Common ownership and competition: Evidence from the cement industry?

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Abstract

The common ownership hypothesis associates partial overlaps in the ownership structure of competing firms with softened competition, to the detriment of consumer welfare. While the increase in common ownership among listed firms in recent years is a well documented fact, the evidence on actual anti-competitive effects remains ambiguous. I take the theory to a new testing ground, which appears *a priori* susceptible to common ownership effects: the cement industry. To include unlisted firms and avoid relying on accounting measures, I combine price data and infer market shares from reported plant-level emissions for France, Germany, Spain, and the United Kingdom. In a detailed model of the German cement market and a four-country panel, I do not detect an association between common ownership and the cement price level consistent with the common ownership theory. The findings add to scepticism regarding the results from other product markets and multi-industry studies, and suggest that vocal policy advice on the treatment of asset managers and index investment products may be premature.

Keywords: common ownership

JEL Codes: G32, G34, L13, L21, L22, L61

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1 Introduction

A traditional assumption in economics and finance is that firms engage in competition with the aim of maximising value for their shareholders. This is typically operationalised using own-firm profit maximisation. However, institutional investors often hold stakes in several, potentially competing, companies within industries (e.g., Kotz, 1979). With the emergence of indexing and the rapid accumulation of assets under management by a small number of large asset managers,[1] such *common ownership* has been increasing over time. This empirical observation is well documented for several U.S. industries and product markets, and among the largest U.S. public companies (e.g., Backus et al., 2021b); similar trends can be found in Europe, albeit at a lower absolute level (e.g., Seldeslachts et al., 2017; Banal-Estañol et al., 2022). Economic theory suggests that common ownership between competing firms reduces the incentive for them to engage in potentially costly competition, as firms seek to maximise the value of their owners' diversified portfolios instead of their own value.

This theoretical result, the *common ownership hypothesis*, has been well established since the 1980s (Rubinstein et al., 1983; Rotemberg, 1984). Empirical research regarding the common ownership hypothesis has gained considerable momentum since the initial publication of a study associating common ownership with increased prices in the U.S. airline industry (Azar et al., 2018a). While this and similar papers highlight potential policy implications, the existence of the purported anti-competitive effects on product markets remains contested. There is a clear need for additional empirical research. In this context, I study the European cement industry, contributing evidence on common ownership from a previously unstudied product market and from outside the U.S.. Improving over several existing product market and multi-industry studies, the analysis does not rely on accounting measures to infer the country-level product price and market shares, and includes market shares held by unlisted firms. This is possible by combining price data from statistical offices with market share data derived from plant-level reporting to the European Union's Emissions Trading System (EU ETS).

The cement industry presents a fertile testing ground for the common ownership hypothesis for two related reasons: First, the cement market in most developed countries is an entrenched oligopoly, with a small number of large players. The significant capital expenditures and permitting associated with a new cement (clinker) plant are barriers to capacity expansion and to new entrants. The final product is homogeneous and largely standardised. These features regularly make cement markets a close fit to the canonical Cournot model of competition. This model also underpins the *modified Herfindahl–Hirschman index*, which

[1] Most notably BlackRock, Vanguard, and State Street, collectively dubbed the "Big Three."

has become the workhorse measure for market concentration taking common ownership into account. Taken together, these aspects of cement markets facilitate their econometric analysis and lend additional credibility to the internal validity of results. Second, the cement industry has a history of collusive behaviour: the Private International Cartels (PIC) data set due to Connor (2020)[2] contains 34 cartels in cement markets investigated by competition authorities between 1990 and 2019, ten thereof in Western Europe.[3] While plausible channels of operation are as much subject to debate as the effects of common ownership themselves, this track record suggests that cement markets are particularly susceptible to collusive behaviour.

In an in-depth model of the German cement market 2005–2020 as well as in a four-country panel including France, Germany, Spain, and the United Kingdom (UK) over the same time period, I do not detect the positive association between common ownership and the cement price level suggested by the common ownership hypothesis. In the analysis of the German market, the association is sensitive to specification and time period, and, at times, appears to be significantly negative–a finding at odds with the prediction of the common ownership hypothesis. The panel analysis robustly points to no significant association in either direction. In sum, the current results suggest that the findings of anti-competitive common ownership effects in other markets may not generalise, or may only apply within the U.S., or may be type I errors. Therefore, and with a view to other research similarly detecting no meaningful common ownership effects, full-throated policy advice on the regulation of common owners and index investment products appears premature.

The rest of this working paper proceeds as follows. The following section 2 reviews the empirical literature on common ownership and competition starting with Azar et al. (2018a) and situates the present paper within it. Section 3 introduces the data set used, with a focus on the determination of market shares and the derivation and measurement of common ownership. It also documents the evolution of common ownership in the cement markets of the four countries up to 2020. The methodology, corresponding regression results regarding the association of common ownership and cement price, and robustness checks for the German cement market as well as the four-country panel are presented in section 4. Section 5 briefly summarises the findings and takeaways. The appendices contain detailed variable definitions (A), discuss the derivation of market shares from emissions (B), and present detailed results of IV first stages (C) and the robustness checks (D).

[2] The data set has been transferred to the OECD, where it is maintained as the *OECD International Cartels Database.*

[3] As of 2019, five of these 34 cases remained open with no fines, damages, or other penalties issued.

2 Related literature

This paper adds to the empirical literature on the common ownership hypothesis, the potential relation between ownership overlap and product market competition. The starting point of modern contributions to this literature is the study of airline ticket prices in the U.S. by Azar et al. (2018a). They document a substantial level and rising trend of common ownership on U.S. flight routes 2001–2014 and associate common ownership with significantly higher ticket prices. Complementing their panel regression analysis with a difference-in-difference approach using BlackRock's 2009 acquisition of Barclays Global Investors as a source of exogenous variation in common ownership, they claim a causal link. These findings have triggered a debate on their internal and external validity, and have prompted much new work in this area.

Broadly, the empirical contributions on common ownership and competition can be categorised into two groups, as I do in table 1: case studies of specific product markets and multi-industry studies. The present working paper clearly belongs to the former group. In this group, the evidence on anti-competitive effects of common ownership effects remains mixed. The findings by Azar et al. (2018a,b) on U.S. airline tickets and by Azar et al. (2022) on U.S. bank deposits are contested by Dennis et al. (2022) and Gramlich and Grundl (2017), respectively; evidence from generics entry in the pharmaceutical industry (Newham et al., 2019) and seed prices Torshizi and Clapp (2021) is more in favour of the common ownership hypothesis, while no effects are found in the U.S. cereals market by Backus et al. (2021a).

The most prominent multi-industry studies come to contradicting conclusions: He and Huang (2017) associate common ownership, *inter alia*, with higher market share growth and higher operating margins, while Koch et al. (2021) detect no effects on mark-ups and profitability. Boller and Morton (2020) and Gibbon and Schain (2022) offer evidence consistent with the common ownership hypothesis from S&P 500 index entrants and the European manufacturing sector, respectively. However, three of the four papers (the exception is Boller and Morton, 2020) rely on rather coarse industry definitions instead of product markets, and proxy price levels as well as market shares with accounting data. Except for Gibbon and Schain (2022), the treatment of unlisted firms is crude. In sum, these studies aim for validity across markets at the expense of internal validity.

Table 1: Selected recent empirical literature on common ownership and competition

A. Market case studies		
Market	Paper	Finding
Airlines	Azar et al., 2018a,b	Airline ticket prices 3 to 12 per cent higher due to CO
	Dennis et al., 2022	Effect of CO on prices detected by Azar et al. (2018a) sensitive to specification and confounded by market share variation; no evidence for a causal effect
Bank deposits	Azar et al., 2022	Causal effect of generalised concentration, combining market concentration and CO, on deposit-related fees and thresholds
	Gramlich and Grundl, 2017	Sign of any interest rate effects of CO is not robust; effects small in magnitude
Pharmaceuticals (generics)	Newham et al., 2019	CO between brand firm and generics producers reduces generics entry
Ready-to-eat cereals	Backus et al., 2021a	Classical own-profit maximisation more consistent with price data than CO hypothesis
Seeds	Torshizi and Clapp, 2021	CO contributes to higher seed prices

B. Multi-industry studies		
Firms & market definition	Paper	Finding
380 S&P 500 entrants & competitors	Boller and Morton, 2020	CO increase associated with index entry causes higher abnormal returns, consistent with the CO hypothesis
European manufacturing firms (listed & unlisted), by 3-digit NACE & country	Gibbon and Schain, 2022	CO increases firm mark-ups; effect driven by lower-tech firms
U.S.-listed firms, by 4-digit SIC	He and Huang, 2017	CO causes higher market share growth, fosters product market coordination, and increases operating margins
U.S.-listed firms, by 4-digit NAICS or 3-digit SIC	Koch et al., 2021	CO not associated with higher mark-ups and industry profitability, nor with lower non-price measures of competition

Besides the literature chiefly concerned with the direct effects of common ownership on competition, which mostly considers prices and mark-ups, recent research also investigates potential effects of common ownership on other parameters of firm behaviour, such as innovation (Antón et al., 2021; Li et al., 2023), investment (Gutierrez and Philippon, 2017), mergers and acquisitions (Brooks et al., 2018; Antón et al., 2022), and corporate social responsibility (Cheng et al., 2022; Dai and Qiu, 2021). Less developed is the literature examining plausible mechanisms by which common ownership could induce changes in firm behaviour; an example is Antón et al. (2023), who focus on management incentives. As these strains of the literature, which are not directly concerned with (price) competition, are of less relevance for the present working paper, the interested reader is referred to the excellent reviews by Schmalz (2018, 2021).

3 Data and variables

3.1 Market shares

Obtaining accurate data on market shares presents a key obstacle to studying the relationship between firm ownership and competition. Using company revenues as a proxy for market shares, as done in many papers in the field, is not advisable for several reasons: First, some privately held firms do not report their revenues publicly. Second, reported revenues often reflect activities other than the product market of interest, with no revenue split reported. In the case of cement firms, this is regularly the sale of aggregates and ready-mix concrete. Third, for international firms, headline revenues are often provided on a consolidated basis and are not sufficiently broken down by geographic markets. Hence, this working paper makes use of the fact that the production of cement clinker, the main component of cement that gives cement its binding characteristics, is associated with substantial emissions of greenhouse gases (GHG), and that such emissions have therefore been included in the European Union's Emissions Trading System (EU ETS) since its start in 2005.[4] Under this "cap and trade" scheme, covered installations must for each year surrender carbon credits (EU Allowances) commensurate to their direct GHG emissions. For this purpose, covered installations are required to monitor and report their GHG emissions. As the majority of direct GHG emissions associated with the production of cement clinker are raw material-related and the production process and technology are highly similar across plants, these installation-level emissions reports can be used to proxy production levels in the cement industry ex post. A more detailed justification of this approach and supporting evidence are presented in Appendix B. In a first step, the installation-level annual emissions are allocated to months, adjusting for intra-year events such as kiln stoppages and plant closures, as ob-

[4] In the EU, the production of cement clinker accounts for approximately 3 per cent of total GHG emissions (Emele et al., 2022).

tained from press reports and company filings. Then, these adjusted monthly emissions are used to compute plant-level market shares by country. In a final step, country-level market shares of cement companies are computed by mapping plants to companies for each month. Mergers and acquisitions are reflected based on their respective closing dates.

3.2 Company ownership information

Ownership information for public companies relevant in the four studied countries, France, Germany, Spain and the United Kingdom, from January 2005 through December 2020 is based on shareholder data reported by Refinitiv Eikon. The reported holdings are then aggregated to account for fund families and extensively checked and, where necessary, corrected using hand-collected ownership information from company reports and notifications of major shareholdings. For the several privately held companies, ownership information is obtained from various sources including company reports, media coverage, and publications by competition authorities.

3.3 Modified Herfindahl–Hirschman index

With the firm-level market shares and ownership information at hand, we can proceed to quantify the level of market concentration and ownership concentration. We follow Schmalz (2018) and other contributions in using a modified version of the traditional Herfindahl-Hirschman index (HHI) for these purposes. A first modified Herfindahl-Hirschman index (MHHI) to accommodate horizontal joint ventures was proposed by Bresnahan and Salop (1986). The version accounting for overlapping owners of competitors in general, used in the recent common ownership literature and in this working paper, is due to O'Brien and Salop (2000). As discussed above, the MHHI is derived from the Cournot model of oligopolistic competition, to which cements markets are a close fit. The MHHI can be computed as

$$MHHI = \sum_j \sum_k s_j s_k \frac{\sum_i \gamma_{ij} \beta_{ik}}{\sum_i \gamma_{ij} \beta_{ij}}, \tag{1}$$

where s_j is the market share of firm j, γ_{ij} the control share of shareholder i in firm j and β_{ij} the ownership share of i in j. This can be reformulated as

$$MHHI = \underbrace{\sum_j s_j^2}_{\text{HHI}} + \underbrace{\sum_j \sum_{k \neq j} s_j s_k \frac{\sum_i \gamma_{ij} \beta_{ik}}{\sum_i \gamma_{ij} \beta_{ij}}}_{\text{MHHI Delta}}, \tag{2}$$

so that the MHHI is additively decomposed into the traditional HHI and MHHI Delta. MHHI Delta can be interpreted as the additional concentration due to common ownership. HHI and MHHI are naturally confined between zero and one, where zero corresponds to an atomistic market structure with infinitesimal firms and one corresponds to monopoly. For ease of reading, HHI and MHHI are rescaled to zero to 10,000 in this text and the following figure 1 and table 2.

Figure 1 presents the evolution of HHI, MHHI, and MHHI Delta for the cement market in each of the four countries under consideration. To aid the interpretation, one can refer to the horizontal merger guidelines issued by the European Commission and the U.S. antitrust agencies.[5] In three countries studied, traditional market concentration as measured by the HHI has remained remarkably stable in the years 2005 to 2020, fluctuating between 2787 and 3858 in France, between 1248 and 1531 in Germany, and between 1275 and 1745 in Spain, without a discernible trend. This relative stability can be attributed to the high barriers to entry to the industry (start-up costs, permits) as well as to the actions of competition authorities. Particularly noteworthy are the asset disposals agreed between the European Commission and Holcim and Lafarge in connection with their merger, which would have otherwise substantially concentrated the French and the German market. In the UK market, the agreed disposal of Lafarge Tarmac's assets with the exception of the Cauldon cement plant even led to a decrease in the HHI of around 600 points, from above 2700 to around 2100. The closing of the Lafarge-Holcim merger occurred in July 2015 and is marked with a dashed grey line in figure 1. The associated disposal of assets to CRH closed in August 2015. Overall, with a view to the guidance by U.S. agencies, the French and UK market in particular can be characterised as concentrated. Concentration at the ownership level, however, follows a different pattern in all four countries. In France, the market entry of CRH through the acquisition of assets from LafargeHolcim increases MHHI Delta by more than 200 points. After a multi-year period of MHHI Delta below 100, this is the starting point of an upward trend in common ownership, with MHHI Delta durably exceeding 1000 points beginning mid-2019 driven by common shareholders of LafargeHolcim, HeidelbergCement, and CRH. In the UK, MHHI Delta exhibits an even more pronounced upward trend, exceeding 2000 points

[5] According to the EU guidelines, the European Commission is "unlikely to identify horizontal competition concerns" in mergers if (a) the post-merger HHI is below 1000, (b) the post-merger HHI is between 1000 and 2000, with the merger contributing an increase below 250, or (c) the post-merger HHI exceeds 2000, with the merger contributing an increase below 150 (European Commission, 2004). The U.S. Department of Justice and Federal Trade Commission (2010) classify markets into unconcentrated markets (HHI below 1500), moderately concentrated markets (HHI between 1500 and 2500), and highly concentrated markets (HHI above 2500). According to their guidance, mergers resulting in unconcentrated markets or mergers associated with an increase in HHI below 100 are "unlikely to have adverse competitive effects." If the resulting markets are either moderately concentrated or highly concentrated, however, mergers associated with increases in HHI of more than 100 "potentially raise significant competitive concerns."

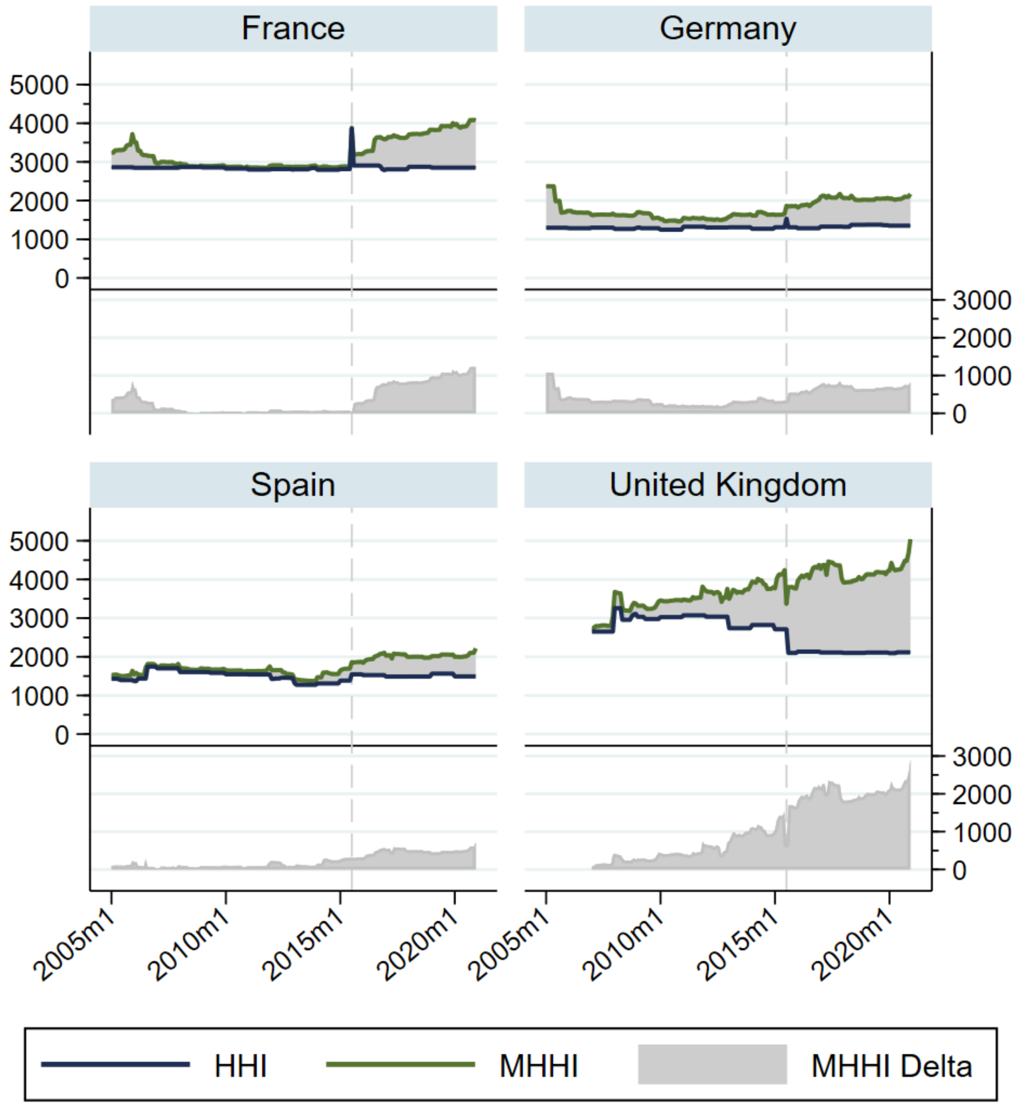
in 2019 and 2020. Key contributors are overlapping shareholders at CRH, CEMEX, and HeidelbergCement. In the context of concentrated underlying cement markets in France and the UK, these levels of additional concentration would have the potential to raise significant concerns of competition authorities if interpreted in the light of horizontal merger guidelines. In Germany and Spain, common ownership as measured by MHHI Delta does not reach the magnitude observed in France and the UK. This can be attributed to large players being privately held or being listed, but family controlled through a majority shareholding. Nonetheless, common ownership in both countries starts to rise in 2014, reaching MHHI Delta values above 500. In Germany, the Lafarge-Holcim merger and remedial disposals to CRH, which precluded an increase in the HHI by roughly 200 points, is associated with an increase in MHHI Delta of almost similar magnitude. Despite the disposals required by the European Commission, the Lafarge-Holcim merger is hence associated with an approximately 200-points rise in the MHHI, which considers both market share and common ownership concentration. For the German market, the competition regulator effectively accepted a commensurate rise in common ownership to prevent a rise in concentration at the level of market shares.

3.4 Price data and other variables

The main dependent variable in the tests of the common ownership hypothesis in this working paper is a price index for cement. As explanatory variables, the detailed model of the German market uses a volume index for cement production to proxy demand, alongside price indices for lime, the most important raw material in the production of cement clinker, for lignite, as a proxy for various fuels for the cement kiln, and for electricity. The four-country panel model is limited to an energy price index, as the detailed input price indices available for Germany are not available for the other European countries. The control variables are closely aligned with those used by Hüschelrath et al. (2013) in their assessment of the German cement cartel[6] and have been validated with an industry expert. For the model of the German market, an instrumental variables approach is applied, with indices for the volume of new orders in construction sectors as instruments for the volume of cement production, similar to the instrumentation used Hüschelrath et al. (2013). Additionally, temperatures are used as an instrument. A detailed description of all variables, including source information, can be found in Appendix A.

[6] This cartel broke down starting November 2001. A leniency application was filed and the official investigation by the German Federal Cartel Office commenced in 2002. Hence, this cartel does not affect the time series used in this working paper, which begin in January 2005.

Figure 1: Time series of market and ownership concentration in cement markets



This figure presents the country-level evolution of the convential Herfindahl–Hirschman index (HHI), the modified Herfindahl–Hirschman index allowing for common ownership ($MHHI$), and the differential between both attributable to common ownership ($MHHI\ Delta$). In this figure and the text of the paper, HHI and $MHHI$ are expressed on a scale from 0 to 10,000 for ease of reading; in the regression analyses, a scale of 0 to 1 is used. The figure comprises a separate chart for each country included in the analysis. The top part of each chart presents the HHI (solid blue line) and the $MHHI$ (solid green line), with the differential, $MHHI\ Delta$, as the grey shaded area in between both. The bottom part breaks out the evolution of $MHHI\ Delta$. The dashed vertical line in each chart marks the closing of the Lafarge-Holcim merger in July 2015, which visibly impacts HHI and $MHHI$ in all countries. Data is at the month-country level, running from January 2005 (UK: January 2007) through December 2020. Underlying market shares are computed from plant-level verified emissions recorded by the EU Emissions Trading System. The ownership data comes from multiple sources including Refinitiv Eikon and company filings.

3.5 Summary statistics

Table 2 presents summary statistics for all variables, with panel A referring to the more detailed data set for the German market and panel B referring to the panel data set covering France, Germany, Spain and the United Kingdom. The data for France, Germany (both data sets), and Spain cover the entire 192-months period under consideration, from January 2005 through December 2020. The UK data run from January 2007 through October 2020 (166 months). This is due to missing plant-level verified emissions data in the EU ETS in 2005 and 2006, and missing November and December 2020 data in the Eurostat output price index database. In each month, 15 to 16 firms are active in the German market, up to eleven of which are privately held. In France, three to four firms are active (none privately held), four to five are active in the UK (up to one privately held), and nine to eleven in Spain (up to three privately held). The cement price indices, $Price_t$ and $Price\_panel_{t,i}$, which are the dependent variables in the analysis of section 4, as well as the input price indices generally start below 80 in 2005 and rise through the index base value of 100 in 2015. Among the input cost indices, energy inputs display the greatest volatility. The activity measures $Production_t$ and $Construct\_activity_{t,i}$, also with base values 2015 = 100, share strong seasonality, but show different developments in each country over the longer term in the observation period. In particular, construction activity in Spain experiences a sustained reduction in the context of the Great Recession. $Orders\_build_t$ and $Orders\_eng_t$ are used (alongside $Temperature_t$) to instrument $Production_t$ in the analysis of the German market. These two indices mirror the strong seasonality of construction activity, bottoming in January and peaking typically prior to August, with peak-to-trough differences ranging from 20 to 60 index points. $Temperature_t$ follows a similar seasonal pattern, with minima typically in January or February and peaks in July or August, and 12-month rolling temperature averages of five to seven degrees Celsius. $HHI_{t,i}$ and $MHHI\ Delta_{t,i}$ are discussed in detail in the preceding section and plotted in figure 1.

Table 2: Summary statistics

A. German market *Jan-2005 through Dec-2020*						
	Obs.	Mean	P25	P50	P75	S.D.
Variables of interest						
$Price_t$	192	94.65	90.05	96.50	100.60	9.48
HHI_t	192	1307.66	1285.68	1303.79	1324.80	37.06
$MHHI\ Delta_t$	192	466.20	322.27	388.28	664.09	213.89
Control variables						
$Production_t$	192	99.12	87.95	108.05	115.95	24.56
$Electricity_t$	192	98.98	90.45	100.15	105.20	13.12
$Lignite_t$	192	94.47	85.70	98.40	101.20	8.63
$Lime_t$	192	93.40	83.20	95.65	101.40	10.79
Instruments						
$Orders\_build_t$	192	99.54	85.40	99.40	111.80	18.75
$Orders\_eng_t$	192	105.22	93.45	108.05	118.80	20.24
$Temperature_t$ (°C)	192	5.82	1.07	5.22	11.16	5.68

B. Four-country panel *France, Germany, Spain, United Kingdom; Jan-2005 through Dec-2020*						
	Obs.	Mean	P25	P50	P75	S.D.
Variables of interest						
$Price\_panel_{t,i}$	742	96.46	91.90	99.30	101.00	7.59
$HHI_{t,i}$	742	2047.24	1351.23	1701.34	2827.93	706.33
$MHHI\ Delta_{t,i}$	742	537.01	116.64	369.86	689.34	550.94
Control variables						
$Energy\_price_{t,i}$	742	94.57	88.30	96.95	102.70	12.11
$Construct\_activity_{t,i}$	742	106.43	93.40	104.50	114.60	25.48

This table reports summary statistics for the price, market concentration, common ownership, and other variables underlying our analysis. Variables are defined in Appendix A. The reported values are levels; in the subsequent regressions, the natural logarithm is applied to variables where appropriate. In this table and the text of the paper, HHI and $MHHI$ are expressed on a scale from 0 to 10,000 for ease of reading; in the regression analyses, a scale of 0 to 1 is used. Panel A of the table presents statistics for the analysis of the German market, with 192 observations covering January 2005 through December 2020. Panel B reports statistics for the panel analysis including France, Germany, Spain, and the UK. The 742 month-country observations comprise 192 monthly observations (January 2005 through December 2020) from France, Germany, and Spain, respectively, and 166 monthly observations from the UK (January 2007 through October 2020).

4 Methodology and results

4.1 German market

Initially, I focus on the German market, for which the availability of detailed producer price indices enables a static time series regression specification that carefully controls for relevant input prices. In the initial specification, the natural logarithm (log) of the cement price index is estimated as a linear function of the logs of production volume and input prices, as well as HHI and $MHHI\,Delta$. Furthermore, a linear time trend is added to rule out finding spurious relationships between $Price_t$ and input prices due to a general trend in inflation:

$$\begin{aligned} ln(Price_t) =& \beta_0 + \beta_1 ln(Production_t) + \beta_2 ln(Lignite_t) + \beta_3 ln(Lime_t) \\ &+ \beta_4 ln(Electricity_t) + \beta_5 HHI_t + \beta_6 MHHI\,Delta_t \\ &+ \beta_7 t + \epsilon_t \end{aligned} \tag{3}$$

Column (1) of table 3 shows the result of an OLS estimate with Newey-West standard errors. In this set-up, significant positive coefficient estimates are obtained for the price of electricity, the time trend t, and the constant. HHI_t and $MHHI\,Delta_t$ receive a significantly negative coeefficent estimate, which is at odds with the common ownership hypothesis.

An obvious concern of this basic approach is the probable interdependence of the demand for cement, proxied by $Production_t$, and the price of cement, the dependent variable. For instance, a price reduction may lead to additional demand for cement–an instance of reverse causality. This endogeneity problem can lead to biased and inconsistent estimates in the OLS set-up. To overcome it, I introduce two instrumentation strategies for $Production_t$. The first aligns with Hüschelrath et al. (2013) and uses construction activity as an instrument. To capture construction activity, we use two indices for new order volumes, which are mutually exclusive, but collectively exhaustive of the main construction industry in Germany. As cement is exclusively used in construction,[7] New order volumes in construction of buildings and civil engineering hence naturally drive the demand for concrete, the key ingredient of which is cement. At the same time, the cost of the cement used will only be a small portion of the total costs of a construction project and hence not significantly influence new orders (exclusion restriction). A second instrumentation approach relies on ambient temperature minima. Frost and snow regularly prevent earthworks in winter, which are usually required before placing concrete. Cold weather also prolongs the time concrete requires to set; frost

[7] According to the industry association VDZ *(Verein Deutscher Zementwerke e.V.)*, 35 per cent of cement consumption in Germany in 2020 was in civil engineering, 31 per cent in residential construction, and 34 per cent in non-residential construction.

can severely damage freshly poured concrete. Hence, low temperatures naturally reduce the demand for cement. At the same time, effects of ambient temperatures on the cement price other than through construction activity do not appear to be plausible. In particular, the cement production process and input availability are independent of temperatures.

With these instruments–construction activity and temperature minima–at hand, the instrumental variable regression is implemented using the IV-GMM estimator. This estimator allows to derive standard errors robust to heteroskedasticity and autocorrelation. Columns (2)-(4) in table 3 present the results of the second stage IV estimates alongside summary information on the first stages; the full first stage results are contained in Appendix C and confirm the strength of the instruments. In column (2), $Orders\_build_t$ and $Orders\_eng_t$ are used to instrument $Production_t$. In column (3), $Temperature_t$ is used. Column (4) makes use of all three variables as instruments. The results of the instrumented regressions are in line with the results of the simple OLS set-up. In particular, the significantly negative coefficient estimates for HHI_t and $MHHI\,Delta_t$ persist. Accordingly, there is no evidence for the positive association between ownership overlap and higher prices predicted by the common ownership hypothesis.

A final consideration in the model of the German market concerns seasonality. However, neither the dependent variable $ln(Price_t)$ nor the regression residuals exhibit autocorrelation patterns consistent with significant seasonality. Augmenting the regression models shown in table 3 with calendar month dummies and testing for their joint significance also does not indicate the presence of unaccounted seasonality.

4.2 European panel

The analysis of the market in just one country, albeit with a detailed and well-justified model specification, comes with challenges to both internal and external validity. Regarding the former, the number of observations and hence statistical power is naturally limited.[8] For this reason, e.g. Azar et al. (2018a) and Backus et al. (2021a) investigate a panel of routes and cities, respectively. Regarding the latter, there may be country-specific features such as the presence of prominent privately held players or specific national (governance) regulations that preclude common ownership effects from occurring. Therefore, it is sensible to broaden the analysis to a multi-country panel set-up. I focus on four European economies, France, Germany, Spain, and the UK, which enables the use of EU ETS data to gauge market shares. All four countries constitute large enough markets not to be materially influenced by import and export activities. In addition, the countries exhibit different dynamics in the cement

[8] Considering the German market, this is particularly true for market concentration as measured by the Herfindahl–Hirschman index, which exhibits very little variation over time.

Table 3: German market: Simple and IV regressions, in logs

Dependent var.:	$ln(Price_t)$			
Model:	OLS	IV GMM		
	(1)	(2)	(3)	(4)
Instrument(s):		$ln(Orders\_build_t)$ $ln(Orders\_eng_t)$	$Temperature_t$	All Three
$ln(Production_t)$	−0.002	−0.003	0.008	−0.000
	(0.006)	(0.008)	(0.010)	(0.008)
$ln(Lignite_t)$	0.076	0.123	0.089	0.111
	(0.099)	(0.109)	(0.102)	(0.095)
$ln(Lime_t)$	−0.035	−0.022	−0.040	−0.054
	(0.204)	(0.241)	(0.201)	(0.213)
$ln(Electricity_t)$	0.146*	0.126	0.147*	0.121
	(0.088)	(0.098)	(0.087)	(0.094)
HHI_t	−4.238**	−3.398**	−4.332**	−3.427**
	(1.734)	(1.444)	(1.723)	(1.445)
$MHHI\ Delta_t$	−1.160**	−1.028**	−1.137**	−1.061***
	(0.467)	(0.410)	(0.468)	(0.387)
t	0.002***	0.002**	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
$Constant$	4.132***	3.851***	4.071***	4.061***
	(1.381)	(1.449)	(1.375)	(1.277)
First stage				
Observations		192	192	192
Adj. R^2		0.586	0.577	0.718
Instrument significance		136.85*** F(2,183)	217.17*** F(1,184)	165.78*** F(3,182)
Second stage				
Observations	192	192	192	192
R^2	0.931	0.929	0.930	0.929

This table shows regressions of the natural logarithm of the monthly cement price index on common ownership concentration, HHI, various control variables, and a time trend. Variables are defined in Appendix A. Data runs from January 2005 through December 2020. Column (1) presents results for a simple OLS model. Columns (2)–(4) report the results for instrumental variables regressions. In column (2), $ln(Production_t)$ is instrumented using two volume indices of new construction orders in Germany; in column (3), the instrument is temperature minima; in column (4), all three instruments are combined. The detailed first stage results for columns (2)–(4) can be found in Appendix C. Heteroscedasticity- and autocorrelation robust (Newey-West) standard errors in parentheses. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

market, as illustrated by figure 1, and construction activity has followed different trajectories over the observation period. Unfortunately, the detailed input price data used in the model for the German market is not available on a consistent basis for all countries. Hence, I confine myself to a simpler model that features a construction activity index and an energy price index as control variables:

$$\begin{aligned} ln(Price\_panel_{t,i}) = & \beta_0 + \beta_1 ln(Construct\_activity_{t,i}) + \beta_2 ln(Energy\_price_{t,i}) \\ & + \beta_3 HHI_{t,i} + \beta_4 MHHI\,Delta_{t,i} + \beta_5 t + \alpha_i + \epsilon_{t,i} \end{aligned} \tag{4}$$

Table 4 presents the results of the panel analysis, which is carried out using the fixed-effects (within) estimator with standard errors clustered at the country and month levels. Column (1) of the table corresponds to the specification above, while column (2) supplements the model with a set of calendar month dummies. These are included as autocorrelograms of the dependent variable and of the residuals from column (1) suggest the presence of seasonality in at least one of the four panel countries. Indeed, an F-Test confirms the joint significance of the set of dummies in column (2). The coefficient estimates are highly similar in both regressions; only the coefficient estimate for construction activity, the control variable proxying cement demand, is significant and positive. The coefficient estimates HHI_t and $MHHI\,Delta_t$ remain insignificant. Hence, in line with the findings for the German market in the preceding subsection, no evidence in favour of the common ownership hypothesis can be reported.

4.3 Robustness

Time period of MHHI Delta

In the baseline specifications, the variable of interest is $MHHI\,Delta_t$, capturing the contemporaneous degree of common ownership. However, there are several arguments why using contemporaneous $MHHI\,Delta$ could veil common ownership effects in regressions: First, the ownership data is as of month-end, while price data is collected mid-month by statistical offices. Hence, changes in common ownership may occur in a given month *after* the collection of prices. Second, the mechanism, if any, mediating the effect of common ownership on competition may require a certain amount of time to operate. For instance, management could learn about ownership changes with delay. Related to this point, third, the ownership data is based on filings for which the respective regulator usually grants a notification period.[9] Hence, I repeat the regressions presented in the preceding subsections 4.1 and 4.2 including $MHHI\,Delta$ lagged by one to six months. Table D.1 in Appendix D presents the coefficient estimates for $MHHI\,Delta$ at the various lags with the respective significance level. For the analysis of the German cement market as well as for the panel,

[9] For instance, the German Securities Trading Act (*Wertpapierhandelsgesetz*) requires notification of threshold crossings within four trading days; the U.S. Securities and Exchange Commission (SEC) grants institutional money managers 45 days from the end of each quarter to disclose their holdings (Form 13F).

Table 4: Four-country panel, in logs

Dependent variable:	$ln(Price\_panel_{t,i})$	
	(1)	(2)
$ln(Construct\_activity_{t,i})$	0.108**	0.134***
	(0.026)	(0.021)
$ln(Energy\_price_{t,i})$	0.146	0.177
	(0.084)	(0.081)
$HHI_{t,i}$	−0.362	−0.316
	(0.634)	(0.589)
$MHHI\,Delta_{t,i}$	−0.438	−0.453
	(0.614)	(0.584)
t	0.001	0.001
	(0.001)	(0.000)
$Constant$	3.414***	3.144***
	(0.559)	(0.496)
Country FE	Yes	Yes
Calendar month FE	No	Yes
Observations	742	742
Countries (i)	4	4
R^2	0.599	0.619

This table reports results for the fixed-effects panel regressions of the natural logarithm of the monthly cement price index on common ownership concentration, HHI, two control variables, and a time trend. Variables are defined in Appendix A. Data runs from January 2005 through December 2020 for France, Germany, and Spain, and from January 2007 thorough October 2020 for the UK. Column (1) presents results for the baseline specification 4; column (2) additionally includes a set of calendar month dummy variables to control for seasonality. Standard errors are clustered at the country and month levels. The overall R^2 is reported. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

results are very similar to the baseline results with no lag.

Outlier due to LafargeHolcim merger

The most significant corporate transaction relevant to cement markets in the time period under investigation in this working paper is the merger of Swiss Holcim AG and French Lafarge SA. As described in greater detail in Appendix D, the merger leads to an outlier in the market concentration (captured by HHI and $MHHI$) in France, Germany, and the UK, in July 2015. This is due to an approximately one month delay between the completion of the merger between Lafarge and Holcim, and the closing of a related disposal of assets in these three countries. To rule out that this outlier, clearly visible in figure 1 at the dashed vertical line, drives the results, I replicate the baseline analysis excluding July 2015. The corresponding estimates for the German model using all three instruments (new orders, temperature) are presented in table D.2, column (1). While it remains negative and significant at the 10 per cent level, the coefficient estimate on $MHHI\,Delta_t$ is now closer to zero and no longer significant at the 5 per cent level. In the panel set-up, results remain virtually unchanged when excluding the outlier month, as displayed in columns (1) and (3) of table D.3. In summary, the outlier in July 2015 appears to contribute to the significantly negative coefficient estimate on $MHHI\,Delta_t$ in the model of the German market; however, across the German and the panel analysis, removing the outlier does not uncover the positive association between overlapping ownership and cement prices the common ownership hypothesis would suggest.

EUA price

Our baseline specification of the model for the German market includes key material and energy inputs, aligned with Hüschelrath et al. (2013). However, with the introduction of the EU ETS at the beginning of 2005, the price of an emissions allowance (EUA) has also become a relevant factor. When cumulative emissions in any year are below the emissions covered by EUAs held by a plant, production levels could be reduced to be able to sell EUAs to other market participants; conversely, if cumulative emissions equal or exceed the EUAs held, any additional production would require the purchase of additional EUAs to avoid a shortfall. According to an industry expert interviewed in connection with this research, such considerations indeed enter production planning when EUA prices are high. This motivates the inclusion of $EUA\,Price_t$ as an additional control variable. This addition, however, does not alter the baseline findings in relation to $MHHI\,Delta$, as can be seen from table D.2, column (2), and table D.3, columns (2) and (4).

Wage level

For Germany, the Federal Statistical Office also makes available monthly indices of hourly wages by industry starting in January 2010. While employment regulation and collective agreements limit the flexibility of labour input and dampen variation between firms, there are several mechanisms firms can use to adjust labour input, e.g. through overtime, temporary staff, and furlough schemes. Therefore, labour costs remain a relevant factor in the short term. For this reason, I include the hourly wage index for the sector *Manufacture of other non-metallic mineral products*, which includes cement manufacturing, as control variable

$Wage\_hourly_t$ in a final robustness check. The results are presented in table D.2, columns (3) and (4). In column (4), the index is used alongside the price of EUAs discussed in the preceding paragraph. With the inclusion of $Wage\_hourly_t$, observations in the years 2005–2009 are lost; it is thus not surprising that there are appreciable changes in the estimated coefficient for several variables. $MHHI\,Delta_t$, in particular, is estimated with a significantly negative coefficient as in the baseline specification when excluding $EUA\,Price_t$ (column 3). Adding $EUA\,Price_t$ renders the coefficient estimate insignificant.

5 Conclusion

This working paper takes the common ownership hypothesis, which proposes a causal effect of overlapping shareholders between competing firms on the level of competition in the relevant product market, to a novel and, at the outset, fertile testing ground: the European cement industry. This industry seems to be particularly suitable for establishing any effect of common ownership for several reasons: an oligopolistic market structure with substantial barriers to entry, a homogeneous product, and instances of collusive behaviour in the past. Indeed, I document a clear pattern of rising common ownership, as measured by $MHHI$ *Delta*. In particular, by accepting the divestment of assets to CRH as a remedy for clearing the Lafarge-Holcim merger in 2015, the European Commission appears to have traded an increase in market concentration for an increase in common ownership in France and Germany. Nonetheless, an association between common ownership and the cement price level consistent with the common ownership hypothesis cannot be detected. While I am pursuing extensions of the present working paper, the current results suggest that the findings of anti-competitive common ownership effects in select U.S. markets, such as airlines and bank deposits, may not be applicable to other industries or non-U.S. jurisdictions, or may be instances of type I error. More research is needed to render credible policy advice on the treatment of common institutional owners and on the regulation of index investment strategies, which are a key driver of recent increases in common ownership. Such research should carefully define product markets and identify the relevant firms and market shares based on thoughtful assumptions.

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Appendix A. Variable definitions

Table A.1: Definition of variables and source information

A. German market *Jan-2005 through Dec-2020*	
$Price_t$	Monthly index of cement prices in Germany, reported as a component of the producer price index for industrial products published by the German Federal Statistical Office (code # 61241). The index is computed from transaction prices collected mid-month from a representative sample of industrial enterprises, with base year 2015 = 100.
HHI_t	The Herfindahl-Hirschman index, defined as the sum of squared market shares of all firms j: $$HHI = \sum_j s_j^2$$ The market shares are derived for each month in two steps: First, the annual verified emissions recorded by the EU ETS for each plant are allocated to individual months, allowing for kiln stoppages and plant closures reported in company disclosures and the media. Second, plants are allocated to firms using information from company filings and media reports. In the case of mergers and acquisitions, the closing date of the transaction is considered.
$MHHI\ Delta_t$	The difference between the modified Herfindahl-Hirschman index (MHHI) accounting for common ownership, and the conventional HHI described above: $$MHHI = \sum_j \sum_k s_j s_k \frac{\sum_i \gamma_{ij}\beta_{ik}}{\sum_i \gamma_{ij}\beta_{ij}} = \underbrace{\sum_j s_j^2}_{\text{HHI}} + \underbrace{\sum_j \sum_{k \neq j} s_j s_k \frac{\sum_i \gamma_{ij}\beta_{ik}}{\sum_i \gamma_{ij}\beta_{ij}}}_{\text{MHHI Delta}},$$ where s_j is the market share of firm j, γ_{ij} the control share of shareholder i in firm j and β_{ij} the ownership share of i in j. The shareholder structures are compiled on a monthly basis from multiple sources including Refinitiv Eikon, company annual reports, other regulatory filings, press reports, and the German Federal Cartel Office's sector inquiry.
$Production_t$	Monthly index of cement production in Germany, reported by the German Federal Statistical Office as part of the indices of production in manufacturing (code # 42153). Base year 2015 = 100.

Continued on next page

$Electricity_t$	Monthly index of electricity prices for high voltage industrial customers in Germany, reported as a component of the producer price index for industrial products published by the German Federal Statistical Office (code # 61241). The index is computed from transaction prices collected mid-month from a representative sample of industrial enterprises, with base year 2015 = 100.
$Lignite_t$	Monthly index of lignite prices in Germany, reported as a component of the producer price index for industrial products published by the German Federal Statistical Office (code # 61241). The index is computed from transaction prices collected mid-month from a representative sample of industrial enterprises, with base year 2015 = 100.
$Lime_t$	Monthly index of lime prices in Germany, reported as a component of the producer price index for industrial products published by the German Federal Statistical Office (code # 61241). The index is computed from transaction prices collected mid-month from a representative sample of industrial enterprises, with base year 2015 = 100.
$Orders\_build_t$ $Orders\_eng_t$	Volume indices of new orders in the main construction industry, structural engineering (*Hochbau*) and civil engineering (*Tiefbau*). Unadjusted monthly indices published by the German Federal Statistical Office (code # 44111).
$Temperature_t$ (°C)	Monthly arithmetic mean of the daily minimum air temperature in degrees Celsius, averaged between Berlin, Dusseldorf, and Munich, obtained from the German Meteorological Service (*Deutscher Wetterdienst*).
B. Four-country panel *France, Germany, United Kingdom, Spain; Jan-2005 through Dec-2020*	
$Price\_panel_{t,i}$	The monthly domestic output price index for cement, in national currency, with base year 2015 = 100, from Eurostat's producer prices in industry.
$HHI_{t,i}$	For each country as described above in panel A of this table.
$MHHI\ Delta_{t,i}$	For each country as described above in panel A of this table.
$Energy\_price_{t,i}$	The monthly total output price index for energy, in national currency, with base year 2015 = 100, from Eurostat's producer prices in industry.
$Construct\_activity_{t,i}$	Volume index of production in construction. Calendar adjusted monthly data published by Eurostat.

Appendix B. Inferring market shares from emissions

Theoretical foundation and limitations

Using plant-level European Union Emissions Trading System (EU ETS) verified emissions to infer country-wide market shares in the cement industry is equivalent to postulating a very close cross-sectional correlation between emissions and contemporaneous volumes of cement sold in the domestic market. For this correlation to hold, some assumptions are needed. These are mainly:

1. Uniform monitoring and reporting of GHG emissions across firms
2. Uniform specific GHG emissions[10] across firms
3. No market shares held by firms not covered by the EU ETS
4. No material imports or exports of cement clinker or cement

Regarding assumptions (1) and (2) above, it is essential to understand the source of GHG emissions in the production of cement.

The production of cement comprises two main steps (see, for instance, Emele et al., 2022): First, the production of cement clinker. Cement clinker is the main ingredient of cement. It accounts for approximately 70 per cent of cement (the "clinker-to-cement ratio") and gives cement the property of, in combination with water, hardening and binding together aggregates. Second, the grinding and mixing of cement clinker with additives to form the final product. The first production step is carried out in integrated cement plants and its direct (scope 1) emissions are covered by the EU ETS under activity code 29. The step involves heating up mainly ground limestone and clay to around 1450°C in a cement kiln. At these temperatures, cement clinker is formed through several related chemical reactions. Importantly, the limestone *calcinates*, i.e., calcium carbonate decomposes into calcium oxide and carbon dioxide:

$$CaCO_3 \longrightarrow CaO + CO_2$$

This chemical reaction is responsible for around 60 per cent of direct (scope 1) GHG emissions caused by cement clinker production Czigler et al. (2020). These emissions, also referred to as *raw material-related emissions*, are naturally invariant and will not depend on the specifications of a cement plant. The remaining 40 per cent of direct GHG emissions in cement clinker production are related to heating the raw materials (*energy-related emissions*) Czigler et al. (2020), in particular to firing the kiln. These energy-related emissions can vary from plant to plant depending on the process, technology and the kiln fuels used. However, in practice, such variation is likely limited, as, to the best of the author's knowledge, the cement plants in operation during 2005 through 2020 in the four countries studied used the same kiln design, a rotary kiln with preheater. In addition, all cement plants in Germany and most cement plants in the three other countries used the same type of clinker production

[10] "Specific emissions" refer to the amount of emissions per unit of production, as opposed to total emissions.

process ("dry process").[11] The second main step in the production of cement, the grinding and mixing of cement clinker with other materials, occurs in cement mills. This production step is not covered by the EU ETS directly; as the large grinders are powered by electricity, they do not contribute to the direct emissions of a cement plant.

Considering the specific direct and indirect GHG emissions from the production of cement, circa 50 per cent can be attributed the direct, raw material-related emissions from the production of clinker; circa 35 per cent can be attributed to the direct, energy-related emissions from the production of clinker; circa five per cent are indirect emissions from grinding; and another circa ten per cent are miscellaneous direct and indirect emissions including, for instance, material logistics Czigler et al. (2020).

Regarding assumption (1) above, one can hence conclude that a circa 85 per cent share of specific GHG emissions associated with cement production are covered by the EU ETS, as these are direct emissions occurring at integrated cement plants. Such installations have been covered by the EU ETS from its inception in 2005 and their emissions reports are subject to monitoring requirements and verification by an accredited third party. Hence, save for criminal misreporting of emissions, the EU ETS registries constitute a reliable data source.

Regarding assumption (2), uniform specific GHG emissions across firms, 50 per cent of emissions occurring in the cement production correspond to the volume of clinker used in an invariant manner. Hence, variation in specific direct emissions across plants and firms can be introduced only by different energy-related emissions (due to production technology and combustion fuel) and by different clinker-to-cement ratios. As the production technology has converged to dry process rotary kilns and cement is largely standardised, a material effect of such variation appears to be unlikely.

Lastly, assumptions (3) and (4) relate to market shares held by firms not covered by the EU ETS and to imports and exports. Since cement clinker and cement are stable solids, they can be traded, including across borders. Hence, firms covered by the EU ETS could sell both products abroad, or import additional volumes. Furthermore, cement clinker could be procured, domestically or from abroad, and be ground to cement by third parties. Because the EU ETS does not cover grinding stations, market shares held by cement companies not operating their own clinker production but manufacturing cement from purchased clinker cannot be captured using emissions data. Two factors serve to mitigate such concerns in the set-up of this study: Firstly, cement and cement clinker are heavy materials with a comparatively low value per tonne; transport costs hence reduce the attractiveness of trading them over longer distances[12] and incentivise the operation of *integrated* plants combining clinker production and cement grinding in one site. Secondly, I focus on four geographically large (as opposed to small open) developed countries, in which the level of dependence on imports in heavy materials is naturally lower. Nonetheless, these aspects remain limitations of the emissions methodology used in this paper.

[11] Carbon Capture, Utilisation and Storage (CCUS) technologies are in development to decarbonise the cement industry. However, during the sample period, no CCUS systems were operational at the plants covered.

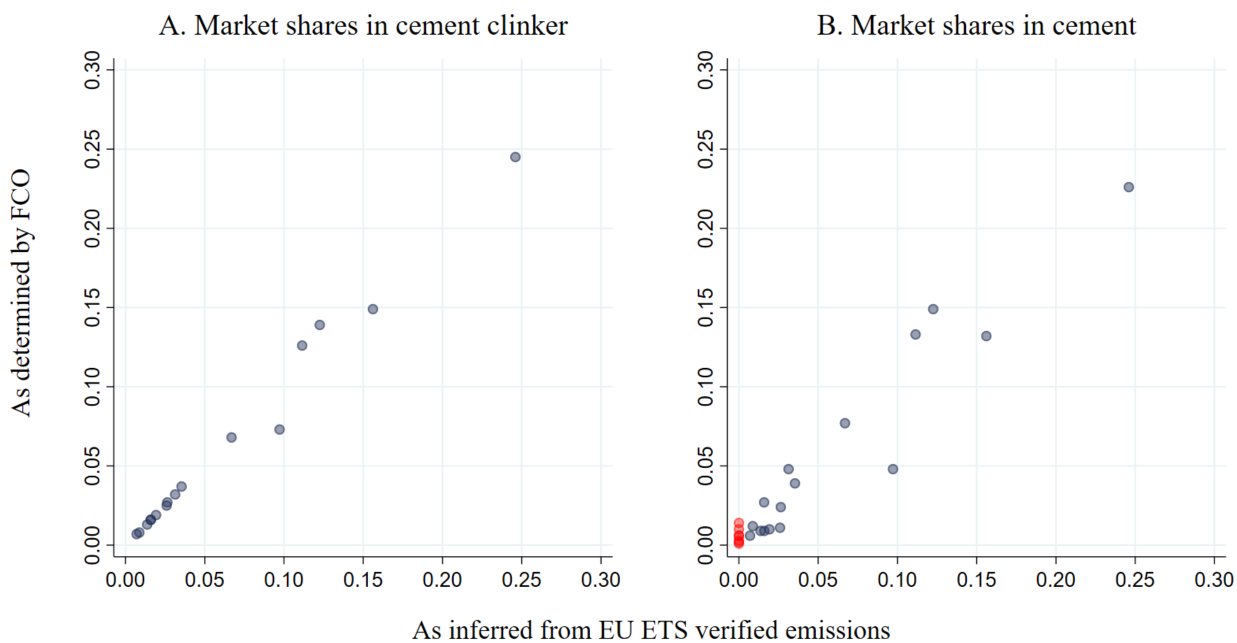
[12] According to the German Federal Cartel Office, 90 per cent of cement volumes by German facilities were delivered within a radius of 130 km (Bundeskartellamt, 2017).

Validation

In the light of the limitations outlined, it is crucial to validate the methodology of inferring market shares in the cement industry from emissions data using another data source. Since emissions are used here to calculate market shares precisely because such information is not readily available, such a comparison is difficult. Companies and industry associations deliberately hold back on market share data for reasons of competition law.[13] An exception is the year 2013 in the cement industry in Germany. For this year, the German Federal Cartel Office (FCO, *Bundeskartellamt*) conducted an official sector inquiry cement and ready-mix concrete (*Sektoruntersuchung Zement und Transportbeton*, published in 2017). A sector enquiry enables the FCO to investigate the state of competition in an industry or economic sector of concern and endows it with subpoena powers to obtain information. Figure B.1 plots the market shares determined by the FCO against those computed from emissions data. Of particular interest is panel B on the left, which exhibits market shares for cement (as opposed to the pre-product cement *clinker*). Although the emissions data, as outlined above, does not capture cement producers that do not manufacture their own cement clinker, the emissions-inferred market share closely align with those published by the FCO. Calculating the Herfindahl–Hirschman index (HHI) based on the FCO data yields an HHI of 1323 for cement clinker (panel A in figure B.1) and 1227 for cement (panel B), while the emissions data implies an HHI of 1311. The Pearson correlation coefficient between the FCO-determined and the emissions-inferred market shares is 0.992 for cement clinker and 0.966 for cement, each significant at the 0.1 per cent level. These results support the thesis that the market shares derived from the emissions are sufficiently close to the actual market shares for cement.

[13] For example, the German Federal Cartel Office requested an association of the cement industry to cease collecting and sharing information on market shares among its members in 2010.

Figure B.1: 2013 market shares in the German cement industry



This figure compares the market shares inferred from the plant-level verified emissions recorded by the EU Emissions Trading System (EU ETS) for 2013 (x-axis) to the market shares determined by the German Federal Cartel Office (FCO) for the same year as part of their inquiry into the German cement market (y-axis). Panel A compares the market shares from emissions to the market shares calculated by the FCO for cement *clinker*, the main ingredient of cement. Panel B compares the market shares from emissions to the market shares calculated by the FCO for *cement*. Each bubble represents one firm. The red bubbles in panel B represent cement firms that do not produce clinker and hence are ignored when using emissions data, as their plants are not covered by the EU ETS.

Appendix C. German market: First stages

Table C.1: German market: First stages of IV regressions in logs

Dependent var.:	$ln(Production_t)$		
	(1)	(2)	(3)
Instrument(s):	$ln(Orders\_build_t)$ $ln(Orders\_eng_t)$	$Temperature_t$	All Three
$ln(Orders\_build_t)$	0.613***		0.573***
	(0.219)		(0.167)
$ln(Orders\_eng_t)$	0.834***		0.393***
	(0.140)		(0.124)
$Temperature_t$		0.040***	0.025***
		(0.003)	(0.002)
$ln(Lignite_t)$	0.302	0.034	0.454
	(0.679)	(0.426)	(0.564)
$ln(Lime_t)$	−0.715	−0.713	−1.003
	(1.247)	(0.845)	(0.943)
$ln(Electricity_t)$	0.093	0.067	0.100
	(0.272)	(0.234)	(0.202)
HHI_t	−1.928	1.251	−3.167
	(5.594)	(3.928)	(3.252)
$MHHI\,Delta_t$	−2.114	0.057	−0.892
	(1.282)	(1.039)	(0.890)
t	0.000	0.003	0.001
	(0.002)	(0.002)	(0.002)
$Constant$	−0.336	6.681*	2.350
	(4.457)	(3.470)	(2.905)
Observations	192	192	192
Adj. R^2	0.586	0.577	0.718

This table presents the first stage results of the instrumental variables regressions presented in columns (2)–(4) of table 3. The instrumented variable is $ln(Production_t)$. In column (1), two volume indices of new construction orders in Germany are used as instruments, corresponding to column (2) of table 3; in column (2), the instrument is temperature minima (column (3) of table 3); in column (3), all three instruments are combined (column (4) of table 3). Heteroscedasticity- and autocorrelation robust (Newey-West) standard errors in parentheses. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

Appendix D. Robustness checks

Tables

Table D.1: $MHHI\ Delta$ coefficient estimates for varying lags

Dep. variable	Regression (Instr.)	Lag of $MHHI\ Delta$ in months: 0	1	2	3	6
$ln(Price_t)$	OLS	−1.160**	−1.121**	−1.134**	−1.202***	−1.432***
	IV GMM (New orders)	−1.028**	−1.016**	−1.025***	−1.129***	−1.285***
	IV GMM (Temperature)	−1.137**	−1.114**	−1.149***	−1.234***	−1.435***
	IV GMM (All three)	−1.061***	−1.063***	−1.091***	−1.148***	−1.339***
$ln(Price\_panel_{t,i})$	Panel FE	−0.438	−0.451	−0.477	−0.505	−0.567
	Panel FE, CM FEs	−0.453	−0.468	−0.502	−0.528	−0.570

This table reports the coefficient estimates on $MHHI\ Delta$ at various lags, from none to six months, obtained by re-estimating the four baseline regressions used for the German model (table 3) and the two baseline fixed-effects regressions used in the four-country panel (table 4). The top four rows correspond to the simple and IV models of the German market, the bottom two rows to the fixed-effects panel models. This robustness check is discussed on page 15. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

Table D.2: German market: Robustness checks

Dependent var.:	$ln(Price_t)$			
Model:	IV GMM			
Instruments:	$ln(Orders\_build_t)$, $ln(Orders\_eng_t)$, and $Temperature_t$			
	(1)	(2)	(3)	(4)
Robustness check:	ex. Jul-2015	EUA Price	Wages	EUA Price & Wage
$ln(Production_t)$	0.002	0.002	0.004	0.001
	(0.009)	(0.008)	(0.004)	(0.003)
$ln(Lignite_t)$	0.169*	0.085	0.036	0.045
	(0.092)	(0.092)	(0.093)	(0.078)
$ln(Lime_t)$	−0.008	−0.072	0.119	0.298**
	(0.217)	(0.195)	(0.133)	(0.136)
$ln(Electricity_t)$	0.197**	0.122	−0.014	−0.052**
	(0.080)	(0.097)	(0.019)	(0.023)
HHI_t	−5.681***	−3.514**	−0.493	−0.398
	(1.267)	(1.397)	(0.300)	(0.267)
$MHHI\ Delta_t$	−0.709*	−1.260***	−0.451**	0.060
	(0.376)	(0.425)	(0.206)	(0.189)
t	0.001**	0.002***	0.000	−0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
$EUA\ Price_t$		−0.000		0.010***
		(0.003)		(0.003)
$Wage\_hourly_t$			0.490	1.063***
			(0.331)	(0.335)
$Constant$	3.534***	4.253***	1.761	−1.390
	(1.269)	(1.143)	(1.524)	(1.521)
First stage				
Observations	191	188	132	131
Adj. R^2	0.717	0.700	0.720	0.719
Instrument	162.40***	165.59***	122.30***	108.81***
significance	F(3,181)	F(3,177)	F(3,121)	F(3,119)
Second stage				
Observations	191	188	132	131
R^2	0.933	0.924	0.954	0.967

This table presents the results of four robustness checks based on the model of the German market instrumenting $ln(Production_t)$ with all three instruments discussed ($ln(Orders\_build_t)$, $ln(Orders\_eng_t)$, and $Temperature_t$; the corresponding baseline results are presented in column (4) of table 3). In column (1), the model is re-estimated excluding the July 2015 observation, which is an outlier due to the Lafarge-Holcim merger, as discussed in detail in this appendix on page 31. Columns (2) and (3) each augment the baseline model with one additional control variable: the price of an EU Allowance, $EUA\ Price_t$, in column (2), and an index of hourly wages, $Wage\_hourly_t$, in column (3). Column (4) presents results including both additional control variables. Inclusion of the additional control variables reduces the number of available observations due to missing data at the beginning of the 2005–2020 timeframe under consideration. Heteroscedasticity- and autocorrelation robust (Newey-West) standard errors in parentheses. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

Table D.3: Four-country panel: Robustness checks

Dependent variable:	$ln(Price\_panel_{t,i})$			
Model:	Baseline model		Calendar month FE	
	(1)	(2)	(3)	(4)
Robustness check:	ex. Jul-2015	EUA Price	ex. Jul-2015	EUA Price
$ln(Construct\_activity_{t,i})$	0.107**	0.103**	0.134***	0.132***
	(0.026)	(0.023)	(0.021)	(0.021)
$ln(Energy\_price_{t,i})$	0.148	0.135	0.178	0.165
	(0.085)	(0.092)	(0.082)	(0.090)
$HHI_{t,i}$	−0.353	−0.335	−0.308	−0.292
	(0.661)	(0.737)	(0.617)	(0.696)
$MHHI\,Delta_{t,i}$	−0.430	−0.383	−0.445	−0.401
	(0.628)	(0.696)	(0.598)	(0.665)
t	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)
$EUA\,Price_t$		−0.001		−0.001
		(0.005)		(0.005)
$Constant$	3.407***	3.482***	3.138***	3.207***
	(0.567)	(0.588)	(0.505)	(0.537)
Country FE	Yes	Yes	Yes	Yes
Calendar month FE	No	Yes	No	Yes
Observations	738	729	738	729
R^2	0.600	0.580	0.620	0.603

This table presents the results of two robustness checks based on the two baseline fixed-effects panel regressions shown in table 4. In columns (1) and (3), the panel regressions are re-estimated excluding the July 2015 observation, which is an outlier due to the Lafarge-Holcim merger, as discussed in detail in this appendix on page 31. In columns (2) and (4), the models are each augmented with the price of an EU Allowance, $EUA\,Price_t$, as an additional control variable. This is associated with a reduction in the number of observations due to missing EUA price data in 2005. Standard errors are clustered at the country and the month levels. The overall R^2 is reported. $*$, $**$, $***$ indicate a 10%, 5%, and 1% level of significance, respectively.

Background on the Lafarge-Holcim merger and disposal

The merger between Holcim AG and Lafarge SA was announced in April 2014 as a "merger of equals" by way of an exchange offer.[14] As the combination of Lafarge's and Holcim's assets would have entailed substantial concentrations in the cement and aggregates markets of several EU member states, both companies negotiated a list of assets to be disposed with the European Commission in order to obtain clearance. In the four countries examined in this working paper, the agreed disposals included all of Holcim's assets in France except for one cement plant, Lafarge's assets in Germany, and the Lafarge Tarmac assets in the UK except for one cement plant.[15] Lafarge and Holcim then negotiated and received approval by the European Commission for the disposal of these assets to the Irish building materials group CRH plc.[16] The merger was completed in July 2015, creating LafargeHolcim. However, the closing of the asset disposal to CRH only occured in August of the same year.[17] For this reason, the computed HHI and $MHHI$ values show an outlier in July 2015, as visible in figure 1. In this month, the reported market concentration is elevated as the agreed disposals have not yet been completed. In August 2015, the divested assets are then transferred to CRH, reducing the combined market share of Lafarge and Holcim in France and Germany again to a level similar to the pre-merger period.

[14] See the press release "A merger of equals to create LafargeHolcim, the most advanced group in the building materials industry" (April 7, 2014), available from https://www.holcim.com/media/media-releases/a-merger-equals-create-lafargeholcim-most-advanced-group-building-materials-industry

[15] See the press release "European Commission provides clearance for proposed merger of Holcim and Lafarge" (December 15, 2014), available from https://www.holcim.com/media/media-releases/european-commission-provides-clearance-proposed-merger-holcim-and-lafarge

[16] See the press release "Holcim and Lafarge receive European Commission's approval for CRH as buyer of divestment assets" (April 24, 2015), available from https://www.holcim.com/media/media-releases/04242015-Holcim-Lafarge-European-Commission-approval-CRH-buyer-divestment

[17] See the press release "CRH announces completion of Lafarge-Holcim transaction" (August 3, 2015), available from https://www.crh.com/media/press-releases/2015/crh-acquisition-lh-transaction-completes