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Cementing Relationships: Vertical Integration, Foreclosure, Productivity, and Prices*

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Abstract

This paper looks at the reasons for and results of vertical integration, specifically with regard to its possible effects on market power as proposed in the recent theoretical literature on foreclosure. It uses a rich data set on producers in the cement and ready-mixed concrete industries over a 34-year period to perform a detailed case study. While some empirical patterns are consistent with foreclosure theory, there is no evidence supporting broader implications of the theory. Instead, prices fall and quantities rise in markets that become more integrated, and entry rates do not seem systematically lower. We suggest an alternative mechanism that is consistent with all the empirical evidence; namely, that higher productivity producers are more likely to vertically integrate, and as has been documented elsewhere, are also larger, more likely to grow and survive, more likely to operate in the most competitive markets, and charge lower prices. All of these patterns are seen in data, while not all are implied by foreclosure theory.

I. Introduction

Is vertical integration a device for firms to create and harness market power, or does it enhance efficiency and improve social welfare (or both)? This paper looks at this issue in two vertically linked industries, using an extraordinarily rich data set on their producers, by investigating patterns of productivity, scale, input and output prices, and entry and exit across integrated and unintegrated firms.

The reasons for, and results of, vertical integration (VI) have been a topic of considerable attention since Coase's (1937) landmark paper. Moreover, economic theories of vertical mergers have evolved largely as a response to, and in some cases, a driver of antitrust policy. Recent years have seen a surge in new theoretical work on the topic, particularly with regard to formalizing and extending the theoretical arguments for the possible harm that can arise through vertical integration's foreclosure, or market power, effect.[1]

This study utilizes integration episodes in the cement (SIC 3241) and ready-mixed concrete (SIC 3273) industries between 1963 and 1997 as an empirical laboratory to investigate the causes and consequences of vertical mergers, particularly regarding evidence on the predictions of modern foreclosure theory.[2]

Several features of these industries make them favorable for a case study. Their downstream markets are highly geographically segmented (especially for ready-mixed, where the vast majority of ready-mixed output is shipped less than 100 miles). These nationwide industries are therefore actually collections of many quasi-independent geographic markets, providing us with considerable variation to empirically identify the effects of interest.

Second, much of this variation is driven by factors exogenous to local market structure in the cement and ready-mixed industries. This is because the end user of these industries' outputs—the construction sector—accounts for most of their ultimate sales, but the cost shares of cement and ready-mixed among the construction sector's intermediate inputs are small. For

[1] Examples from this literature include Salinger (1988), Ordover, Saloner, and Salop (1990), Hart and Tirole (1990), Bolton and Whinston (1993), and Nocke and White (2003). Snyder (1995), Rey and Tirole (2003), and Bernheim and Whinston (2004) offer comprehensive surveys.

[2] In the hopes of nipping any reader confusion in the bud, let us be clear from the beginning: while often interchanged colloquially, cement is *not* concrete. Instead, cement—made by baking limestone and clay or shale together in a kiln and grinding the result into a power—is a single but important ingredient in concrete production. Ready-mixed concrete is produced by mixing cement with sand, gravel, and water (and sometimes small amounts of chemical admixtures), and is what is contained in the familiar trucks with the spinning barrels on their backs. Thus cement is the upstream industry and ready-mixed firms are the downstream producers.

example, while 97 percent of ready-mixed output was purchased by the construction sector, ready-mixed only accounted for 2 percent of the construction sector's costs.[3] This means shocks to the competitiveness of the local cement or ready-mixed markets (that would lower average cement or concrete prices, say) are unlikely to spur a construction boom. This is a handy fact because it allows us to be reasonably confident that by using these measures, we are examining the reactions of integration to truly exogenous demand differences.

Third, cement and ready-mixed concrete are relatively homogeneous in physical attributes and have little if any brand-driven differentiation. The competitive effects we might find—on prices, say—are therefore more likely to arise due to market structure changes than alteration in the product mix.

Finally, we have access to large amounts of production information on producers in these industries. This affords more variation in vertical market structures (thousands of producers operating in hundreds of local markets over a 34-year time span) than was typically available to previous researchers and allows us to study interactions of market features that previous studies had to look at in isolation. But perhaps most importantly, it means we can explore for the first time elements of theoretical models that have not yet (to our knowledge) been studied empirically. These include vertical integration's long-run competitive impacts, specifically with regard to entry and exit. They also include the links between productivity and integration which, as will be seen below, provide an alternative explanation other than foreclosure for our empirical results.

These empirical findings, documented below, are summarized as follows.

- Vertically integrated producers in both industries are larger, have higher labor productivity levels, and are more capital intensive than their unintegrated counterparts in the same market. Further, integrated producers in the ready-mixed industry have higher total factor productivity levels and sell their output at lower prices than unintegrated producers.
- Formerly unintegrated ready-mixed producers who become part of an integrated firm see substantial increases in their labor productivity levels and smaller TFP increases. Interestingly, this occurs in concert with substantial declines in the producer's output and

[3] These values were taken from the 1987 Benchmark Input-Output tables

inputs (except, of course, the drops in the latter are greater than the former). No noticeable changes in any production features occur in newly integrated cement plants.

- Ready-mixed plants that enter as part of an integrated firm are larger than unintegrated entrants. They also have higher productivity levels and somewhat lower prices.
- There are more integrated firms and they have larger combined market shares in more competitive markets (where the exogenous determinant of competitiveness is local demand density).
- While unintegrated producers are more likely to exit than integrated producers, this difference disappears once one controls for multi-plant-firm status and TFP.
- Markets with a greater extent of integrated ready-mixed producers (measured either by the market share or number of integrated firms) have lower average ready-mixed prices and higher total quantities sold, even controlling (respectively) for market competitiveness and size. Moreover, within-market increases in integration rates are associated with average price declines and quantity growth.
- For both ready-mixed and cement, total entry rates (measured either on a plant or firm basis) are slightly higher in more integrated markets. Unintegrated plant entry rates alone are not significantly affected by the extent of integration.

As we discuss below, some of these empirical patterns are consistent with foreclosure theory. However, we do not find evidence of foreclosure's broader, "bottom line" implications. Instead, prices fall and quantities rise in markets that become more integrated, and entry rates rise if anything in markets where there are more integrated producers. We suggest an alternative mechanism that is both consistent with both sets of empirical features—those that do match the theory *and* those that do not. Specifically, the data may reflect a process of more productive companies growing (sometimes vertically), competing with and sometimes forcing the exit of less efficient producers. If these high-productivity firms are more apt to integrate, and we show evidence below that this is the case and suggest reasons why, then all of the empirical patterns summarized above can be explained. The data also suggest the success of these more productive firms is socially beneficial, lowering prices and raising output as markets become more integrated.

This paper builds on an empirical literature that, in comparison to the resurgent theoretical literature surrounding the vertical foreclosure debate, has been relatively thin.

Grimm, Winston and Evans (1992) study railroad destination pairs served by a single firm. They find that increased interline competition—competing railroads that connect intermediate points on the otherwise monopolized route—reduces welfare distortion. Waterman and Weiss (1996) and Chipty (2001) find that U.S. cable television systems that are integrated with program suppliers are more likely to include their own suppliers' paid content. Chipty (2001), however, argues that higher quality programming is offered in integrated markets, resulting in higher consumer surplus. Hastings and Gilbert (2002) utilize both within and across market integration status variation in producers of a homogeneous good (wholesale gasoline without additives). They examine the effect of vertical mergers on the wholesale price paid by competing independent gasoline retailers, and find that the closer the competitor, the higher the wholesale price it has to pay.[4] Rosengren and Meehan (1994) find no support for foreclosure theory in event studies of the effects of vertical merger announcements and antitrust challenges on the stock prices of merging and rival firms. Snyder (1995b, 1995c), uses similar methods on a different set of industries and finds support for foreclosure.[5]

The next section documents cement and ready-mixed concrete's patterns of integration over the sample period. It also discusses the evolution of economic theories of vertical integration over the same time frame, because this academic debate was mirrored by adjustments in policies aimed at vertical integration in the two industries and social welfare. After discussing empirical implications of alternative models, we go on to test them one-by-one (after a short discussion on the data used in the project). A discussion section concludes.

[4] Hastings (2004) analyzes the impact of a multi-market vertical merger on *retail* gasoline prices in California. She finds that reducing the market share of unintegrated retailers led to higher retail prices. However, she does not draw any connection with her work with the foreclosure literature, instead ascribing the finding to product differentiation between branded and unbranded gasoline.

[5] The large number of policy actions taken by the FTC in the cement and concrete industries in the 1960s and 70s (more on this below) also spurred at the time a small literature on the impact of forward integration by cement producers. These papers, however, preceded the recent theoretical literature, and as such do not directly test for such effects. They did, however, center around the issue of whether and how integration might enhance market power. Allen (1971) reviews evidence brought forth in the FTC's 1966 report on these industries (U.S. Federal Trade Commission 1966). While institutionally instructive, this study does not conduct formal statistical tests of economic hypotheses. McBride (1983) attempts to do so, finding a negative correlation between average cement prices in 17 markets and the cumulative number of market ready-mixed plants acquired by cement firms. He explains these results as resulting from the fact that forward integration into concrete makes it easier for cement plants to "adjust" their prices to accommodate demand swings, presumably due to (undocumented) collusive agreements in cement pricing that are be easier to monitor than concrete prices. However, Johnson and Parkman (1987) argue accounting for pre-existing price trends makes this result statistically insignificant.

II. Vertical Integration in Cement and Ready-Mixed Concrete: History, Policy, and Theory

Our data spans a 34-year observation period, from 1963 to 1997. Over this time the cement and ready-mixed industries experience two distinct periods of integration, separated by an over decade-long period of initial disintegration and then stability. Table 1, which reports the fraction of cement and concrete industry plants and sales accounted for by integrated producers, shows this evolution. The first merger wave occurred in the early and mid 1960s and was driven primarily by forward integration by cement producers. Between 1963 and 1967, the fraction of cement plants in vertically integrated firms rose from 21.9 to 47.4 percent. A similar rise (though at a much lower level) occurred in the ready-mixed concrete industry, from 1.8 to 3.2 percent of plants. The fractions of sales due to integrated firms for the respective industries show analogous patterns at higher levels.

This initial merger wave caught the attention of the antitrust authorities. Between 1960 and 1969, the FTC brought 15 antitrust cases against cement companies that had purchased concrete firms. Every one ended in divestiture of ready-mixed plants. The antitrust stance against vertical mergers in the cement and concrete industries is summarized in a 1966 report prepared by the FTC (1966). The report dismisses efficiency enhancing explanations for vertical mergers in the industry and cites several possible anticompetitive effects of forward acquisitions by cement firms. The first and foremost concern is the possibility of limiting unintegrated cement firms' market access; the report then argues that such diminished access to concrete outlets would in turn lead to higher entry costs for unintegrated cement suppliers, decreasing competition. Moreover, it claims that vertical acquisitions could also increase the (entry) costs of unintegrated concrete firms. Finally, the report points out that elimination of large downstream customers would decrease ready-mixed producers' bargaining power relative to cement producers.

The vigorous enforcement action (no other single industry saw as many vertical merger challenges during the period) put a chilling effect on such mergers throughout the 1970s. At the same time, however, the economic foundations of the so-called "naïve foreclosure theory" brought forth by the FTC report were under attack by "Chicago School" critiques. Allen (1971), Posner (1976), and Bork (1978) pointed out that in cases of fixed-proportions technology (as cement is for ready-mixed concrete), a monopolist upstream producer cannot profit from monopolizing its downstream market.[6] Thus, vertical mergers would only occur in the case where there are efficiency gains, such as through improving production technologies, eliminating double marginalization, or the alleviation of hold-up problems when relationship-specific investments are important.

These and similar arguments influenced antitrust authorities in the Reagan and first Bush administrations and softened official views toward vertical mergers considerably. Indeed, between 1980 and 1992, only two vertical antitrust cases (in any industry) were initiated. And in 1985, the FTC explicitly eased its enforcement policy regarding cement and ready-mixed vertical mergers.[7] Industry firms responded by reintegrating. Between 1982 and 1992, the fraction of cement plants in vertically integrated firms rose from 32.5 to 49.5 percent (and the fraction of sales grew from 49.5 to 75.1 percent).[8] For ready-mixed the corresponding growth was from 3.0 to 11.1 percent for plants and a 8.5 to 14.4 percent rise in the share of industry sales.

The theoretical debate pendulum swung back in the other direction in the late 1980s, as several authors formulated game-theoretic models to formalize certain conditions under which vertical mergers would indeed have anticompetitive effects. An archetypal example of these newer foreclosure models, and one that might best fit the institutional details of the cement and concrete industries, is the "ex-post monopolization" model of Hart and Tirole (1990).[9] It is the predictions of this class of models—which form the vanguard of current thinking on the subject—that we seek to test here.

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[6] The reasoning is simplest to grasp in the case where the distribution sector is perfectly competitive. In this case, the profit maximizing price of the final output will be the same regardless of whether the monopolist prices the product optimally for its distributors, who incur a selling or transformation cost, or the monopolist internalizes the selling/transformation cost by selling it himself. Vernon and Graham (1971), however, point out that in the case where the downstream firm can substitute away from the monopolist supplier's input, a vertical acquisition may increase the monopolist's profits, though the welfare effects of such a merger is ambiguous.

[7] 50 Federal Register 21507 (1985). The announcement cites the "developments in economic thinking." It also states that mergers in the cement industry were no longer subject to special consideration after 1977.

[8] The decline in integration seen from 1992 to 1997 was most likely due to a demand-driven bout of unprecedented entry in the cement industry, which saw a net gain of 61 (mostly unintegrated) plants over the five year period, up from 1992's 218 plants (which was near the industry's long-run average). The possibility of renewed antitrust enforcement action by the Clinton administration is another possibility, though we are aware of no cases that were actually brought in either industry.

[9] We thank Michael Whinston for an insightful discussion that led us to this model. The model is also described in detail in Snyder (1995) and Rey and Tirole (2003), and is used in the experimental study of Martin, Normann, and Snyder (2001).

The Hart and Tirole (1990) framework has upstream homogeneous-good producers with asymmetric marginal costs competing in prices. In the cement-concrete context, one can think of these cost differences arising because a local cement producers would have a distinct transport cost advantage over more distant producers. In other words, we can without loss of generality think of a local monopolist U providing the essential input. Suppose that this monopolist supplies two downstream producers, D_1 and D_2.

The structure of the game is as follows: U offers each D_i a (possibly nonlinear) tariff $T_i(\cdot)$. D_i then orders a quantity q_i and pays $T_i(q_i)$. The D_i then produce q_i, observe each others' outputs, and set prices. Downstream competition is modeled as Bertrand with capacity constraints, which yields, under conditions described in Kreps and Scheinkman (1983), the Cournot outcome.

Let (Q^m, p^m) be the monopoly price and quantity if U also had monopoly power in the downstream market. If U offers the quantity & tariff schedule $(q_i, T_i) = (Q^m/2, p^mQ^m/2)$ to the downstream producers, it can achieve monopoly profits. However, Hart and Tirole (1990) point out that offering this contract may not be credible if the contracts are secret or can be secretly renegotiated ex-post. If one downstream firm did agree on the above contract terms, it can be shown that the monopolist has an incentive to sell more than $Q^m/2$ to the other downstream firm.[10] But this of course means the first will be reluctant to sign its contract in the first place. Hart and Tirole (1990) show that the equilibrium of the game in which "secretly renegotiable" contracts are written is one in which U sells Cournot quantities to the downstream firms, yielding less than the monopoly profit to U.

When U can forward integrate, however, it can commit to reducing supply. U could sell Q^m through its subsidiary and sell nothing to the other downstream firm. Of course, this polar case is unlikely to happen in reality because the other downstream firm could try to buy input from a more distant supplier. A more realistic solution to the model would be for the integrated firm to instead price the input such that the quoted price just undercuts the more distant supplier. This leads to an asymmetric Cournot outcome in the downstream market, where the unintegrated downstream firm is at a cost disadvantage. Integration occurs in equilibrium if the combined profits of the integrated firm's plants under the asymmetric Cournot outcome are higher than in the symmetric, unintegrated Cournot outcome.

[10] The monopolist takes $Q^m/2$ as given for the contracted firm, and reoptimizes quantity for the other firm using the "right-shifted" version of the residual demand curve. This does not necessarily yield $Q^m/2$ as the optimum quantity.

Note how this model formalizes an intuition expressed in FTC report. Absent vertical integration, the cement producer is "tempted" to sign larger contracts than is optimal for a monopolist. Vertical integration serves to align the incentives of the upstream and downstream firms. This version of the Hart and Tirole (1990) model, however, is silent about what happens to (potential) competitors in the upstream market. However, Hart and Tirole also provide a variant—the "scarce needs" model -- in which two upstream competitors with the same marginal costs but different fixed costs of operation and/or entry—where vertical integration becomes profitable if it leads to the exit/non-entry of one of the upstream firms.

Table 2 summarizes the main predictions of this model regarding the consequences of vertical mergers. We seek to test these implications in turn below.

III. Data

A. Plant-Level Ownership, Productivity, and Prices

The core of our analysis uses plant-level microdata from the 1963, 1967, 1972, 1977, 1982, 1987, 1992, and 1997 Census of Manufactures (CM). The CM is comprehensive; we observe every U.S. cement and ready-mixed concrete plant operating in the respective census year. A typical CM has 220 cement and 5200 ready-mixed plants (the number of cement plants has risen of late while the ready-mixed numbers has been roughly constant for the past 25 years). The CM microdata contain a wealth of information on plants' production activities that we describe and exploit below. Crucially here, they also contain firm identification numbers for each plant. (Plants, or "establishments" in Census Bureau terminology, are unique physical locations at which products are manufactured. A firm can own one or more plants.) Thus we are able to observe when a single firm owns several plants in either or both industries, making it and its component plants vertically integrated.[11]

The comprehensiveness of the CM is extremely useful. We can observe every plant's integration status in each census year. Additionally, because the CM contains permanent plant identifiers that are invariant to ownership changes, we are able to track any changes in this status over time. Entry and exit of plants and firms between census years are completely observable as well, allowing us to look at vertical integration's long-run impact on markets.

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[11] In future versions we will consider alternative, less discrete integration measures that capture the relative contribution of each industry to a vertical integrated firm's total revenues.

Besides this ownership information, the CM contains data on plant revenues, several employment measures (total number of employees, number of production workers, production worker hours), the book values of and investment in equipment and building capital stocks, inventories, expenditures on inputs (the total wage bill, supplements to wages, production worker wages, energy expenditures, and intermediate materials purchases), and state and county codes. We use the production data both directly and to calculate other technological measures of interest. These include labor productivity (output per hour) and total factor productivity. Both will play a prominent role in our empirical investigation. Details of these constructions can be found in the data appendix.

For some of our ready-mixed concrete plants, we augment this base data with the CM Product and Materials Supplements. These auxiliary files contain, by plant, highly detailed product-level information on outputs and materials inputs (defined at the seven-and six-digit SIC level, respectively). On the output side, this includes the total value and the physical quantity of product shipments. Conveniently for us, most plants in the ready-mixed concrete industry are highly specialized; virtually all of their production (roughly 95 percent of revenue on average) comes from sales of ready-mixed, which is itself a seven-digit product.[12] Therefore for those ready-mixed plants with available product supplement data, we can measure output in either dollars or physical units (cubic yards, in this case). The product-level data is also useful because we can use it to calculate average unit prices (measured on a free-on-board basis), offering a rich set of producer price observations collected across various firm organizational structures and different local markets. The CM Materials Supplement, analogously to the product files, gives plants' total expenditures and purchased quantities of intermediate-input products. Hence we observe the amount of cement used, and the unit cement prices faced by, hundreds of ready-mixed producers.[13]

[12] Other concrete products such as block, pre-fabricated structural members, and pipe are typically made by producers in concrete industries other than SIC 3273. Likewise, the share of these other industries' revenues accounted for by ready-mixed is miniscule.

[13] Several interesting data and conceptual issues arise with the Products and Materials Supplements. Unlike the specialized ready ready-mixed industry, cement plants produce a number of seven-digit products (different cement types based on their chemical composition). This makes cement plants' average unit output prices more difficult to construct and somewhat less meaningful. For now we focus on the ready-mixed output prices, but plan in future versions to construct price indices based on the mix and unit prices of the various cement products. Since the intermediate materials files are at the six-digit level, the similar problem is not manifested in the data on cement use by concrete manufacturers: they simply all buy "cement." This makes constructing unit input prices easy, although perhaps one should be mindful about any persistent differences in types of cement usage across concrete plants

Unfortunately, the CM does not offer full coverage of every production variable discussed above. Very small plants (typically with fewer than five employees)—called Administrative Record (AR) establishments—have imputed data for most production variables. These AR plants amount to roughly one third all establishments, though their small size implies they compose a much smaller share of employment and output. Because of the imputations, we exclude these plants from those analyses that involve comparisons of production variables (e.g., productivity or prices). However, we are of course able to use these plants when computing entry and exit rates or integration status. Additionally, not every variable was collected in each census. Equipment capital stocks, for instance, were not collected in 1963 and 1997, making it impossible to compute TFP values and capital-to-labor ratios during these years. Finally, the CM Product and Materials supplements are not comprehensive; they not only exclude all AR plants, but also have imputed values for some non-AR respondents (which we attempt to remove from our sample). The coverage of the Materials files is the sparser of the two, accounting for roughly half of the plants covered by the Product supplement.

B. Local Markets in the Cement and Ready-Mixed Concrete Industries

One of the more useful attributes of these industries as a forum for testing foreclosure theory is the fact that they are comprised of many local markets. This naturally raises the empirical issue of how to suitably define markets for the industries. We choose to use different (but closely related) market definitions for cement and concrete. For cement, we consider a market to be the Bureau of Economic Analysis's Economic Area (EA). EAs are collections of counties usually—but not always—centered on Metropolitan Statistical Areas (MSAs). Counties are selected for inclusion in a given EA based upon their MSA status, commuting patterns, and newspaper circulation configurations, subject to the condition that EAs contain only contiguous counties. There is no requirement that EA boundaries coincide with state boundaries. The selection criteria ensure that counties in a given EA are economically intertwined. This

(though technological constraints in the industry make this unlikely). Further, it is not clear exactly what reported cement prices reflect in vertically integrated concrete plants. We discuss this more below. Finally, we are unable to observe the destinations for output shipments or the origins of intermediate materials productions, so we cannot directly test whether integrated cement producers restrict their shipments to downstream plants outside the firm.

classification process groups the roughly 3200 U.S. counties into 172 markets that are mutually exclusive and exhaustive of the land mass of the United States.[14]

We choose a smaller market definition for ready-mixed concrete. This is suggested by the fact that average concrete shipment distances are lower than in the cement industry, and by the related fact that there are a much larger number of ready-mixed plants and they are geographically ubiquitous. Conveniently, the Bureau of Economic Analysis disaggregates EAs into Component Economic Areas (CEAs). These subdivisions are again based on commuting and newspaper circulation patterns within EAs to make the divisions as economically natural as possible. There are 348 CEAs, an average of two per Economic Area, but larger and denser EAs typically have more CEAs than do those in less populated areas.[15]

These market definitions are obviously imperfect compromises between conflicting requirements. We especially wish to limit across-market interactions between ready-mixed producers. While there are bound to be some across-market concrete sales in reality, the high transport costs of the industry make this unlikely. In addition to the Commodity Transport Survey data discussed above, conversations with industry managers also suggest similar implications; stated maximum ideal delivery distances were between 30- and 45-minute drives from the plant. CEAs are large enough to minimize cross-market shipments. (An additional factor minimizing cross-market shipments is that most CEA boundaries are in outlying parts of urban areas and are thus less likely to be near areas heavily populated with concrete plants.) Balanced against this consideration is to not make markets so large as to result in very little competitive interaction between many of the included establishments. Plants placed in too large a market may not all respond to the same market forces—either external or the actions of industry competitors.

C. Market Size and Density

As we mention above, an advantage of studying integration in these industries is that the size of their downstream user, the construction sector (SICs 15-17), is likely exogenous to the specifics of local competition in either industry. In many of our empirical tests below, we use

[14] See U. S. Bureau of Economic Analysis (1995) for more detailed information about EA creation.

[15] For example, the Kansas City EA is comprised of the Kansas City (Kansas-Missouri), Lawrence (Kansas), and St. Joseph (Missouri) CEAs, while the Bangor (Maine) Component Economic Area is the only CEA in the Bangor EA.

measures of the size and demand density of the local construction sector as exogenous covariates. These are created from County Business Patterns construction employment data. We aggregate this county level information to the CEA and EA levels.[16] Market size is measured simply as logged total employment. Demand density is calculated as the (log of the) number of construction-sector workers per square mile in the market. As Syverson (2004a, 2004b) discusses, differences in the density of construction sector activity across local markets create exogenous variation in the intensity of competition within local ready-mixed concrete markets. By extension we expect that similar effects operate, though on a broader geographic scale, in the cement industry.

IV. Empirical Results

A. Are Integrated Producers Different?

We first test whether plants in integrated and unintegrated firms are at all dissimilar, and if so, characterize how they differ. To allow the cleanest possible comparison, we estimate the following parsimonious specification separately for each industry:

$$y_{emt} = \gamma_{mt} + \alpha_{VI} VI_{emt} + \varepsilon_{emt}, \quad (1)$$

where y_{emt} is the outcome value of interest (specific to a plant e operating in market m in year t), γ_{mt} is a market-year fixed effect (recall that a market is defined as an EA for cement and a CEA for ready-mixed concrete), and VI_{emt} is a dummy equal to one if the plant belongs to an integrated firm. Obviously, α_{VI} captures the mean difference between integrated and unintegrated producers. By including fixed effects, we are identifying this mean difference using variation within market-years, removing the influence of broader spatial or time-specific unobservables.

The results of this regression for several variables of interest are presented in Table 3. Note first the productivity differences. Within ready-mixed markets, integrated concrete plants' labor productivity levels are 33 percent (29 log points) higher than their unintegrated

[16] County Business Patterns data occasionally have missing observations due to data disclosure regulations. The construction sector's ubiquity and abundance of small firms allows full disclosure of total employment in nearly all counties, however (employment data is withheld in roughly 1.5 percent of the county-year observations). We impute employment when missing by multiplying the number of establishments in each of nine employment ranges (which are always reported) by the midpoint of their respective employment ranges, and summing the result. The impact of using imputes is likely to be even less than their proportion indicates, as the typically small nondisclosure counties are less likely to contain ready-mixed plants.

counterparts in the same market. Their TFP levels are also higher, though the gaps are much smaller; the mean difference in revenue-based TFPR is 2.8 percent and physical-quantity-based TFPQ difference is 4.8 percent.[17] The smaller TFP differences reflect the fact that integrated plants have over 10 percent more capital per worker. In the cement industry, integrated producers also appear to have higher labor productivity levels (by 9.3 percent) than unintegrated cement plants in their market, but there are no statistically significant TFP differences.

Besides being more productive, integrated ready-mixed plants are larger in terms of real revenues than unintegrated plants in the same market. Note, though, that integrated ready-mixed plants do not employ significantly more workers or utilize more labor hours, as manifested in the higher labor productivity result. There are differences in labor *composition*, however: nonproduction workers comprise a smaller share of the labor force in integrated plants.[18] Comparing cement plants, integrated producers are also larger in terms of total sales, have a smaller share of nonproduction workers, and have higher capital labor ratios than their unintegrated counterparts. Unlike the concrete comparisons, however, they also employ more labor (measured in either employees or hours).

In sum, then, integrated producers are larger and more productive in both the upstream and downstream industries, though the productivity differences in the upstream market appear to be driven solely by capital deepening. This is in line with the predictions of the Hart and Tirole (1990) foreclosure model above, which implies a greater propensity to integrate by lower-cost producers. (However one must appeal to separate variants of the model, each with a different set

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[17] The construction of these TFP measures is described in detail in the appendix. They differ in their measure of output. TFPR uses plant revenue deflated to a common year using industry-level price deflators for the plant's respective industry. This is the standard practice in the literature. However, any within-industry price dispersion will be built into the output measure; all else equal, lower-price plants will look less productive because their revenue will be lower. If within-industry price variations reflect differences in local demand conditions rather than quality differentiation—a distinct possibility in a homogeneous-product industry like ready-mixed concrete—revenue-based TFP confounds technological with demand factors. Therefore we also construct a TFP measure using physical output data from the CM Product Supplement, where TFP differences are determined by differences in the number of cubic yards of concrete plants can produce with a fixed set of inputs, rather than differences in the total revenue from production.

[18] Production workers—all other employees are considered nonproduction workers—are defined by the Census Bureau as, "Workers (up through the line-supervisor level) engaged in fabricating, processing, assembling, inspecting, receiving, packing, warehousing, shipping (but not delivering), maintenance, repair, janitorial, guard services, product development, auxiliary production for plant's own use (e.g., power plant), record keeping, and other closely associated services (including truck drivers delivering ready-mixed concrete). Exclude proprietors and partners."

of assumptions about cost differences in the downstream industry, to obtain the productivity-difference implication for both upstream and downstream producers.)

We would note, though, that the results are also consistent with efficiency-enhancing mergers. If there are complementarities between the merging parties' productivities, Koopmans' (1951) assignment model and Becker's (1973) matching model predict assortative matching to emerge in equilibrium. Thus more productive firms in the two industries are both the most likely to integrate and have the most to gain from doing so. We shall return to this possibility several times below.

B. Integration's Effect on Producers Becoming Integrated

The patterns documented above show that integrated plants are indeed different. However, they less useful for determining whether the differences cause, or are caused by, vertical integration. In this section, we take a closer look at the effects integration has on producers. We do so in three ways. The first compares changes in continuing plants who become integrated to those in the same market who remain unintegrated, conditioning on plant survival (that is, the plant must exist in both the current and previous CM). This first-differences specification controls for unobservable plant-level effects that may predict integration status, thereby making it more likely that the estimated effects reflect integrations' causal impacts. The second comparison is between new plants (i.e., those making their first appearance in a CM) that enter as part of an integrated firm and those that enter in an unintegrated firm. The third contrasts integrated entrants with unintegrated incumbents. We again include market-year fixed effects in all cases, so the estimated differences control for common market-level shocks.

The outcomes from these specifications for ready-mixed producers are shown in Table 4. As with the cross-sectional differences above, we look at the impacts on several technological attributes.

Panel A shows notable differences among continuing ready-mixed concrete plants. When plants become integrated, they also become more productive relative to their market counterparts that remain unintegrated. Labor productivity increases by over 10 percent, and there are positive (but not significant) gains in TFPR and TFPQ. Somewhat surprisingly, these newly integrated ready-mixed plants also appear to shrink after the merger—at lease in relative terms (recall that we include market-year fixed effects, so the reported coefficients give relative growth rates): revenues go down by a third more, and total labor hours are cut by 36 percent.

It appears that the decline in production by acquired concrete plants is compensated, at least in part, by new entrants. In Panels B and C, which compare integrated entrants to unintegrated entrants and unintegrated incumbents (respectively), we see that newly entering ready-mixed plants that are vertically integrated are noticeably more productive (both in labor productivity and TFP terms) than both unintegrated entrants and unintegrated incumbents in their markets. These integrated entrants have considerably higher sales than unintegrated entrants (though they actually hire less labor), but are smaller than incumbent producers. They have a lower nonproduction worker ratio and are more capital intensive than both comparison groups.[19]

Similar comparisons for cement plants—not reported here—found no significant differences among either continuing plants or entrants. This suggests, interestingly, that the differences seen between integrated and unintegrated cement producers are driven by selection into integration based upon pre-existing differences, while differences among ready-mixed concrete plants result at least in part as a direct result of becoming part of an integrated firm. Moreover, the largest impact vertically integrated firms have on concrete markets in terms of productivity may be through their newly built plants. We will return to these points below.

C. Market Characteristics and the Propensity to Vertically Integrate

The Hart and Tirole (1990) foreclosure theory above predicts that upstream firms will decide to integrate in markets where commitment problems are more severe. That is, if upstream firms benefit from integrating because they can better commit to restricting output to downstream firms, we would expect foreclosure-based vertical integration to be more likely in markets where upstream producers would find it easier to renege on arm's-length supply contracts. In such markets, downstream firms are less likely to enter into these supply contracts in the first place given that they realize the upstream firm's ex-post incentives. Vertical integration is necessary to harness market power in such situations.

While reneging possibilities are impossible to quantify directly, they may be correlated with market observables. Specifically, all else the same, we might expect markets where

[19] We also conducted comparisons between integrated new entrants and continuing plants in the *same* vertically integrated firm. The entrants are smaller than their firm counterparts, but there were no differences in productivity or factor intensities.

downstream producers are easier to contact will offer greater possibilities for cement firms to renege on supply agreements. Simply put, when there are a lot of concrete firms nearby, a cement producer is likely to find it easier to set up surreptitious supply arrangements, increasing the commitment benefit of integrating.[20]

We look for such a correspondence in the data by regressing the extent of vertical integration on (separately) three market-level proxies for the ease of reneging: demand density, market size, and the number of ready-mixed firms. The former two benefit from their exogeneity to the extent of integration, and density captures the physical proximity of downstream firms in a way that market size alone cannot. The number of concrete firms in the market, while obviously endogenous, is perhaps the most direct measure of alternative possibilities for a cement producer tempted to break a vertical supply contract.

We estimate a market-level regression using the market share of vertically integrated firms (i.e., the fraction of sales from integrated producers) as the dependent variable. Separate results by industry are obtained. As discussed above, we use different market definitions for the two industries: the smaller CEAs for ready-mixed concrete and EAs for cement. We report the results in Table 5.

The results indicate that market shares of integrated firms are larger in markets with higher demand density, in both the concrete and cement industries. We find the same correlation in direction and magnitude when market size is used instead to measure commitment problems. A greater number of ready-mixed firms in the market is also associated with more vertical integration, although the coefficient estimate is not statistically significant.[21]

On whole these results are consistent with the foreclosure model above, if our explanatory variables are good proxies for commitment problems faced by upstream suppliers. But here again, as with the above results showing integrated producers are more efficient, there is an alternative explanation. In very competitive markets, price elasticities are high (indeed one could argue this is a tautology). With high elasticities, the return to being a lower-cost producer

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[20] Of course, this effect could be balanced somewhat if it is also easier for ready-mixed firms to monitor their supplier's behavior in dense markets.

[21] We have also conducted plant-level regressions, not reported here, in a similar spirit. These estimated the probabilities that continuing plants become integrated by the next CM and that new plants enter as part of integrated firms as functions of our commitment proxies. We found similar qualitative results—integration is more likely in markets that are denser, larger, and have more concrete firms. The most robust of these results (across industries and for continuers and entrants) were those using demand density as the commitment proxy.

is larger, since being able to undercut competitors' prices will lead to larger gains in sales. Syverson (2004a, 2004b) argues that an important determinant of market competitiveness in ready-mixed is demand density (i.e., the amount of construction activity per unit area), because proximity to concrete producers is one of the primary determinants of concrete consumers' substitution opportunities. In markets that happen to have high demand density, then, we should expect producers' price elasticities to be higher, and the return to being lower cost greater. Integrating firms, which from above we know to have higher productivity levels, would therefore prefer to locate (either through buying existing plants or by building new ones) in denser markets. This, of course, is the pattern seen in the data.[22]

D. How Does Integration Affect Unintegrated Producers' Survival Prospects?

Foreclosure models predict that firms can use leverage afforded by vertical integration to force unintegrated rivals out of business. We visit that implication in this section by looking at how integration affects unintegrated producers' survival probabilities.

The first test directly compares exit probabilities across integrated and unintegrated producers. We simply estimate (1) using as the dependent variable an indicator dummy equal to one if the plant dies by the next census (i.e., does not show up in the following CM).[23]

The results are shown in Panel A of Table 6, columns 1 and 3. Integrated plants in both industries have higher survival rates than do their unintegrated competitors. The implied differences are substantial; the mean differences in exit rates are 0.057 in ready-mixed (that is, integrated concrete plants have a 5.7 percentage-point lower probability of exit) and 0.104 for cement. As a point of comparison, the unconditional exit probabilities across all plants in the two industries are 0.323 in the ready-mixed concrete industry and 0.199 for cement. Integrated cement producers, therefore, are only half as likely to die between censuses as the average plant.

These results match the predictions of foreclosure theory. But increased survival rates are also in accordance with the extensive evidence showing that more productive plants are less likely to exit (see, for example, Baily, Hulten, and Campbell (1992); Olley and Pakes (1996);

[22] The estimated positive influence of market size and the number of ready-mixed firms could arise from their correlation with density. Further, the number of concrete firms could well be itself a measure of market competitiveness.

[23] As a robustness check, we have also run probit exit models for all specifications in this section and found similar results.

Bartelsman and Doms (2000); Aw, Chen, and Roberts (2001); and Foster, Haltiwanger, and Syverson (2003)). We have already seen above that integrated plants have higher productivity levels. Therefore these survival-rate differences may reflect in part integrated producers' productivity advantages rather than success at strengthening their market power.

There may also be factors involved with being in a large firm that enhance survival probabilities but would not show up in plant-level TFP. For example, if multi-unit firms can more easily gather financial capital (either through internal transfers across plants or through increased access to external credit markets), plants in such firms are more equipped to ride out a temporary downturn than credit-constrained single-plant firms. The results in Dunne, Roberts, and Samuelson (1989) suggest there are such survival-enhancing elements inherent to belonging to a multi-unit firm. Note, however, that this influence on survival would not show up in standard plant-level TFP measures.[24]

To account for these factors, we add two covariates to the survival regressions: a dummy indicating that a plant belongs to a multi-unit firm, and plant TFPR. While all vertically integrated firms are multi-plant firms by definition, multi-plant firms need not be vertically integrated (and indeed most are not in the ready-mixed industry, as we shall further discuss below). The outcomes are in columns 2 and 4 of Panel A.

As can be seen, the coefficient on the vertical integration dummy shrinks in magnitude considerably and becomes insignificant. That is, the fact that vertically integrated plants are more likely to survive seems to arise because these plants happen to be in large firms and have relatively high productivity levels. This conditional equivalence is inconsistent with foreclosure theory, which implies there is a *per se* survival benefit of being vertically integrated. However, our proposed alternative "efficiency" based story of vertical mergers does not predict a differential impact of integration except through its correlation with productivity and size.

Next we look at the impact of vertical integration in a market on the survival prospects of unintegrated producers. Unlike the exercise above, which characterizes the differences in exit probabilities across producer types, this test asks whether the *quantity* of integrated production in a market impacts unintegrated producers' exit likelihoods. That is, we see whether unintegrated producers in markets with more (or larger) integrated firms are less likely to survive. We do so

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[24] Another possibility is that firm size reflects the long-run productivity values of its component plants (as suggested by the above literature), and size acts as a sort of "permanent TFP" measure.

by regressing an exit indicator on measures of the extent of integration in the market. We employ two such measures: the share of sales accounted for by vertically integrated firms and the total number of integrated firms operating in the market. These capture different margins along which integration can vary across markets; the former picks up growth of previously integrated firms as well as any increases in the number of VI firms, the latter focuses on extensive-margin growth. We also control for demand growth between the current and future CM and the TFP level of the unintegrated producer.

The results are in Panel B of Table 6. Even after controlling for market demand growth and the unintegrated plant's TFP level (higher levels of either imply a lower exit probability, as expected), unintegrated firms are more likely to exit in more integrated markets. The estimates suggest, for instance, that an additional VI firm in a market is associated with a 1.5 percentage point higher exit probability for unintegrated ready-mixed producers (recall the unconditional exit probability is 0.323). The results for the cement industry are more amorphous. While higher market shares for VI firms imply greater exit likelihoods for unintegrated plants, and the point estimates are commensurate with those in the ready-mixed results, the coefficient estimates are not statistically significant at the five percent level. Further, the coefficient on the number of VI firms is essentially zero.[25]

This second set of results does indicate that for unintegrated ready-mixed concrete producers at least, a larger presence of vertically integrated firms in the market makes survival less likely. Again this result is consistent with both the predictions of foreclosure theory and efficiency-driven integration. Foreclosure implies a larger presence of integrated competitors implies greater market power leverage can be applied to force the exit of unintegrated opponents. In the efficiency-merger case, more integration in a market implies a larger presence of more efficient competitors since integrated producers have higher productivity levels. This heightens competitive pressures on less productive unintegrated plants, making some no longer viable.

E. Integration and Cement Input Prices for Ready-Mixed Producers

Foreclosure models hold important implications regarding the relative input costs of

[25] We have also estimated a specification that compares exit probabilities to changes in integration, rather than initial levels. The results—which are available upon request—are similar for cement, but the significant and positive impact of higher integrated-firm market shares on unintegrated ready-mixed producer exit becomes negative and insignificant.

integrated and unintegrated producers. The ability to "raise rivals' costs" is a key element of the market power gain afforded by vertical integration in such models.

We are able, using CM Materials supplement data, to compute average unit prices paid by ready-mixed concrete plants for cement inputs. While the coverage of the materials supplement is not as comprehensive as the core CM, we still have over 8700 plant-level cement price observations available.

We perform two comparisons of these prices. The first uses specification (1) to compare average prices paid by ready-mixed producers for cement inputs across integrated and unintegrated plants in the same CEA-year. The results are shown in the first numerical column of Table 7. As can be seen, there is no discernable difference between the cement unit prices reported by integrated and unintegrated producers.

The second test measures what happens to the prices paid for cement when ready-mixed plants become vertically integrated. As with the above specifications that look at changes in productivity, size, employment, and capital intensity upon integration, we compare cement input price growth in newly integrated plants to those in the same market who remain unintegrated. The rightmost column of the table reports the outcomes. Again, we observe no noticeable difference in those plants that become integrated.[26]

These tests find no systematic differences in cement input costs across integrated and unintegrated ready-mixed producers. However, we would like to emphasize that these results should be interpreted with caution. It is far from clear what the reported transfer prices from integrated concrete makers reflect. The Census Bureau instructs establishments to report the value of internal materials transfers (recall that our unit prices are computed as the ratio of expenditures to quantities of use for specific intermediate materials), "at their full economic value (the value assigned by the shipping plant, plus the cost of freight and other handling charges)." It is possible that the results above simply reflect accurate "marking to the market" of internal transfer prices by integrated plants.[27]

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[26] We have also looked at what happens to the cement prices faced by unintegrated continuers face when the markets in which they operate become more integrated (measured again by either growth in the market share or number of vertically integrated firms). Regressions of cement price changes on changes in integration (controlling for demand growth) yielded positive but insignificant coefficients: 0.011 (0.109) in the change-in-market-share specification and 0.020 (0.019) for the change-in-number regression.

[27] One fact that may be helpful in this regard is that integrated concrete producers do not always buy all of their cement in house, so that the reported values may in part be based on actual market prices faced by those plants.

F. Extent of Integration and Market Power

Perhaps the most important prediction of the foreclosure theory is that vertical integration will be accompanied by market power in the downstream market. This occurs either directly through vertical integration's facilitating upstream producers' quantity restriction commitments, or indirectly through the forced exit or decreased entry of unintegrated competitors in the upstream market. Therefore concrete consumers in markets where producers are integrated should, all else being equal, suffer from greater exertion of market power by suppliers. In this section we look in various ways at how the presence of vertical integration impacts ready-mixed concrete prices, quantities of concrete sold, and entry rates in both the cement and concrete industries.

F.1. Prices and Quantities

We first regress the (log of the) quantity-weighted average ready-mixed concrete price in a market—calculated from our plant-level price data—on the two extent-of-integration measures also used above: the total market share and number of vertically integrated firms operating in the market. (Results using a simple rather than weighted average were similar to those reported here.) Because Syverson (2004b) shows that competition-driven selection and lower markups imply lower average prices in dense markets, we also include market demand density as a covariate in the regressions. Controlling for density is especially important because, as shown above, vertical integration is more likely in dense markets. Failing to include density separately in the regression would attribute some of density's own impact on prices to the influence of vertical integration instead.

The results are shown in the first two numerical columns in Panel A of Table 8. It is apparent that more integrated markets have lower average prices, even controlling for demand density. The estimates imply that going from a market with no integrated producers to one where integrated firms hold a market share of 0.316 (the average share conditional upon at least one VI producer being in a market) corresponds to a decline in the average ready-mixed price of

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Unfortunately, we are unable to address this in detail because we cannot separate input purchases based on the supplier (nor for that matter are we able to identify the specific buyers of output from integrated cement producers). We are exploring the possibility of backing out the true cement costs faced by integrated producers using the data available on cost shares and total costs.

4.1 percent, or just under one-fourth of its across-market standard deviation. Likewise, the estimates imply an additional integrated firm in the market corresponds to a 3 percent drop in average prices. Note as an aside that denser markets have lower average prices, as found in Syverson (2004b); here it holds even when controlling for integration intensity.

These results are not on their face consistent with foreclosure theory. However, if there are market-specific unobservables correlated with both integration intensity and lower prices, the results above could obtain even if integration has no actual negative price impact (though any correlation with unobservables would have to be particularly strong for a foreclosure-driven positive price effect to still yield negative coefficient estimates). Therefore we estimate the same specification including market fixed effects. The results are shown in columns 3 and 4 of Panel A. The negative correlations between average prices and the extent of integration remain, though the coefficients have smaller magnitudes and lose their statistical significance.[28]

We look at plant-level patterns in concrete prices in Panel B. The first numerical column shows the results from estimating (1) using plants' (logged) concrete prices. On average, integrated producers' ready-mixed prices are a statistically significant 2.1 percent lower than unintegrated producers in the same market. The second column shows the price change (relative to unintegrated continuers in the same market) of continuing plants that become integrated. These newly integrated plants have slightly—1.4 percent—more positive price changes than their cohorts that remain unintegrated, but the difference is not statically significant. The third and fourth columns contrast the prices of integrated entrants to unintegrated entrants and unintegrated incumbents, respectively (all comparisons are again within market-year). As with the broader comparison in the first column, integrated producers' have lower prices than the unintegrated comparison groups. The implied prices differences also have roughly the same magnitude, but the smaller sample sizes make the estimates insignificant.

These price comparisons, both at the market and plant level, indicate no connection between greater vertical integration and higher prices. This is in stark contrast with the prediction of foreclosure theory. However, greater market power not only implies higher prices,

[28] The alert reader may notice that within-market *growth* in demand density weakly implies higher prices, while differences in density levels across markets are negatively related to prices. This is because the competition-driven selection effects creating the negative correlation are long-run effects, and thus show up in the cross section. Changes in density between CMs, however, are short-run increases in demand and act to drive prices up in the immediate term.

but lower quantities as well. We see whether or not this is the case using similar specifications to the average market price tests above, but replacing the average price with the total market quantity sold as the dependent variable. Here we must be particularly careful with regard to measurement issues. Because the CM Product supplement is not comprehensive, we cannot calculate total market quantities directly simply by adding across market plants. We instead utilize revenue data, which is available for all plants. Yet revenue data alone is insufficient to accurately measure market quantities because it incorporates price variation across plants. This fact remains even though we adjust revenues across years to 1987 dollars using an industry-level price index. Because this deflator is not market specific, our unadjusted revenue measure would overstate (understate) output in markets with higher (lower) than average prices. Therefore we measure the total quantity of ready-mixed sold in a market as total market revenues divided by the market's quantity-weighted average price used in the above regressions.

As with the average ready-mixed prices above, we regress this market-level quantity data (in logs) on the market share and number of vertically integrated firms in the market. The only other difference in this specification is that density is replaced with our market demand measure, logged total construction sector employment. This change is made given the conceptual necessity of controlling for overall market scale when looking at quantity effects and a lack of theoretical argument for including density itself. Again as with the price regressions, we estimate specifications both excluding and including CEA fixed effects.

The results are presented in Panel A of Table 9. Contrary to the prediction of vertical foreclosure, greater vertical integration implies more output. This is true both in the cross section and in response to changes in integration within markets. The implied effects are sizeable. According to our estimates, a market where integrated firms have a 0.316 market share has roughly 18 percent more output than one of the same size with no integrated producers. Adding another vertically integrated firm to a market also raises total ready-mixed quantities by 7 percent.

Once again, we complement the market-level results with plant-level analysis. Panel B contrasts physical outputs of integrated producers with those of various comparison groups. The first column shows that integrated ready-mixed producers have considerably higher concrete output levels than their unintegrated competitors in the same market. However, as seen in the revenue comparisons above, ready-mixed plants that become integrated actually *shrink* output (some 18 percent) relative to unintegrated continuers. This is balanced in part, though, by the fact that new integrated plants are larger than both unintegrated entrants and incumbents. This can be seen in the estimates in the two rightmost columns.[29]

While using within-market variation helps relieve concerns about unobservables correlated with integration, prices, and quantities driving the results, we intend to go still further in future versions of the paper. Specifically, we will use the variation in antitrust authorities' enforcement regimes discussed above to instrument for the extent of integration in a market. The logic is as follows. From 1967 to 1977, the FTC operated under an announced policy of challenging any vertical merger involving ready-mixed concrete firms that were one of the four largest in their market or that used over 50,000 barrels of cement per year. This hard-and-fast rule was dropped in 1977, and as mentioned above, virtually all vertical merger challenges stopped after 1981. Naturally, the combined market share of firms fitting the FTC's guidelines will vary across markets for reasons likely unrelated to equilibrium prices (or at least that are independent of prices conditioning on market density). We can use this variation both in the cross section and in time series as an exogenous shifter in the extent of integration; conditioning on density, one would expect markets with a high combined market share of such firms to be less integrated in 1967 and 1972 than in other years and other markets with lower shares.

Preliminary results obtained with this instrumental variables strategy are reported in Table A1. Save for one coefficient (the average-price specification using the market share of VI firms to measure the extent of market integration and without fixed effects), the signs of the estimates remain as before: greater integration—either across or within markets—implies lower average prices and higher quantities. Of course, we do lose precision in the estimates with the instrumental variables approach; the standard errors are larger than before and most of the estimates statistically insignificant (including the positive estimate from the average price

[29] The net expected output change due to the entry of a new integrated firm into a market, then, depends on the difference between the opposing output reductions of newly acquired plants and the additional output from newly built plants. In a separate regression not reported here, we look at this overall impact by comparing the total growth in market revenue due to a new integrated firm in the market (that is, the total real revenues of its acquired and newly built plants minus the acquired plants' real revenue in the previous CM) to the real revenue growth of continuing firms in the same market. We find that the former is substantially larger than the latter; new VI firms raise total market sales at rates greater than do incumbents.

regressions). However, the two that are significant are consistent with the benchmark results in Tables 8 and 9.[30]

The price and quantity tests described here suggest quite strongly that vertical integration does not facilitate the exercise of market power in the cement and ready-mixed industries. Average prices are lower and quantities sold greater in more integrated markets (measured either by the market share or number of VI firms), even controlling for market-level density and size. These patterns also hold with regard to changes in the extent of integration within markets. Producer microdata offer similar results: vertically integrated plants sell more and charge lower prices on average than their unintegrated competitors in the same markets, and the net impact of the entry of a vertically integrated firm into a market is positive because the decline in output from acquired plants is compensated by additional output from newly built plants.

F.2. Entry

Even if there is no apparent increase in prices or quantities in the market, a vertical merger may lead to higher entry barriers, as suggested by the FTC Report and some foreclosure models. These could have important long-run effects on market structure and welfare. We turn to the link between entry and vertical integration here.

We compute two types of entry rates for each market. One is plant based and is calculated as the number of new entrants in the market divided by the average number of plants over the current and previous census. Using the average number of establishments in the denominator rather than just the value from the previous census is advantageous because it bounds entry rates at two rather than infinity (while still being a monotonic transformation of the more traditional rate measure). This reduces the influence of observations from small markets that would otherwise have infinite or extremely high computed entry rates.[31]

The second entry rate is firm based. Here the definitional issues are more complex. Unlike establishments, which are geographically unique, firms can operate in several markets.

[30] We also estimated market price effects on the subsample of CEA-years that were involved in multi-market mergers. The idea, as with Gilbert and Hastings (2002), is to use arguably random variation in the extent of integration across the several markets experiencing a single-firm merger event to identify integration's impacts. We include merger-episode fixed effects (there are dozens of multi-market mergers over our observation period) to isolate this source of variation. We find, in results not reported here, further support for the above results: greater integration is correlated with lower average ready-mixed prices (though the estimates are too imprecise to be statistically significant).

[31] We also weight by market demand in our regressions to further adjust for the small-market effect.

We must therefore take a stand on how to treat entry of existing firms into new geographic markets. For example, if a company that has operated in Texas for fifteen years builds a plant in Ohio, is that entry? We consider it as such, because of the highly geographically segmented nature of these industries' product markets. Note that this entry could occur either through the firm building a new plant or by purchasing an existing one; that is, a market could experience no establishment entry but would experience firm entry. The implied entry rates for a market are simply the number of entry episodes divided by the average number of firms operating in the market across the past two censuses.

The empirical specification is straightforward and similar to the market-level integration regressions run above. We regress the market-year entry rate on the extent of vertical integration in the market, measured by the market share of vertically integrated establishments. We run these specifications separately by industry, and again define CEAs as the relevant markets for ready-mixed concrete and EAs for cement. We also estimate effects for overall entry rates (including both integrated and unintegrated producers) and for unintegrated producers alone.

The results are presented in Table 10. Panel A reports those corresponding to overall entry rates. As can be seen, overall plant and firm entry rates are higher in markets where integrated firms have a larger market share. This is true for both industries, though the differences are only large enough to be statistically significant in the case of ready-mixed firm entry rates.

The effect of integration on the entry rates of unintegrated producers is murkier. Here, the coefficients are of mixed signs and are in all cases insignificant. Going by point estimates alone, the data show lower establishment-level entry rates and higher firm-level entry rates for unintegrated ready-mixed producers. Perhaps this reflects that fact that nonintegrated firms still enter markets with integrated competitors at the same rates, but they do so with fewer plants. The converse pattern holds in the cement industry. Given the imprecision of the estimates, however, these explanations are speculative.[32]

On whole, these findings offer little evidence to support the foreclosure notion that an increase in vertical integration is associated with lowered entry into a market. Overall entry rates

[32] We have estimated these entry specifications including market fixed effects, as well as a set that instrument for integrated-firm market share using the "FTC rule" instruments discussed above. In every case the extent-of-integration coefficients are positive regardless of the entry rate.

increase, if anything, and there are no statically discernable impacts on entry rates of unintegrated producers in either industry.

V. Discussion

The patterns we have documented so far yield what are at best mixed results for the predictions of foreclosure theory. We do find that vertically integrated plants in both industries are more productive than their unintegrated counterparts, and unintegrated producers are more likely to exit. These implications can be drawn from the archetypal Hart and Tirole (1990) foreclosure model outlined above. However, there are several patterns not consistent with the predictions of the theory: exit rates of integrated and unintegrated producers are not lower once we adjust for multi-unit firm status and plant TFP levels, average prices are lower and total quantities larger in less integrated markets, average prices fall and quantities increase within markets when they become more integrated, and there is no evidence that entry rates are systematically different across markets with differing presences of integrated producers. The contradictions regarding market prices, quantities, and entry rates are perhaps the most important from the standpoint of evaluating the impact of vertical integration on social welfare. They do not suggest that integrating has given more market power to the integrators; indeed, if anything integration has accompanied reductions in market distortions.

We have suggested throughout the discussion of the results that an alternative mechanism *is* consistent with all of the empirical patterns. It is well documented that more productive plants are larger, more likely to grow, have better survival prospects, are more likely to operate in more competitive markets, and tend to pass on to their customers their cost advantages in the form of lower prices.[33] If efficient firms also happen to be more likely to integrate, then, all of the results seen above will obtain. Plants purchased by integrating firms will become more efficient.[34] New plants in integrated firms will have higher productivity levels and be larger. Integrated firms will take over market share and force out smaller, less efficient unintegrated rivals (though not equally efficient plants in multi-unit firms). Entry rates may not be impacted if technological

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[33] See, for example, Aw, Chen, and Roberts (2001); Baily, Hulten, and Campbell (1992); Bartelsman and Doms (2000); Foster, Haltiwanger, and Syverson (2003); Olley and Pakes (1996); Roberts and Supina (1996); and Syverson (2004a, 2004b).

[34] McGuckin and Nguyen (1995) also find that plant ownership changes are associated with labor productivity growth, although they do not focus on vertical acquisitions.

entry costs are unchanged. Prices will be lower and quantities higher in more integrated markets. Prices will fall with more extensive integration within a market, and quantities will rise.[35]

Of course, this alternative explanation offers new questions of its own. What are the productivity gains that efficient cement firms can pass on to their newly integrated ready-mixed plants? Ready-mixed is a business where logistics is important; deliveries of a perishable product are desired by time-sensitive buyers in many locations, often simultaneously. If a central coordinating body could improve dispatch efficiency, this might explain why plants belonging to large vertically integrated firms become more productive. This may also be reflected in the fact seen above that vertically integrated plants have lower nonproduction employee shares than do unintegrated plants; a single worker could be able to handle the coordinated logistics of several plants that were handled separately (by separate workers) before integration. This begs the question, however, why cement firms need to be the coordinating body. What is special about cement?

A possible answer is that there *isn't* anything special about cement, at least with regard to coordinating logistics. There has been considerable consolidation in the U.S. ready-mixed industry during our period of observation. In 1963, 3999 firms owned 4621 ready-mixed plants, but by 1997, only 2898 firms owned 5252 plants. However, much of this consolidation came through horizontal mergers of ready-mixed firms rather than vertical cement-concrete pairings. The fraction of ready-mixed plants that were part of multiple-unit firms more than doubled between 1963 and 1997, from 24.8 to 55.6 percent. Since the corresponding fractions of vertically integrated plants were 1.8 and 10.6 percent (see Table 1), clearly horizontal integration is the more common form of consolidation, and the majority of merged plants have folded into firms without cement divisions. Coordination and its possible efficiency gains, therefore, have not been exclusive to vertically integrated firms. Coordination may depend more on the size of the organizing body than its industry background.[36]

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[35] A second reason these last results may obtain is the elimination of double marginalization made possible through vertical integration. In future versions, we plan to estimate the extent of the gain from eliminating double marginalization. Theoretically, removing this market distortion should not be reflected in TFP, since it does not affect technologies. This presents a possible empirical strategy for gauging the relative sizes of the marginalization and productivity effects.

[36] That is not to say that a large firm in *any* industry could harness coordinating economies, of course. But cement shares a final demand sector with ready-mixed and the two industries do have other key elements in common, such as the prominence of logistical concerns.

Regardless of the technological source of the productivity gains, it is apparent that encroachment by an integrated firm into a market is likely to raise productivity. Integrated firms do this in two ways: by shrinking both outputs and inputs, but the latter more than the former, among continuing plants; and reallocating this output to newly built plants that are not only more productive than new unintegrated plants but unintegrated incumbents as well.

This raises another question about a productivity-survival-reallocation explanation for the observed patterns. Why would cement producers entering the concrete industry bother to purchase existing plants if only to shrink them and shift output to new plants? Seemingly, they could simply build more (or larger) new plants when entering. We speculate that perhaps the value of these pre-existing plants is tied up not in their productive capacities but in their intangible capital. Despite the physical homogeneity of the output, there are important services that come bundled with ready-mixed (such as timely delivery) that differentiate producers from one another. These may also benefit from and facilitate the formation of long-term working relationships between concrete producers and construction firms. These links built with customers form the intangible capital stock of the ready-mixed firm. Therefore, by buying pre-existing plants, a forward-integrating cement producer buys these connections that would otherwise be more costly (or with less certain return) to build from scratch. There is some suggestive evidence for this notion. In his testimony before FTC investigators, the president of National Portland Cement Co. stated that acquiring an existing ready-mixed business is easier than entering from scratch, since "The ready-mixed business, as we analyze it, is a very personal type of business and the operators develop personal relationships with contractors over many, many years. To go in and go through developing those relationships on the part of a newcomer would assure you that you are going to lose money for 3, 4, 5 years."[37] Having obtained the valuable capital of the acquired firm, the integrated producer lowers utilization of the acquired firms' less useful physical capital and replaces it with its own by building new plants.[38]

These explanations are, at best, built on circumstantial evidence, but they do involve what

[37] FTC (1966), p. 106. The same report also quotes the testimony of an Alpha Portland Cement Co. executive who claimed that entry by his company into ready-mixed production would require an initial investment of $3-$5 million (1966 dollars) and up to 5 years would be required to establish securely in the market.

[38] An interesting possibility that we plan on testing in a future revision is that the acquiring cement firm realigns the geographic pattern of output between the plants of the acquired firm and its own newly constructed establishments. Specifically, whether the acquirer shrinks the pre-existing firms operating in relatively slow construction areas of the CEA and builds new plants in whatever the high-demand areas happen to be in the CEA.

are in our opinion interesting economic questions. We see further in-depth analyses into these issues as being a ripe area for future research.

VI. Concluding Remarks and Ongoing Work

Our empirical results from the cement and concrete industries so far do not support vertical foreclosure theories. One should, of course, be very careful in trying to generalize these results to other industries and/or markets. Vertical integration decisions of firms are driven by many different considerations, of which vertical foreclosure may or may not be one. Our study is an attempt to study the long term effects of the decision to integrate in this particular industry, utilizing the abundance of plant level data and large variation across time and across many geographically separate markets.

An important caveat that we are trying to address in ongoing work is the endogeneity of vertical integration decisions. As described in section IV.F.1, one can utilize "mechanical" policy rules imposed by the FTC specific to mergers in this industry during the 1967-1977 period as a source of exogenous variation in the likelihood of merger between cement and concrete firms. Preliminary results using such instruments in the market-level average price and quantity regressions were reported above in Section F.1.

We also plan to provide additional supporting evidence for the alternative (to foreclosure) explanation we provide in Section V as to what we believe has transpired in this industry. Specifically, we will investigate whether the impact of other types of mergers on plant-level and market-level outcome variables are similar to the effects we have estimated for vertical mergers. These other types of mergers include horizontal mergers and acquisitions of ready-mixed plants by firms who were previously in neither the cement or RMC industries. Horizontal mergers, of course, can very well be driven by market power concerns. However, if the primary reason for acquisitions is efficiency, we should expect to find little difference across the outcomes of vertical mergers as opposed to other types of mergers. We are currently in the process of identifying instances of these other acquisition types to conduct these tests.

Data Appendix

We describe here details on the construction of our production variables.

Labor Hours. Production worker hours are reported directly in the CM microdata. This value is then scaled up to total hours by multiplying by the ratio of total employees to production workers. This assumes, in essence, that non-production worker hours equal production worker hours within plants.

Capital Stocks. Equipment and building capital stocks are plants' reported book values of each capital type deflated by the book-to-real value ratio for the corresponding three-digit industry. (These industry-level equipment and structures stocks are from published Bureau of Economic Analysis data.) Any reported machinery or building rentals by the plant are inflated to stocks by dividing by the type-specific rental cost from Bureau of Labor Statistics data (CITATION HERE). The total productive capital stock k_{it} is the sum of the equipment and structures stocks.

Real Materials and Energy Use. Materials and energy inputs are simply plants' reported expenditures on each divided by their respective industry-level deflators from the National Bureau of Economic Research Productivity Database.

Labor Productivity. We measure labor productivity as plant output per worker-hour, where output is the real value of shipments and hours are constructed as above.

Total Factor Productivity (Revenue- and Physical-Quantity-Based). We measure productivity using a standard total factor productivity index. Plant TFP is computed as its logged output minus a weighted sum of its logged labor, capital, materials, and energy inputs. That is,

$$TFP_{it} = y_{it} - \alpha_{lt} l_{it} - \alpha_{kt} k_{it} - \alpha_{mt} m_{it} - \alpha_{et} e_{it} ,$$

where the weights α_j are the input elasticities of input $j \in \{l, k, m, e\}$. While inputs are plant-specific, we use industry-level input cost shares to measure the input elastiticies.[39] These cost shares are computed using reported industry-level labor, materials, and energy expenditures from the NBER Productivity Database (which is itself constructed from the CM). Capital expenditures are constructed as the reported industry equipment and building stocks multiplied by their respective capital rental rates in cement and ready-mixed concrete's corresponding two-digit industry.[40]

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[39] Implicit in this index is a potentially important assumption, that returns to scale are constant. If the scale elasticity were instead different from one, each of the input elasticities α_j should be multiplied by the scale elasticity. In earlier work, Syverson (2004a) finds that returns to scale in ready-mixed concrete are essentially constant. In future versions, we will test for robustness the results regarding cement plant productivity.

[40] Capital rental rates are from unpublished data constructed by the Bureau of Labor Statistics for use in computing their Multifactor Productivity series. Formulas, related methodology, and data sources are described in U.S. Bureau of Labor Statistics (1983) and Harper, Berndt, and Wood (1989).

For both industries, we construct TFP measures using plants' reported revenues (deflated to 1987 dollars using price indexes from the NBER Productivity Database) as an output measure. This is the standard measure used in the literature. However, for ready-mixed plants when data is available, we also construct a TFP measure based on the plant's physical output (taken from the CM Product Supplement). This removes the influence of within-industry price variation on the output measure. We denote our revenue-based productivity measures TFPR and physical-output- (quantity-) based total factor productivity is called TFPQ.

We must make one adjustment to the output data when computing TFPQ. Since ready-mixed plants can produce multiple products (though most do not, as discussed above), but inputs are reported on an establishment-wide rather than product-specific basis, we must impute the share of inputs allocated to ready-mixed production in multi-product plants. We do so by dividing reported ready-mixed output by its share of total establishment sales. This adjustment method in effect assumes inputs are used proportionately to each product's revenue share. (For example, a plant producing 1000 cubic yards of ready-mixed concrete accounting for 80 percent of its revenues will have the same TFP as a completely specialized plant producing 1250 cubic yards with same measured inputs.)

Output and Factor Prices. We use product-level revenue and physical production and consumption data from the CM Product and Materials Supplements to compute ready-mixed plants' unit concrete output prices and cement factor input prices. We then adjust these to a common 1987 basis using the corresponding four-digit-industry-level shipments deflators from the NBER Productivity Database.

There are two important notes regarding these calculated unit prices. First, the value of shipments (sales revenue) data is collected on a free-on-board basis, i.e., exclusive of any shipping costs. Prices should reflect not the delivered cost of the ready-mixed but rather what one could buy it for at the plant gate. Second, the unit prices are annual averages. This can be shown to be equivalent to a quantity-weighted average of all transaction prices charged by the plant during the year. We do not observe product-specific data for administrative record (AR) plants, so they are dropped from the analysis as in the core sample. We also remove a small number of gross outliers having prices greater than five times or less than one-fifth the median in a given year, and limit the sample to those plants with ready-mixed sales accounting for over one-half of yearly revenues. (This sample criterion is not very restrictive in practice; most ready-mixed producers are specialists.) Finally, we attempt to exclude any non-AR plants who have (mostly because of incomplete reporting) physical quantities imputed by the Census Bureau. Unfortunately, these imputes are not flagged. To distinguish and remove imputed product-level data from the sample, we use the techniques described in detail in Roberts and Supina (1996) and Foster, Haltiwanger, and Syverson (2003).

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Table 1. Evolution of Vertical Integration in the Cement and Ready-Mixed Concrete Industries

Year	1963	1967	1972	1977	1982	1987	1992	1997
Percentage of cement plants that are vertically integrated	21.9	47.4	41.9	34.8	32.5	35.2	49.5	30.5
Percentage of cement sales from vertically integrated producers	25.2	51.2	48.4	41.0	49.5	51.3	75.1	55.4
Percentage of ready-mixed plants that are vertically integrated	1.8	3.2	3.8	3.1	3.0	5.5	11.1	10.6
Percentage of ready-mixed sales from vertically integrated producers	6.1	8.9	10.0	8.7	8.5	11.3	14.4	14.2

Table 2: Predictions Regarding Consequences of Vertical Mergers

	FTC (1966)	"Chicago School"	Hart and Tirole (1990) "ex-post monopolization"	Hart and Tirole (1990) "scarce needs"
Integration incentive stronger for:		more efficient U & D firms	more efficient U firm	more efficient D firm
Merger is more likely in markets where:	there is excess capacity	returns to cost savings are highest	"commitment" problem is more severe	
Exit of unintegrated downstream firm	more likely		more likely	
Exit of unintegrated upstream firm	more likely		more likely	
Intermediate good quantity (sold to unintegrated downstream firm)	decreases	no change?	decreases	decreases
Intermediate good price (sold to unintegrated downstream firm)	increases		increases	increases
Final good price	increases	can decrease	increases	increases
Final good output	decreases	can increase	decreases	decreases
Entry into downstream market	less likely		less likely	
Entry into upstream market	less likely		less likely	

Table 3. Within-Market Differences Between Integrated and Unintegrated Producers

A. Ready-Mixed Concrete

	Labor Prod.	TFPR	TFPQ	Real Revenue	Total Emp.	Total Hours	Nonprod. Worker Ratio	Capital-Labor Ratio
N	31,091	18,017	8555	31,801	31,516	31,105	31,511	18,720
R^2	0.217	0.174	0.307	0.213	0.167	0.165	0.180	0.330
Vertically Integrated	0.291*	0.028*	0.043*	0.272*	0.010	0.040	-0.018*	0.102*
	(0.019)	(0.009)	(0.014)	(0.034)	(0.033)	(0.034)	(0.007)	(0.030)

B. Cement

	Labor Prod.	TFPR	Real Revenue	Total Emp.	Total Hours	Nonprod. Worker Ratio	Capital-Labor Ratio
N	1447	875	1454	1450	1447	1450	885
R^2	0.564	0.495	0.558	0.581	0.571	0.498	0.550
Vertically Integrated	0.093*	-0.002	0.788*	0.623*	0.645*	-0.028*	0.261*
	(0.044)	(0.046)	(0.108)	(0.099)	(0.099)	(0.011)	(0.095)

Notes: This table report differences in key dependent variables (listed at the head of each column) across integrated and unintegrated producers in the ready-mixed concrete and cement industries. The reported coefficients are those for an indicator variable denoting that a plant is in a vertically integrated firm. Market-year fixed effects are included in all specifications. An asterisk denotes significance at five percent.

Table 4. Becoming Integrated: Ready-Mixed Concrete Continuers and Entrants

A. Continuers (conditioning on being unintegrated in previous CM)

Growth of:	Labor Prod.	TFPR	TFPQ	Real Revenue	Total Emp.	Total Hours	Nonprod. Worker Ratio	Capital-Labor Ratio
N	15,935	8608	2439	16,375	16,290	15,949	16,287	9175
R^2	0.194	0.212	0.419	0.275	0.204	0.235	0.182	0.189
Newly Integrated	0.104*	0.024	0.101	-0.406*	-0.402*	-0.445*	-0.029	0.018
	(0.049)	(0.025)	(0.055)	(0.060)	(0.062)	(0.064)	(0.022)	(0.076)

B. Integrated Entrants Compared to Unintegrated Entrants

	Labor Prod.	TFPR	TFPQ	Real Revenue	Total Emp.	Total Hours	Nonprod. Worker Ratio	Capital-Labor Ratio
N	8182	5511	2183	8,511	8376	8188	8375	5779
R^2	0.326	0.348	0.395	0.327	0.314	0.313	0.330	0.420
Vertically Integrated	0.326*	0.054*	0.035	0.139	-0.131*	-0.129	-0.043*	0.267*
	(0.045)	(0.020)	(0.041)	(0.076)	(0.070)	(0.075)	(0.014)	(0.068)

C. Integrated Entrants Compared to Unintegrated Incumbents

	Labor Prod.	TFPR	TFPQ	Real Revenue	Total Emp.	Total Hours	Nonprod. Worker Ratio	Capital-Labor Ratio
N	17,602	12,014	5970	17,870	17,781	17,609	17,778	12,435
R^2	0.240	0.205	0.349	0.231	0.196	0.197	0.226	0.380
Vertically Integrated	0.359*	0.040*	0.045	-0.281*	-0.517*	-0.521*	-0.066*	0.261*
	(0.038)	(0.017)	(0.028)	(0.062)	(0.058)	(0.062)	(0.012)	(0.057)

Notes: This table reports differences in key dependent variables (listed at the head of each column) across integrated and unintegrated producers. Panel A compares growth rates across integrated and unintegrated continuers (plants that survive for two consecutive CMs). Panel B compares integrated and unintegrated entrants (plants appearing in their first CM). Panel C compares integrated entrants to unintegrated incumbents. Market-year fixed effects are included in all specifications. An asterisk denotes significance at five percent.

Table 5. Propensity to Integrate and Ease of "Reneging"

	Concrete			Cement		
	[1]	[2]	[3]	[4]	[5]	[6]
N	1734	1734	2768	440	440	700
R^2	0.054	0.051	0.034	0.063	0.062	0.067
Demand Density	0.021*			0.021*		
	(0.004)			(0.004)		
Total Demand		0.025*			0.025*	
		(0.006)			(0.006)	
ln(# of concrete firms)			5.40e-3			2.33e-3
			(4.45e-3)			(7.89e-3)

Notes: The dependent variable is the total market share of vertically integrated firms. Demand density is measured as the (log of) the number of construction-sector workers per square mile in the market. Total demand is logged construction workers. Ready-mixed concrete market is defined as a CEA; cement markets are EAs. See text for details. Standard errors are clustered by market. An asterisk denotes significance at five percent.

Table 6. Integration and Exit Probabilities

A. Likelihood of Exit Across Integrated and Unintegrated Plants

	Concrete		Cement	
	[1]	[2]	[3]	[4]
N	35,075	24,072	1412	980
R^2	0.085	0.097	0.452	0.483
VI dummy	-0.057*	-0.011	-0.104*	-0.010
	(0.013)	(0.015)	(0.034)	(0.040)
MU dummy		-0.093*		-0.254*
		(0.007)		(0.059)
TFPR		-0.052*		-0.022
		(0.013)		(0.056)

Notes: The dependent variable is a dummy indicating plant exit by next CM. Market-year fixed effects are included in all regressions. An asterisk denotes significance at five percent.

B. Unintegrated Producers' Exit Probabilities and the Extent of Integration in the Market

	Concrete		Cement	
	[1]	[2]	[3]	[4]
N	18,412	22,759	481	481
R^2	0.003	0.004	0.041	0.036
Mkt Sh. Of VI Firms	0.109*		0.110	
	(0.039)		(0.074)	
Number VI firms		0.015*		-0.001
		(0.005)		(0.013)
Future Demand	-0.036*	-0.038*	0.024	0.028
Growth	(0.014)	(0.014)	(0.075)	(0.077)
TFPR	-0.071*	-0.072*	-0.016	-0.022
	(0.015)	(0.015)	(0.047)	(0.047)

Notes: The dependent variable is a dummy indicating plant exit by the next CM. The sample is restricted to non-VI plants. Standard errors clustered by market. An asterisk denotes significance at five percent.

Table 7. Integration and Cement Input Prices for Ready-Mixed Producers

	Within-market price difference between all integrated and unintegrated	Change in price for continuing plants
N	8718	3131
R^2	0.562	0.556
Vertically Integrated Dummy	0.005	-0.008
	(0.007)	(0.026)

Notes: This table shows comparisons in prices for cement inputs reported by integrated and unintegrated ready-mixed producers. Market-year fixed effects are included in all regressions. An asterisk denotes significance at five percent.

Table 8. Integration and Ready-Mixed Concrete Prices

A. Market-level price regressions—dependent variable is quantity-weighted average ready-mixed price in market

	[1]	[2]	[3]	[4]
N	1567	1567	1567	1567
R^2	0.053	0.063	0.439	0.437
Mkt Sh. Of VI Firms	-0.129*		-0.073	
	(0.028)		(0.049)	
Number VI firms		-0.030*		-0.006
		(0.006)		(0.011)
Density	-0.014*	-0.013*	0.034	0.034
	(0.005)	(0.005)	(0.020)	(0.020)
Market Fixed Effects	No	No	Yes	Yes

B. Plant-level price regressions

	Within-market price difference between all integrated and unintegrated	Change in price for continuing plants	Within-market price difference between integrated and unintegrated entrants	Within-market price difference between integrated entrant and unintegrated incumbents
N	12,656	4025	2999	7360
R^2	0.437	0.453	0.600	0.429
Vertically Integrated	-0.021*	0.014	-0.028	-0.020
	(0.006)	(0.035)	(0.017)	(0.012)

Notes: This table shows the impact of integration on ready-mixed concrete prices. Panel A shows the results of regressing the quantity-weighted average ready-mixed price in a market on measures of the extent of vertical integration in the market, the market's demand density, and market (CEA) fixed effects in some cases. Standard errors are clustered by market. Panel B compares plant-level prices across various sets of integrated and unintegrated producers. Market-year fixed effects are included in each of the panel's specifications. An asterisk denotes significance at five percent.

Table 9. Integration and Ready-Mixed Concrete Quantities

A. Market-level quantity regressions—dependent variable is total physical units of concrete sold in market

	[1]	[2]	[3]	[4]
N	1567	1567	1567	1567
R^2	0.775	0.783	0.911	0.91
Mkt Sh. Of VI Firms	0.583*		0.159	
	(0.109)		(0.169)	
Number VI firms		0.169*		0.070*
		(0.022)		(0.031)
Demand	0.845*	0.798*	0.457*	0.452*
	(0.020)	(0.021)	(0.107)	(0.105)
Market Fixed Effects	No	No	Yes	Yes

B. Plant-level physical quantity regressions

	Within-market quantity difference between all integrated and unintegrated	Change in quantity for continuing plants	Within-market quantity difference between integrated and unintegrated entrants	Within-market quantity difference between integrated entrant and unintegrated incumbents
N	12,656	4025	2999	7360
R^2	0.361	0.457	0.528	0.371
Vertically Integrated	0.480*	-0.175	0.349*	0.047
	(0.046)	(0.096)	(0.112)	(0.083)

Notes: This table shows the impact of integration on ready-mixed concrete quantities. Panel A shows the results of regressing the total market quantities (measured in logged thousands of cubic yards) on measures of the extent of vertical integration in the market, a market demand measure (logged construction sector workers), and market (CEA) fixed effects in some cases. Standard errors are clustered by market. Panel B compares plant-level physical quantities across various sets of integrated and unintegrated producers. Market-year fixed effects are included in each of the panel's specifications. An asterisk denotes significance at five percent.

Table 10. Integration and Entry Rates

A. Overall entry rate = number of entrants ÷ avg. in market over last two CMs

	Concrete		Cement	
	Plant-level entry rate	Firm-level entry rate	Plant-level entry rate	Firm-level entry rate
N	1386	1386	312	312
R^2	0.050	0.047	0.118	0.046
mkt. share of integrated	0.057	0.155*	0.020	0.054
firms in base year	(0.044)	(0.044)	(0.044)	(0.049)

B. Unintegrated producer entry rate = number of entrants ÷ avg. in market over last two CMs

	Concrete		Cement	
	Plant-level entry rate	Firm-level entry rate	Plant-level entry rate	Firm-level entry rate
N	1386	1386	312	312
R^2	0.064	0.063	0.022	0.029
mkt. share of integrated	-0.025	0.055	0.015	-0.020
firms in base year	(0.040)	(0.039)	(0.042)	(0.047)

Notes: This table shows the impact of integration on entry rates. Panel A shows the results of regressing overall plant- and firm-level entry rates in a market (see text for definitions) on the market share of integrated firms in the base year. Panel B shows similar results for entry rates of unintegrated producers alone. Observations are weighted by market demand. (Similar patterns were observed using lagged number of VI firms as the explanatory variable, not reported here.) Standard errors are clustered by market. An asterisk denotes significance at five percent.

Table A1. Integration and Ready-Mixed Concrete Prices and Quantities—"FTC Rule" Instrumental Variables Estimates

A. Market-level price regressions—dependent variable is quantity-weighted average ready-mixed price in market

	[1]	[2]	[3]	[4]
N	1567	1567	1567	1567
Mkt Sh. Of VI Firms	0.168 (0.209)		-0.185 (0.361)	
Number VI firms		-0.010 (0.018)		-0.088 (0.150)
Density	-0.020* (0.008)	-0.015* (0.006)	0.034 (0.020)	0.040 (0.025)
Market Fixed Effects	No	No	Yes	Yes

B. Market-level quantity regressions—dependent variable is total physical units of concrete sold in market

	[1]	[2]	[3]	[4]
N	1567	1567	1567	1567
Mkt Sh. Of VI Firms	1.575* (0.598)		2.095 (1.570)	
Number VI firms		0.681* (0.267)		0.630 (0.609)
Demand	0.822* (0.025)	0.615* (0.100)	0.454* (0.102)	0.410* (0.106)
Market Fixed Effects	No	No	Yes	Yes

Notes: This table shows the impact of integration on market-level prices and quantities of ready-mixed concrete. Panel A shows the results of regressing the quantity-weighted average ready-mixed price in a market on measures of the extent of vertical integration in the market, the market's demand density, and market (CEA) fixed effects in some cases. Standard errors are clustered by market. Panel B regresses total market quantities (measured in logged thousands of cubic yards) on measures of the extent of vertical integration in the market, a market demand measure (logged construction sector workers), and market (CEA) fixed effects in some cases. In all specifications, the measure of vertical integration has been instrumented for using the total market share of ready-mixed firms subject to the FTC's "merger action" rule for the industry interacted with an indicator for the 1967 and 1972 CMs. In the price regressions, demand density is also included in the instrument set. First-stage F-tests for instrument relevance are 16.86 (16.52 without density) for the market share of VI firms and 22.11 (5.50 without density) for the number of VI firms. See text for details on the intuition and construction of these instruments. An asterisk denotes significance at five percent.