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The impact of cartelization on pricing dynamics: Evidence from the German cement industry

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**The Impact of Cartelization
on Pricing Dynamics**

Evidence from the German Cement Industry

Kai Hüschelrath and Tobias Veith

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Non-technical summary

Although the pricing dynamics of hardcore cartels have been studied intensively from a theoretical perspective, empirical evidence is still rare. We combine publicly available data with a unique private data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers to study the pricing dynamics during and after the breakdown of a German cement cartel. We find that, first, after the breakdown of the cartel, cartel members reduce net prices to a far larger extent than gross prices and that, second, non-cartel members slip under the price umbrella of the cartel to increase profits. Our results have important implications for both the design of screening tools to detect cartels as part of public enforcement and the calculation of damages as part of private enforcement of competition law.

Das Wichtigste in Kürze

Während sich die Preisdynamik von Kartellen in den vergangenen Jahren einer intensiven Diskussion von theoretischer Seite erfreut hat, ist empirische Evidenz bislang sehr spärlich gesät. Wir kombinieren öffentlich verfügbare Daten mit einem privaten Datensatz bestehend aus rund 340.000 Rechnungspositionen von 36 größeren und kleineren Kunden deutscher Zementhersteller und untersuchen die Preisdynamik während und nach dem Zusammenbruch eines deutschen Zementkartells. Unsere Ergebnisse zeigen einerseits, dass die Kartellanten nach dem Zusammenbruch des Kartells ihre Nettopreise sehr viel deutlicher absenkten als die entsprechenden Bruttopreise. Andererseits belegen unsere empirischen Analysen, dass die Nicht-Kartellanten ihre Preise über das Wettbewerbsniveau anhoben und auf diese Weise ebenso von der Kartellabsprache profitierten. Unsere empirischen Ergebnisse erlauben die Ableitung wichtiger Politikimplikationen sowohl für die Ausgestaltung von Preismonitoring-Systemen als Teil der öffentlich-rechtlichen Kartellverfolgung als auch die Ermittlung von Schadenshöhen als Teil der privatrechtlichen Durchsetzung des Kartellrechts.

THE IMPACT OF CARTELIZATION ON PRICING DYNAMICS

EVIDENCE FROM THE GERMAN CEMENT INDUSTRY

Kai Hüschelrath* and Tobias Veith*

November 2011

Abstract

Although the pricing dynamics of hardcore cartels have been studied intensively from a theoretical perspective, empirical evidence is still rare. We combine publicly available data with a unique private data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers to study the pricing dynamics during and after the breakdown of a German cement cartel. We find that, first, after the breakdown of the cartel, cartel members reduce net prices to a far larger extent than gross prices and that, second, non-cartel members slip under the price umbrella of the cartel to increase profits. Our results have important implications for both the design of screening tools to detect cartels as part of public enforcement and the calculation of damages as part of private enforcement of competition law.

Keywords Antitrust policy, cartels, umbrella pricing, net prices, cement, screening, damages

JEL Class L41, L61, K21

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1 Introduction

There is no question that the fight against hardcore 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

Despite the recent successes in the fight against hardcore cartels, it seems likely that a substantial fraction of cartels remain undetected. For example, 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, both competition authorities and private parties have incentives to further improve their respective detection and intervention instruments. One general possibility for such improvement is to gain knowledge on the behavior of hardcore cartels in general and their pricing dynamics in particular and to use these insights to improve public and private enforcement instruments such as screening tools or the calculation of damages.

Against this background, we contribute to the rather small empirical literature on the pricing dynamics of hardcore cartels by combining publicly available data with a unique private data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers. In addition to a general comparison of the private data set with publicly available price data, we particularly investigate, first, to what extent gross prices and net prices differ both during and after the breakdown of the cartel. Second, we focus on answers to the question whether and to what extent the pricing dynamics of cartel members and non-cartel members diverge during and after the breakdown of the cartel. Both types of new empirical evidence allow the derivation of important policy conclusions for the design of screening tools to detect cartels as part of public enforcement and the calculation of damages as part of private enforcement of competition law.

The paper is organized as follows. The second section provides an overview of existing research on the pricing dynamics of hardcore cartels. Although several empirical studies exist, the majority of contributions approaches these issues from a theoretical perspective. The

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>.

subsequent third section provides brief overviews of the German cement industry 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 a detailed description of the public and private data sets, the subsequent Section 4.2 makes use of the richness of the private data set by, first, analyzing the difference between gross and net prices during and after the cartel breakdown. Subsequently, Section 4.3 introduces a further perspective by differentiating between the pricing dynamics of cartel members and non-cartel members during and after the breakdown of the cement cartel. Section 4.4 complements the rather descriptive evidence of the preceding sections with an econometric analysis. The fourth section is closed by a discussion of the policy implications of the empirical results by focusing on both public and private enforcement of competition law. Section 5 concludes the paper with a review of the key empirical results and the derived policy implications.

2 The pricing dynamics of hardcore cartels

The economics of hardcore cartels² have attracted the attention of several generations of researchers. Although this fascination of cartel-related research is surely driven by a multitude of factors, several key specifics of hardcore cartels make them a particularly interesting study object. First, cartels typically face internal stability problems due to the short-run incentives of individual members to deviate from the conspiracy. As a consequence, cartels have to implement monitoring and sanctioning mechanisms in order to stabilize their agreements. Second, although cartelization typically increases the profits of the cartel members it comes at the substantial cost of allocative, productive and dynamic inefficiencies harming both the economy in general and the consumers in particular. Consequently, hardcore cartel agreements are prohibited in most jurisdictions around the world on a per-se basis. This constellation raises the questions of, first, how antitrust authorities can detect and prosecute cartels and, second, what strategies cartel members follow to hide their illegal conspiracies. Third, due to the per-se illegality of hardcore cartels, firms that are found guilty of cartelization do not only face fines as part of public enforcement of competition law but are also obliged – as part of private enforcement – to pay damages to parties harmed by the collusive agreements. Both types of intervention raise the question how the respective fines or damages should be derived by the respective authority or court.

² Hardcore 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.

Against this background, the following two sub-sections concentrate on one specific sub-topic out of the entire field of cartel-related research: the pricing dynamics of cartels. While Section 2.1 presents a review of related theoretical research, Section 2.2 concentrates on empirical studies that specifically investigate the pricing dynamics of firms during and after the breakdown of a cartel.

2.1 Review of theoretical research

The pricing dynamics of hardcore cartels have been studied intensively from a theoretical perspective. In the following, we concentrate our review on the most important research strands – for the purposes of this paper – such as the general incentives to form hardcore cartels, key characteristics of cartel pricing, pricing dynamics of cartel members and non-cartel members and pricing dynamics after a cartel breakdown.³

Following basic oligopoly theory, firms have an *incentive to form hardcore cartels* because coordinating the respective competitive activities leads to greater profits than acting independently. The basic rationale for this allegation lies in the internalization of a negative externality. In a competitive market, a firm is simply interested in how much a reduction in its own output benefits itself, while it ignores the (positive) effect that a reduction in output has on the profits of the other firms in the market. A cartel internalizes this effect by taking into account how changes in the output level of each firm affect joint cartel profits. As a consequence, it pays for the cartel to reduce total output below the competitive level leading to increases in both market price and joint profits.

Given the identified key aim of increasing profits through price increases, one *key characteristic* of a new cartel agreement is a non-transitory increase of the (mean) price. In addition to such simple ‘price monitoring’, the detection of hardcore cartels can make use of further indicators (see generally Harrington, 2008). For example, the analysis by Athey et al. (2004) suggests that the foundation of a cartel can be expected to lead to a reduction in the price variance as, for example, frequent adjustments of cartel agreements are costly and would complicate the detection of deviations from the cartel agreement. As a consequence, it can be expected that the transition from a non-cartel state to a cartel state is characterized by a decrease in price variance (and vice versa).

With respect to the *pricing dynamics of cartel members and non-cartel members*, the large literature on cartel formation investigates under which circumstances cartels are internally and

³ A detailed review of the theoretical, empirical and experimental findings can be found in Bolotova et al. (2008).

externally stable. In a quantity-setting oligopoly context, Selten (1973) shows that although the majority of firms must be members of the cartel, it may be optimal for smaller fringe firms to stay out of the cartel.⁴ However, although in this model context, the equilibrium prices are identical, the optimal individual outputs and profits diverge between cartel members and non-cartel members. The very small literature on so-called umbrella pricing confirms this basic result. In the context of a dominant firm price leadership model, Blair and Maurer (1982) find that while cartel members and non-cartel members both charge the same price in equilibrium, cartel members reduce individual outputs while non-cartel members increase outputs (see also Blair and Piette Durrance (2009)).⁵ In a recent paper, Bos and Harrington (2010) endogenize cartel formation in the context of an infinitely repeated price game with homogeneous goods where firms are heterogeneous in their capacities. They find that, when a cartel is incomplete, “... the colluding firms set a price that serves as an umbrella, with non-cartel members pricing below it and producing at capacity whereas cartel members restrict supply below capacity” (Bos and Harrington (2010), p. 108). They further confirm the earlier result of Selten (1973), namely that sufficiently small firms will not be part of a cartel while a larger firm is more inclined to join it.

A different set of theoretical papers investigates the change in pricing dynamics due to either the *introduction of antitrust policy* in general or the introduction of (or change in) specific competition policy instruments. In an early paper, Block et al. (1981) study the relationships between antitrust enforcement and optimal collusion in a simple (static) theoretical framework. The authors show that the presence of an antitrust authority will change the incentives of a profit-maximizing cartel in the sense that it will not set the monopoly price anymore basically because a higher price-cost markup makes an investigation of the antitrust authority more likely. However, the cartel will nevertheless charge a price above the competitive level which is determined by both the size of the expected fine and the probability of detection. In a more recent seminal paper, Harrington (2004b) diverges from

⁴ Following the seminal paper by Selten (1973), cartelization pays for all firms in the market as long as this number is sufficiently small. However, if the number of firms exceeds a threshold level – 5 firms in Selten’s model – then it is more profitable to become a cartel outsider. However, fringe firms by no means have to cause the breakdown of the cartel but can even have a stabilizing influence. A cartel is found to be stable as long as $f+3 \geq k \geq f+2$, with f being the number of fringe firms and k the number of firms in the cartel. As $f+k=n$, the above expression can be rearranged and expressed as follows: $(n+1)/2+1 \geq k \geq (n/2)+1$.

⁵ Blair and Romano (1989) propose a simple test to differentiate between cartel member and non-cartel members. The authors argue that after cartel formation, the cartel members typically have incentives to decrease individual outputs (under the assumption of identical individual cost functions). Non-cartel members, however, typically have incentives to increase their output in order to take advantage of the cartel. As a consequence, an analysis of the output decisions around the time of cartel formation can indicate whether a particular firm decided to join the cartel or rather stayed out of it.

the static approach of Block et al. (1981) and studies the cartel pricing dynamics in the presence of an antitrust authority. One of his key results is that the introduction of antitrust laws can lower the prices set by the cartel "... but can also allow them to charge higher prices by loosening the incentive-compatibility constraints associated with collusion" (Harrington (2004b), p. 671). Other contributions which especially investigate the effect of the introduction of leniency programs on cartel (price) behavior include Motta and Polo (2003), Aubert et al. (2005) or Houba et al. (2009).

In addition to research on cartel formation and cartel pricing dynamics during the cartel, a small literature investigates the complementary question of *pricing dynamics after the cartel breakdown*. Most prominently, Harrington (2004a) investigates post-cartel pricing during litigation. Based on an oligopoly model with n price-setting firms offering symmetrically differentiated products, he shows that the application of the 'before and after approach' for the derivation of the 'but-for' price provide the (former) cartel members with an incentive to price higher in the period from the breakdown of the cartel to the conclusion of the private lawsuit. This form of strategic behavior leads to an overestimation of the but-for price and therefore an underestimation of the harm caused by the cartel agreement.

2.2 Review of empirical research

Empirical evidence on the pricing dynamics of hardcore cartels is rare. Existing research largely consists of a substantial number of case studies focusing on the workings of specific cartels and investigating how they operated, how effective they were in sustaining collusion and how large the generated welfare losses actually were. Examples of such studies – not described further here – are Porter (1983), Ellison (1994), Porter and Zona (1999), Genesove and Mullin (2001), Röller and Steen (2006) or Asker (2010). Complementary to these specific case studies, several contributions present inter-industry studies of samples of cartels from various perspectives such as average overcharges, cartel duration, or reasons for cartel breakdown in a mostly qualitative fashion (see Connor and Lande (2006) and Levenstein and Suslow (2006) for surveys). Although most of those studies also discuss price-related effects of cartelization, they typically fall short of detailed (disaggregated) price data which allows a sophisticated analysis of the pricing dynamics during or after the cartel.⁶

A more specific and relatively new strand of empirical literature makes use of the (theoretically derived) price and price variance differences between competition and

⁶ There is also a large empirical literature investigating various factors that affect the likelihood of collusion. Kaplow (2011) presents an overview of this strand of research.

cartelization to develop screening tools to proactively detect hardcore cartels. 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 significant variety of screening approaches has been developed (see, e.g., Harrington (2008) for an overview), investigations of price and price variance recently gained special importance.

In a seminal paper, 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.

Last but not least, Bolotova et al. (2008) use ARCH and GARCH models to investigate the differences in the mean and the variance of the price distribution during collusive and competitive phases of the citric acid cartel and the lysine cartel. The authors not only find overcharges from 9 to 25 percent per pound for both cartels but also observe that the variance of prices during the lysine cartel was lower and the variance of prices during the citric acid cartel was higher than during the competitive periods. They explain the alleged counterintuitive results for the citric acid cartel with external forces which cannot be controlled by the cartel such as import competition. Bolotova et al. (2008) therefore conclude that more research is needed in developing successful screens for cartel detection.

In addition to the specific screening-related empirical literature, a different strand of research more generally investigates the reactions of *cartel firms' pricing dynamics* to differences (or changes) in competition policy. Block et al. (1981), for example, find for the US bread industry that an increase in the Department of Justice's (DOJ) enforcement capacity or filing of a DOJ price-fixing complaint had a negative effect on the price markups. Clarke and Evenett (2003) show for the case of the international vitamins cartel that the cartel reduced its overcharges in jurisdictions with tough cartel enforcement. Finally, Symeonidis (2000) analyses the effect of the introduction of anti-cartel laws in the United Kingdom in 1956 and finds that price competition increased and led to lower margins in industries which had been previously cartelized.

We contribute to the empirical case-based strand of research. We use a unique private data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers to study the pricing dynamics during and after the breakdown of a German cement cartel. In particular, we present new empirical evidence on, first, the differences between gross prices and net prices and, second, the differences in the pricing dynamics of cartel members and non-cartel members both during and after the breakdown of the cartel. Both types of new empirical evidence have important implications for both public and private enforcement of competition law.

3 The German cement industry and the German cement cartel

An important precondition for an economic analysis of the pricing dynamics of a hardcore cartel is a profound understanding of both the respective industry in general and the cartel agreements in particular. As a consequence, this section concentrates on, first, an overview of the key economic characteristics of the German cement industry, and second, a characterization of the latest German cement cartel.

3.1 The German cement industry

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.”⁷ 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)⁸ and 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 cartel⁹

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

⁷ 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>

⁸ See European Commission decision of *Cembureau*.

⁹ This section largely follows Friederiszick and Röller (2010).

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.

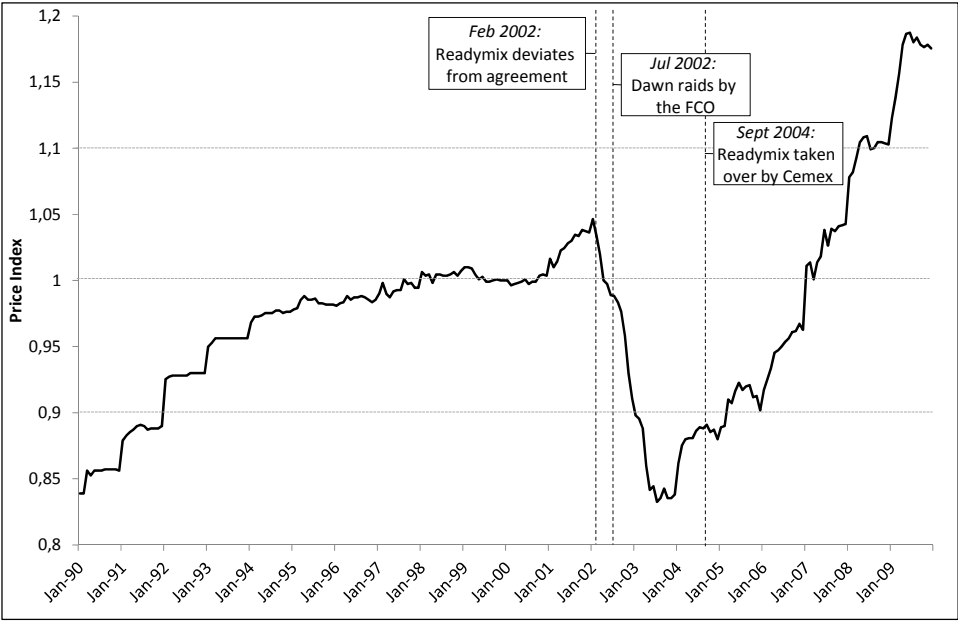


Figure 1: The public price index for cement from January 1990 to December 2009
Source: Own graph following Friederiszick and Röller (2010), p. 599

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.¹⁰

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.¹¹

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 evidence on the impact of cartelization on pricing dynamics

In this section, we present new empirical evidence on cartel pricing dynamics during and after the breakdown of the latest detected German cement cartel. In particular, we investigate two aspects of cartel pricing dynamics that have not been addressed by the empirical literature so far: differences in gross and net pricing behavior and differences in cartel members and non-cartel members pricing behavior. Following a characterization of the public and private data sets in Section 4.1, the subsequent Sections 4.2 and 4.3 investigate both the pricing dynamics of gross and net prices and cartel members and non-cartel members from a largely descriptive perspective. Subsequently, Section 4.4 presents a complementary econometric analysis to base our policy conclusions – derived in Section 4.5 – on more robust foundations.

¹⁰ 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).

¹¹ 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 Characterization of public and private data sets

Empirical analyses of hardcore cartels are often restricted to the use of public data sets. Although there is no doubt that such analyses can provide valuable insights, private data sets typically have the advantage of providing richer and more detailed information. For the German cement market and the German cement cartel, we are in the unique position to have both public and private data sets to investigate the pricing dynamics during and after the cartel breakdown. As public data has been repeatedly used in both academic studies and court investigations, we start with a brief description of this data set, followed by a detailed characterization of the private data.

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 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, as public data collection demands a continuous approach by each interviewed company, changes in the gross-net price difference are not reflected in the index.

The *private raw data set* was collected for the enforcement of antitrust damage claims 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 cartelized and non-cartelized.¹² 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 delivery. Furthermore, the data set allows for gross-net price comparisons. The gross-net price difference is determined by rebates, early payment discounts or free-off charge deliveries ('rebates' in the remainder of this paper; see Section 4.4.1 below for a detailed characterization). We focus on CEM I cement and use further invoice information on providers and places of delivery for data adjustments and the aggregation procedure.¹³ In particular, prices are adjusted to monthly average prices using alternative aggregation methods. Standard trucks are able to carry up to

¹² For confidentiality reasons, data was aggregated and used in an anonymous form.

¹³ 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).

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 hardly any of 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, supplier and customer. In a second step, 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.

4.2 Descriptive analysis of pricing dynamics

In this section, we present descriptive evidence on two particular pricing aspects in the German cement market during and after the breakdown of the cartel: gross and net pricing dynamics and cartel members and non-cartel members pricing dynamics.

4.2.1 Gross and net pricing dynamics

Pricing dynamics are often studied on the basis of gross prices. Although such an analysis is likely to provide substantial insights into the pricing behavior of firms, it ignores the impact of one strategic pricing instrument: the granting of rebates, early payment discounts or free-off charge deliveries ('rebates' in the following). For customers, these instruments lead to a factual price reduction questioning the gross price as a suitable basis for making purchasing decisions (as long as the suppliers differ substantially with respect to their rebate policy). As a consequence, as soon as the net price actually paid is significantly smaller than the gross price, economic analysis should ideally relate to net prices rather than gross prices as these reflect market prices depending on individual supplier-customer relationships. *Ceteris paribus*, the importance of these relationships increase with the market concentration on both sides.

In a cartel context, gross-net price differences can matter from at least three perspectives. First, during the cartel agreement, cartel members are typically only able to monitor gross prices but not net prices. As a consequence, cartel members might have possibilities (and incentives) to secretly deviate from the cartel agreement by reducing net prices rather than gross prices (in order to attract further projects or customers). Second, after the breakdown of the cartel, the cartel members might have incentives to reduce net prices to a larger degree than gross prices as, e.g., public price indices are expected to be based on gross prices rather

than net prices. As cartel offices and courts may use publicly available price data to estimate but-for prices, keeping gross prices high after the breakdown of the cartel has a direct negative effect on the amount of damages calculated on the basis of gross prices (instead of net prices). Third, rebates may reduce the overall market transparency.

Given this brief assessment of the general relevance of a gross-net price comparison the next step aims at comparing public and private data sets. As public data is only available in index form, we converted the private price data into indices. We have calculated private monthly average gross prices and net prices across all customers and suppliers and converted this data to gross and net price indices with the base period January 2000 (to make it comparable to the public index). The results are shown in Figure 2.

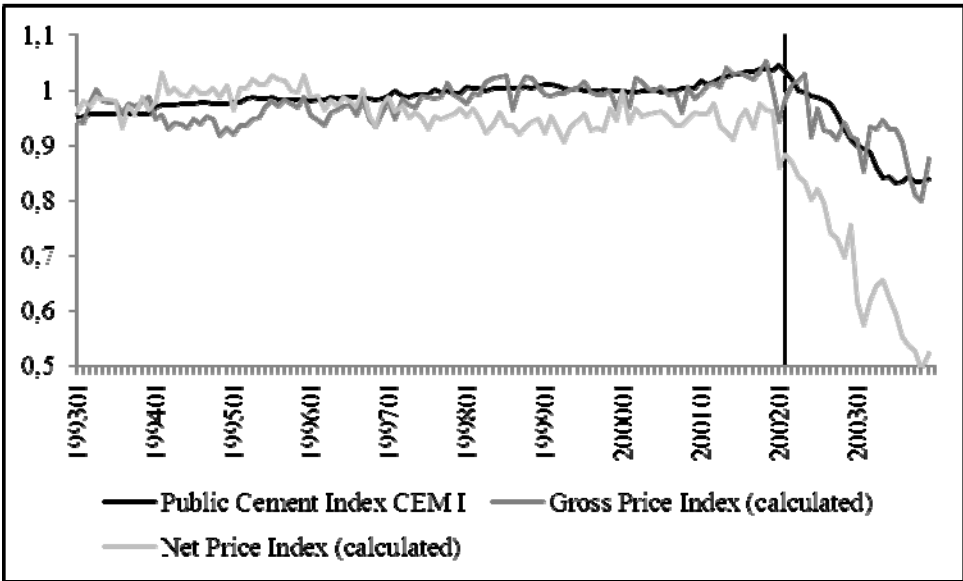


Figure 2: Comparison of public and private price indices

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

As shown in Figure 2, the gross price index based on private data is higher correlated with the public index than the net-price index ($r = 0.87$ for the gross-price correlation versus $r = 0.65$ for the net-price correlation).¹⁴ Furthermore, the net price index shows a substantially larger drop after the breakdown of the cartel than the gross price index suggesting that firms reduce net prices to a far larger extent than gross prices. This particularly important observation will be investigated further in the subsequent sections.

Complementary to a comparison of the public and private prices indices, Figure 3 provides further evidence on both price indices by plotting the month-by-month changes of the public and private price indices (gross and net values).

¹⁴ We use the 12-month moving-average approach as private data is much more volatile than public data.

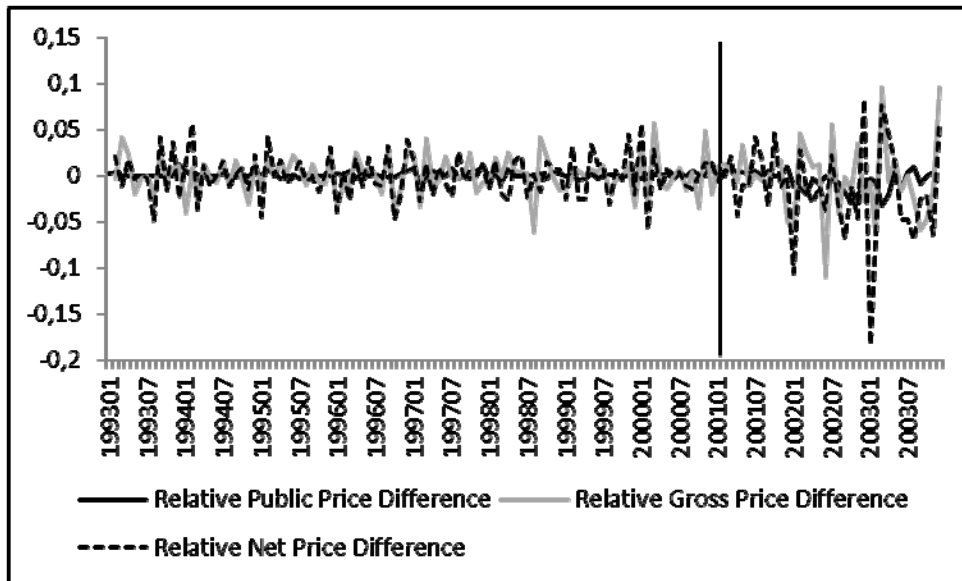


Figure 3: Month-by-month changes of public and private price indices

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

As implied by Figure 3, a much higher variation coefficient is found for net price data ($\rho = 2.87$) than for public and private gross price data ($\rho = -0.05$, $\rho = -0.37$), which differ even more in the post-cartel period. This observation confirms existing research showing an increase in price variation after the cartel breakdown. Furthermore, one additional reason for the observed difference in variation between public and private data must be seen in the low number of data points for calculating the public dataset. As cartel members are repeatedly found to dominate a market due to their size, these companies are stronger represented in public indices. In consequence, changes of public indices are much weaker, first, due to the number of reported transactions and, second, due to lower price variation during the cartel period. As a result, estimates based on the public index underestimate the impact of the cartel breakdown both in size and variation as shown in the graphs above.

Given these first important insights on the gross-net price difference, its significance can be clarified further by plotting the average gross-net price difference together with the respective 90-percent confidence interval. The results are shown in Figure 4.

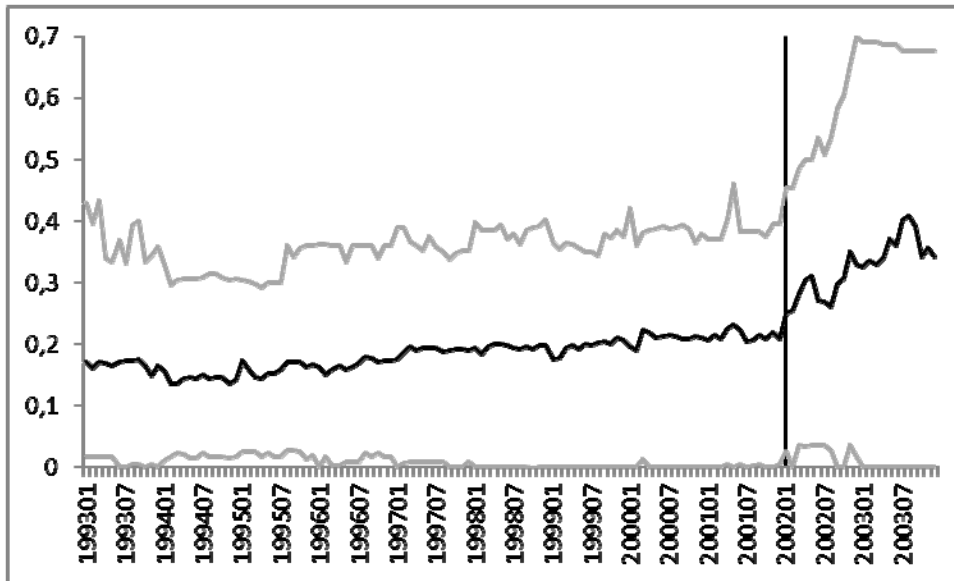


Figure 4: Development of relative price reduction due to rebates (in %)

Source: own calculations based on private price data

As revealed by Figure 4, rebates fluctuate around 20 percent during the cartel period with a lower volatility, i.e. a smaller confidence interval, than after the cartel breakdown. The granted price reductions increased significantly after the breakdown of the cartel reaching values of nearly 40 percent towards the end of 2003. Additionally conducted structural break analyses provide evidence for a significant break in the price development around the date of the cartel breakdown as determined by the FCO.¹⁵ As further shown in Figure 4, while the confidence band is rather constant during the cartel, it widens substantially after the cartel breakdown. We therefore conclude that the cartel agreement apparently is not only reflected by a certain rigidity in gross prices (as already seen in the prior analysis) but also led to certain price rigidity with regard to net prices.

4.3 Cartelists and non-cartel members pricing dynamics

Given the identified differences between gross and net prices, this section adds a further empirical perspective on the pricing dynamics of cartels: a differentiation between cartel members and non-cartel members. As already discussed in Section 2 above, economic theory generally suggests that, first, especially smaller firms might be able to realize a larger profit by staying out of the cartel and, second, that these non-cartel members typically have incentives to raise their price above the competitive level (under the price umbrella of the cartel). In the following, we use the private data set to investigate differences in prices and price volatilities between cartel members and non-cartel members during and after the

¹⁵ Depending on the test structure, results vary between December 2001 and February 2002.

breakdown of the cartel. In this respect, Figure 5 plots monthly gross prices (upper chart) and net prices (lower chart) for cartel members and non-cartel members.

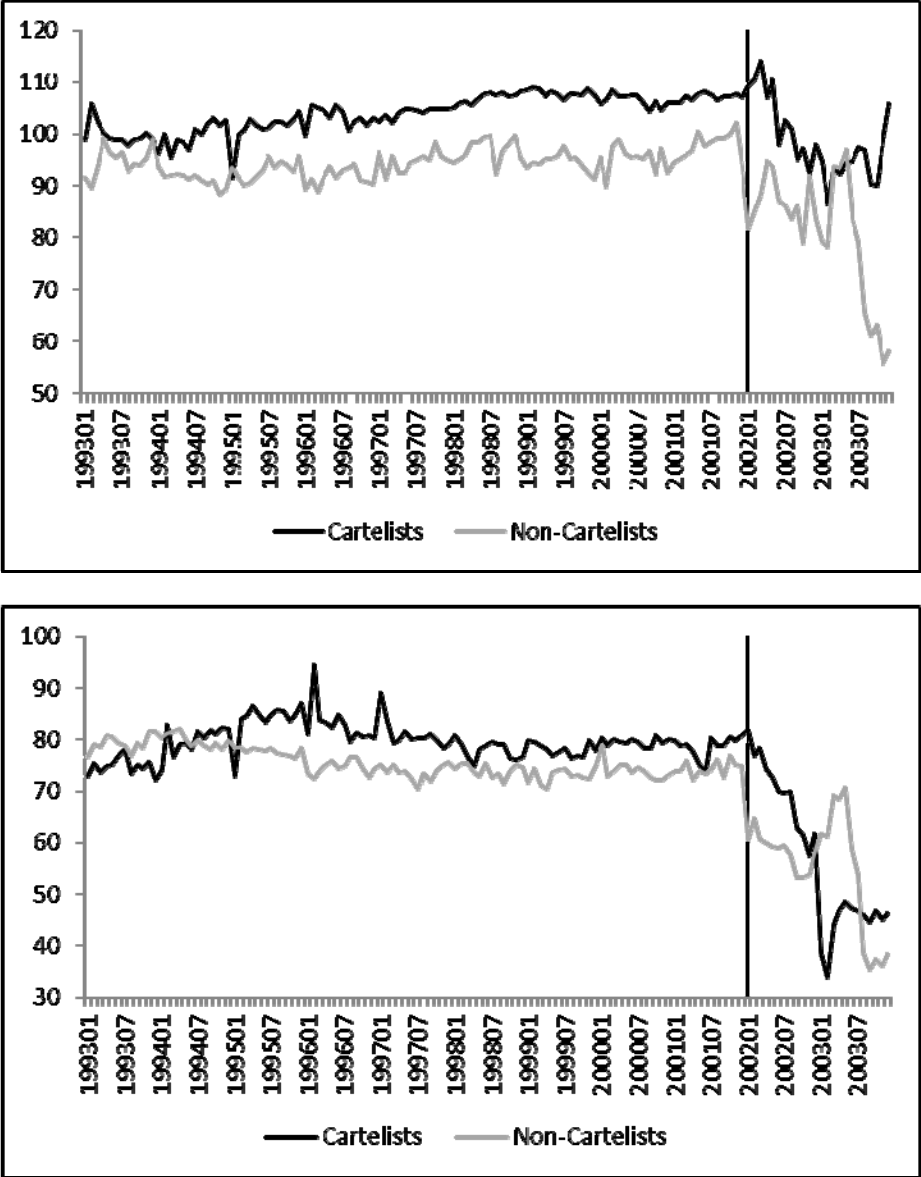


Figure 5: Average gross prices (upper graph) and average net prices (lower graph) of cartel members and non-cartel members

Source: own calculations based on private price data

As shown in Figure 5, gross prices of cartel members are significantly above gross prices of non-cartel members whereas this difference shrinks when focusing on net prices. As further shown in the figure, the cartel breakdown led to a gross price drop for the cartel members from around EUR 110 per ton to below EUR 90 per ton whereas the price dropped from around EUR 100 to below EUR 60 per ton for non-cartel members. While these descriptive findings provide evidence for a significant difference in gross-price reductions between cartel members and non-cartel members, reductions of net-prices are much more similar in size as

net prices were closer to each other not only shortly before the breakdown but also during the entire cartel period. Interestingly, the pricing dynamics of the non-cartel members diverges substantially from that of the cartel members particularly in the post-cartel period. First, gross prices strongly diverge in the sense that both prices of cartel members and non-cartel members follow a downward trend until the beginning of 2003 whereas afterwards cartel members' prices stabilize and even turn upwards while gross prices of non-cartel members experience a significant drop. Second, turning to net prices, non-cartel members drop their prices more quickly after the breakdown of the cartel than cartel members. Third, while the cartel members basically face a more or less continuous downward trend in net prices in the first year after the breakdown of the cartel, non-cartel members show a period of substantially increasing prices. However, this increase is found to be only temporary and followed by a substantial drop in the price index also for the non-cartel members ending up with an average price of about EUR 40 in December 2003 (which is about EUR 10 lower than the average price for the cartel members).

Searching for an economic explanation of this rather unexpected behavior of the cartel members, we have conducted tests on differences in prices and variation coefficients between cartel members and non-cartel members over the entire period of the data set. In particular, we have compared differences in pricing dynamics between the cartel period and the post-cartel period. Table 1 presents the results of t-tests comparing average prices and volatilities.

Table 1: Differences in prices and variation coefficients of cartel members and non-cartel members

	<i>total period</i>	<i>cartel</i>	<i>post-cartel</i>
Gross Prices	$p_c > p_{nc}$	$p_c > p_{nc}$	$p_c > p_{nc}$
Net Prices	$p_c > p_{nc}$	$p_c > p_{nc}$	$p_c = p_{nc}$
Relative Price Change	$rpc_c = rpc_{nc}$	$rpc_c = rpc_{nc}$	$rpc_c = rpc_{nc}$
Variation Coefficient (Gross Prices)	$vc_c < vc_{nc}$	$vc_c < vc_{nc}$	$vc_c < vc_{nc}$
Variation Coefficient (Net Prices)	$vc_c = vc_{nc}$	$vc_c > vc_{nc}$	$vc_c < vc_{nc}$

Source: Own calculations based on private price data.

As shown in Table 1, cartel members' gross prices are significantly higher than non-cartel members' gross prices for all observation periods. Results on net prices diverge in the sense that significantly higher cartel members' net prices are found for the cartel period; however, they are not significantly different in the post-cartel period. Keeping in mind that the number

of observations for the cartel period exceeds the number of observations for the post-cartel period, the results on net prices strongly support the expectations from the theoretical literature. In contrast, month-by-month relative price changes do not significantly differ between cartel members and non-cartel members, neither for the total observation period nor for the cartel and post-cartel periods.

Even more striking are the findings on gross-price and net-price volatilities. We use variation coefficients to compare volatilities as we have found cartel members' prices to be significantly higher than non-cartel members' prices. Variation coefficients are significantly higher for non-cartel members both in the cartel period and also in the post-cartel period when considering gross prices. These results support the findings of the theoretical literature as collusion leads to price coordination of the colluding firms.

Interestingly, the results are different when considering net prices. Over the total observation period no significant difference is found between cartel members and non-cartel members, however, cartel members' price volatility is significantly higher than the non-cartel members' price volatility in the cartel period and significantly lower in the post-cartel period. Comparing gross-price and net-price volatilities, we find gross-price variation coefficients to be significantly lower during the cartel period for both cartel members and non-cartel members.

Given these results, we can conclude that cartel members seem to mimic collusive behavior concerning gross prices, thus, providing signals to other cartel members. Furthermore, cartel members try to keep customer relationships by offering price reductions depending on factors such as delivered quantities or payment history of customers. As a consequence, net-prices stronger reflect individual relationships between suppliers and customers and possibly mitigate the price increasing effect of cartels.

4.4 Econometric analysis of pricing dynamics

In the preceding two sections, our line of reasoning was largely guided by a rather descriptive analysis of the data. Although this approach already provided valuable insights, simple price comparisons ignore possible drivers of prices other than the cartel and the colluding (or non-colluding) firms. Furthermore, spurious effects might exist in the sense that the previous results depend on characteristics such as demand changes or differences in product characteristics which overlay with the observed drivers. In order to get a better understanding of further market aspects and their influence on prices and price differences, we extend our analysis to a multivariate regression approach. We first present our modeling approach in

Section 4.4.1, followed by a brief discussion of the descriptive statistics. Section 4.4.3 presents our estimation results and discussion.

4.4.1 Modeling approach

Our modeling approach can be sub-divided into two parts. First, we concentrate on an analysis of gross and net prices. Second, we investigate gross-net price differences. With respect to the former, we use the following Equation (1) to analyze gross prices and the impact of other drivers which might affect gross and net prices:

$$price_{it} = \alpha^p + \beta_{cartel}^p cartel_{it} + \beta_{cartelist}^p cartelist_{it} + region_{it} ' \beta_{reg}^p + strength_{it} ' \beta_{str}^p + \beta_{demand}^p demand_{it} + \beta_{cons}^p overall\ consumption_{it} + \varepsilon_{it}^p \quad (1)$$

Equation (1) characterizes prices as a function of the cartel and the cartel members, market dummies, product characteristics and measures for economic growth and individual customer demand. In particular, the *cartel* dummy takes the value ‘1’ for the period before February 2002 and ‘0’ otherwise; the cartel member dummy is ‘1’ if the supplier was a cartel member (independent of the period) and ‘0’ if the supplier stayed outside of the cartel. Although there is no apparent economic reason to separate the German cement market into different submarkets, we include market dummies *region* for North, South, East and West depending on the unloading point to test for regional differences. While we concentrate on CEM I cement, the product quality still varies based on its liquid consistence (a measure of *strength*) which is either 32.5 N/mm², 42.5 N/mm² or 52.5 N/mm². Moreover, as described above, invoice-position related demand for the most part reflects transportation capacity restrictions.¹⁶ As we expect long-run demand to be the base line for price reductions (not invoice-position related quantities), we use annual *demand* as a measure of quantity. However, annual demand is highly right-skewed which we correct by using the measure in log-form. Finally, *overall consumption* corresponds to the index of production for precast concrete units and is used as a proxy for economic growth in the construction sector.

While the estimation of Equation (1) considers gross prices and net prices separately and ignores supplier-customer related effects on their distance, we take this further restriction into account with the analysis of gross–net price differences. The gross–net price difference is the sum of invoice-related rebates and price reductions which are attributable to individual market transactions based on corresponding sales. Credits which are not directly attributable to invoices are distributed on a yearly basis. Complementary to the analysis of gross and net

¹⁶ 84.4 percent of more than 255.000 market transactions under scrutiny used in the analysis relate to deliveries of quantities between 27 tons and 30 tons.

prices, we consider gross–net price differences in relative terms (as the range of price reduction is increasing with gross prices):

$$price\ diff_{it} = 1 - \frac{net\ price_{it}}{gross\ price_{it}} \quad (2)$$

We assume that the relative price difference depends on similar drivers as the prices themselves. Moreover, we add net prices to calibrate for level effects.¹⁷ However, as net prices are used as explanatory variables and as further explanatory variables are expected to correspond to those of prices at least partially, we employ a two-step estimation approach besides GLS estimations to control for the endogeneity of prices. We therefore estimate the following equation by, first, taking prices as exogenous and, second, by instrumenting prices by Equation (1).

$$price\ diff_{it} = \alpha^{pd} + \beta_{price}^{pd} price_{it} + \beta_{cartel}^{pd} cartel_{it} + \beta_{cartelist}^{pd} cartelist_{it} + region_{it}' \beta_{reg}^{pd} + \beta_{demand}^{pd} demand_{it} + \varepsilon_{it}^{pd} \quad (3)$$

The right-hand side of Equation (3) differs from Equation (1) through the inclusion of the *price* variable. Furthermore, the strength and consumption variables are excluded from Equation (3) as we expect these variables to affect prices but not the relative price difference.

4.4.2 Descriptive statistics

For our econometric analysis, we use the private data set characterized in Section 4.1 above. The descriptive statistics of the data set are presented in Table 2.

¹⁷ Instead of net prices, gross prices could alternatively be used. However, combining both gross and net prices as explanatory variables is impossible for collinearity reasons.

Table 2: Descriptive statistics

	Mean	Std. Dev.	Min	Max
Gross price	97.97	19.69	31.83	253.22
Net price	75.09	16.51	1.30	228.41
Price diff.	0.22	0.15	-0.00	0.98
Log(demand)	13.02	1.77	5.53	18.53
Overall Cons.	136.43	13.55	107.9	161.7
Cartelist	0.49	0.50	0	1
Cartel	0.88	0.33	0	1
North	0.04	0.20	0	1
South	0.43	0.50	0	1
West	0.23	0.42	0	1
East	0.30	0.46	0	1
32.5	0.36	0.48	0	1
42.5	0.58	0.49	0	1
52.5	0.06	0.24	0	1

Source: own calculations based on private price data

Table 2 provides a first overview over the data used for estimating Equations (1) and (3) and their alternative specifications. Gross prices (net prices) vary around EUR 97.97 (EUR 75.09) with average prices of EUR 99.06 (EUR 77.22) in the cartel period and EUR 85.12 (EUR 58.51) in the non-cartel period. The relative price difference is 22 percent of the gross price with on average 21 percent in the cartel period and 26 percent afterwards. Around 49 percent of aggregated invoice information is from cartel members with cartel members' average gross prices (net prices) of EUR 102.69 (EUR 76.76) and non-cartel members' average gross prices (net prices) of EUR 89.60 (EUR 71.98). These findings provide first evidence that cartel members charge higher gross and also higher net prices from customers but also offer higher relative discounts (24 percent versus 17 percent). Among the data collected Germany-wide, the major share of observations relates to the southern and eastern regions. Finally, Table 2 reveals that the medium strength cement type makes up 58 percent of the cement in the data set.

4.4.3 Estimation results and discussion

In this section, we present our estimation results and discussion. We follow the modeling approach described above and differentiate between the analysis of gross and net prices on the one hand and the analysis of gross-net price differences on the other hand.

Analysis of gross and net prices

As invoices repeatedly refer to the same places of delivery, we use GLS estimations based on clustered variances for the price equations. In doing so, we not only control for places of delivery but also for supplier-customer relations as customers stay the same for places of delivery and also suppliers are only rarely switched. Estimation results are provided in Table 3.

Table 3: Estimation results for price equations

	gross price (1)	gross price (2)	net price (3)	net price (4)
Cartel	14.03 *** (2.39)	19.26 *** (2.45)	15.93 *** (1.45)	15.91 *** (1.45)
Cartelist	7.96 *** (2.12)	16.67 *** (3.31)	-1.68 (1.36)	-1.71 (2.17)
Cartelist x cartel		-10.18 *** (3.40)		0.03 (2.42)
Overall Cons.	0.03 (0.04)	0.35 (0.37)	-2.02 (0.30)	-2.02 (0.30)
Log(demand)	0.31 (0.36)	0.03 (0.04)	0.16 (0.03)	0.16 (0.03)
East	-13.23 *** (2.34)	-13.55 *** (2.33)	-13.46 *** (1.48)	-13.46 *** (1.50)
West	-12.05 *** (2.17)	-12.54 *** (2.21)	-8.34 *** (1.83)	-8.34 *** (1.87)
North	10.84 *** (2.62)	10.81 *** (2.60)	0.42 (2.22)	0.42 (2.22)
42.5	5.73 *** (1.08)	5.73 *** (1.08)	5.50 *** (0.84)	5.50 *** (0.84)
52.5	15.48 *** (2.82)	15.60 *** (2.80)	16.47 *** (1.97)	16.47 *** (1.97)
Constant	75.66 *** (7.14)	70.50 *** (7.10)	68.01 *** (6.21)	68.03 *** (6.19)
# Obs.	14024	14024	14024	14024
F	44.19	44.78	58.34	52.71
R2	0.34	0.34	0.42	0.42

*Note: ***: significance level < 0.01, **: 0.01 <= significance level < 0.05, *: 0.05 <= significance level < 0.1; standard errors in brackets; Source: own calculations based on private price data*

Columns (1) and (2) show the estimation results of gross-price estimations whereas Columns (3) and (4) refer to the net-price estimations. As we have found differences between cartel members' and non-cartel members' prices from the prior descriptive analyses, we add interaction terms to check whether these findings are significant when controlling for additional price drivers.

Based on these estimations we find significantly higher prices in the cartel period both for the gross price estimations but also for the net-price estimations. Ignoring interaction terms, the cartel effect is even higher for the net price equation which has also been found in the descriptive analysis based on Figure 5. In contrast to the cartel effect, cartel members' dummies show diverging results for gross- and net-price estimations: While cartel members' gross prices are significantly higher than non-cartel members' gross prices, the estimation results show no significant difference in net prices.

Moreover, cartel members' gross prices differ even more from non-cartel members' gross prices in the post-cartel period. In general, this difference is given by the sum of the cartel member dummy and the interaction term. Introducing the interaction term for cartel members and the cartel period significantly increases the cartel member coefficient (comparing Estimations (1) and (2)).¹⁸ Moreover, the absolute interaction term coefficient closely corresponds to the increase of the cartel member coefficient, which means that the cartel coefficient in Equation (1) mainly represents the difference between cartelists and non-cartelists in the cartel period. In contrast, when the interaction term turns to 0 (i.e., in the post-cartel period), the cartel member coefficient still remains at its higher level in Equation (2). The specification with the interaction term provides more insights on the issue that cartel members choose significantly higher gross prices in the post-cartel period.

Although cartel net prices are on average higher than non-cartel net prices, no significant difference is found between cartel members and non-cartel members. Even introducing the interaction term does not significantly change results. This divergence between cartel members' and non-cartel members' gross prices and net prices provides an indication that non-cartel members and cartel members choose similar instruments to attract customers and keep long-run customer relationships.

Turning to control variables, neither from economic growth nor from demand a significant influence could be identified for both price specifications. In contrast, the remaining control variables support expectations with respect to cement type differences.

Analysis of gross - net price differences

So far, we have analyzed gross and net prices separately. In consequence, supplier-customer related price reductions were not part of the estimations. In a second step, we introduce this further restriction by considering price differences as specified in Equations (2) and (3). Table

¹⁸ The interaction term between cartel member and cartel takes the value 1 for transactions with cartelists in the cartel period and 0 otherwise.

4 provides the estimation results for Equation (3) where we, first, ignore the potential endogeneity challenge (Column (1)), second, use a two stage approach with specification (3) from above for instrumenting the net price (Column (2)) and, finally, include interaction terms both into the first stage and into the second stage estimation (Column (3)).

Table 4: Estimation results for price differences equation

	price difference		
	(1)	(2)	(3)
Cartel	0.03 * (0.02)	-0.02 (0.03)	0.02 (0.03)
Cartelist	0.08 *** (0.02)	0.08 *** (0.02)	0.14 *** (0.03)
Cartelist x cartel			-0.06 ** (0.03)
Net price	-0.00 *** (0.00)	-0.00 ** (0.00)	-0.00 ** (0.00)
Log(demand)	0.01 *** (0.00)	0.02 *** (0.00)	0.02 *** (0.00)
East	-0.05 *** (0.02)	-0.02 (0.02)	-0.02 (0.02)
West	-0.05 *** (0.02)	-0.04 ** (0.02)	-0.04 ** (0.02)
North	0.08 *** (0.02)	0.07 *** (0.02)	0.07 *** (0.02)
Constant	0.38 *** (0.06)	0.17 *** (0.11)	0.13 *** (0.11)
# Obs.	14024	14024	14024
F / Wald	44.69	174.88	182.81
R2	0.32	0.28	0.28

Note: ***: significance level < 0.01, **: 0.01 <= significance level < 0.05, *: 0.05 <= significance level < 0.1; standard errors in brackets; Source: own calculations based on private price data

In contrast to the independent price estimations, only a weakly significant cartel influence is found for the difference between gross and net prices which even vanishes with the two-stage approach. In contrast, cartel members offer on average significantly higher rebates than non-cartel members which are even higher in the post-cartel period as shown by the sum of the cartel member coefficient and the interaction term coefficient. These findings suggest that cartel members, more than non-cartel members, use rebates as a strategic instrument to tie customers. While gross prices are directly observable either in terms of reported representative transactions to the FSO or through reports to industry associations, net prices typically cannot be monitored and may therefore be used as strategic instruments (with a potential to even destabilize the cartel agreement).

Turning to the post-cartel period, cartel members' gross prices are significantly higher than non-cartel members' gross prices; however net prices do not differ significantly. Moreover, the more restricted estimation approach on price differences provides further evidence of higher rebates granted by cartel members particularly in the post-cartel period. Combining these outcomes, we find cartel members to extend the strategic application of rebates in the post-cartel period. With the breakdown of the cartel, pricing dynamics can be monitored even worse by both competitors and the antitrust authority. Using rebates to keep and attract customers reduces this transparency further. First, neither cement producers nor customers are interested to reveal loyalty credits to competitors and, second, the antitrust authority needs a comprehensive reasonable suspicion for dawn raids.¹⁹ As rebates could hardly be monitored without comprehensive actions by the competition authority – and even have not been in the focus of investigations by these authorities to our knowledge – they are an easy-to-implement tool to mask individual deviations from cartel agreements and to reduce suspicions of a change in market structure and competition.

Turning to the control variables, higher demand has a significantly positive impact on price differences. For customers with a ten-percent higher demand, the gross-net price difference is on average two percent higher (which is independent from the change in market structure). While no significant size effect has been found for the price equations, the annual demand is used by suppliers to determine (relative) rebates. However, as no significant size effect is found with the gross and the net price approaches (but the estimation of the price difference equation nevertheless shows a significant quantity effect), it can be concluded that further idiosyncratic drivers are in place which affect customer-related price differences besides annual demand. We control for this additional variation with place-of-delivery clustering by allowing for within-group correlations.²⁰ The regional control dummies reflect the findings on prices already shown in Table 3 above. In regions where both gross and net prices are higher (North and South) higher rebates are granted to customers whereas rebates are lower in regions with lower prices (West and East).

In a nutshell, we have compared gross and net prices for cartel members and non-cartel members to detect patterns which depend on the suppliers' role in the market. While both cartel members and non-cartel members set higher prices in the cartel period, cartel members choose even higher gross prices than non-cartel members. By introducing an interaction term

¹⁹ Please note that the cement cartel at hand is special in this regard as dawn raids followed the whistleblowing by one of the former cartel members (Readymix).

²⁰ However, while we have no additional information on the individual supplier-customer relations, an introduction of additional control dummies would provide no further insights on how they affect prices.

for cartel members and the cartel period, we were able to show that cartel members' gross prices are particularly higher than non-cartel members' gross prices in the non-cartel period. In contrast, net prices do not significantly differ. As suppliers report gross prices to industry associations and also to statistical offices in a regular way, higher gross prices after the cartel breakdown alleviate signals for a potential change in market structure and, thus, the danger of public market interventions. In contrast, gross-net price differences are independent from the cartel period but are higher for cartel members. While cartel members keep gross-prices higher in the post-cartel period they offer higher discounts to customers which brings their net prices to the level of non-cartel members' net prices.

4.5 Policy implications

The empirical analysis and results described in the preceding sections demand a detailed discussion of their policy implications. Given the relevance of price effects of cartel agreements for both public and private enforcement of competition law, the discussion in this section differentiates between these two types of enforcement.

4.5.1 Public enforcement

In general, the antitrust enforcement process within a system of public enforcement consists of basically two steps: The respective conduct has to be detected and subsequently prosecuted and 'penalized'. Given the per se illegality of hardcore cartels, the key challenges of an antitrust authority are two-fold. On the one hand, it needs to work on ways to reduce the incentives to form cartels. On the other hand, it must address the question how it can detect and intervene against existing cartels.

Focusing on the possibilities to detect conspiracies in the remainder of this section, recent research has especially argued that the use of screens might be helpful in detecting cartels. Based on the examples of successful applications of variance screens, our empirical results support the potential effectiveness of such tools. Although it is above the scope of this paper to develop a full-fledged market screening tool (see Hüscherlath and Veith, 2011), our results suggest that, first, price screens can be a helpful tool – for both antitrust authorities and customers of cartelized industries – in the detection of hardcore cartels. As shown above, prices (and variation coefficients) changed significantly after the breakdown of the cartel thereby providing possibilities to proactively detect such cartels.

Second, our results suggest that the application of screening tools based on gross prices faces a reduced effectiveness as firms might reduce prices through rebates rather than reductions of the gross price. As a consequence, antitrust authorities (with the help of further

field specialists) could develop screening tools to be applied to net prices and rebates rather than gross prices. This is especially true as the standard calculation technique of the public price index – focusing on the gross rather than net prices – might draw an incomplete picture of the price behavior of a respective industry. While gross prices might provide a sufficient indication of price behavior in less concentrated industries, our findings suggest that major market participants in cartelized industries use gross prices to mask actual market behavior.

Third, although not the key focus of the paper, the development of the public price index plotted in Figure 1 above reflects one stylized fact of many detected cartels, namely that prices begin to increase again relatively quickly after the typically observed price drop following the detection of the cartel. This finding suggests that cartel detection successes might be short lived (from the consumer's perspective) as firms either manage to reinstate the cartel or learn to collude tacitly. As a consequence, competition authorities are well advised to monitor the respective markets after the detection and prosecution of the cartel to impede the immediate reconstruction of the conspiracy. The implementation of an obligation for every cartel member to report gross *and* net prices to the competition authority for several years following the detection and prosecution of a cartel agreement might ease such monitoring activities.

4.5.2 Private enforcement

Complementary to the public enforcement of competition law by state authorities, private parties such as customers or consumers are typically entitled to bring antitrust lawsuits when they were harmed by a competition law infringement. 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 though compensation (see generally Wils, 2009, for a detailed assessment).

From an economic perspective, a system of private antitrust enforcement must have convincing answers to particularly two questions: (a) which parties are damaged? and (b) by how much are they damaged?²¹ In other words, any elaborate thinking on private antitrust enforcement needs to focus on the identification and quantification of damages.

²¹ Please note that we omit a possible third question, namely how the respective parties were damaged. Although the focus in this respect typically lies on elevated prices and reduced profits, economic theory would also support a detailed investigation of, e.g., the impact on quality or innovation incentives (see Oxera (2009)).

Identification

The quantification of damages caused by a hardcore cartel must be based on an identification and detailed assessment of the potentially damaged parties. In general, harm can be caused on the upstream level, the level of the cartelized industry and the (downstream) customer level. Focusing on the latter two types of harm in the remainder of this section²², on the level of the cartelized industry, it is in principle possible that non-cartel members have suffered due to the cartel agreement (e.g., if the cartel successfully imposed exclusionary practices on a maverick firm²³). Despite these possibilities of harm for non-cartel members, the theoretical research discussed in Section 2 above rather suggests that non-cartel members often manage to take advantage of the cartel through an increase in prices above the competitive level thereby profiting from the ‘price umbrella of the cartel’. For the case of the latest German cement cartel, the empirical analysis above indeed suggests that the non-cartel members profited from the cartel by charging slightly lower but still elevated prices. Although a robust conclusion in this matter would demand an estimation of the but-for price (which is outside the scope of this paper) it appears at least likely that the non-cartel members also profited from the cartel agreement.

On the downstream customer level, the so-called ‘direct’ effect of the cartel is the damage caused by charging elevated prices to the direct purchasers of the cartel product. This type of damage is the typical cartel related damage and as such, including damages caused by the cartel via the above described umbrella effects of cartel agreements, is subject of most private antitrust suits. As described in the preceding paragraph, our empirical results suggest the existence of such harm.

Quantification

Given the identification of the potentially damaged parties, the next step is the quantification of the respective damages. Focusing on downstream direct purchasers for the time being²⁴, the damages are generally calculated by multiplying the difference between the price charged by the cartel and the price that would have existed in the absence of the cartel (the so-called ‘but for’ price) with the respective sales volumes. Based on our empirical results reported above,

²² On the upstream level, input suppliers of the cartel members might be damaged due to the reduction in sales volume caused by the cartel. Furthermore, the reduction in sales might lead to diseconomies of scale in the production process of the input suppliers and correspondingly might lead to an increase in its average total costs. As a consequence, every firm using the input product is eventually harmed by the cartel agreement due to elevated input prices.

²³ See Röller and Friederiszick (2010) for a general discussion and Scott Morton (1997) for empirical evidence.

²⁴ The extension of the analysis downstream would demand the consideration of potential pass-on rates, i.e. the possibilities of firms to pass-on higher input costs to the subsequent downstream level. The larger this downstream pass-on is, the smaller is the damage actually suffered on the direct customer level.

both the derivation of the actual cartel prices paid in each period of the cartel and the estimation of the price for each period in the absence of the cartel need to take the following aspects into account in order to derive robust and meaningful damage estimates.

First, damages calculations as part of private enforcement should be based on net prices rather than gross prices. The reason is simply that the net price actually paid by the customers matters for the correct calculation of damages and not the gross price. Second, as long as public price indices are used to estimate the but-for price, e.g. by studying the price developments after the cartel breakdown, the respective damage estimates are likely too low given the identified strategy of cartel member to reduce gross prices through rebates.

Third, our results for the group of non-cartel members suggest that they likely still profited from the cartel agreement by charging elevated prices (compared to the competitive but-for price). As a consequence, it seems likely that customers had to pay elevated prices also to non-cartel members due to the existence of the cartel. Although the behavior of the non-cartel members can be classified as rational in the sense that the firms maximized profits given the existence of the cartel, they nevertheless sold their products at elevated prices and realized a larger profit suggesting that these damages were caused by the cartel agreement as well.

5 Conclusion

Although the pricing dynamics of hardcore cartels have been studied intensively from a theoretical perspective, empirical evidence is still rare. We have combined publicly available data with a unique private data set of about 340,000 market transactions from 36 smaller and larger customers of German cement producers to study the pricing dynamics during and after the breakdown of a German cement cartel. In particular, we have investigated, first, to what extent gross prices and net prices differ both during and after the breakdown of the cartel and, second, whether and to what extent the pricing dynamics of cartel members and non-cartel members diverge in the cartel and non-cartel periods.

Our empirical analysis revealed that both gross prices and net prices were significantly higher in the cartel period than in the non-cartel period. Moreover, by comparing cartel members' and non-cartel members' gross prices, we found cartel members to keep gross-prices significantly higher in the post-cartel period. As gross prices are not only reported to industry associations and statistical offices but might also be used by antitrust authorities as part of market monitoring procedures, cartel members have incentives to keep these prices high during but also after the breakdown of the cartel agreement. Turning to net prices, we found no difference between the cartel members and non-cartel members price behavior after

the breakdown of the cartel. Furthermore, our analysis suggested that net prices are used to tie customers after the cartel breakdown. Therefore, cartel members compete in net prices but keep gross prices high. Our findings on gross-net price differences estimations supported these findings. While only weak evidence was found for the cartel – post-cartel difference, a significant difference was found between cartel members’ and non-cartel members’ price differences due to substantial rebates granted by cartel members particularly in the post-cartel period.

Given our empirical results, we are able to derive several important policy conclusions for both public and private enforcement of competition law. With respect to *public enforcement*, our results suggest, first, that price screens can be effective detection tools for both antitrust authorities and customers of cartelized industries. Second, in applying such tools, net prices rather than gross prices should be used as only the former capture real price behavior. Third, after the detection and prosecution of a hardcore cartel, competition authorities are well advised to monitor the respective markets (on the basis of gross *and* net prices) to impede the immediate reconstruction of the conspiracy.

With respect to *private enforcement*, our results suggest that, first, damages calculations should be based on the prices actually paid, i.e. net prices, rather than gross prices. Second, as long as public price indices are used to derive the but-for price, e.g. by studying the price developments after the cartel breakdown, the respective damage estimates are likely too low given the identified strategy of cartel members to reduce gross prices through rebates and to keep gross prices high after the breakdown of the cartel. Third, our results for the group of non-cartel members suggest that – although the respective firms on average price slightly below the cartel – they likely still benefit from the cartel agreement by charging elevated prices (compared to the competitive but-for price). As a consequence, it seems likely that the customers also in this respect pay elevated prices due to the existence of the cartel.

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