The High and Falling Price of Cement in Africa[*]

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Abstract

Prices for several intermediate inputs, including cement, are higher in developing economies—particularly in Africa. Combining recent data from the International Comparison Program with a global directory of cement firms we estimate an industry equilibrium model to distinguish between drivers of international price dispersion: demand, costs, conduct, and entry. Developing economies feature both higher marginal costs and higher markups. African markets are not characterized by less competitive conduct and, if anything, feature lower barriers to entry. Yet the small size of many national markets limits entry and competition and explains most of the higher markups and prices. Policy implications are discussed.

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1 Introduction

The prices of several goods, including intermediate inputs such as cement, broadband internet, steel reinforcement bars, and urea fertilizer, are highest on average in low-income economies, many of which are in Africa (Figure 1).[1] This fact is important because higher prices for intermediate goods can slow economic growth (Jones, 2011). Moreover, this evidence runs counter to the broad tendency for prices to be lower in low-income countries, which is sometimes referred to as the "Penn effect" (Summers and Heston, 1991).

The explanation for this cross-country pattern in price levels is not certain. One view is that higher prices reflect higher costs of production. An alternative view is that higher prices might instead reflect a higher markup. To the extent that prices do reflect a higher markup, a variety of economic forces could lie underneath. Regulatory requirements (e.g., environmental standards, operating licenses) or disadvantageous market institutions (e.g., borrowing constraints, expropriation risk) can increase entry costs and reduce entry and competition. Given entry, collusive conduct (e.g., cartels) also increases markups. Higher markups could reflect a small market size that is unable to sustain more than a few competitors. The appropriate policy response, if any at all, critically hinges on quantifying the relative importance of these forces. Such a quantification exercise is complicated by a lack of consistent data on prices, quantities, and market structure across economies.

This paper distinguishes between these hypotheses in the case of Portland cement, an industry that is both of intrinsic relevance but also affords a number of methodological advantages. Cement is a critical input in the construction sector and thus in aggregate investment, with the average economy spending 1.3 percent of GDP on it in our data. We combine a recent panel of internationally comparable prices from the 2011 and 2017 rounds of the International Comparison Program (ICP) with a directory of cement firms in 99 economies on all continents and country-level attributes from various data sources.

These data allow us to estimate an empirical model of the global cement industry that can tease apart and quantify drivers of markups and costs. The equilibrium can be described by two equations. The first defines industry prices as the product of average markups and marginal costs in the industry. Markups depend on the elasticity of demand, the number of incumbents, and firms' conduct. The second equilibrium condition pins down the number of firms willing to pay the fixed entry cost to operate in a market. The structural parameters of the model are informative about demand, supply, entry, and conduct in the cement industry. We discuss their identification and estimation, show that our structural estimates are

[1] Hassan (2016) finds that the overall price level falls with national income among low-income economies in Africa. Higher prices in low-income economies have been documented for generic pharmaceuticals (Silverman et al., 2019) and mobile internet (Faccio and Zingales, 2017).

consistent with previous studies and industry reports of the cement industry, and perform sensitivity analyses about the validity of the moment conditions and the functional forms we use, before turning to policy implications.

Analysis of this important industry yields three insights relevant to African development. First, in an industry characterized by a relatively homogeneous product, variance in marginal costs explains the majority of price variation, relative to markups. Africa stands out because it had the highest average US dollar cement price of any continent in 2011, the highest average marginal cost, and the second highest average markup. However, by 2017 the average cement price in Africa had fallen by one-third, due three-fifths to a decline in marginal cost and two-fifths to a decline in the markup. This result casts doubts on views that emphasize deep rooted institutional differences leading to permanently higher cement prices and markups.

Second, to the extent that markups in Africa remain high, our estimates suggest this is not due to higher barriers to entry or to widespread cartel conduct across the continent. We identify fixed costs from actual firm entry decisions and find them to be economically significant and in line with figures reported in industry publications. These costs however are not systematically higher in Africa compared to other continents, suggesting that Africa does not have extraordinarily high barriers to entry. We identify conduct following the argument in Bresnahan (1982) generalized by Berry and Haile (2014).[2] While Cournot competition provides an accurate characterization of conduct in the average market, we estimate differences in conduct across economies. Conditional on the number of firms, more geographic concentration of urban centers within a national market lowers markups, while contact between firms in other countries, which theoretically could facilitate collusion, increases markups, consistent with evidence from the United States (Syverson, 2004; Evans and Kessides, 1994). Yet, quantitatively these factors cannot account for the high price of cement in Africa.

Third, our estimates suggest that higher prices and markups reflect the small economic size of many national markets on the continent. Fixed costs of establishing a cement plant imply increasing returns to scale and a minimum threshold market size below which a firm will not enter. Many African countries have small market sizes that can only support a limited number of firms.[3] Once market size is properly accounted for by measures of demand and transportation costs, cement markets in Africa do not appear to be characterized by

[2]The conduct parameter characterizes the oligopoly solution concept, conditional on market concentration, costs, and demand elasticity. Different values of the parameter distinguish between perfect competition, Cournot competition, and a cartel that jointly maximizes firms' profits (Atkin and Donaldson, 2015). Joint profit maximization can be illegal whereas Cournot competition need not be (Whinston et al., 2008; Fox and Bakhoum, 2019).

[3]Some are also landlocked, or with less road density. Importing cement is thus expensive.

especially high levels of distortions. Consistently with this view, rapid entry and a decline in marginal cost occurred in Africa at a time of rapid economic growth. Our evidence is thus in line with Hallward-Driemeier and Pritchett (2015) who observe that, across countries, it is likely the fundamentals of costs and demand, rather than rules and regulations, that guide firm decision-making. We discuss the policy implications of these findings in the conclusions.

Though our findings come from a single industry, they contribute to the understanding of differences in market structures across countries. In low- and middle-income economies, the concentration of sales and employment is substantially higher (Mitton, 2008). High markups in sufficiently many industries in the economy can lead to lower aggregate income in the economy as a whole (Edmond et al., 2018; De Loecker et al., 2020; Baqaee and Farhi, 2020). However, little is known about the underlying causes of low competition. One hypothesis is that it is enforced by oligarchies led by major producers that use political power to erect entry barriers against new entrepreneurs (Acemoglu, 2008). In support of this hypothesis, empirical work has documented regulation of entry by governments (Djankov et al., 2002), damages from cartels (Ivaldi et al., 2016), and relatively lower profit margins in non-tradable sectors in countries with greater legal scope for antitrust policies (Besley et al., 2020). The case of the cement industry however points to an alternative hypothesis in which, due to large fixed costs, market size plays a comparatively more important role in accounting for higher concentration and markups. This intuition could be relevant to explain price levels in other industries with substantial fixed investment, such as telecommunications and banking.

Related Literature. Given its economic importance and methodological appeal, a large industrial organization literature has studied the cement industry. These studies have sought to describe the industry equilibrium in a specific economy, for instance as in Brazil (Salvo, 2010), India (Bhayani, 2010), Norway (Röller and Steen, 2006) and the U.S. (Jans and Rosenbaum, 1996; Newmark, 1998; Ryan, 2012; Miller and Osborne, 2014; Fowlie et al., 2016; Miller et al., 2022a). We use a similar microeconomic approach, but ask what are the underlying causes of variation in prices and market structure across countries, a research question pioneered by Bain (1966). The most related work to ours in this vein is that of Ghemawat and Thomas (2008), who use the global cement directory to study the strategic decision of multinational cement firms to enter national markets, though do not estimate costs (and thus markups) as we do.

A distinct literature in macroeconomics asks a different question: How can distortions in markets for goods like cement with strong complementarity in other sectors account for differences in aggregate income across countries? For instance, Donovan (2021) shows how excessively high fertilizer prices can decrease productivity and increase food prices, making it less safe for subsistence households to take entrepreneurial risk. Fried and Lagakos (2020) show how excessively low electricity prices can lead to rationing and outages that retard capital accumulation. These results and others by Jones (2011) suggest policy makers interested in growth should be concerned with prices and the efficiency of markets for intermediate goods. Yet, the appropriate policy in any one market hinges critically on quantifying the relative importance of costs and markups in determining the equilibrium price. Our paper speaks to this literature by demonstrating how consistent data on prices, quantities, and market structure across economies can be used to achieve this goal. Easterly (1993), Jones (1994), and Hsieh and Klenow (2007) previously sought to explain differences across countries in the price of investment relative to consumption without data on market structure.

A closely related paper is Beirne and Kirchberger (2023), who use the same data as we do to document the high price of cement (and other products) and concentration in African markets, and seek to understand their drivers.[4] Our approach differs from theirs in fundamental ways. In the spirit of the "structure-conduct-performance" approach associated with Bain (1966), Beirne and Kirchberger (2023) estimate a log-linear reduced form equation between prices and market concentration. In contrast, our paper estimates a structural model of supply and demand to identify drivers of prices, market concentration, and markups. The structural approach has three main advantages. First, as Miller et al. (2022b) highlight, the reduced-form approach assumes the elasticity of prices to market concentration is constant, whereas the structural approach captures heterogeneity depending on the baseline market concentration (i.e., prices are more sensitive to changes in concentration in highly concentrated markets). Second, the reduced-form approach only models the component of prices determined by market concentration, implicitly holding marginal cost constant across markets, whereas the structural approach also models marginal cost as a function of observables. These two advantages allow the structural model to better fit the data. For example, the structural model predicts a median price decrease in Africa between 2011 and 2017 equal to 90% of the median price decrease observed in the data, but the reduced form approach predicts a much smaller decrease, equal to only 60% of what is observed in the data. The structural model also predicts more of the variation across continents than does the reduced form approach. Third, and finally, by estimating costs, conduct, and demand in addition to specifying a model of how they determine markups, we are able to statistically test whether markups in Africa are due to differences in either costs, conduct, or demand, and illustrate how changes in these variables can change markups and prices. While the reduced form approach can only explain variation in prices due to change in market concentration,

[4] The high price of cement and concentration in African markets has been highlighted using the 2011 ICP data and other sources (World Bank, 2016).

a structural approach endogeneizes market concentration as a function of both fixed and variable costs.

Despite these differences, our papers also have important complementarities. Beirne and Kirchberger (2023) propose a general equilibrium macroeconomic model in which aggregate capital stock in Africa is most sensitive to changes in market concentration in the cement industry. If cement markups decrease the aggregate capital stock in Africa, as implied by their macroeconomic model, our findings suggest that the capital stock can be most effectively increased by policies that favor market integration, rather than by deregulation of entry or cartel enforcement. An exciting avenue for future work is to implement our microeconomic approach in more industries, and to use a macroeconomic framework to trace the implications of differences in costs, conduct, and demand for aggregate productivity.

The paper unfolds as follows. Section 2 presents the industry background, data, and motivating facts. Section 3 introduces the model. Section 4 applies the model to the global cement industry and presents our identification and estimation strategies. Section 5 reports the main empirical results and considers potential threats and sensitivity to identification assumptions. Section 6 analyzes the drivers of international price dispersion with special attention to Africa. Section 7 concludes and discusses policy implications.

2 Industry Background, Data and Motivating Facts

This section provides background on the cement industry. It also describes our data and three facts about cement markets in Africa that motivate our research.

2.1 Industry Background

Technology. Portland cement (hereafter cement) is the most widely used type of hydraulic cement, which hardens when combined with water. The main inputs to cement production are limestone, clay, and gypsum, which are heated in a kiln to form clinker. Clinker is ground into a fine powder, which is finished cement. In turn, cement is a major input to ready-mix concrete, which is cement mixed with gravel, sand, and water, and delivered to a construction site. Cement production technology has improved over time. Looking at the US between 1973 and 2013, Macher et al. (2021) document the progressive adoption of more efficient kiln technology, especially by large plants facing favorable competitive and demand conditions.[5]

[5]Detailed cross-country information about production technology is unfortunately unavailable. However, we observe a country's quality of road infrastructure, which is a major determinant of transportation costs in the cement industry. The panel dimension of our data also allows us to explore changes in production

The cement industry is characterized by increasing returns to scale at the firm level (Norman, 1979). An important source of increasing returns is the capacity installation cost equaling about US$150 million per megaton (million tons) of annual production capacity (Cembureau, 2021). This fixed cost must be paid back by earnings over time, implying a minimum threshold market size below which firms do not enter. As a result, installed capacity is closely related to consumption volume across economies, as shown in Figure 2. Economies below the 45^o line do not have enough domestic production capacity to satisfy consumption, and import some consumption. At very low levels of consumption, most economies are below the 45^o line, and several have no domestic production capacity at all. However, as consumption increases, it becomes more common for economies to have domestic production capacity in excess of consumption and export cement.

Market Structure. Cement is expensive to store and transport over land. Combined with the large fixed cost, transportation costs imply the industry is characterized by local oligopolies (or monopolies) with limited competition between adjacent land areas. Ocean transport of cement between countries exists. A first-order approximation is that the ports of entry act as a large capacity plant subject to the same terrestrial transportation issues that inland plants face. We consider countries as markets and let the ports be an additional competitor. Given transportation costs, physical proximity to large markets could determine the extent of import penetration, as could tariffs. Both local and multinational firms are active in the industry. While local firms by definition only serve their market, multinationals may strategically enter markets where they face familiar competitors, potentially facilitating collusion (Ghemawat and Thomas, 2008).

2.2 Data

Prices and Quantities. Cement prices and market exchange rates are measured by the International Comparison Program (ICP), which provides a panel of internationally comparable prices, based on a survey of national statistical offices in 2011 and 2017 that recorded the average price of one metric ton of ordinary Portland cement for use in construction.[6] Average prices were recorded using either nationally-representative surveys underlying the local consumer and producer price indices, or a special survey fielded for purpose of the ICP.

costs over time.

[6]Several minor adjustments are made to the price series to ensure comparability over time within economies. For instance, between 2011 and 2017, some countries re-denominated their currencies (e.g., Zambia), changed the reporting unit to dollars to local currency (e.g., Liberia), or adopted the Euro (e.g., Latvia and Lithuania). In all these cases, the ICP adopts procedures to ensure comparability of prices over time. See World Bank (2020b) for more details.

The ICP 2011 and 2017 data are viewed as a very reliable source for homogeneous goods like cement.[7] National cement consumption, domestic production, and exports in 2011 and 2017 are reported in megatons (millions of metric tons) by the Global Cement Report, a trade publication (Armstrong et al., 2013, 2019).

Number of Firms. The Global Cement Report also records the number, identities and capacities of firms operating in each country in 2011 and 2017. Market structure is measured using the concentration-adjusted number of firms, given by $N_{it} \equiv 1/H_{it}$, where H_{it} is the Herfindahl index of capacity concentration in country i at time t.[8] The concentration-adjusted number of firms is calculated using the capacity of each cement group (accounting for common ownership of multiple plants) and treating the ports of entry as an additional cement group with capacity equal to the value of imports. This approach allows imports to compete directly with domestic producers, while also subjecting imports to similar marketing costs as domestic producers.[9]

A practical advantage of this measure is that it reduces the correlation of our measure of market structure with market size, which may arise for instance in the few especially large markets in the data. For instance China had 27 firms in 2017, but it has a concentration-adjusted number of firms of 6.2. The U.S., in comparison, had 22 firms and a concentration-adjusted number of firms equal to 11.4. Further, this transformation allows us to capture information on market share in a way that is theoretically consistent with the model in Section 3. Armstrong et al. (2013, 2019) do not report the capacities of all firms in China, India, the U.S., and Vietnam, just the largest. In these cases, we include in H_{it} an additional firm whose capacity is defined as the difference between total capacity and the sum of the capacities of the individual firms whose details are reported.

Our data also include a measure of multi-market contact (MMC), which we compute as the average number of times firms meet in other markets, as suggested by Jans and Rosenbaum (1996). If this number is two, for instance, the average pair of firms in the market meets twice in other markets. The number is zero if there is no contact between any pair of firms outside of the market. Whinston et al. (2008) show theoretically that multi-market contact can make collusive agreements between firms easier to sustain, as deviations

[7] Deaton and Aten (2017) identify issues in the 2005 ICP round and review improvements. These issues do not affect our analysis as we employ data from the 2011 and 2017 rounds.

[8] This definition can be derived as an equilibrium condition under Cournot competition, in which firms choose quantity given capacity (see, e.g., Berry and Reiss, 2007). This is an appropriate oligopoly solution for the cement industry, given sunk capacity investment.

[9] When H_{it} is calculated using only the capacity shares of domestic producers, the correlation with the measure including imports is 0.98, consistent with the fact that in most countries imports are a small share of consumption.

from the agreement in one market may be punished in others.

Additional Market Attributes. The ICP contains information about nominal GDP in US dollars at market exchange rates, construction expenditure as a share of GDP, total population, and the price of one liter of diesel. We also collect data about other country-level characteristics. These include kilometers of road per square kilometer of land, which summarizes the quality of national road infrastructure (Meijer et al., 2018), the concentration of urban centers, measured as the sum of the squared population share of each urban center within the country (Florczyk et al., 2019), and the number of procedures to start a business (World Bank, 2020a).[10] From the Federal Institute for Geosciences and Natural Resources (2023) we calculate the share of carbonate terrain (e.g. limestone, dolomite) for each country. Information about the effectiveness of anti-monopoly policy comes from a survey by the World Economic Forum (Schwab, 2019). The presence of known cement cartels is obtained by the Private International Cartel database (Connor, 2020). Bilateral distances between country centroids come from the CEPII (Head and Mayer, 2014).

Final Sample. The final sample includes 99 economies with available data on cement and input prices, consumption and production quantities, the number of cement firms, and other market characteristics. 91 economies have at least one producer, while the remaining 8 import all their cement consumption. Over the two years of the panel, 2011 and 2017, our sample has 168 observations. Descriptive statistics for this sample are provided in Table 1.

2.3 Motivating Facts

We present three facts about African cement markets that motivate our research and discuss alternative hypotheses behind them.

Fact 1. *The average price of cement in Africa was the highest of any continent in 2011, and consumption was the lowest.*

The first column of Panel A of Table 2 reports average prices in each continent and year in our sample, showing that the price in Africa was the highest in 2011, at \$252/t. This pattern is also visible on the global map of prices in Figure 3. High cement prices on the continent have been highlighted by others (World Bank, 2016; Beirne and Kirchberger, 2023), in part

[10]In 2021, the World Bank discontinued the Doing Business project, due to concerns about how indicators like the number of procedures to start a business were aggregated into national rankings in "ease of doing business." This indicator will continue to be measured by the B-READY project, the successor to Doing Business. We use our model to validate this de jure indicator and test whether it is positively related to de facto entry costs in the cement industry.

because they stand in stark contrast to the implications of the classic theory of international price differences (Balassa, 1964; Samuelson, 1964; Bhagwati, 1984). According to this theory, lower wages in Africa should lead to a lower price of cement. Even though cement production is not labor intensive, lower productivity in the non-tradable sector could reduce the price of other locally procured inputs (Hsieh and Klenow, 2007). While high prices could lead to lower consumption by moving down the demand curve, lower consumption could also reflect exogenously lower demand conditional on prices, due for instance to lower GDP per capita or population in African countries. The fourth column of Panel A of Table 2 shows that Africa also had the lowest level of cement consumption.

Fact 2. *African economies have on average fewer cement firms and less production capacity than other continents.*

The first column of Panel B of Table 2 indicates the number of concentration-adjusted firms in the average economy in Africa in 2011 was equal to 2, the lowest of any continent. The fourth column of Panel B of Table 2 shows that average installed capacity in each African economy was similarly low, at 3 megatons per annum in 2011.

Fact 3. *The average price of cement in Africa fell by more than any in other continent between 2011 and 2017, coinciding with entry and capacity installation.*

The second and third columns of Panel A of Table 2 show the average price of cement in Africa had fallen by one-third to $167/t in 2017, a substantially lower level than in North America. In just six years, cement in Africa was less expensive than in several other continents (comparing the 2011 and 2017 maps in Figure 3 also illustrates the pattern). A potential explanation for the fall in prices is shown in fifth and sixth columns of Panel B of Table 2. Between these years there was a substantial increase in the average number of firms (by 34%) and average installed capacity (by 70%). In percentage terms, the increase in capacity was more than double than in other continents.

Discussion of Hypotheses. An important question is the extent to which the observed increase in the number of firms and capacity explains the decline of cement prices in Africa and, if so, through which channels. The evidence suggests potential roles for both reductions in marginal costs and in markups through entry of new firms.

Figure 4 shows a plot and linear best fit line of the change in price in a economy between 2011 and 2017 and the change in the number of firms. Changes in prices in this figure are real, adjusted for inflation by subtracting off the change in the local PPP price index. Several African economies including Burkina Faso, Cameroon, Cote d'Iovire, Mali, and Zambia experienced substantial declines in price and increases in the number of firms. Other economies including Lesotho, Mauritius, and Sierra Leone experienced substantial reductions in prices without changes in market structure, suggesting a role for reductions in marginal cost.

Another important question is whether high prices reflect higher barriers to entry or widespread cartel conduct across the continent. Figure 5 summarizes the candidate hypotheses. The upper-left panel shows that the effectiveness of anti-monopoly policy as measured by Schwab (2019) is highest in Europe and North America and the second lowest in Africa, which has been used to explain high prices in Africa (World Bank, 2016; Cherif et al., 2020). The upper-right panel shows instead that less than 10 percent of consumption is covered by a known cartel in Africa, while more than 90 percent of cement consumption is sold under a cartel in Europe (Connor, 2020). Taken at face value, this result suggests Africa is less cartelized than other continents. Of course, cartels in Africa could be unknown because of less effective anti-monopoly policy leading to fewer investigations, so this evidence is not conclusive.

The bottom-left panel shows that procedures to start a business in Africa are more compared to Europe and North America (World Bank, 2020a), suggesting entry barriers might play a role. However, Hallward-Driemeier and Pritchett (2015) show that there is no correlation between this de-jure measure of entry costs and the de-facto time business owners report to get an operating license, so it need not affect actual entry costs. The last (lower right-hand) panel points to yet another potential hypothesis, showing the average cement consumption by continent. Here, African markets have the lowest average cement consumption, indicating small market size and potentially low demand. This evidence is however not conclusive, since low consumption is endogenous to high prices.

3 A Model of the Global Cement Industry

This section introduces a model of the global cement industry grounded in the empirical industrial organization literature (Bresnahan, 1982; Porter, 1983; Sutton, 1991; Berry and Waldfogel, 1999; Berry and Reiss, 2007) to identify and quantify the drivers of international price dispersion, and their decline in Africa. The model delivers predictions about equilibrium prices and markups as well as their determinants.

3.1 Theory

Set Up. Each economy is a distinct market, and market concentration is determined endogenously as the result of a two-period game. In the first period, firms indexed by j form expectations about profits and decide whether to pay the fixed cost to operate in each market

i. In the second, they choose the quantity to supply in each market they entered, q_{ij}. Firms differ in terms of private marginal costs' shocks, which are unobserved to them when making entry choices and only revealed upon entry. We denote N_i the number of entrants in market i. The equilibrium of the game is solved by backward induction. The model treats the two years of data (2011 and 2017) as independent equilibria, and we omit a time subscript.

Equilibrium. Conditional on entry, firms choose q_{ij} to maximize profits in each market i:

$$\max_{q_{ij} \geq 0} \sum_i P(Q_i, \mathbf{D}_i) q_{ij} - C_j(q_{ij}, \mathbf{C}_i) - F(\mathbf{F}_i). \tag{1}$$

The continuously differentiable inverse demand in each market is given by $P(Q_i, \mathbf{D}_i) = Q^{-1}(P_i, \mathbf{D_i})$ where Q_i is total quantity consumed in market i and $\mathbf{D}_i$ is a vector of (exogenous) market characteristics that affect demand in that market. Each firm j may have different costs in each market given by a variable cost function $C_j(q_{ij}, \mathbf{C}_i)$. Market-level entry costs are given by $F(\mathbf{F}_i)$. $\mathbf{C}_i$ and $\mathbf{F}_i$ are vectors of (exogenous) variables affecting marginal and fixed costs in economy i respectively. Fixed costs include technological features of the industry (e.g., amortization of capacity installation), regulatory barriers (e.g., environmental licenses), and other market institutions that hinder entry (e.g., credit frictions, expropriation risk).

In Appendix A, we show that the industry equilibrium is characterized by two equations:

$$M_i \equiv \frac{P(Q_i, \mathbf{D}_i)}{\overline{MC}_i} = \left(\frac{\eta_i}{\eta_i - \lambda_i H_i} \right) \quad \text{and} \quad \pi_i(N_i) \geq F(\mathbf{F}_i) > \pi_i(N_i + 1). \tag{2}$$

Markups (M_i) are defined as the ratio between local prices and the average of the marginal costs of incumbent firms $\overline{MC}_i = \frac{1}{N_i} \sum_{j=1}^{N} C'_j(q_{ij}, \mathbf{C}_i)$. They depend on the market price elasticity of demand, defined as $\eta_i \equiv -\left(\frac{\partial P(Q_i, \mathbf{D}_i)}{\partial Q_i} \frac{Q_i}{P_i} \right)^{-1}$, the concentration-adjusted number of firms, which is $H_i = 1/N_i$, and the conduct parameter, $\lambda_i \equiv \partial Q_i / \partial q_j$, which captures firms' beliefs about the post-entry game. When $N_i = 1$ and $\lambda_i = N_i = 1$, there is a monopoly. When $N_i > 1$, there is an oligopoly. $\lambda_i = N_i$ corresponds to the case of an oligopoly jointly maximizes profits, whereas $\lambda_i = 1$ implies Cournot competition. The right-hand side of equation (2) determines the equilibrium number of firms in market i. $\pi_i(N_i)$ are expected revenues of the entrants, which must be greater or equal to fixed cost in market i, $F(\mathbf{F}_i)$.

3.2 Predictions

The model delivers several predictions about market concentration and therefore prices in each market. We summarize them in the following Proposition.

Proposition 1 (Drivers of market concentration)**.** *Given the demand elasticity η, the following variables can increase market concentration summarized by the markup:*

1. *Market characteristics $\mathbf{D_i}$ (e.g., smaller population, lower income) implying a smaller market size Q_i at any price P_i, reducing the number of firms that choose to enter, increasing concentration H_i.*

2. *Marginal cost shifters $\mathbf{C}_i$ (e.g., transportation costs) leading to higher marginal costs and therefore higher prices, which reduce demand and therefore reduce the number of firms that choose to enter, increasing concentration H_i.*

3. *Higher fixed cost shifters $\mathbf{F}_i$ (e.g., regulatory barriers) implying higher fixed costs for all firms, reducing the number of entrants, increasing concentration H_i.*

4. *Cartel conduct by firms, summarized by $\lambda_i = 1/H_i > 1$, rather than $\lambda_i = 1$.*

4 Estimation

We now take the model to the data using specific functional forms. We present the empirical counterpart to the model's equations and discuss identification and estimation.

4.1 Estimating Equations and Identification

Demand. The total quantity of cement in economy i and year t, Q_{it}, is assumed to be function of the price P_{it} (measured in US dollars, for comparability across countries) and exogenous market characteristics $\mathbf{D}_{it}$:

$$\ln(Q_{it}) = \alpha_{\mathbf{0},\mathbf{t}} + \alpha_1 \ln(P_{it}) + \alpha_{\mathbf{D}}\mathbf{D_{it}} + \xi_{it}. \tag{3}$$

The market price elasticity of demand (expressed as a positive number) is $\eta_{it} = -\alpha_1$.[11] To identify the elasticity, we assume cement exports to the world of the nearest neighboring country are unrelated to local demand, summarized by the exclusion restriction $E[EXPORTNEAREST_{it}\xi_{it}] = 0$. These exports correlate negatively with price (Figure 6) and proxy for the availability of low-cost imports: if a firm in country i prices too high,

[11] We experimented with a heterogeneous elasticity, for instance that varies with the construction share of GDP, GDP per capita, or price. We found that demand becomes less elastic when construction is a greater share of GDP, but this interaction is not statistically significant. Allowing the elasticity to vary by insignificant heterogeneity in the construction share of GDP did not significantly change our quantitative estimates of the markup, so we report here a model with a constant elasticity of demand. The elasticity did not vary significantly with GDP per capita or price either.

competitors can import cement from country i's neighbor, especially if the neighbor has excess production capacity. Identification rests on the assumption that the threat of imports from the neighbor can shift prices (Salvo, 2010), but is plausibly unrelated to unobserved local demand ξ_{it}.[12]

Genesove and Mullin (1998) use a similar approach to identify the elasticity of demand for sugar in the U.S., instrumenting for the U.S. price with the volume of sugar imports to the U.S. from Cuba in a time series. Most of our variation in contrast is cross sectional, across countries, so we use exports of different countries. Suppose a country in our sample were the U.S. as in the sugar example; then we are using the equivalent of Cuban exports to the world to instrument for price in that country. Compared to the approach of using the neighbor's imports, using the neighbor's exports to the world provides us with greater assurance that the instrument is unrelated to local demand, since exports to the world are determined by international demand. Consistent with this, the neighbor's exports of cement are generally either much more or much less than local consumption of cement: the standard deviation of the ratio of the nearest neighbor's exports to local consumption is 1.5.

Our baseline specification includes in $\mathbf{D_{it}}$ (the log of) population, GDP per capita, and construction share of GDP. The model also includes (the log of) the exchange rate as a control, since prices P_{it} are measured in US dollars. All are plausibly exogenous, with population and GDP per capita determined over the long term. The share of cement in construction investment (13.5 percent in our sample), leads construction investment to be considered exogenous to unobserved cement demand or costs (Syverson, 2004). An assumption required for identification of any demand elasticity is that shocks to demand for complements and substitutes enter into the error term ξ_{it} as a scalar index (Berry and Haile, 2014). While we do not observe consumption of such goods in each economy, we include the log of the construction share of GDP as a control that is correlated with demand for these goods. The vector $\alpha_{\mathbf{0,t}}$ includes a constant and a time dummy. We test the robustness of our estimate of the demand elasticity to alternative sets of controls in Section 5.2.

Marginal Cost. Marginal costs are projected onto covariates $\mathbf{C}_{it}$ in order to control for and describe the role of observables. We assume that average marginal costs are log-linear:

$$\ln(\overline{MC_{it}}) = \begin{cases} \beta^{\mathbf{K}}_{\mathbf{0,t}} + \beta^{\mathbf{K}}_{\mathbf{C}}\mathbf{C}^{\mathbf{K}}_{\mathbf{it}} + \omega^{K}_{it} & \text{if } N_{it} > 0; \\ \beta^{\mathbf{O}}_{\mathbf{0,t}} + \beta^{\mathbf{O}}_{\mathbf{C}}\mathbf{C}^{\mathbf{O}}_{\mathbf{it}} + \omega^{O}_{it} & \text{if } N_{it} = 0. \end{cases} \tag{4}$$

[12]Identification is achieved by the credibility of the threat and not the actual amount of cement imports. We show that our findings are robust to alternative definitions of import threats in Section 5.2.

Since costs in import reliant economies may differ, we distinguish two cost functions depending on whether domestic production capacity exists at all. The superscript K indicates markets with at least one entrant and, therefore, domestic production capacity. Our baseline specification includes the following potential drivers of costs in $\mathbf{C^K_{it}}$: cement exports to the world of the nearest neighboring country, the share of terrain carbonate (e.g., limestone, dolomite) in a country, road density, and (the log of) the price of diesel and the exchange rate. The superscript O indicates markets with no domestic production capacity which therefore import all of their cement. In this case, $\mathbf{C^O_{it}}$ corresponds to an open economy benchmark in which pricing is driven by the exchange rate. The vectors $\beta^{\mathbf{K}}_{\mathbf{0,t}}$ and $\beta^{\mathbf{O}}_{\mathbf{0,t}}$ include a constant and a time dummy. We assume cost shifters $\mathbf{C}_{it}$ are uncorrelated with unobserved marginal cost shocks. This assumption is standard in the literature (Berry, 1994; Berry et al., 1995).

Marginal costs are unobserved in practice but can be retrieved using the structure of the model. Substituting the demand elasticity estimated in equation (3) and equation (4) into equation (2) yields the equilibrium price in each market as a function of the empirical markup and marginal cost:

$$\ln(P_{it}) = \ln\left(\frac{-\alpha_1}{-\alpha_1 - \lambda_{it} H_{it}}\right) + \ln(\overline{MC_{it}}). \tag{5}$$

Rearranging equation (5) delivers an empirical distribution of marginal costs across countries.

Fixed Costs. Fixed cost covariates $\mathbf{F}_{it}$ enter through the following function:

$$\ln(F_{it}) = \gamma_{\mathbf{0,t}} + \gamma_{\mathbf{F}} \mathbf{F_{it}} + \sigma \epsilon_{it}. \tag{6}$$

σ is a scale parameter and ϵ_{it} is distributed standard normal, hence fixed costs have a log-normal distribution. The right-hand side of equation (2) delivers a break even condition that the number of firms equal to N_{it} is observed in equilibrium if and only if fixed costs are such that N_{it} firms make a profit but $N_{it}+1$ firms would not. Under this condition, the empirical likelihood of each observation is:

$$\begin{aligned} L_{it}(\theta) = {} & \Phi\left(\frac{1}{\sigma}\left[\ln\left(\frac{Q'_{it}}{N_{it}}\left(\frac{-\alpha_1 N_{it}}{-\alpha_1 N_{it} - \lambda_{it}} - 1\right)\overline{MC_{it}(\beta)}\right) - F_{it}(\gamma)\right]\right) \\ & - \Phi\left(\frac{1}{\sigma}\left[\ln\left(\frac{Q'_{it}}{N_{it}+1}\left(\frac{-\alpha_1 (N_{it}+1)}{-\alpha_1 (N_{it}+1) - \lambda_{it}} - 1\right)\overline{MC_{it}(\beta)}\right) - F_{it}(\gamma)\right]\right) \end{aligned} \tag{7}$$

where Φ is the standard normal cumulative density function, and Q'_{it} is the sum of domestic consumption and exports (distinct from Q_{it}, or domestic consumption, which is used in the demand estimation). We use the concentration-adjusted number of firms $N_{it} = 1/H_{it}$ to estimate the fixed costs of entry.

Equation (7) allows to identify fixed costs by the revealed profitability of the market using a comparison between the observed market and a counterfactual market with one additional firm, conditional on estimates of the parameters related to demand and marginal cost (Berry and Waldfogel, 1999). Our baseline specification includes in $\mathbf{F_{it}}$ the (standardized) number of procedures to start a business and the log of the exchange rate. The vector $\gamma_{\mathbf{0,t}}$ includes a constant and a time dummy. We let σ be common to all observations.

Conduct. We consider two alternative specifications for conduct. A first version of the model assumes a non-cooperative industry equilibrium in each country:

$$\lambda_{it} = \lambda_{it}^{COURNOT} = 1. \tag{8}$$

We refer to this formulation as the Cournot model. A second specification of the model projects conduct onto a constant and certain market attributes:

$$\lambda_{it} = \lambda_{it}^{CONDUCT} = \lambda_0 + \lambda_1 URBCON_i + \lambda_2 MMC_i. \tag{9}$$

In markets with no production capacity we treat the entry ports as a single firm earning the monopoly markup, i.e., $\lambda_{it}H_{it} = 1$. The variable $URBCON_i$ is the concentration of urban centers. This term captures spatial competition and the extent to which firms face each other. The variable MMC_i is the measure of multi-market contact between multinationals. Both $URBCON_i$ and MMC_i are time-invariant and standardized, so that the estimated value of the constant λ_0 corresponds to the conduct in a market with the average concentration of urban centers and average multi-market contact. The Conduct model is identified using a demand instrument that shifts marginal revenue but not marginal cost following the argument of Bresnahan (1982) generalized by Berry and Haile (2014). Intuitively, price changes induced by shifts in marginal revenues holding marginal costs constant are informative about the degree of competition in a market. For instance, there is no change under perfect competition.

Joint Estimation. The Cournot and Conduct models are estimated separately in the presence of the three endogenous variables $\langle P_{it}, Q_{it}, N_{it} \rangle$ using the generalized method of moments (GMM). Within each specification there are three estimating equations: (i) the demand curve, equation (3); (ii) the profit maximization condition relating prices and marginal costs conditional on conduct, equation (5); and (iii) the likelihood of the observed number of firms given fixed costs, equation (7). All parameters are jointly estimated to ensure the asymptotic standard error of each parameter accounts for estimation error in all three equations (see Appendix B for the moment conditions). With these assumptions, the Cournot model is just identified.

To estimate the Conduct model, we follow Berry and Waldfogel (1999) and use population as a demand-side instrument excluded from the cost function, which in our model shifts demand conditional on the construction share of GDP.[13] Formally, we incorporate this idea with additional moment conditions $E[\ln(POP_{it})^n \omega_{it}] = 0$ where $n \in \{1, 2\}$. Conduct is identified under the assumption that urban concentration and multi-market contact are uncorrelated with unobserved shocks to marginal costs, i.e., $E[URBCON_{it}\omega_{it}] = 0$ and $E[MMC_{it}\omega_{it}] = 0$. The concentration of urban centers is plausibly exogenous to present unobserved costs because it is determined over the long run. Multi-market contact is a strategic choice determined by decisions to enter markets other than market i, and so is plausibly exogenous to costs in market i. We do not require that urban concentration and multi-market contact are orthogonal to demand shocks. In Section 5.2, we evaluate the sensitivity of markup estimates to potential violations of these exclusion restrictions. Further, since the exclusion restrictions including ω_{it} depend on the set of variables included in $\mathbf{C_{it}}$, to assess robustness we estimate conduct using the same identifying assumptions but alternative specifications of the marginal cost function.

5 Results

We now present the estimates of the empirical model. We also discuss threats to identification and robustness of our results.

5.1 Baseline Estimates

Table 3 reports estimated coefficients of the two model specifications, Cournot and Conduct. The far right column of Table 3 reports the p-value from Welch's test of the null hypothesis of equality of the coefficients across the two models. This hypothesis is not rejected for any coefficient, providing initial evidence that conduct approximates Cournot on average.

Demand. Price sensitivity in the Cournot model is statistically significant with $\eta = 1.436$ (standard error = 0.275). The Kleibergen-Paap F-statistic of the first stage relationship is

[13] An alternative approach to identifying conduct would be to assume that the number of firms in the market, which also shifts markups, is uncorrelated with unobserved marginal cost, i.e., $E[N_{it}\omega_{it}] = 0$. However, given that marginal cost could still enter into a firm's entry decision, such an assumption is not attractive.

28.68, confirming the relevance of the instrument. Population, GDP per capita, and the construction share of GDP all have a statistically significant and positive effect on demand, as expected. The effect of the exchange rate is quantitatively and statistically insignificant indicating our results are unaffected by the use of a common currency to measure prices. The Conduct model exhibits demand coefficients very similar to the Cournot model.

Estimates of an inelastic demand curve are broadly in line with industry accounts and existing studies of the industry. Previous literature using US data documents a range between 2.0 and 7.3 (Miller et al., 2022a). Higher absolute values are found when estimating demand at the firm or plant level (Miller and Osborne, 2014). Conversely, when observations are aggregated at the market level within the US, the elasticity tends to be lower in absolute terms (Fowlie et al., 2016). Our estimate of the demand elasticity based on cross-country data aligns with this pattern.

Marginal Costs. Estimates of the equilibrium pricing condition reveal drivers of marginal costs in the industry. Consider first economies with domestic production capacity (i.e., $N_{it} > 0$). Consistent with limited technological progress in the six-year time period studied, we find no significant trend in costs. The cement exports of the nearest neighbor are negatively related to costs in both models, as already explained in Section 2.1 and demonstrated indirectly in Figure 6.

In both models, the exchange rate, which may affect the price of imported inputs, does not appear to relate to the price, though the diesel price is a significant contributor to costs, pointing to an important role of transportation costs for cement, which is heavy and also has a low value per unit of weight compared to many other goods.[14] The share of terrain carbonate in the country is not significant, suggesting that local supplies of this input are not a major determinant of prices. The road density of a country, which summarizes the quality of national road infrastructure, has a negative and statistically significant coefficient in both models, suggesting that the quality of domestic infrastructure is associated with lower transportation costs and, hence, end-consumer prices. Turning to the economies without domestic production capacity, we find that they are, as expected, qualitatively different from economies with domestic production capacity. Costs in these markets have fallen over time.

Our baseline specification of marginal costs emphasizes that factors affecting the cement trade (cement exports of the neighbor, road density, the price of diesel) explain significant variation in pricing. It is possible to benchmark this estimate to an alternative estimate of

[14]When including price of electricity in addition to the price of diesel in the marginal cost function and estimating on the smaller sample of economies where both variables are available, the coefficient on the price of electricity is not statistically significant, though the coefficient on the price of diesel remains so.

marginal costs based on the prices of the inputs to cement, which follow, roughly, a recipe per ton of cement equal to 0.64 tons of lime, 0.33 ton of silica clay, and 0.025 ton of gypsum (CivilToday.com, 2023). Unfortunately, prices of these inputs are not available in the ICP or other cross-country data sets, and so could not be included in the model. However, they are available for the U.S. (Kelly and Matos, 2020), so we are able to compare our model's estimates of marginal cost in the U.S. to the sum of the products of each of these input requirements and their price per ton. Since coal is an important energy source for cement production in the U.S., with about 0.4 tons of coal consumed per ton of cement (Rubenstein, 2012), we add to the sum this input requirement times the US coal price from the Energy Information Administration (2023). In 2017, this back-of-the-envelope calculation yields an expected marginal cost of \$126/ton in the U.S., compared to the value of \$110/ton estimated by our model, a 14 percent difference. In 2011, the difference is 3 percent. This comparison lends some support to our estimates. Though we are not able to test this hypothesis directly, the results also suggest that factors having to do with transportation costs (road density and the diesel price) could be correlated with other input prices, as would be predicted by a trade model.

Fixed Costs. Estimates of the entry model indicate that (the log of) fixed costs in the average market are positive and precisely estimated, with a constant in the Cournot model equal to 3.822 (s.e. = 0.233) and standard deviation term $\sigma = 1.334$ (s.e. = 0.109). These values appear consistent with capacity installation costs reported by industry sources. In 2011, installation costs were approximately US\$150 million per megaton (million tons) of annual capacity (Cembureau, 2021).[15] The average market in our sample has 14 megatons of annual capacity per firm (measuring the number of firms, as in estimation, as the inverse of the Herfindahl index), which at this price will cost US\$2,175 million to install. This implies that for a discount rate of $\exp(3.822)/\$2,175 = 0.02$ the annuity value of fixed costs equals the expected total cost of installing capacity in the average market. The coefficient associated with the exchange rate, which may affect fixed costs to the extent that capital is imported, has a positive and significant effect on fixed costs. The (Z-score of) the procedures required to start a business have a positive, though statistically insignificant relation with fixed costs.

Conduct. The estimated value of the constant is $\lambda_0 = 1.555$ (s.e. = 0.348), and we cannot reject that this coefficient is equal to one, suggesting the average market looks most like the

[15]Cembureau reports a euro value for 2021, which we convert to dollars in 2011 using the current exchange rate and the US GDP deflator.

Nash equilibrium of the Cournot model. Recall that for a cartel, all firms behave jointly as a monopolist and $\lambda = 1/H_{it}$. The estimated value is much lower than the average value of $1/H_{it} = 3.4$, as reported in Table 2, indicating the cartel model does not fit.

The conduct parameter illustrates how market attributes shape the extent of market power, conditional on market concentration. The first is the concentration of urban centers. The coefficient $\lambda_1 = -0.244$ (s.e. $= 0.075$) is statistically significant and negative, suggesting that the market becomes more competitive when the concentration of urban centers increases. This finding hints that in countries with less concentrated urban centers, firms may serve different locations to be closer to specific markets and take advantage of internal transport costs to gain market power. Second, the parameter value $\lambda_2 = 0.285$ (s.e. $= 0.089$) indicates that more multi-market contact between firms is also associated with larger markups.[16]

Model Fit. We use the estimated model to predict prices, quantities, and the number of firms in all countries. Figure 7 shows model-based variables against those in the data for the years 2011 and 2017. There are two takeaways. First, the model-simulated variables are positively and strongly correlated with the ones observed in the data: the correlation between simulated and actual quantities is 96%, the correlation between simulated and actual prices is 59%, and the correlation between simulated and actual number of firms is 33%. These correlations are unconditional and statistically significant at the 1% level. Second, there is no evidence from the plot that our model systematically under- or over-predicts Africa. Table 4 shows further that the supply and demand error distributions are similar between Africa and other continents, confirming measurement error is not better or worse in Africa. We investigate what makes Africa different in Section 6.3.

5.2 Robustness

A battery of robustness tests gives us confidence in the estimated model.

Sensitivity to Identification Assumptions. We now consider whether and how potential violations of the exclusion restrictions could affect our results. As a preliminary test, in the over-identified Conduct model, a Sargan-Hansen test cannot reject the hypothesis that

[16] We also experimented with the inclusion of the effectiveness of anti-monopoly policy in the conduct equation. However, this variable is not statistically significant and, if anything, is associated with less competitive conduct (i.e., higher lambda). One possible explanation for this result is that anti-monopoly policy tends to be more effective where conduct is less competitive to begin with. For these reasons, and since the sign and significance of the coefficients associated with urban concentration and multi-market contact are unaltered compared to the baseline model, we exclude effectiveness of anti-monopoly policy from the structural equation of conduct.

the instruments are uncorrelated with the observed errors in this model (J-statistic is 0.842, p-value 0.656). For transparency, as suggested by Andrews et al. (2017), in Table 5 we also investigate the estimated markups' sensitivity to beliefs about the effect of a one-standard-deviation change in the moment restricting the covariance between each instrument and either unobserved demand or costs shocks.

We consider separately each excluded instrument, that is, each instrument that does not enter the demand or marginal cost equations directly. Cement exports to the world of the nearest neighbor are excluded from the demand. The sensitivity indicates that markups are responsive to changes in moments restricting the covariance of this variable with ξ_{it}. Four instruments are excluded from the marginal cost curve. Of these, the markup is most sensitive to changes in the moments associated with (the log of) population and the unobserved cost error. The markup is much less sensitive to changes in the moment associated with the concentration of urban centers, and even less sensitive to changes in the moment associated with multi-market contact. A one-standard-deviation change in the moment restricting the covariance of multi-market contact with ω_{it} would leave the markup virtually unchanged.

There are two inferences from this sensitivity analysis. First, the identifying variation in the model comes primarily from the the exclusion of cement exports to the world of the nearest neighbor from the demand function and population, and to a lesser extent the concentration of urban centers, from the cost function. The relative values of these variables between countries are determined by history, and so are plausibly exogenous to unobserved costs in the industry in 2011 and 2017. Second, if one is concerned about potential violations of the other exclusion restrictions (i.e., that multi-market contact is chosen endogenously given unobserved local costs), if such violations were present, they would have limited effect on the results, especially in the Cournot model.

Functional Form of Marginal Costs. Another potential threat to identification relates to the fact that, through the moment conditions involving ω_{it}, estimates of the conduct parameter also depend on the variables $\mathbf{C_{it}}$ included in the marginal cost function (Backus et al., 2021). To assess this threat, Table 6 reports estimates of the conduct parameter for the same model as in Table 3, but with three alternative specifications of marginal cost for countries with production capacity. Alternative 1 is more parsimonious including only the exchange rate, the price of diesel, and a constant. In this specification we again cannot reject a Cournot equilibrium in the average market, and the effects of concentration of urban centers and multi-market contact remain the same sign and statistically significant. Alternative 2 includes all variables in the specification in Table 3, and their squares, and Alternative 3 is the same as Alternative 2, but with all possible interactions. In these alternatives, the sign, magnitude, and significance of coefficients and failure to reject Cournot in the average market remains.

Alternative Demand System. Table 7 reports alternative estimates of equation (3). Column 2 is the baseline specification in Table 3. In all columns the demand elasticity is greater than 1, consistent with the exercise of market power. The model in Column 1, which includes no market characteristics, yields $\eta = 1.946$ (s.e. $= 0.813$). The Kleibergen-Paap F-statistic of the first stage relationship is 29.01, above the Stock and Yogo (2005) threshold. The lower standard error in Column 2 motivates retaining the demand shifters in the baseline demand curve.

In addition, in Column 3, we include the price of diesel and the price of aggregate, i.e., gravel, which combined with cement makes concrete. These two prices may affect the ready-mix concrete industry, which is a major consumer of cement. In this specification these variables do not have a significant association with demand, and the elasticity changes little relative to Column 2, at $\eta = 1.449$ (s.e. $= 0.373$), though it has a higher standard error. For these reasons, and because the ICP reports the price of aggregate for a smaller set of countries, we prefer the specification in Column 2 to that in Column 3. In Column 4, the GDP per capita of the nearest neighboring country is included as a control for the fact that demand in this country may be correlated with local demand. Reassuringly, this control is not statistically significant and the estimated elasticity does not change materially. This result also provides suggestive evidence in support of our instrument exclusion restriction.

Column 5 shows that our results are robust to an alternative measure of threat of cement imports. Instead of using the cement exports to the world of the nearest neighbor, we instrument prices with the cement exports of all countries weighted by their inverse distance. Identification is achieved by the import threat coming from all neighboring economies and not just the nearest one. The elasticity does not change significantly, but the F-stat is lower.

In Column (6), we interact cement prices with a year dummy. The coefficient associated with the price of cement alone in column (6) is -1.399 (s.e. $= 0.275$), statistically equal to the one estimated in Column (2). The coefficient associated with the interaction term is slightly negative at -0.058 (s.e. $= 0.452$), though statistically insignificant. In Column (7), we use the cost shifters included in equation (4) as instruments (i.e., the price of diesel, road density, cement exports of the nearest neighbor, and terrain carbonate as a share of total land area). The coefficient associated with the price of cement in Column (7) is -1.622 (s.e. $= 0.155$), statistically indistinguishable from Column (2).

Column (8) includes the year-to-year population growth rate to our baseline specification in Column (2), while Column (9) includes the year-to-year urban population growth rate.

The coefficients associated with both variables are positive but not statistically significant, and the demand elasticity implied by both specifications is statistically equal to the demand elasticity in Column (2). Therefore, we do not include these two additional controls in our baseline model. For reference, Table C.2 replicates Table 7, but using OLS instead of 2SLS and including the instruments as additional controls. Except for the first column, in which no controls are included, the OLS estimate of the demand elasticity is always larger than the 2SLS one.

Implications of the Estimated Model and their Stability. Table 2 shows that the price of cement fell in all continents between 2011 and 2017, particularly for African economies. Figure 8 illustrates that both versions of our model predict approximately 90% of the median observed price change in Africa. We compare those predictions with those implied by the "structure-conduct-performance" approach (Bain, 1966; Beirne and Kirchberger, 2023). We experiment with two approaches. In the first, we compute the price change predicted by an OLS regression of cement prices on number of incumbent firms, population, GDP per capita, local diesel price, road density, land area (all variables in logarithms) and a time fixed effect. In the second, as in Beirne and Kirchberger (2023), we compute the price change implied by the same regression except we instrument the number of firms with the number of carbonate deposits and include the inverse hyperbolic sine of total carbonate area as an additional control.[17] Figure 8 shows that the change in fitted values of these reduced form regressions only explains about 60% of the actual change in Africa. Additionally, the structural model, especially the Conduct version, performs better than the reduced form approach at predicting price changes in the rest of the world. This comparison highlights the advantage of our structural approach over a reduced-form one.

We then compare the price change predicted by the baseline Conduct model with the changes implied by alternative specifications of the Conduct model. Tables 6 and 7 show that the conduct and demand elasticity estimates are robust across different specifications. Therefore, the implications of the Conduct model remain consistent across all these specifications. Instead, we investigate the robustness of the predictions of the Conduct model under the three alternative specifications of marginal costs in Table 6. Figure 9 shows the results. The first bar corresponds to the second one in Figure 8. The next three bars refer to each of the three alternatives we consider. Reassuringly, all models predict a price drop in Africa between 2011 and 2017. Quantitatively, alternatives 2 and 3 deliver a comparable change to the baseline model. Perhaps unsurprisingly, the first and less rich specification delivers a smaller price change. In sum, the main predictions of the Conduct model are

[17] The estimates of these two specifications in levels can be found in Table C.1.

robust to a number of alternative specifications of the demand and supply functions.

6 International Price Dispersion and Changes

With an estimate of the empirical model in hand, we can now describe the roles of marginal cost and markups in determining the price of cement in Africa and other continents, and distinguish between the drivers of market concentration described in Proposition 1.

6.1 Average Prices, Markups, and Marginal Costs by Continent

Table 8 reports a variance decomposition of prices, splitting the variation into the markup and marginal cost. Markups are calculated using coefficients from the Conduct model, in order to capture variation in conduct across economies. Prices are divided by these markups to yield marginal costs. Overall, the majority of the variance appears to come from marginal cost rather than the markup. Markups and marginal costs co-vary negatively in the sample, but only slightly.

Table 9 evaluates the role of markups and marginal costs in explaining the sharp decline of cement prices worldwide, as per the motivating facts in Section 2. The table reports average prices, decomposed into marginal costs and markups, by continent and year. This sample is restricted relative to the estimation one to include only the balanced panel of economies with capacity in both years, ensuring we compare like with like between years. In this restricted sample, the price of cement has fallen on average by 19.5 percent between 2011 and 2017 overall. This decline is smaller than in Table 2, indicating the overall average price decline was to a significant extent driven by countries moving from being importers to having at least one domestic producer.

Table 9 also shows that the average markup in the cement industry in 2011 is a 62.9 percent premium over marginal cost, while the average markup in 2017 has fallen to 46.2 percent. Non-zero markups are in line with expectations, given increasing returns to scale. Comparing markups across continents, we see that in 2011, markups in Africa were the second highest of any continent, equal to 78.1 percent on average. The highest markups were in South America, at 89.6 percent on average, and the lowest were in Asia, at 28.5 percent on average. All continents but North America experienced a decline in markups between 2011 and 2017. The average marginal cost in Africa was the highest of any continent in 2011. Africa stands out as experiencing the largest decline in marginal cost between 2011 and 2017. Asia, North America, and South America experienced increasing marginal costs. Together, these results suggest that both greater than average market concentration and higher operating costs played a role in determining the high average price of cement in Africa in 2011.

These patterns apply to the entire distribution of prices, markups, and marginal costs and not just to their means. Figure 10 reports the density of (the log of) cement prices, (the log of) cement marginal costs, and markups for African countries and the rest of the world. Between 2011 and 2017, there is limited change in the distribution of prices in the rest of the world. Yet in Africa the price distribution contracts significantly and moves to the left in 2017, such that the price distribution is centered around median for the rest of the world, and prices in Africa are no longer outliers with respect to the rest of the world. These changes are driven by both marginal cost and markups. The distribution of marginal cost is similar in Africa compared to the rest of the world, though skewed more to the right in both years. In 2017, several African countries have lower marginal costs than any country in the data in the rest of the world. In Africa, the center of the markup distribution also moves to the left between the two years, though average markups remain higher in Africa compared to the rest of the world. Taken together, these results suggest that markups and marginal costs in Africa were high but declining over the sample period.

6.2 Why is Africa Different? The Role of Market Size and Marginal Costs

Our analysis identifies high marginal costs and small market size as the main drivers of market concentration and high cement prices in Africa. Here, we use the model to gauge the potential effects of policies aiming at expanding the size of the market or improving production technology.

Design of Policy Counterfactuals. We allocate to all African countries in our sample the demand (GDP per capita and population), marginal costs, fixed costs, or conduct covariates of the US in 2011. We change one variable at a time while keeping the others constant. This counterfactual describes how the market would change if low- and middle-income economies in Africa had the characteristics of the US. The counterfactual scenario is calculated as follows. Variables are changed, changing either demand, marginal costs, fixed costs, or conduct. For a given number of firms, new quantities and expected profits are calculated using the demand curve and cost parameters. This exercise is repeated adding a new firm at each iteration until the break even condition no longer holds. The counterfactual price is the price that holds when the next firm would make negative profits. The procedure is initialized using $N_i = 1$. Therefore, the counterfactual number of firms is allowed to be higher or lower than the one we observe in the data depending on the change in demand, costs, or conduct assigned to each country.

Counterfactual Results. Figure 11 reports the results. Assigning to African countries the GDP per capita and population of the US delivers the strongest price reduction, equal to -34.6%. This means that the median African market would experience a 190.4% increase in cement consumption, implying a price elasticity to market size of approximately -0.181.[18] This estimate is consistent with previous literature (Jaravel, 2021), and it should be understood as a lower bound since our model does not account for potential endogenous responses in innovation that could further lower marginal cost and prices, which could lead to a higher elasticity.

Giving to African countries the marginal cost covariates of the US also reduces prices, though less that in the first case (-24.1%). Perhaps surprisingly, assigning African countries the fixed costs and conduct of the US yields a price increase (+9.3% and +11.2%, respectively) consistent with the fact that fixed costs are estimated to be higher in the US compared to Africa and conduct is estimated to be less competitive in the US compared to in Africa.

Overall, these results suggest high returns in Africa to investments that increase demand or reduce costs, with the mechanism being that these investments can induce entry, and decrease markups, since African markets start from a base with a small number of firms. Additionally, changing demand produces similar effects as the changes in costs. This highlights the potential for both demand and supply side policies to achieve significant price reductions by increasing market access, defined by dividing demand in each market by the cost of reaching that market, in the presence of increasing returns to scale. However, it casts doubt on the proposition that they are highly complementary, and so need to be executed in concert.

6.3 Why is Africa Different? Additional Regressions

Our model-based decomposition points to an important role for market size and aggregate demand. Another way to see this is from a regression analysis: once aggregate demand is controlled for, the Africa dummy is much smaller.

Drivers of Prices. Table 10 reports regressions of (the log of) the US dollar cement price on a fixed effect for the African continent and a set of controls accounting for the drivers of

[18] Notice that the elasticity of prices to changes in market size is not constant in our model and varies based on the initial level of competition in each market.

market concentration identified in Proposition 1, which we add progressively.[19] In Column 1, the estimated Africa coefficient is statistically significant, equal to 0.380 (s.e. = 0.064). Column 2 includes cement exports to the world of the nearest neighbor, the price of diesel, and road density leading the Africa coefficient to fall to 0.164 (s.e. = 0.066), indicating that about three fifths of the difference in the cement price is explained by higher transportation costs and the absence of large cement importers in Africa. Column 3 includes the import tariff on cement (which is only available for a subset of economies). Including this variable changes the Africa coefficient only slightly relative to Column 1, indicating tariffs cannot explain the higher price in Africa.

Demand factors, specifically population, have more explanatory power. Column 4 includes the same variables as in Column 2 and population and GDP per capita, which lead the Africa coefficient to fall to 0.060 (s.e. = 0.072) and be no longer statistically significant. After marginal costs, differences in demand shifters account for the rest of the high price of cement in Africa. Column 5 includes also the construction share of GDP, and the Africa coefficient does not change.

Conduct and entry barriers do not explain higher prices. Column 6 includes procedures to start a business and the Africa coefficient changes little. Column 7 includes the two conduct variables and these lower the Africa coefficient, suggesting that they can account for some of the higher price in Africa, but overall this variation is much less important than variation in marginal costs and demand.

Structural Estimates. Table 11 shows an alternative version of the model in Table 3 where Africa fixed effects in demand, costs and conduct are included alongside the continuous variables. This specification provides a test of whether African cement markets differ from those in other continents conditional on observable characteristics. The estimates reveal that Africa does not have a statistically different demand elasticity, marginal costs or conduct compared to other continents. Interestingly, fixed costs are estimated to be significantly lower in Africa. This evidence again rejects the hypothesis that African markets are less competitive because of higher entry barriers.

[19] Table C.3 shows a similar analysis for the variable log PPP GDP per capita, in place of the Africa fixed effect. As shown in Figure 1, the two are highly correlated when measured at the country level. This specification provides a test of Penn effect, i.e., the tendency of prices to be lower in low-income countries.

7 Conclusions

Distortions in key industries could have critical effects on growth. Substantial attention has thus been paid to high price levels in Africa, in the cement as well as other industries. While these high price levels run counter the Penn effect, they are expected in the presence of increasing returns to scale, which imply that lower income economies with smaller markets have fewer firms and higher markups.

We develop an empirical industry model to distinguish between four drivers of international price dispersion in the global cement industry: demand, marginal costs, conduct, and fixed costs. We estimate the model by combining data from the International Comparison Program, that gives us comparable cement prices across countries and over time, with a global directory of cement firms.

Contrary to common belief, our model estimates show that cement was not more expensive in Africa due to anti-competitive conduct or high entry barriers (e.g., due to corruption). Instead, the small size of many national markets limited competition and enabled incumbents to sustain higher markups. Consistently with this view, rapid entry and a decline in marginal cost occurred in Africa at a time of rapid economic growth. Future research, using a dynamic rather than static industry model, could distinguish how much of this marginal cost decline was exogenous, and how much was endogenous, due to investment and innovation undertaken by firms given the expectation of rising demand.

Our findings have implications for public policy, specifically the long-standing program to reduce entry barriers and increase competition in low- and middle-income countries. While we would not necessarily advocate against further reduction of entry barriers or more antitrust investigations, our results challenge the hypothesis that in the cement industry such policies could have a substantial impact on markups and prices.

From a methodological point of view, we demonstrate how a transparent industry equilibrium model and data on market prices, quantities, and market structure can be used to answer important questions in economic development. This approach could be fruitfully applied to other industries, such as telecommunications and banking.

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Tables and Figures

Table 1: Summary Statistics. The Table reports the summary statistics of the variables included in our sample of 99 countries. Summary statistics are computed pooling together observations in 2011 and 2017, the two years of our panel.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
Cement expenditure/GDP	168	0.0133	0.0125	0.000620	0.0738
Cement expenditure/construction investment	168	0.135	0.171	0.00750	1.417
Cement imports/cement consumption	168	0.409	0.378	0	1.016
Log of cement consumption	168	14.92	1.896	11.51	21.56
Log of cement price, USD	168	4.998	0.454	4.169	6.180
Log of USD/LCU	168	-3.714	2.956	-10.02	1.273
Log of construction share of GDP	168	-2.199	0.491	-4.017	-1.124
Log of GDP per capita	168	8.281	1.491	5.526	11.48
Log of population	168	16.40	1.687	12.97	21.05
Log of the price of diesel, USD	168	-0.103	0.541	-2.708	1.074
Cement exports of nearest neighbour (Mt)	168	1.156	2.882	0	21
% carbonate terrain (e.g. limestone, dolomite)	168	0.101	0.130	0	0.779
Number of procedures to start a business	168	8.452	3.420	2	19
Road density (km per km^2)	168	0.514	1.210	0.0123	9.574
Urban concentration (Herfindahl)	168	0.400	0.316	0.00771	1
Multimarket contact	168	0.989	2.179	0	13.17
Production capacity (=1)	168	0.893	0.310	0	1
Known cartel (=1)	168	0.220	0.416	0	1
Concentration-adjusted number of firms (1/H)	156	3.294	2.752	1	13.98
MNCs' share of production capacity	121	0.693	0.316	0	1.591
New entrants' share of production capacity	60	0.284	0.260	0.0162	1
Effectiveness of anti-monopoly policy	142	3.957	0.768	2.350	5.779

Table 2: Trends in the Global Cement Industry by Continent. The concentration-adjusted number of firms is $N_i \equiv 1/H_i$, where H_i is the Herfindahl index of capacity concentration. The sample is the balanced panel of all economies in which prices and quantities are observed in 2011 and 2017, including economies without domestic production capacity. Continent groupings follow Nunn and Puga (2012), with Fiji, the only economy in our data set in Oceania, grouped with economies in Asia.

Panel A: Prices and Quantities

	Average price USD/t			Total consumption Mt		
	2011	2017	Δ	2011	2017	Δ
Africa	252.26	167.09	–33.8%	67.1	81.7	21.7%
South America	197.45	175.60	–11.1%	74.5	64.4	–13.5%
Europe	163.67	145.69	–11.0%	80.6	76.5	–5.0%
North America	151.83	176.03	15.9%	75.6	100.8	33.3%
Asia	107.03	96.43	–9.9%	2599.2	2994.3	15.2%
Total	189.09	142.99	–24.4%	2896.9	3317.7	14.5%

Panel B: Entry and Capacity Expansion

	Average number of firms (concentration-adjusted)			Average capacity Mt		
	2011	2017	Δ	2011	2017	Δ
Africa	2.0	2.7	34.6%	3.0	5.1	70.3%
South America	2.4	3.9	61.2%	18.8	25.8	37.6%
Europe	3.0	3.2	7.6%	21.6	27.4	26.8%
North America	5.9	5.3	–10.5%	35.3	42.7	21.0%
Asia	4.6	5.5	20.7%	175.1	218.7	24.9%
Total	2.7	3.4	26.6%	64.3	81.0	26.1%

Table 3: An Empirical Equilibrium Model of the Global Cement Industry. The table shows the estimates of the Cournot and Conduct models. The last column reports the p-value associated with the null hypothesis that the estimated coefficients of the two models in each row are equal at the 5% level. All variables are in natural logs except the indicators for whether the year is 2017, the constants, the nearest neighbor's cement exports, z-scored number of procedures to start a business, z-scored concentration of urban centers, and z-scored multi-market contact. There are 168 observations.

	Cournot		Conduct Parameter		P-value
Variable	Coefficient	S.e.	Coefficient	S.e.	H_0: Equality
Demand:					
Constant	6.097	2.093	6.097	2.093	1.00
Year (=2017)	-0.149	0.094	-0.149	0.094	1.00
Price of cement (USD)	-1.433	0.275	-1.436	0.275	0.99
Exchange rate (USD/LCU)	0.016	0.018	0.016	0.018	1.00
Construction share of GDP	0.397	0.099	0.398	0.099	0.99
GDP per capita (USD)	0.336	0.045	0.336	0.045	1.00
Population	0.866	0.038	0.867	0.038	0.98
Supply (with domestic production capacity):					
Constant	4.589	0.138	4.330	0.156	0.21
Year (=2017)	-0.049	0.060	0.044	0.077	0.34
Neighbor's cement exports (level)	-0.036	0.008	-0.027	0.008	0.42
% terrain carbonate (e.g. limestone, dolomite)	-0.021	0.272	-0.002	0.334	0.97
Exchange rate (USD/LCU)	-0.010	0.010	-0.005	0.011	0.73
Price of diesel (USD)	0.345	0.052	0.266	0.063	0.33
Road density (km per km^2)	-0.082	0.029	-0.067	0.027	0.70
Supply (without domestic production capacity):					
Constant	4.267	0.583	4.275	0.580	0.99
Year (=2017)	-0.364	0.166	-0.356	0.166	0.98
Exchange rate (USD/LCU)	-0.012	0.066	-0.008	0.066	0.97
Fixed cost:					
Constant	3.822	0.233	4.187	0.230	0.27
Year (=2017)	-0.426	0.220	-0.443	0.248	0.96
Exchange rate (USD/LCU)	0.080	0.067	0.083	0.042	0.97
Procedures to start business (Z-score)	0.101	0.118	0.102	0.128	0.99
Standard deviation term	1.334	0.109	1.502	0.114	0.28
Conduct:					
Constant			1.555	0.348	
Concentration of urban centers (Z-score)			-0.244	0.075	
Multimarket contact (Z-score)			0.285	0.089	
Sargan-Hansen J-Statistic			0.842		
Sargan-Hansen test p-value			0.656		

Table 4: Error Decomposition. We compute the mean and standard deviation of the demand and supply error empirical distribution functions by continent that we obtain using the Conduct model. We cannot reject the null hypothesis that the two groups have the same average demand and supply errors.

Continent	Mean $\widehat{\omega}$	Std $\widehat{\omega}$	Mean $\widehat{\xi}$	Std $\widehat{\xi}$
Africa	-0.035	0.571	0.001	0.464
Rest of World	0.030	0.474	0.004	0.338

Table 5: Sensitivity of Markup following Andrews, Gentzkow and Shapiro (2017). All excluded instruments are listed, i.e., those that do not enter the demand or marginal cost equations directly. For the instrument excluded from the demand, sensitivity can be interpreted as the sensitivity of the markup to beliefs about the effect of a one-standard-deviation increase in each instrument on unobserved demand in the average market. For the instruments excluded from supply, sensitivity be interpreted as the sensitivity of the markup to beliefs about the effect of a one-standard-deviation increase in each instrument on unobserved marginal cost in the average market.

	Sensitivity
Instrument excluded from demand	
Cement exports of neighbor	-39.887
Instruments excluded from supply	
Log of population	-23,403
Log of population squared	-8.792e^{-15}
Concentration of urban centers	-0.597
Multimarket contact	7.402e^{-12}

Table 6: Robustness of Conduct to Alternative Specifications of Marginal Cost. The table reports the estimated conduct parameters for the same model as in Table 3, but with different specifications of marginal cost for countries with production capacity. Alternative 1 includes only the exchange rate, the price of diesel, and a constant. Alternative 2 includes all variables in the specification in Table 3, and their squares. Alternative 3 is the same as Alternative 2, but with all possible interactions.

	Coefficient	S.e.
Alternative cost model 1		
Concentration of urban centers	-0.267	0.080
Multimarket contact	0.267	0.091
Constant	1.592	0.340
Alternative cost model 2		
Concentration of urban centers	-0.242	0.077
Multimarket contact	0.265	0.094
Constant	1.428	0.360
Alternative cost model 3		
Concentration of urban centers	-0.237	0.077
Multimarket contact	0.314	0.093
Constant	1.487	0.344

Table 7: 2SLS Alternative Specifications of Demand for Cement. The instrument for price is the cement exports of the neighboring country in columns 1-4, 8 and 9, and is the cement exports of all countries weighted by their inverse distance in column 5. In column 6, we use cement exports of the neighboring country and its interaction with a time dummy. In column 7, we use the cost shifters included in equation (4) as instruments. The neighboring country is the one with the nearest geographic distance. All variables are in natural logs, except the indicator for whether the year is 2017, the constant, year-to-year (YoY) population growth rate, and year-to-year (YoY) urban population growth rate. Robust standard errors in parenthesis. Robust standard errors in parenthesis. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity	Quantity
Price of cement (USD)	-1.946**	-1.436***	-1.449***	-1.435***	-1.227***	-1.399***	-1.622***	-1.419***	-1.399***
	(0.813)	(0.275)	(0.373)	(0.285)	(0.310)	(0.275)	(0.155)	(0.276)	(0.271)
Price × (Year=2017)						-0.058			
						(0.452)			
Exchange rate (USD/LCU)		0.016	0.019	0.006	0.014	0.016	0.017	0.016	0.015
		(0.018)	(0.020)	(0.018)	(0.017)	(0.018)	(0.019)	(0.017)	(0.017)
Population		0.867***	0.877***	0.838***	0.883***	0.867***	0.853***	0.872***	0.872***
		(0.038)	(0.039)	(0.033)	(0.038)	(0.037)	(0.035)	(0.040)	(0.039)
GDP per capita (USD)		0.336***	0.320***	0.305***	0.357***	0.338***	0.318***	0.349***	0.358***
		(0.045)	(0.049)	(0.050)	(0.045)	(0.042)	(0.042)	(0.046)	(0.048)
Construction share of GDP		0.398***	0.459***	0.314***	0.397***	0.395***	0.398***	0.394***	0.382***
		(0.099)	(0.113)	(0.092)	(0.094)	(0.101)	(0.105)	(0.099)	(0.099)
Price of diesel (USD)			-0.094						
			(0.117)						
Price of aggregate (USD)			-0.020						
			(0.123)						
Neighbor's GDP per capita				0.037					
				(0.041)					
Population growth (YoY, %)								0.033	
								(0.026)	
Urban population growth (YoY, %)									0.023
									(0.026)
Year (=2017)	-0.333	-0.149	-0.175*	-0.155*	-0.109	0.141	-0.184**	-0.134	-0.132
	(0.304)	(0.094)	(0.098)	(0.093)	(0.098)	(2.239)	(0.089)	(0.098)	(0.101)
Constant	24.808***	6.097***	6.334***	6.276***	4.593**	5.881***	7.439***	5.741***	5.544**
	(4.151)	(2.093)	(2.440)	(2.132)	(2.287)	(1.971)	(1.320)	(2.183)	(2.187)
Observations	168	168	160	157	168	168	168	168	166
R-squared	0.299	0.925	0.928	0.920	0.929	0.925	0.917	0.926	0.926
Elasticity	1.946	1.436	1.449	1.435	1.227		1.622	1.419	1.399
Elasticity, 2011						1.399			
Elasticity, 2017						1.457			
First Stage F-stat	29.01	28.68	20.78	27.22	11.22	10.38	24.80	29.60	28.90

Table 8: Price Variance Decomposition. Using the full sample, we decompose $Var(P) = Var(M) + Var(MC) + 2Cov(M, MC)$ and report the single elements.

$Var(P)$	$Var(M)$	$Var(MC)$	$Cov(M, MC)$
0.206	0.158	0.196	-0.074

Table 9: Average Prices, Markups, and Marginal Costs by Continent. The average price (in US dollars at the market exchange rate), marginal cost, and markups are reported in natural logs. Δ Price is the log difference in costs between 2017 and 2011. Marginal cost is inferred by dividing price by the empirical markup from the Conduct model. Δ MC is the log difference in marginal cost between 2017 and 2011. The markup is the ratio of price over marginal cost as defined in Equation (3), and Δ Markup is the log difference in markup between 2017 and 2011. The sample includes only economies with domestic cement capacity in which all data are available in two years.

Continent	Year	Obs	Price	Δ Price	MC	Δ MC	Markup	Δ Markup
Capacity in both years	2011	59	5.043		4.414		0.629	
Capacity in both years	2017	59	4.848	-0.195	4.386	-0.028	0.462	-0.167
Africa	2011	23	5.406		4.625		0.781	
Africa	2017	23	5.037	-0.369	4.416	-0.209	0.621	-0.160
Asia	2011	23	4.637		4.215		0.422	
Asia	2017	23	4.536	-0.101	4.251	0.035	0.285	-0.137
Europe	2011	5	5.031		4.338		0.693	
Europe	2017	5	4.919	-0.113	4.311	-0.027	0.607	-0.086
North America	2011	3	5.019		4.514		0.505	
North America	2017	3	5.147	0.129	4.642	0.129	0.505	0.000
South America	2011	5	5.264		4.368		0.896	
South America	2017	5	5.159	-0.105	4.785	0.417	0.374	-0.522

Table 10: Regressions of Prices on Market Attributes. We regress the USD price of cement on market attributes to inspect the role of and describe its drivers. Robust standard errors in parenthesis. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$. All variables are in natural logs except the indicator for whether the country is in Africa, the constant, the nearest neighbor's cement exports, z-scored number of procedures to start a business, z-scored concentration of urban centers, and z-scored multi-market contact.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Price	Price	Price	Price	Price	Price	Price
Africa (=1)	0.380***	0.164**	0.394***	0.060	0.059	0.067	0.024
	(0.064)	(0.066)	(0.076)	(0.072)	(0.072)	(0.074)	(0.077)
Neighbor's cement exports (level)		-0.040***		-0.043***	-0.043***	-0.043***	-0.041***
		(0.007)		(0.008)	(0.007)	(0.007)	(0.007)
Price of diesel (USD)		0.393***		0.400***	0.404***	0.415***	0.413***
		(0.049)		(0.049)	(0.050)	(0.052)	(0.051)
Road density (km per km^2)		-0.054**		-0.056**	-0.056**	-0.051**	-0.038
		(0.025)		(0.024)	(0.024)	(0.025)	(0.024)
Cement tariff (simple average)			0.400				
			(0.529)				
Population				-0.060***	-0.062***	-0.063***	-0.128***
				(0.015)	(0.015)	(0.016)	(0.028)
GDP per capita (USD)				-0.026	-0.026	-0.022	-0.030
				(0.026)	(0.026)	(0.027)	(0.027)
Construction share of GDP					0.050	0.054	0.058
					(0.056)	(0.057)	(0.056)
Procedures to start business (Z-score)						0.026	0.033
						(0.028)	(0.027)
Concentration of urban centers (Z-score)							-0.123***
							(0.047)
Multimarket contact (Z-score)							0.016
							(0.025)
Constant	4.824***	4.924***	4.781***	6.177***	6.315***	6.322***	7.494***
	(0.042)	(0.051)	(0.059)	(0.395)	(0.450)	(0.456)	(0.613)
Observations	168	168	139	168	168	168	168
R-squared	0.175	0.391	0.204	0.434	0.437	0.439	0.467

Table 11: Industry Equilibrium Model with an Africa Fixed Effect. We estimate the model in Table 3 adding dummies for the Africa continent in demand, supply (with domestic production capacity), fixed costs, and conduct. There are 168 observations.

	Cournot		Conduct Parameter		P-value
Variable	Coefficient	S.e.	Coefficient	S.e.	H_0: Equality
Demand:					
Africa (=1)	-0.165	0.158	-0.167	0.158	0.99
Supply:					
Africa (=1)	0.039	0.080	0.510	0.660	0.48
Fixed costs:					
Africa (=1)	-0.848	0.367	-2.192	0.737	0.10
Standard Deviation Term × (Africa=1)	-0.486	0.202	1.035	0.904	0.10
Conduct:					
Africa (= 1)			-0.987	1.636	
Sargan-Hansen J-Statistic			0.682		
Sargan-Hansen test p-value			0.711		

Figure 1: Intermediate Goods Prices and National Income. Green markers indicate economies in continental Africa. Prices are measured in US dollars at market exchange rates. The dashed line shows the fit of a local linear regression of each price on national income. The units at which prices are measured and sources are, for cement, one metric ton of ordinary Portland cement (World Bank, 2020b); for steel reinforcement bar, one metric ton of high-yield steel 16mm diameter reinforcement bars (World Bank, 2020b); for urea fertilizer, one metric ton in the month of March AfricaFertilizer.org (2019), and for internet, a month's subscription to wired broadband service International Telecommunications Union (2019). Plots show data from 2017, except for the urea fertilizer plot, which shows data from 2014 and 2013, the last years the United States Department of Agriculture (2019) reports the farm price of urea in the U.S. for comparison.

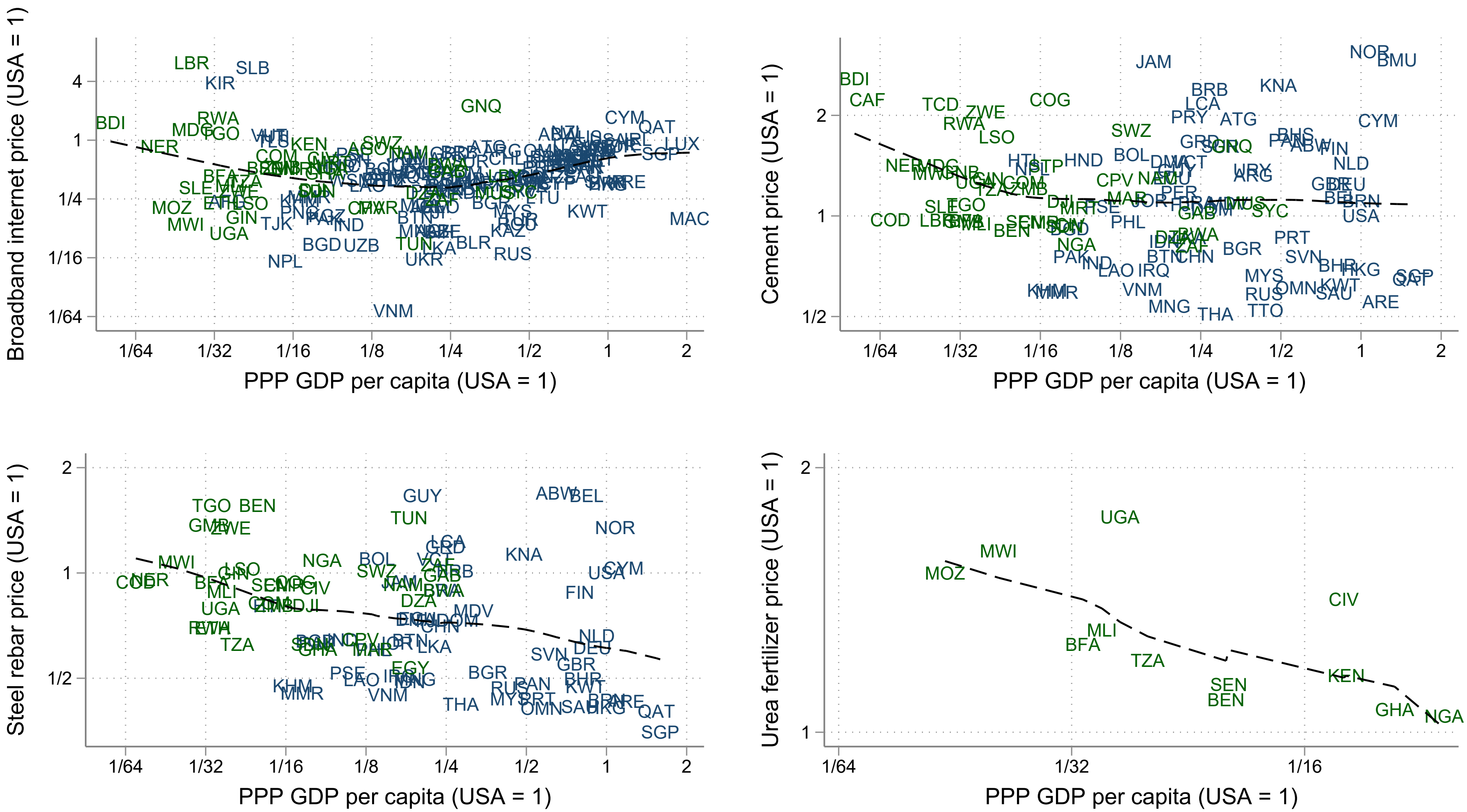


Figure 2: Cement Production Capacity and Consumption. Green markers indicate economies in continental Africa. Consumption is total consumption including imports and local production. Observations with zero installed production capacity and non-zero consumption are reported on the bottom line of the plot. Data from 2017 are shown.

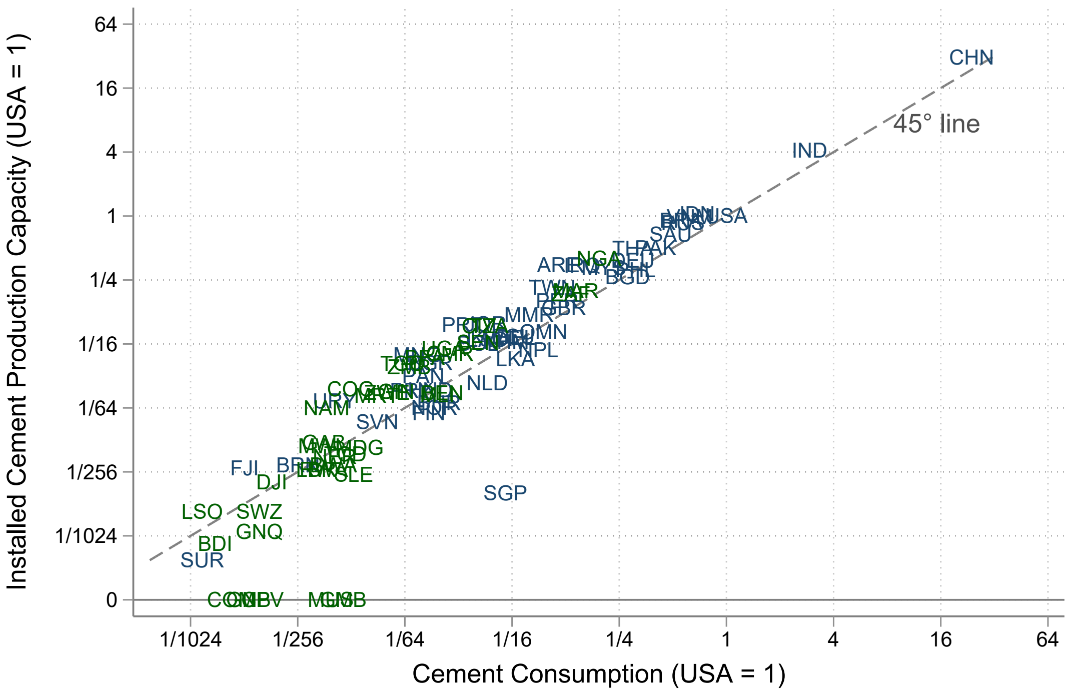


Figure 3: The Price of Cement Across Countries. The choropleth shows the US dollar price of one metric ton of Ordinary Portland cement at the market exchange rate, in 2011 and 2017. Geographic boundaries are as of January 2024.

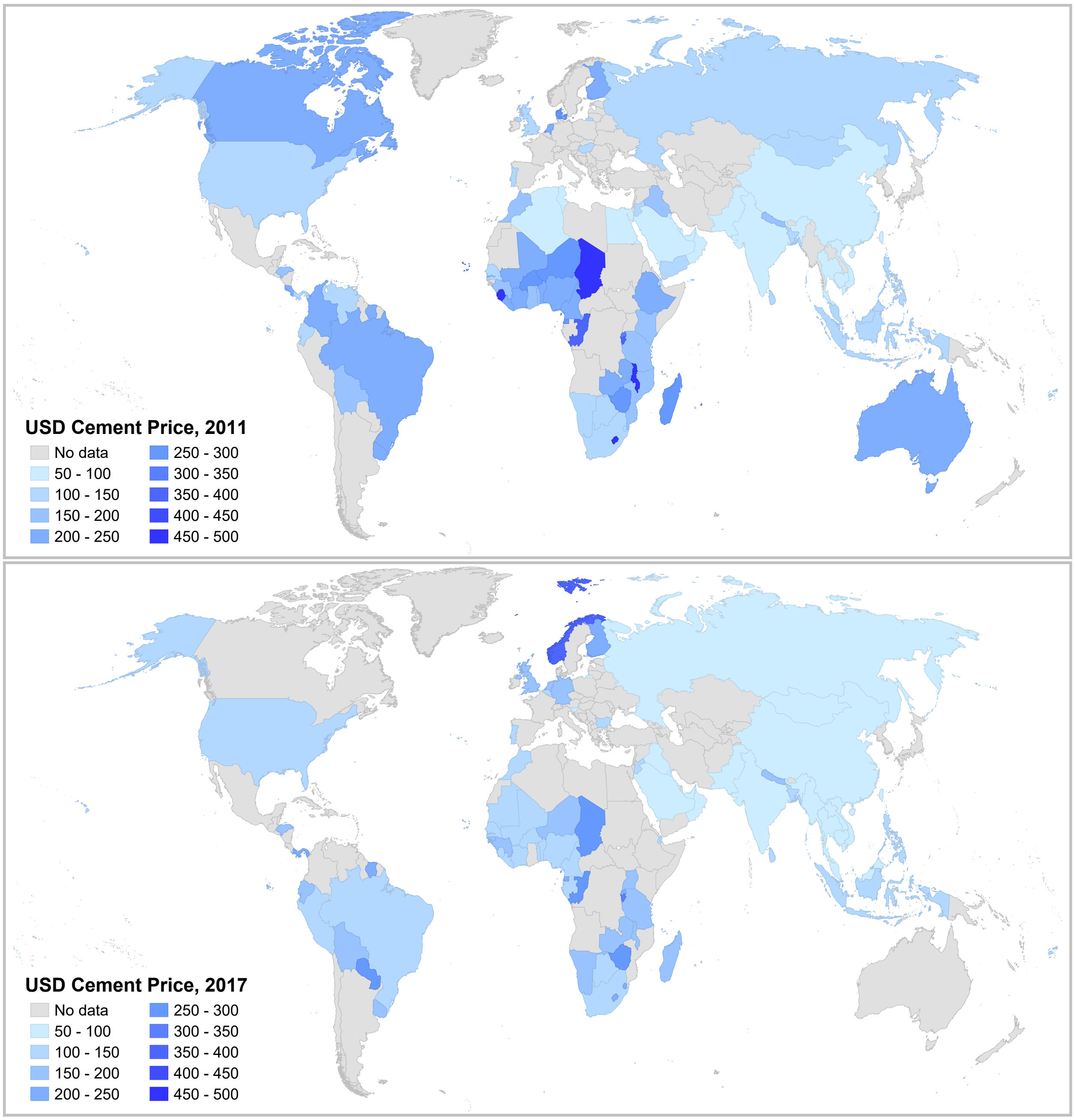


Figure 4: Prices and Entry in the Cement Industry. Green markers indicate economies in continental Africa. Changes are between 2011 and 2017. The change in real cement price is the difference in (the log of) the nominal price per ton in 2017 and 2011 minus the difference in (the log of) the PPP index between the two years. The change in the concentration-adjusted number of firms is the change in the inverse of the Herfindahl index of cement production capacity. All subsidiaries with common group ownership are counted as a single firm. The sample is the balanced panel of economies with price data in both years. The slope of the best fit line is -0.042 (standard error = 0.023)

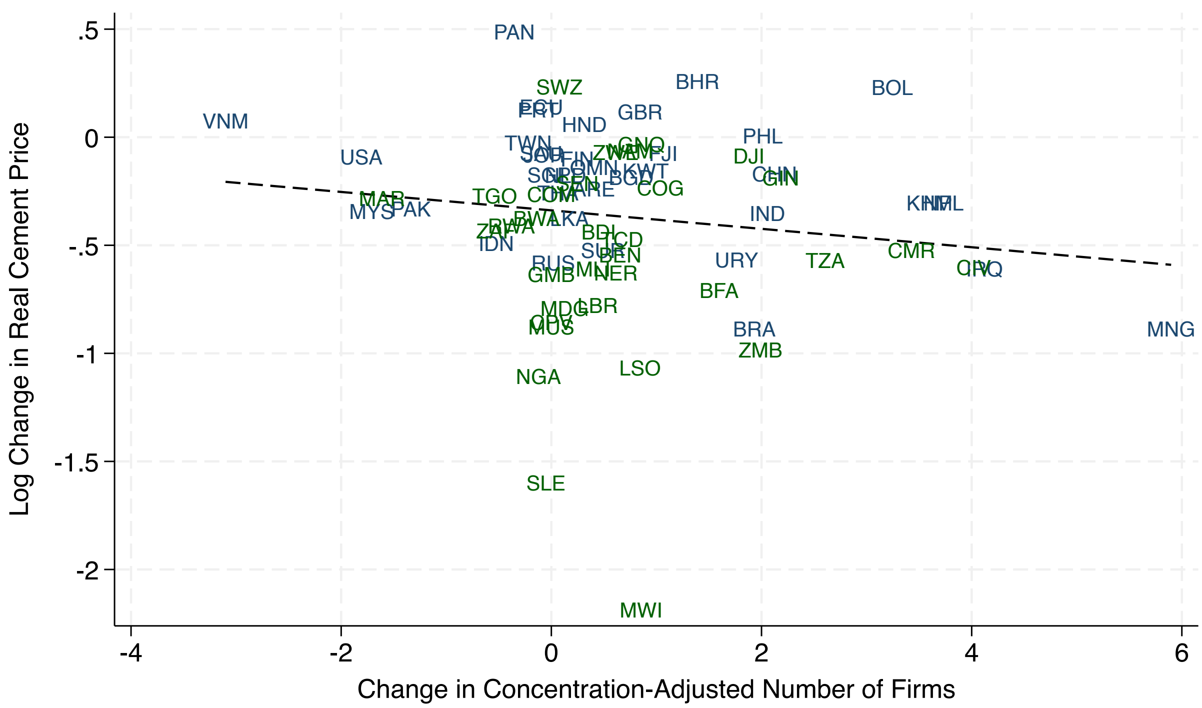


Figure 5: Potential Explanations for Market Power by Continent. Green bars highlight continental Africa. Effectiveness of anti-monopoly policy is measured in a survey of discipline experts by the World Economic Forum (Schwab, 2019). Known cement cartels are those reported in the Private International Cartel database (Connor, 2020). The number of procedures to start a business are from the Doing Business Indicators (World Bank, 2020a). Cement consumption is from the Global Cement Report (Armstrong et al., 2013, 2019). Data are the full analysis sample, pooling 2011 and 2017. Averages are unweighted by consumption.

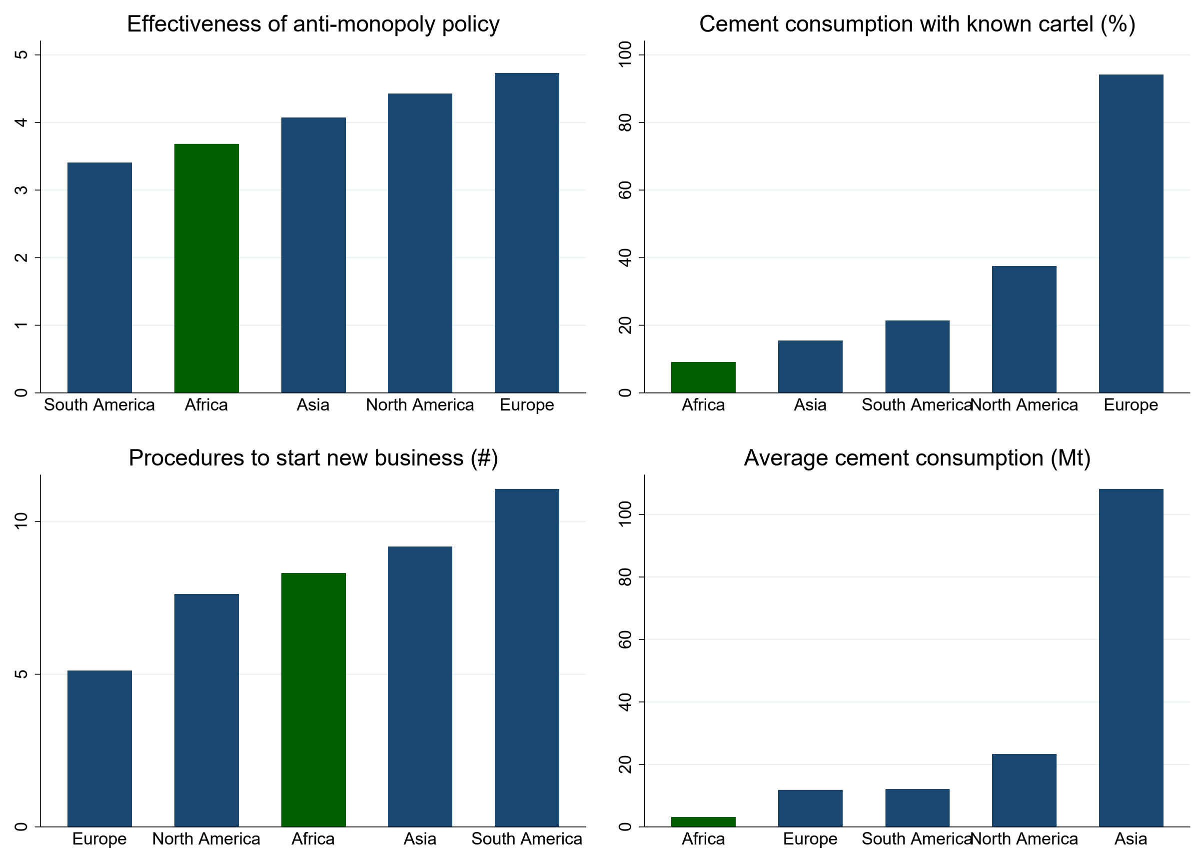


Figure 6: Prices and Exports of the Nearest Neighbor. Green markers indicate economies in continental Africa. The neighboring country is identified using the minimum of the bilateral distances between country centroids reported by Head and Mayer (2014). Data from 2011 and 2017 are shown.

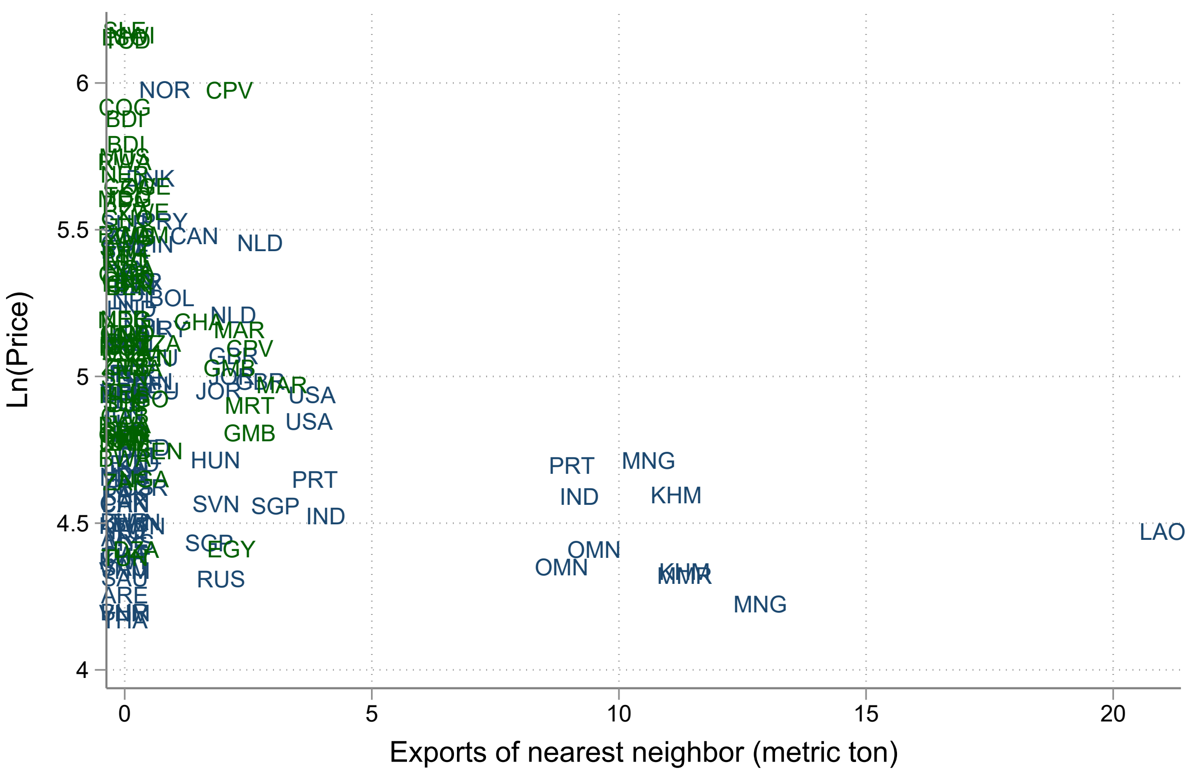


Figure 7: Model-based versus Observed Cement Quantity, Price, and Number of Firms. Green markers indicate economies in continental Africa. The vertical axis contains model-based cement quantity, prices, and number of firms. The horizontal axis shows the corresponding observed variables in the data. Plots are for 2011 and 2017. Dotted line is the 45 degree line.

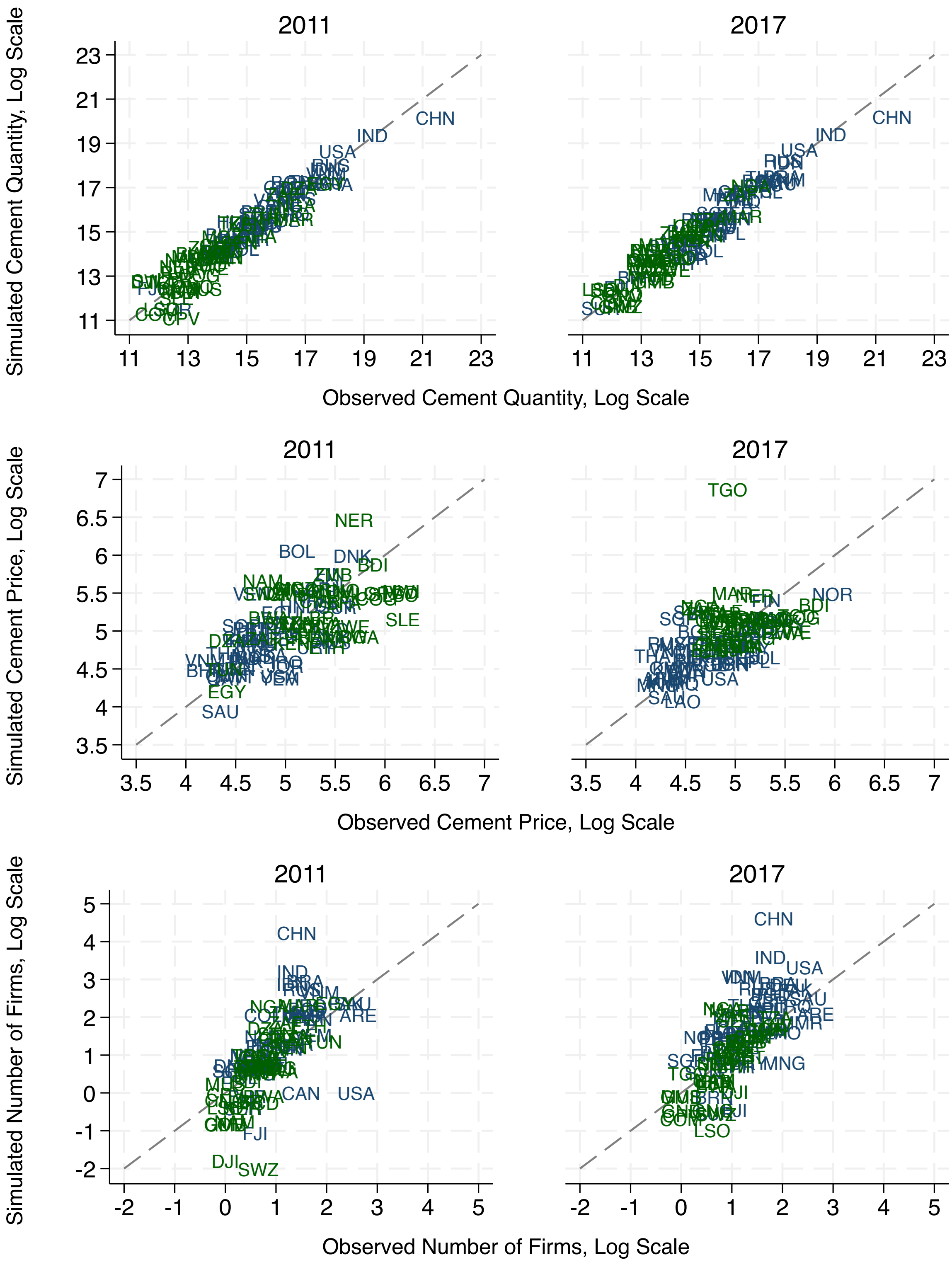


Figure 8: Observed and Estimated Price Changes in Africa, 2011–2017. Shown are median price changes from 2011 to 2017 using different estimation methods. Green bars highlight median changes in continental Africa. Blue bars highlight median changes in the rest of the world. Data, Conduct, and Cournot refer to price changes as observed in the data and as estimated by our Conduct and Cournot models, respectively. OLS refers to the price change predicted by a regression on number of incumbent firms, population, GDP per capita, local diesel price, road density, land area (all variables in logarithms) and a time fixed effect. 2SLS refers to a two-stage least squares expansion on the simple OLS regression, as in Beirne and Kirchberger (2023), where the logarithm of the number of firms is instrumented for by the number of carbonate deposits, and the inverse hyperbolic sine of total carbonate area is included as an additional control.

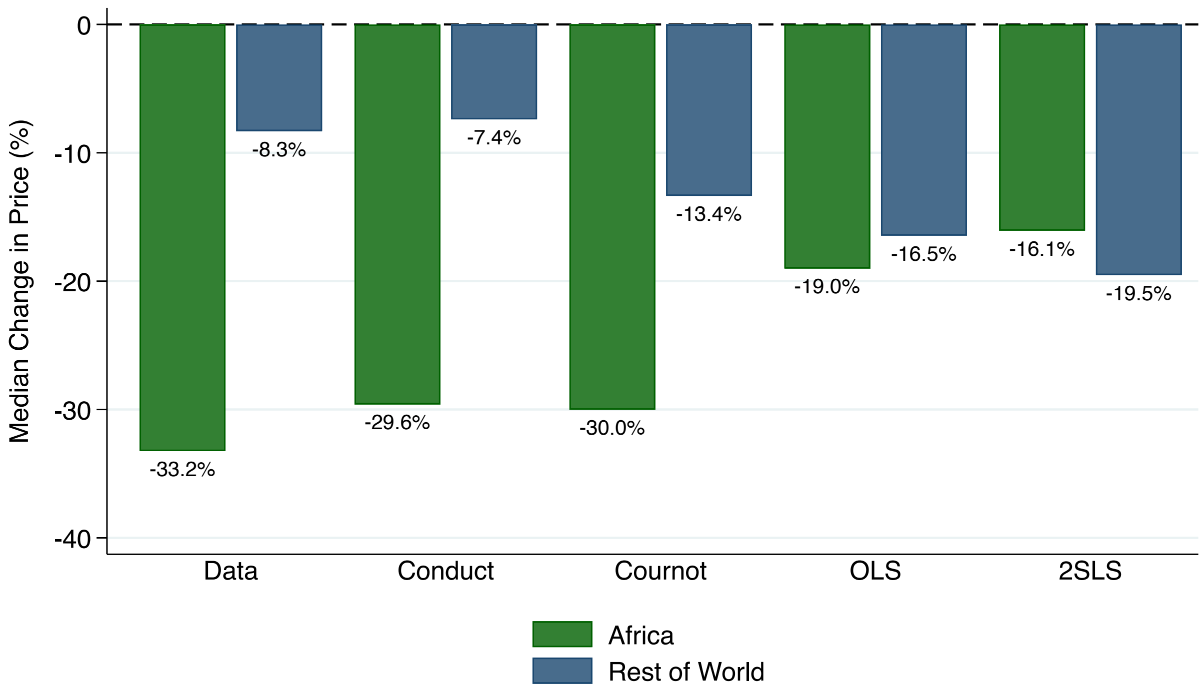


Figure 9: Robustness of African Price Decline to Alternative Marginal Cost Specifications. Shown are median price changes from 2011 to 2017 as estimated by our baseline Conduct model and the model with alternative specifications of marginal cost. Green bars highlight median changes in continental Africa. Blue bars highlight median changes in the rest of the world. As in Table 6, alternative 1 includes only the exchange rate, the price of diesel, and a constant. Alternative 2 includes all variables in the specification in Table 3, and their squares. Alternative 3 is the same as Alternative 2, but with all possible interactions. Green bars refer to African economies, whereas blue bars refer to the rest of the world.

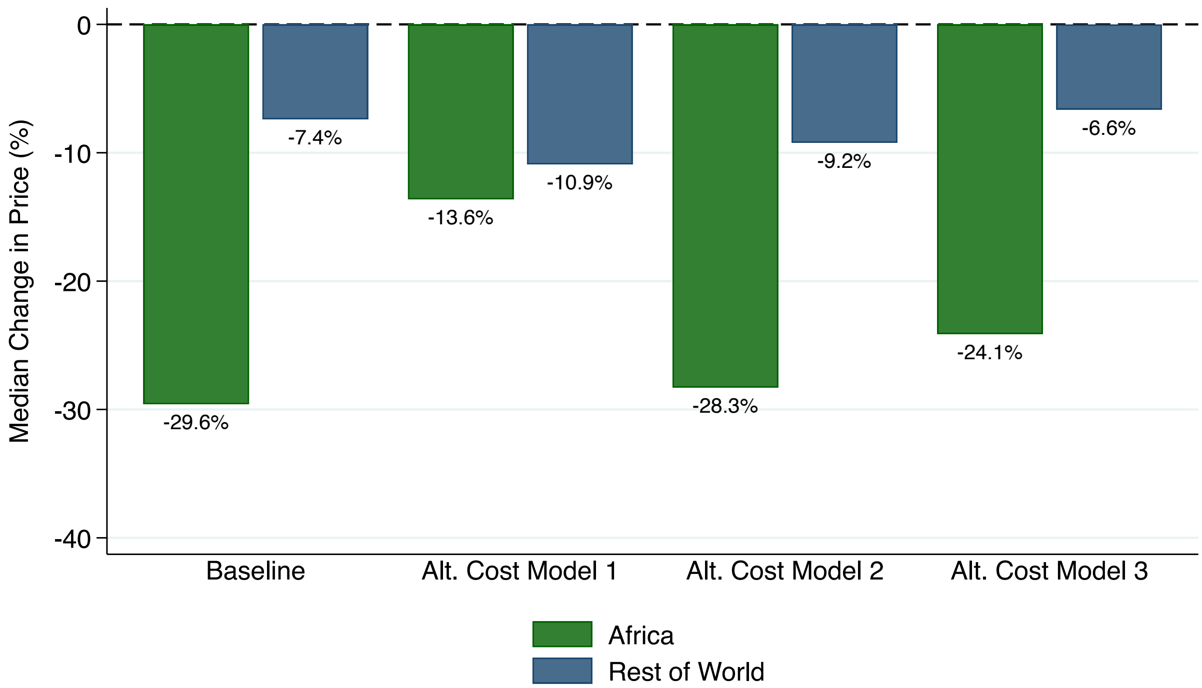


Figure 10: Empirical Densities of Price, Markups, and Marginal Costs. Shown are the empirical densities of log prices in USD, log marginal costs, and markups in 2011 and 2017. Green lines indicate economies in continental Africa. Prices are observed in the data, while marginal costs and markups are estimated using the Conduct model.

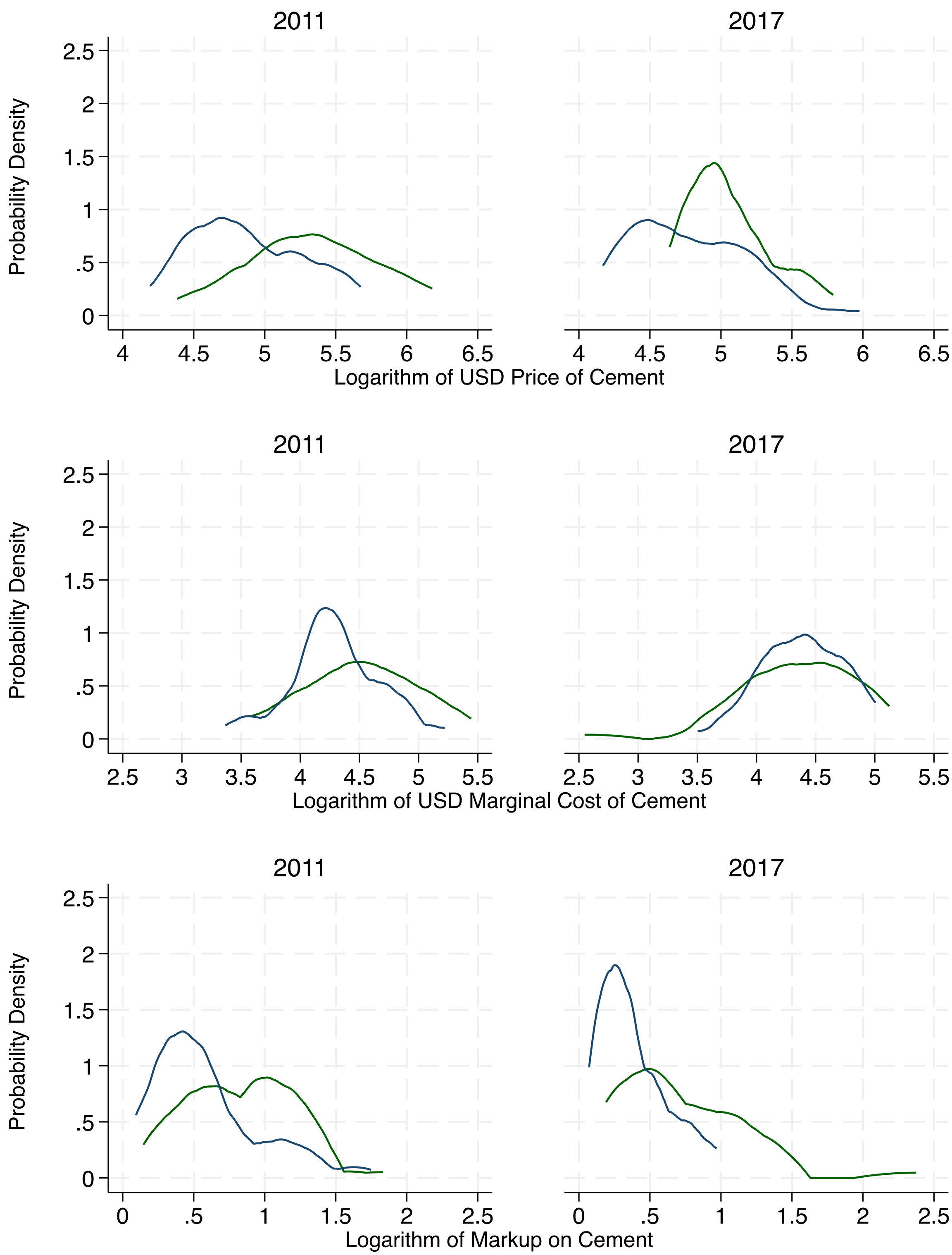
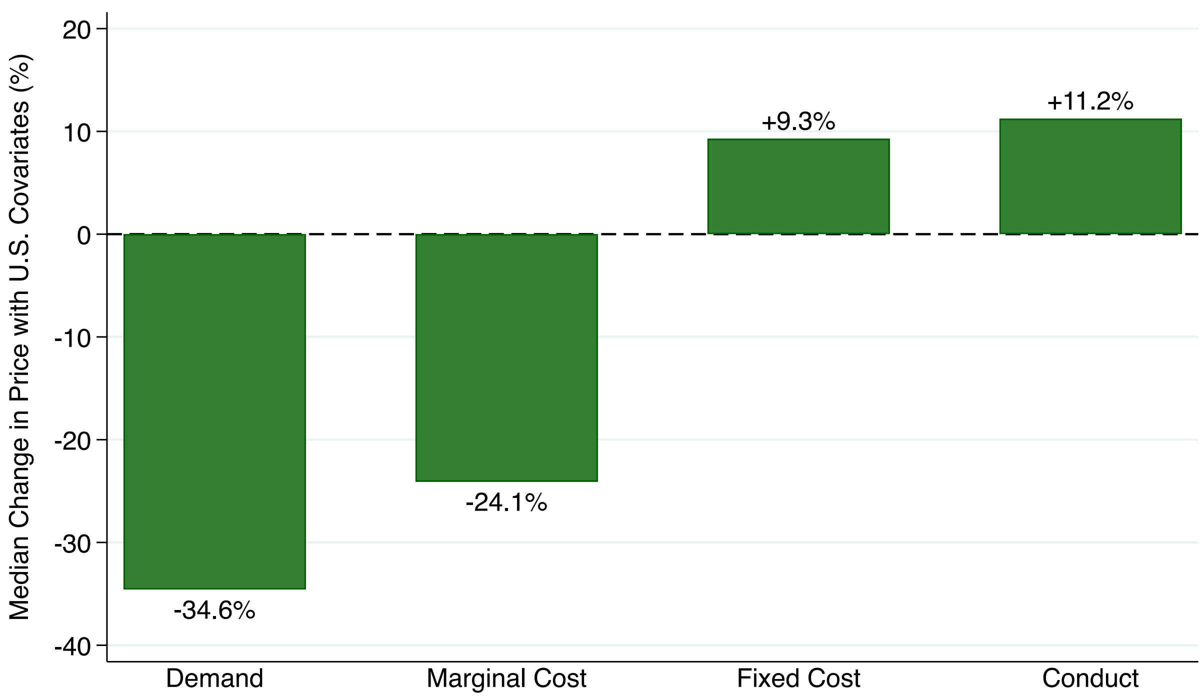


Figure 11: Price Changes in Africa with Counterfactual US Covariates. Shown are median price changes for our counterfactual exercise relative to baseline. The counterfactual exercise assigns values equal to those of the US to African economies in 2011, for covariates of demand, marginal cost, fixed cost, and conduct, respectively.



Appendices

A Derivations of the Entry Model

Equilibrium Pricing. Omitting the arguments in parenthesis, the first-order conditions associated with equation (1) are:

$$P_i + \frac{\partial P_i}{\partial Q_i}\frac{\partial Q_i}{\partial q_{ji}} q_{ji} = MC_{ji}. \tag{A.1}$$

$MC_{ji} \equiv \partial C_j / \partial q_{ji}$ denote the marginal cost of firm j in market i. Define $\lambda_i \equiv \partial Q_i / \partial q_{ji}$ as firm j's beliefs about the post entry game. Define market share $s_{ji} \equiv q_{ji}/Q_i$ and the elasticity of demand $\eta_i \equiv -\left(\partial P_i/\partial Q_i \times Q_i/P_i\right)^{-1}$. Substituting these identities into equation (A.1) yields:

$$P_i + \frac{\lambda_i}{\eta_i} P_i s_{ji} = MC_{ji}. \tag{A.2}$$

Let $MC_{ji} = MC_i + \nu_{ji}$. In words, firm j's marginal cost in market i depends on a common component across firms MC_i and a private shock ν_{ji}. Let $\mathbf{E}[\nu_{ji}] = \delta > 0$. Taking the average of equation (A.2) across all firms in a market delivers:

$$P_i + \frac{\lambda_i}{\eta_i}\frac{P_i}{N_i} = \overline{MC}_i, \tag{A.3}$$

where $\overline{MC}_i \equiv MC_i + \delta$. Using $N_i = 1/H_i$, equation (A.3) can be rearranged to deliver the left-hand side of equation (2).

Entry Choices. Marginal cost shocks ν_{ji} are only known to firms upon entry. Firms use expected marginal costs $\overline{MC}_i$ to compute first-stage expected profits, which implies firm symmetry at this stage. A firm decides to enter if it will at least break even given all other firms' entry decisions. The right-hand side of equation (2) can be written as:

$$\frac{Q_i}{N_i}\left(M_i(N_i) - 1\right)\overline{MC}_i \geq F_i > \frac{Q_i}{N_i + 1}\left(M_i(N_i + 1) - 1\right)\overline{MC}_i. \tag{A.4}$$

The first term denotes expected revenues with the observed number of firms. The last denotes (counterfactual) expected revenues with an additional entrant. A firm's expected revenues are decreasing in the number of competitors because of lower quantity sold and lower markup. Fixed costs are such that N_i firms make non-negative profits but $N_i + 1$ would not.

B GMM Moment Conditions

The GMM estimator chooses $\theta = (\alpha, \beta, \lambda, \gamma, \sigma)$ to minimize the objective function

$$g(\theta) = \sum_{i,t} \begin{pmatrix} Z_{it}\xi_{it}(\alpha) \\ W_{it}\omega_{it}(\alpha, \beta, \lambda) \\ \partial \ln(L_{it}(\alpha, \beta, \lambda, \gamma, \sigma))/\partial\gamma \\ \partial \ln(L_{it}(\alpha, \beta, \lambda, \gamma, \sigma))/\partial\sigma \end{pmatrix},$$

where the vector Z_{it} contains all variables in the demand Equation (3), but replacing $\ln(P_{it})$ with $EXPORTNEAREST_{it})$ to identify the demand elasticity. In the Cournot model, W_{it} contains all variables in the marginal cost function in Equation (4). In the Conduct model, W_{it} also includes columns $URBCON_{it}$, MMC_{it}, and $\ln(POP_{it})^n$ where $n \in \{1, 2\}$. We employ a continuously-updating GMM estimator, which has better small sample properties than the canonical two-step procedure (Hansen et al., 1996). Each equation of the model is estimated separately and these parameters are used as starting values when minimizing the objective function.

C Additional Tables

Table C.1: Regressions of Price and Number of Firms. All regressions include a year fixed effect. "'# Firms (HHI)" refers to the HHI-adjusted number of incumbent firms. "Scale" controls are population, GDP per capita and land area. "Governance" controls are z-scored measures of rule of law, political stability and control of corruption from the World Bank's World Governance Indicators. Road density is sourced from the World Bank's Global Roads Inventory Project. Diesel price is sourced from the World Bank's International Comparison Program. All variables in logs except governance controls. * indicates $p < .05$, ** indicates $p < .01$, and *** indicates $p < .001$. Reported at the foot of the table are median and mean price change in African countries as predicted by each regression.

VARIABLES	(1) Price	(2) Price	(3) Price	(4) Price	(5) Price	(6) Price
# Firms	-0.266^{***}		-0.215^{***}		-0.175^{***}	
	(0.052)		(0.050)		(0.048)	
# Firms (HHI)		-0.301^{***}		-0.291^{***}		-0.218^{***}
		(0.059)		(0.059)		(0.057)
Observations	150	168	150	168	150	168
R-squared	0.317	0.305	0.392	0.372	0.474	0.458
Scale	Yes	Yes	Yes	Yes	Yes	Yes
Governance	No	No	Yes	Yes	Yes	Yes
Road Density	No	No	Yes	Yes	Yes	Yes
Diesel Price	No	No	No	No	Yes	Yes
Median AFR Change	-10.3%	-17.3%	-12.9%	-17.7%	-19%	-19.1%
Mean AFR Change	-16.5%	-17.9%	-14.9%	-16.2%	-17.4%	-18.1%

Table C.2: OLS Alternative Specifications of Demand for Cement. This table replicates Table 7, except using OLS instead of 2SLS. Robust standard errors in parenthesis. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$

VARIABLES	(1) Quantity	(2) Quantity	(3) Quantity	(4) Quantity	(5) Quantity	(6) Quantity	(7) Quantity	(8) Quantity	(9) Quantity
Price of cement (USD)	-2.410***	-1.060***	-0.781***	-1.044***	-1.079***	-1.022***	-0.827***	-1.061***	-1.059***
	(0.248)	(0.102)	(0.111)	(0.104)	(0.100)	(0.135)	(0.120)	(0.102)	(0.102)
Price × (Year=2017)						-0.109			
						(0.202)			
Exchange rate (USD/LCU)		0.016	0.009	0.004	0.013	0.016	0.012	0.015	0.015
		(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)	(0.017)	(0.017)
Population		0.895***	0.917***	0.862***	0.892***	0.894***	0.899***	0.900***	0.898***
		(0.030)	(0.030)	(0.028)	(0.031)	(0.031)	(0.032)	(0.031)	(0.031)
GDP per capita (USD)		0.369***	0.369***	0.330***	0.367***	0.369***	0.356***	0.385***	0.389***
		(0.035)	(0.033)	(0.045)	(0.036)	(0.036)	(0.034)	(0.036)	(0.036)
Construction share of GDP		0.395***	0.413***	0.314***	0.397***	0.391***	0.356***	0.386***	0.380***
		(0.093)	(0.098)	(0.084)	(0.093)	(0.093)	(0.094)	(0.095)	(0.094)
Price of diesel (USD)			-0.292***				-0.336***		
			(0.070)				(0.081)		
Price of aggregate (USD)			-0.128						
			(0.084)						
Population growth (YoY, %)								0.036	
								(0.025)	
Urban population growth (YoY, %)									0.030
									(0.022)
Neighbor's cement exports (level)	-0.020	0.015	0.022*	0.015		0.017	0.026**	0.014	0.014
	(0.038)	(0.012)	(0.012)	(0.012)		(0.017)	(0.012)	(0.012)	(0.012)
Neighbor's exports × (Year=2017)						-0.005			
						(0.023)			
Neighbor's GDP per capita				0.050					
				(0.036)					
Others' exports (distance-weighted)					0.907				
					(2.049)				
% terrain carbonate (e.g. limestone, dolomite)							0.291		
							(0.277)		
Road density (km per km^2, Z-scored)							0.041		
							(0.045)		
Year (=2017)	-0.412	-0.083	-0.081	-0.087	-0.084	0.463	-0.070	-0.069	-0.069
	(0.256)	(0.081)	(0.077)	(0.080)	(0.082)	(1.009)	(0.079)	(0.084)	(0.085)
Constant	27.189***	3.436***	2.055**	3.555***	3.556***	3.244***	2.128**	3.120***	3.098***
	(1.334)	(0.898)	(0.874)	(0.896)	(0.893)	(0.988)	(0.923)	(0.927)	(0.937)
Observations	168	168	160	157	168	168	168	166	166
R-squared	0.310	0.931	0.941	0.928	0.930	0.931	0.937	0.931	0.931
Elasticity	2.41	1.06	.781	1.044	1.079		.827	1.061	1.059
Elasticity, 2011						1.022			
Elasticity, 2017						1.131			

Table C.3: Cement Prices and PPP GDP per Capita. We regress the USD price of cement on market attributes, including GDP per capita adjusted for purchasing power parity. Robust standard errors in parenthesis. * for $p < .05$, ** for $p < .01$, and *** for $p < .001$. All variables are in natural logs except the constant, the nearest neighbor's cement exports, z-scored number of procedures to start a business, z-scored concentration of urban centers, and z-scored multi-market contact.

VARIABLES	(1) Price	(2) Price	(3) Price	(4) Price	(5) Price	(6) Price	(7) Price
GDP per capita (PPP)	-0.139***	-0.058**	-0.206***	-0.069**	-0.071**	-0.067**	-0.064**
	(0.029)	(0.028)	(0.038)	(0.028)	(0.028)	(0.028)	(0.030)
Neighbor's cement exports (level)		-0.045***		-0.044***	-0.044***	-0.044***	-0.041***
		(0.008)		(0.007)	(0.007)	(0.007)	(0.007)
Price of diesel (USD)		0.402***		0.387***	0.392***	0.407***	0.397***
		(0.051)		(0.052)	(0.053)	(0.055)	(0.054)
Road density (km per km^2)		-0.047*		-0.043*	-0.044*	-0.040	-0.025
		(0.026)		(0.024)	(0.024)	(0.025)	(0.024)
Cement tariff (simple average)			-1.011*				
			(0.583)				
Population				-0.069***	-0.070***	-0.073***	-0.132***
				(0.015)	(0.016)	(0.016)	(0.026)
Construction share of GDP					0.057	0.063	0.063
					(0.056)	(0.057)	(0.056)
Procedures to start business (Z-score)						0.028	0.038
						(0.029)	(0.028)
Concentration of urban centers (Z-score)							-0.116**
							(0.046)
Multimarket contact (Z-score)							0.023
							(0.026)
Constant	6.260***	5.544***	6.952***	6.775***	6.944***	6.973***	7.937***
	(0.258)	(0.266)	(0.374)	(0.406)	(0.467)	(0.475)	(0.567)
Observations	163	163	134	163	163	163	163
R-squared	0.139	0.389	0.218	0.453	0.457	0.460	0.486