the cement cartel in Poland. They did not present evidence proving that they had ceased the cartel arrangement at any time. The leniency applicants on the other hand admitted that they had ceased cartel activities at the latest at the date of the leniency application in June 2006. As a consequence of failing to provide evidence to the contrary, the Polish Competition Authority concluded in paragraph 513 of its decision issued on 9 December 2009 that the anticompetitive practice had not yet been terminated.

Again focusing on the results for model 1a, Table 3 reveals that CEM I cement of a strength of 32.5 N/mm^2 / 42.5 N/mm^2 is on average EUR 15.83 / EUR 9.98 cheaper than CEM I cement of a strength of 52.5 N/mm^2.

Comparing the results of the descriptive statistics with the first multivariate modeling results reveals several important observations. For example, when comparing the price differential between the cartel period and the non-cartel period, the descriptive statistics in Table 1 show that the average deflated prices in the cartel period were EUR 76.42, while the non-cartel period showed average prices of EUR 57.47, leading to a price difference of EUR 18.95. The results of the multivariate approach show – exemplary for model 1a – that the cartel price was on average EUR 17.02 higher than in the non-cartel period. The higher price difference for the descriptive approach can be explained by the fact that the multivariate approach includes further simultaneous impact factors on the average price for cement such as, e.g., price fluctuations in different regions. The multivariate approach is therefore expected to lead to more accurate results compared to simple descriptive statistics.

Following the results shown in Table 3, the price in the cartel period was 0.325 higher than in the non-cartel period. In order to calculate the corresponding average price, the average of the logarithm of the non-cartel period prices must be determined (which is found to be 3.981). The average price in the cartel period can then be calculated as exp(3.981+0.325) = 74.14 EUR/t, leading to an absolute cartel overcharge of EUR 20.57. This significantly larger overcharge – compared to the other values found above – can be explained by taking the logarithm of the price variable and the consequential stronger left-shift of larger values compared to smaller values explained above. This has a direct effect on the arithmetic mean. Furthermore, while the distribution of the absolute values in the data set is weakly left-skewed ($\nu = -0.242$), taking the logarithm further increases the left-skewness of the distribution ($\nu = -10.839$). This has a direct impact on the estimation results in the sense that the price during the non-cartel period is lower. As the distribution of the absolute price comes rather close to a normal distribution, the estimation approaches underlying model 1a (based on absolute values) should be preferred over model 1b (based on logarithmic values).

4.3.2. Static panel data models

The previous econometric models ignored both the time component and the individual character of the variables. Static panel data approaches implicitly control for potential influences resulting from time or idiosyncratic drivers. In the following we apply the two most prominent static methods – the random-effects approach and the fixed-effects approach – and compare the respective estimation results.

Technically, the key difference between the pooled model discussed in the previous section and the random-effects model is that the latter allows for changes of independent and dependent variables over time and the consideration of individual effects. Both changes are directly reflected in the estimation equation:

$$p_{it} = \alpha + \varepsilon_i + \beta_C Cartel + \beta_{Pcu} Pcu + \beta_{Yd} Yd_{it} + \beta_{Eastimp} Eastimp \\ + \beta_{F32.5} F32.5 + \beta_{F42.5} F42.5 + u_{it} \tag{3}$$

Equation (3) differs from Equation (2) in the following ways. The dependent variable p_{it} and the yearly demand variable Yd_{it} now consider the time aspect. Although the constant α is again assumed identical for all estimations, time-independent individual deviations exist for every combination of unloading point and customer ε_i. In this respect, it is important to remark that a random-effects estimation assumes a joint normal distribution across all potentially possible unloading point-customer combinations. The individual difference therefore has to be interpreted as an additional time-independent error term leading to a composite error of $v_{it} = \varepsilon_i + u_{it}$.

The fixed-effects specification (Model 2b) differs only slightly from the random-effects estimation just discussed. The respective regression equation has the following form:

$$p_{it} = \alpha_i + \beta_C Cartel + \beta_{Pcu} Pcu + \beta_{Yd} Yd_{it} + \beta_{Eastimp} Eastimp \\ + \beta_{F32.5} F32.5 + \beta_{F42.5} F42.5 + u_{it} \tag{4}$$

While the random-effects specification assumes a joint distribution across all potentially possible unloading point-customer combinations, the fixed-effects approach explicitly models individual differences with a separate constant term α_i for every unloading point-customer combination. This extension therefore allows investigating price differences on an individual basis. The estimation results of both static panel data models are shown in Table 4.

Table 4: Estimation of the price equation (models 2a and 2b)

Estimation technique	Random Effects		Fixed Effects	
	Coefficient (Std. error)	Sign. Level	Coefficient (Std. error)	Sign. Level
	(2a)		(2b)	
Cartel Period	15.059 (0.096)	***	15.062 (0.096)	***
Index of Production Precast Concrete Units (detrended)	0.074 (0.002)	***	0.074 (0.002)	***
Yearly Demand (absolute)	-0.021 (0.001)	***	-0.021 (0.001)	***
East Imports	-0.657 (0.118)	***	-0.658 (0.118)	***
Strength 32.5	-7.328 (0.137)	***	-7.321 (0.137)	***
Strength 42.5	-3.341 (0.120)	***	-3.335 (0.120)	***
Constant	58.686 (1.004)	***	57.130 (0.271)	***
R^2 (within)	0.190		0.190	
R^2 (between)	0.151		0.151	
R^2 (overall)	0.277		0.277	
Wald Chi^2 (6), F (6, 245,269)	57638.7***		9599.3***	
Number of observations	245,477			

*Remarks: Significance level: *** 0 – <0.01, ** 0.01 – < 0.05, * 0.05 – < 0.1*
Source: Own estimations based on transaction data

As revealed by Table 4, both specifications lead to very similar results. Compared to the pooled models, the unloading point is not explicitly included as the panel variable unloading point-customer already contains this information (and therefore considers it implicitly in the model). A comparison of the coefficients of the panel data estimations with the pooled estimations reveals a general downward shift of the coefficients in absolute terms taking the panel structure into account. With the pooled estimation approach, part of the unobserved heterogeneity is absorbed by other variables in the model. In consequence, the corresponding coefficients are larger in absolute terms in the pooled approach. In contrast, taking into account the time and the panel character, the wrongly dedicated ‘part of explanation’ is controlled by the variance clustering in the panel estimation approach which results in less deterred coefficients.

Furthermore, given the observation that a large fraction of the customers buy only one or a small number of different cement types, it is likely that in the pooled model, part of the individual differences of the customers was absorbed by the respective control dummies. As customer characteristics are explicitly controlled in a panel data approach, the impact of the strength variable on price is reduced. Finally, while it was not possible in the pooled model to determine the impact of East Imports on price, the more detailed panel data analysis allows a significant reduction of the model-inherent uncertainty leading to a significant coefficient. The availability of two slightly different panel data approaches finally suggests a reasoning which of the two approaches is more suitable for the case at hand. The Hausman-test investigates whether a panel data set follows a fixed-effects model or rather a random-effects model. As the test provides evidence for a systematic difference between the coefficients is existent ($Chi^2(6) = 32.65$), the fixed-effects approach is the preferred choice.

4.3.3. Estimation results based on aggregated transaction data

In the previous section, we applied two different sets of models to the disaggregated transaction data set. Disaggregated data sets generally have the advantage of containing the most detailed information possible. However, their typically large size together with their substantial heterogeneity lead to strong idiosyncratic heterogeneity and, thus, more scattered distributions in contrast to aggregated data.. As a consequence, it might add value to the analysis to find a sensible way to aggregate the data set. Although some information is inevitably lost during such an aggregation procedure, the aggregation at the same time increases the general manageability of the data set and flattens potential outlier patterns.

Following a couple of tests to assure a sufficient degree of representativeness, the original transaction data set was aggregated as follows. Concerning the key variables, the data set was stratified with respect to supplier, customer, unloading point and strength. This allows the derivation of information on market regions and imports from Eastern Europe. With respect to the time dimension, the data set was aggregated to a monthly basis. The aggregation procedure led to a reduction in the size of the data set to 16,200 observations (a reduction of about 93.4 percent). Again, the analysis focuses on CEM I cement and therefore ignores all other types of cement in the data set. The results for models 1 and 2 described above – now applied to the aggregated data set – are shown in Tables 6 and 7 in the Appendix.

As revealed by Table 6, the aggregation procedure led to a rather small improvement of the model fit as shown by the slightly elevated *adj.* R^2 values. The model variables also show only small changes. The significant shift of the unloading points in the region West identified above led to a corresponding increase in the coefficient of the respective dummies. The aggregation of the price variables led to a slightly right-skewed distribution ($\nu = 0.164$). The distribution of the logarithm of the price variables is still left-skewed, however, converges to the normal distribution ($\nu = -2.737$). With respect to absolute changes, the estimation of the log-linear model (model 1d) led to an average price for the cartel period of $\exp(4.002+0.313) =$ EUR 74.81. The corresponding value of the estimation of the absolute values (model 1c) is found to be EUR 75.55. Again, it can be concluded that the analysis on the basis of logarithmic values led to a stronger deviation. The discussion of the remaining estimation results is omitted here as they differ only slightly from the results for the disaggregated data.

Turning to the static panel data models, contrary to the results for the disaggregated data set, Table 7 shows that the coefficients between the pooled estimation and the panel data estimations differ less from each other. Nevertheless, the difference for the coefficient of the cartel dummy remains rather constant (as already observed for the disaggregated data set). With respect to the coefficient of the *East Import* dummy, the results show a further increase. Due to the strong weighting of the regions South and East in the data set and the significant differences in the respective shares, the panel data set led to a further increase in the explanatory power of this variable. For the same reason, the coefficient of the dummies for the different strengths increase compared to the pooled results.

4.3.4. Discussion of the results

Based on the various model estimations in the preceding two sections, this section provides a final comparison of the major results and a brief discussion of their implications. Although our empirical analysis produced a rich set of results, the overview table below concentrates on our major variable: the price overcharge of the cartel.

Table 5: Overview table of the overcharge estimates

No.	Model	Estimated overcharge in EUR/ton (2010 prices)	Estimated overcharge in percent
Disaggregate transaction data			
1a	Level	17,024	
1b	log-linear	21,077	32.5%
2a	random effects	15,059	
2b	fixed effects	15,062	
Aggregate transaction data			
1c	Level	17,389	
1d	log-linear	20,198	31.3%
2c	random effects	15,638	
2d	fixed effects	15,661	

Source: Own estimations based on transaction data

A comparison of the price overcharges based on disaggregated and aggregated data reveals that the stratification led to a slight increase – with the exception of the log-linear version of the pooled approach – but do not change results substantially. Extending such a comparison to the other variables confirms this general result as the use of aggregated data leads to comparable results with respect to both direction and strength of the respective coefficients. Given the fact that disaggregated data is often not available, our analysis of the data for the German cement cartel suggest that results would not differ much if more aggregated data is applied for the estimations. However, as soon as an aggregation procedure is applied, it is important to base it on objective criteria that do not favor the impact of specific variables.

In a nutshell, the undertaken comparison of various multivariate models shows that they typically lead to slightly different results.[17] In general, two main sources for this observation can be identified: the structure of the applied data set and the chosen estimation model. While the data set typically cannot be changed, the model choice remains the key driving factor of a robust and meaningful multivariate analysis. In order to show the robustness of the received results, it is a well established standard in economic research to apply different models. However, the analyst is still obliged to explain the potential relevance of the chosen models and the included variables in the specific context of the data set and the economic characteristics of the industry under investigation.

Although our results are robust, it is important to point to several caveats of our analysis. First, our data set covers only a fraction of the entire German cement market. As reported above, the data represents a bit less than 10 percent of German cement demand. Second, customers included in the data base are not distributed evenly across Germany but show a concentration in the Eastern and Southern parts of the country. Third, our data set ends in December 2003. Referring to the description of the cartel case in Section 3 above, this period was characterized by the lowest market prices (according to public gross price data). Although results for private data could diverge, our analysis would certainly benefit from additional private data including a few more years after the breakdown of the cartel. Fourth, in direct relation to this, the public trial assumed a price war taking place after the breakdown of the cartel. Although no evidence was published which clearly suggests the existence of a price war, data limitations would foreclose any attempt to model the effect of such an alleged price war.

[17] It is important to note here that even small increases in the overcharge can have substantial effects on the final damage amount. As our estimates refer to the price in EUR per ton, it is easy to show that an increase of a few cents can have a substantial impact for a customer who has regularly bought large quantities of cement.

Last but not least, given the general title of this paper, it is important to remark that the derivation of cartel length and cartel height is not the final stage of the estimation of damages. For example, before the respective volumes can be multiplied with the respective overcharge value, factors such as inflation, interest and possibly also compound interest must be considered and included into the calculation of the final damage value (see Hüschelrath et al. (2012) for an analysis within the German laws and regulations). Furthermore, our analysis in this paper focused on the estimation of damages for direct customers of the cartel. A full-fledged analysis, however, would not only have to consider other potentially damaged parties in upstream or complementary markets, but would also have to discuss the relevance of a possible pass-on of cartel-induced price increases to subsequent stages downstream. We leave these important further aspects for future research.

5 Conclusion

The recent past has seen increased efforts by both academics and practitioners to investigate the pros and cons of various techniques to quantify the harm caused by antitrust infringements. While such general discussions of various methods and models are certainly useful for the promotion of private damages actions, they typically ignore the challenges of applying the respective tools to real-world cases and real-world data.

Against this background, we use a unique private data set of about 340,000 invoice positions from 36 smaller and larger customers of German cement producers to study the value of such transaction data for an estimation of cartel damages. In particular, we investigate, first, how structural break analysis can be used to identify the exact end of the cartel agreement and, second, how an application of before-and-after approaches to estimate the price overcharge can benefit from such rich data sets.

With respect to the first key dimension of cartel damage estimations – *cartel length* – structural break analysis applied to transaction data leads to similar results as publicly available price index data. However, our empirical results do provide an indication that some customers experienced a substantial price drop even before the breakdown of the cartel is reflected in publicly available data. Although it is not the focus of this paper, transaction data can in principle be used to conduct structural break analysis on an individual firm level and would therefore allow a much more detailed analysis of the individual damages of a customer under investigation.

Turning to the second key dimension of cartel damage estimations – *cartel height* (i.e., the price overcharge) – our comparison of various multivariate models shows that they typically lead to slightly[18] different results. In general, two main sources for this observation can be identified: the structure of the applied data set and the chosen estimation model. While the data set typically cannot be changed, the model choice remains the key driving factor of a robust and meaningful multivariate analysis. In order to show the robustness of the received results, it is a well established standard in economic research to apply different models. However, the analyst is still obliged to explain the potential relevance of the chosen models and the included variables in the specific context of the data set and the economic characteristics of the industry under investigation.

Given our empirical results, we can generally conclude that transaction data sets allow for a much more detailed analysis of the cartel than the simple reliance on – typically highly aggregated – publicly available data. Although collecting individual data requires a complex infrastructure, strong efforts by damaged customers and a significant effort in data preparation, the resulting data sets and analyses provide a much more detailed perspective on cartelists' behavior and, thus, allow a much more precise calculation of damages. Admittedly, using transaction data has certain caveats, especially because it is typically available for a sub-set of the damaged parties only. However, the richness of the data allows so many in-depth investigations of the economic effects of the cartel agreement that its regular application in private antitrust cases is desired as long as data collection and preparation procedures are not prohibitively expensive. Especially due to the new software-based accounting systems – which significantly reduce data-related costs – hopes are raised that an application of transaction data sets will soon become the rule rather than an exception in private damage cases and will therefore boost the relevance of private antitrust enforcement in the European Union onto a new level.

[18] It is important to note here that even small increases in the overcharge can have substantial effects on the final damage amount. As our estimates refer to the price in EUR per ton, it is easy to show that an increase of a few cents can have a substantial impact for a customer who has regularly bought large quantities of cement.

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Appendix

Table 6: Estimation of the price equation (models 1c and 1d; aggregated data set)

Dependent Variable	Price		Log (Price)	
	Coefficient (Std. error)	Sign. Level	Coefficient (Std. error)	Sign. Level
	(1c)		(1d)	
Cartel Period	17.389 (1.571)	***	0.313 (0.035)	***
Index of Production Precast Concrete Units (detrended)	0.095 (0.035)	***	0.001 (0.000)	***
Yearly Demand (absolute/log.)	-0.039 (0.005)	***	-0.043 (0.008)	***
East Imports	-2.191 (1.845)		-0.031 (0.024)	
Unloading Point South	1.592 (2.163)		0.043 (0.036)	
Unloading Point West	-10.818 (2.360)	***	-0.110 (0.041)	***
Unloading Point East	-11.182 (2.032)	***	-0.128 (0.037)	***
Strength 32.5	-16.357 (1.811)	***	-0.196 (0.029)	***
Strength 42.5	-11.625 (1.653)	***	-0.129 (0.027)	***
Constant	68.851 (4.643)	***	4.504 (0.097)	***
Adj. R^2	0.437		0.389	
F (9, 201)	69.17***		108.04***	
RMS error	12.447		0.203	
Number of observations	16,196			

*Remarks: Significance level: *** 0 – <0.01, ** 0.01 – < 0.05, * 0.05 – < 0.1*
Source: Own estimations based on private data

Table 7: Estimation of the price equation (models 2c and 2d; aggregated data set)

Estimation technique	Random Effects		Fixed Effects	
	Coefficient (Std. error)	Sign. Level	Coefficient (Std. error)	Sign. level
	(2c)		(2d)	
Cartel Period	15.638 (0.381)	***	15.661 (1.229)	***
Index of Production Precast Concrete Units (detrended)	0.109 (0.009)	***	0.111 (0.009)	***
Yearly demand (absolute)	-0.018 (0.002)	***	-0.015 (0.002)	***
East Imports	-2.659 (0.501)	***	-2.679 (0.501)	***
Strength 32.5	-11.727 (0.470)	***	-11.669 (0.471)	***
Strength 42.5	-7.900 (0.442)	***	-7.832 (0.442)	***
Constant	57.429 (1.551)	***	56.317 (1.229)	***
R^2 (within)	0.250		0.250	
R^2 (between)	0.125		0.115	
R^2 (overall)	0.275		0.269	
Wald Chi^2 (6), F(6, 15,988)	5377.4***		890.3***	
Number of observations	16,196			

*Remarks: Significance level: *** 0 – <0.01, ** 0.01 – < 0.05, * 0.05 – < 0.1*
Source: Own estimations based on private data