Markets

Ready-Mixed Concrete

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This feature explores the operation of individual markets. Patterns of behavior in markets for specific goods and services offer lessons about the determinants and effects of supply and demand, market structure, strategic behavior, and government regulation. Suggestions for future columns and comments on past ones should be sent to James R. Hines Jr., c/o *Journal of Economic Perspectives*, Department of Economics, University of Michigan, 611 Tappan Street, Ann Arbor, MI 48109-1220.

Introduction

Concrete's natural color is gray. Its favored uses are utilitarian. Its very ubiquity causes it to blend into the background. But ready-mix concrete does have one remarkable characteristic: other than manufactured ice, perhaps no other manufacturing industry faces greater transport barriers. The transportation problem arises because ready-mix concrete both has a low value-to-weight ratio and is highly perishable—it absolutely must be discharged from the truck before it hardens. These transportation barriers mean ready-mixed concrete must be produced near its customers. For the same reason, foreign trade in ready-mixed concrete is essentially nonexistent. This article is an introduction to the basics of the market for ready-mix concrete, focusing mainly on its consumers and its producers in the United States, but with occasional comparisons to other countries when contrasts are useful.

A good place to start is to clear up some confusions that I constantly encounter. First, cement and concrete are not the same thing, even though the two terms are often used interchangeably in conversation. Concrete comprises the roads we drive on and the buildings in which we live and work. Cement is an ingredient in concrete; it is mixed with sand, gravel, water, and small amounts of chemical admixtures to make concrete. Cement holds the key reagent that allows concrete to harden (through a chemical reaction called "hydration") into a useful structural material, but it is worthless for such purposes if used by itself. Referring to concrete as "cement" is a bit like referring to bread as "flour."

A second confusion is that the ready-mixed (alternatively: ready-mix) concrete industry is the same as the industry of precast or prefabricated concrete products. Ready-mixed concrete is the fluid form of concrete delivered to construction sites in the familiar barrel-backed mixer trucks (not "cement" trucks!) and poured into a desired shape. Precast or prefabricated concrete products, like block, brick, pipe, and reinforced structural members, are instead made by pouring concrete into molds and curing them on the factory site. In the government industrial classification systems, ready-mix concrete is SIC 3273 or NAICS 32732, while precast or prefabricated concrete products are classified separately, as SICs 3271 and 3272 or NAICS 32733 and 32739. This distinction is a meaningful one: as will be discussed further below, there is—perhaps surprisingly—very little overlap in production of ready-mixed and prefabricated concrete within plants.[1]

The U.S. ready-mixed concrete industry had over $27 billion in annual sales and 107,000 employed workers in 2005. It has experienced solid growth during the past 15 years: real revenues have grown at an average annual rate of 3.8 percent since 1992 (U.S. Census Bureau, 2006b).

Industry History and Background

Ready-mixed concrete's ubiquitous use as a building material is largely because of two advantages. It is cheap. It also allows great diversity in design and function, because in its fluid form, it can be poured into molds of any shape. Concrete's weakness, quite literally, is that while it is reasonably strong when bearing compressive (pushing) loads, it is an order of magnitude weaker in its ability to bear tensile (pulling) forces. This weakness is typically

[1] Both the older Standard Industrial Classification (SIC) and the newer North American Industrial Classification System (NAICS) taxonomies group similar industries together in increasingly detailed categories. Detail is added by including another digit in the industry number. For example, ready-mixed concrete's NAICS number of 32732 indicates the industry is a subset of the manufacturing sector (NAICS 32, as well as 31 and 33), the nonmetallic mineral product manufacturing industry group (NAICS 327), and the cement and concrete product industry group (NAICS 3273). See http://www.census.gov/epcd/www/naics.html for more information and/or a cure for insomnia.

remedied by adding steel reinforcing bars, known as "rebar," making ready-mixed concrete an effective option in many applications.[2]

Concrete was regularly used as a building material throughout the twentieth century, but when the National Ready Mixed Concrete Association was founded in 1930, only a handful of ready-mixed plants operated in the United States. The standard practice at the time was for construction firms to mix their own concrete at the job site using bagged cement and aggregates the contractors purchased themselves. (This practice remains common in developing countries.) However, with the wartime industrial and government building during the 1940s and the housing and highways building boom that followed, demand for ready-mixed rose sufficiently to take advantage of the scale economies of specialized offsite concrete mixers. By 1958, the first year in which the industry was considered a separate four-digit manufacturing industry in the Standard Industrial Classification system, there were 3,657 ready-mixed concrete plants.

Since that time, the industry has continued to grow, albeit with occasional recessionary setbacks. Over the past 30 years, the industry has been shifting from one dominated by single-plant firms to one where multi-plant operations are becoming increasingly common. In 1958, about 3,100 firms owned the 3,657 ready-mixed plants. By 2002, the number of industry plants had increased to 5,570, but the number of industry firms had fallen below 2,600 (U.S. Census, 1963 and 2006a). This consolidation is reflected in the industry concentration measures seen in Table 1. In 1958, the largest four firms in the industry accounted for only 4 percent of output, and the largest 50 firms a mere 21 percent. The analogous values for 2002 were respectively 11 and 42 percent, still low compared to most manufacturing industries, but substantially higher than earlier values. However, these national concentration measures understate concentration within individual geographic markets, which because of the high transportation costs of concrete, better reflects the competitive environment industry producers face.

The Nature of Supply

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[2] Concrete structures are likely to bear tensile loads even if they do not have weight suspended directly from them. Consider a horizontal concrete beam spanning two vertical supports that hold it up from below. If a weight is placed on top of the beam, say halfway between the supports, the beam will bend (though perhaps imperceptibly) into a U-shape. Since the bottom part of the beam will necessarily have to stretch more than the top part when this happens, the bottom will be loaded in tension. Hence tensile weakness would show up as cracking on the beam's underside.

In this section I discuss factors that influence the industry from the supply side: what individual plants look like, how industry firms are structured, technological change, and producer turnover.

A Typical Ready-Mixed Concrete Plant

The manufacturing process for ready-mixed concrete can be crudely analogized to making mud pies, except a typical batch of “batter” weighs 20-40 tons and the output is delivered to customers in $150,000 vehicles. The plants where these pies are made are typically spartan affairs, even as manufacturing facilities go. They include facilities for handling raw materials, usually including steel cement silos (cement must be protected from moisture in the air, lest it harden prematurely), open piles of aggregate (sand, gravel and rock) sorted by size, a payloader and conveyor system for moving aggregate, and a water source. There is also often a structure with limited office space and rooms that house controls for the batcher—the equipment that weighs and feeds the various ingredients into the mixing bin. The bin sits in an elevated structure to allow drivers to pull the mixer trucks, which are the other key pieces of capital equipment found at ready-mixed plants, underneath for loading.

Numbers from the 2002 Census of Manufactures, the latest for which comprehensive data are available, offer a sense of the economic scale of a typical ready-mixed plant. The average value of raw materials inventory on hand at a plant was $81,000. The average book value of its capital stock (both structures and equipment) was $2.2 million, and mean annual sales were $3.9 million. This typical plant had 18 employees, 14 of whom were considered production workers (which includes truck drivers).

Firm Structure

Despite the industry’s move toward consolidation, hundreds of ready-mixed firms are still single-plant operations. In 1997, the most recent year for which such data were available, these producers accounted for 44 percent of industry plants and 80 percent of its firms.

Ready-mixed concrete plants, whether in single-plant firms or not, are usually highly specialized. Plants in the industry fabricate few precast concrete products, despite similarities in precast concrete’s production process and that the ultimate buyers in the construction industry are often the same. Well over 90 percent of ready-mixed plant revenues come from ready-mixed sales, meaning single-plant firms in the industry derive the vast majority of their revenues from their primary product. Plants making prefabricated concrete products are similarly specialized in those products, with less than 10 percent of their revenues accounted for by ready-mixed sales (U.S. Census Bureau, 2006b).

Multi-plant firms with ready-mixed concrete operations tend to be more diversified, but their diversification comes through owning plants in other industries. These can be prefabricated concrete operations, cement plants, or sand and gravel mines. In 1997, about half of the ready-mixed plants that were owned by multi-unit firms were owned by firms that also operated plants in other industries besides ready-mixed concrete. Thus, diversification among larger firms is not universal, since the other half of plants in multi-unit firms are owned by businesses that are ready-mixed specialists.

Technological Change

The basic process for making ready-mixed concrete has not changed for the past 60 years: dry raw materials are measured, loaded into a bin, mixed, placed into a truck, and water is added (sometimes the order of the last two steps is interchanged). The modest technological advances that have occurred in the industry have come in five areas.

The first change is automated batching systems. Batching—the process of weighing and mixing the raw materials before they are loaded on the truck—was once a manual operation. An operator would mechanically control the hopper gates that regulated the flow of raw materials into the central mixing bin, weighing each component while proceeding, often by eye on an analog scale. Automated batching systems, where an operator inputs the “recipe” for a ready-mixed batch into an electronic control system that handles the weighing and mixing operations automatically, began diffusing through the industry during the late 1970s and early 1980s.

A second change is the substantial increase in the capacity of concrete trucks. A 1953 standards publication described certified mixing trucks ranging in capacities from 2.5 to 7.5 cubic years (National Ready Mixed Concrete Association, 1953), with standard capacities at the time being 3.0 to 4.0 cubic yards. Today, the typical truck capacity is 10 cubic yards, with some able to carry as many as 12. However, because a cubic yard of concrete weighs approximately two tons, the gross weight of a fully-loaded 12-yard truck could be upwards of 38 tons. This comes close to states' legal limits, which are uniformly 40 tons (some allow overages with a special permit, but most do not have exceptions when the cargo is divisible like concrete).

A third change is a continuing expansion in the variety of chemical admixtures that can be added to a concrete batch to affect its properties in useful ways. For example, admixtures can affect workability (how easily the concrete can be formed into shapes), curing times, color, porosity, and other attributes. This flexibility in the physical attributes of the final product has increased the range of uses of ready-mixed concrete.

A fourth change involves improvements in logistical coordination gained through the move toward centralized delivery dispatch. Ready-mixed concrete producers are not just manufacturers, they are logisticians: they deliver, typically on short notice, a perishable product to time-sensitive buyers in multiple locations. Owning several plants in a local area and coordinating their deliveries through a central office offers potential productivity gains by consolidating overhead (one dispatcher handles deliveries from several plants that would each have their own dispatcher in single-unit firms) and allowing more efficient use of available resources through cross-plant substitution of production and deliveries. Hortaçsu and Syverson (2007) find evidence of these productivity gains among ready-mixed plants whose owning firms are vertically integrated into cement. Nonproduction workers account for a lower fraction of employment at these plants, consistent with a reduction in overhead labor from moving to central dispatch. Firms' plant location choices also reflect attempts to harness such efficiency benefits. For example Lafarge (2005), an integrated cement and concrete producer, states in its 2004 20-F filing that, "We aim to place our ready mix concrete plants in clusters in each micro market in which we operate in order to optimize our delivery flexibility, capacity and backup capability."[3] While Hortaçsu and Syverson look specifically at vertically integrated firms, the findings suggest that the logistical efficiencies do not rely on vertical structure per se. What appears instead to be important is the total size of the firm's ready-mixed operation in the local market. That is, while plants in vertically integrated firms are more productive on average than unintegrated plants in the same market, they do not have significantly different total factor productivity levels than plants in unintegrated firms with similar local concrete sales. Coordination and its possible efficiency gains are therefore not exclusive to vertically integrated firms, but rather are available

[3] 20-F filings are filings made to the Securities and Exchange Commission by foreign-based companies who sell securities in the U.S. They are essentially non-glossy, higher-content annual reports. They are analogous to 10-K forms filed by domestically based firms.

to any firm with the necessary scale (and the operational ability to manage such operations).

A final technological advance affected the concrete industry, although it actually occurred for the most part outside of the industry. Concrete pumps are used to place concrete on a job site by pumping it through tubes suspended from a boom. These concrete pumps are typically owned and operated by construction contractors or specialty firms, rather than by the ready-mixed producer. Pumps allow virtually uninterrupted placement of concrete and make it easy to change the location where concrete is poured. (The alternative process is to load bucket after bucket with wet concrete, move the buckets one load at a time into place with a crane, and pour the contents into the mold.) Certain admixtures mentioned earlier increase the flowability of wet concrete, improving pumping performance. Pumping is limited in practical terms only by the power of the pumps, which can be quite large. The 92-floor Trump Tower in Chicago, for instance, is being built with the help of a 680-horsepower concrete pump able to lift 3,000 pounds 1,000 feet in one minute (Sleets and Klaxton, 2006).

Environmental Concerns

Ready-mixed concrete plants can emit both waterborne and airborne pollutants. The former include spilled oil or fuel, as well as fine and coarse particles of aggregates and cement, which can be inherently detrimental as well as raise the alkalinity of runoff water to toxic levels. Airborne emission concerns primarily involve dust from the concrete mixing process itself or from trucks driving on unpaved portions of plants. Plants typically monitor potential pollutants and control them as required. Runoff water is often captured in settling ponds that allow solids to be separated before the water is either discharged or recycled. Dust is controlled by hooding mixing facilities and either paving or occasionally spraying-down unpaved areas of the plant.[4]

Producer Turnover

On average, over 30 percent of plants existing in one Economic Census will no longer be

[4] I was a bit surprised to find evidence that some industry producers addressed environmental issues well before the current regulation regime. A panel discussion at the 1958 Annual Convention of the National Ready Mixed Concrete Association involved the control of dust from operations (NRMCA 1958). The subject of discussion involved a plant that was originally located away from developed areas, but was now surrounded by a residential neighborhood. The costly actions taken by the plant were characterized by its manager as a sort of implicit Coasian bargain with surrounding homeowners: the plant would clean up its act in exchange for homeowners not forcing a rezoning that might force the plant to move.

operating five years later when the next census is taken (Foster, Haltiwanger, and Syverson, forthcoming). This level of change might strike some readers as high, but it is within the typical range observed across across four-digit manufacturing industries (Dunne, Roberts, and Samuelson, 1988). Moreover, Collard-Wexler (2006) suggests that turnover rates would be even higher, given the volatility of construction demand for concrete, if not for the presence of large sunk entry costs (some of which may involve the producer's "relationship capital" with its customers—an important factor in the industry that I will describe shortly). As will be seen below, *which* plants survive is determined by both demand- and supply-side factors.

The Nature of Demand

This section discusses factors that influence ready-mixed concrete demand: who the customers are, how one might define a market within the industry, the nature of the product, and its common substitutes.

Ties to Local Construction

The ready-mixed industry's fortunes are closely tied to the level of activity in the construction sector. The sector buys the vast majority of ready-mixed output: 94 percent, according to the 2002 Benchmark Input-Output Tables. Bureau of Labor Statistics annual employment data over 1973 to 2005 show a simple correlation of 0.9 between the employment growth rates of the ready-mixed concrete industry and the construction sector.[5]

The combination of the industry's high transport costs and its reliance on the construction sector imply that the ready-mixed "market" is not a singular, nationwide unit, but instead a collection of quasi-independent local geographic markets. Data from the 2002 Commodity Flow Survey indicate that the average shipment distance for the detailed product category of which

[5] In the government industrial classification systems, the construction sector is SIC 15-17/NAICS 23. The statistics from the Input-Output Tables count purchases by government and the owner-occupied housing sector as construction. This is because the Bureau of Economic Analysis (BEA) now attributes these sectors' hired construction activity to the sectors themselves rather than to the construction industry per se (Horowitz and Planting 2006). The numbers here for 2002 are similar to those from previous Input-Output Tables in which the BEA did attribute government and owner-occupied construction directly to the construction sector.

ready-mixed comprises the majority of shipments ("nonrefractory mortars and concretes") is only 32 miles. By way of comparison, the average distance for all commodities is 546 miles.

The basic demand conditions faced by ready-mixed producers in any given local market therefore depend on how robust construction activity is in that same market, not elsewhere. Moreover, this variation in market demand is likely to be exogenous to the nature of competition among local ready-mixed concrete plants. This is because construction projects require intermediate materials from a wide array of industries, making the cost share of ready-mixed small. Looking at the 2002 Benchmark Input-Output Tables again, ready-mixed concrete accounted for only 3 percent of the construction sector's intermediate materials costs. Therefore a shock to the competitiveness of the local ready-mixed industry (that lowers average concrete prices, say) is unlikely to cause a construction boom. Causation thus travels from construction demand to concrete competitiveness, not in the reverse direction.

To give some sense of the number of plants one might expect in markets of different size, County Business Patterns data indicate that in 2005, the Atlanta Metropolitan Statistical Area (MSA) had 123 ready-mixed plants, the largest of any MSA. (The New York MSA was second with 113.) Here's a sample of some other MSAs: Pittsburgh housed 39 plants, Fresno had 12 plants, and there were five plants in Fargo.

Relationship Capital

Ready-mixed concrete is physically quite homogenous. While concrete can be differentiated along some dimensions (like compressive strength or cure time) by varying the cement-to-water ratio or including chemical admixtures, these differentiations are minor in scope relative to those seen within many manufacturing industries (automobiles or household audio and video equipment, for instance). Moreover, the differentiation in attributes of concrete output *across plants* is likely to be smaller still. Because of transport constraints, every plant typically produces the entire spectrum of ready-mixed concrete varieties, rather than some plants specializing in certain types of concrete and others in different types.

Despite its physical uniformity, a source of non-spatial differentiation does exist in the industry. This entails the "relationship capital" built between specific suppliers and their customers. Long-run buyer-supplier ties, whether driven primarily by business or personal bonds, are common in the industry. While their influence is difficult to quantify, anecdotal evidence is plentiful. For example, a cement company president testified to the Federal Trade Commission that forward integrating into existing ready-mixed concrete firms was easier than building a business from scratch. His reasoning was, "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." (U.S. Federal Trade Commission, 1966).

Substitutes

Ready-mixed concrete faces potential competition from various substitute products. In building construction, prefabricated concrete is the most likely outside option. Concrete block can be used for walls and pre-stressed structural concrete slabs (complete with embedded reinforcing bars) for floors. Recall that prefabricated concrete products are typically made at plants that do not also make ready-mixed, so such substitution does not simply imply buying a different product from the same producer. Another option is to use steel, wood, or stone as building materials. In road construction, asphalt is a popular alternative. Asphalt is physically akin to concrete; it is also comprised of aggregate mixed with a binding agent, except in asphalt the binder is bitumen, a product of petroleum refining, rather than the hydrated cement in concrete. However, most firms making either product do not make both. While variations in the local relative prices of ready-mixed concrete and these substitutes do lead to modest differences in construction practices across geography, there has been no noticeable time trend, at least in the Benchmark Input-Output Tables, in the aggregate intensity of ready-mixed use relative to its substitutes.

Why the Industry's Demand Features Are Useful for Economists

The combination of the fact that the construction sector buys the vast majority of the industry's output, its high transport costs, and the lack of vertical product differentiation, make the industry a useful "laboratory" for empirical researchers. Geographic variation in construction activity, acting through competitive mechanisms described below, creates significant disparities (across hundreds of largely independent markets) in outcomes of potential interest: prices, quantities, productivity levels, factor intensities (each at the plant, firm, and market levels), and firm structures. And as argued above, this variation is arguably exogenous to the supply structure in the local ready-mixed industry. Furthermore, the product's minimal vertical differentiation implies that observed price dispersion is more likely to reflect the effects of firm or market structure on equilibrium prices than systematic product mix differences across markets.

Competition

The demand and supply characteristics of the industry discussed above combine to create a competitive structure for the ready-mixed concrete industry that depends heavily on spatial differentiation.

Competition and Cost-Based Selection

Syverson (2004, 2007) explores the equilibrium market structure implied by such a setting. The more densely located are producers in a market, the easier it is for ready-mixed concrete consumers to substitute among producers. Therefore competition is expectedly more intense in dense markets, where producers hold less spatial market power. If producers have different productivity (cost) levels, it will be harder for inefficient firms to be profitable in dense markets. Thus, concrete producers in denser markets should have higher lower-bound and average productivity levels and less productivity dispersion. Equilibrium price distributions should be similarly truncated, albeit from above rather than below. These patterns are documented in Syverson (2004, 2007), which compare market density to the productivity and price distributions of ready-mixed concrete plants within hundreds of local concrete markets. The papers use the exogenous variations in construction activity density discussed above to identify the effect of density on equilibrium productivity levels and prices of producers.

This selection story uses a fairly static perspective. In reality, of course, the industry experiences constant churning, both through the plant turnover rates discussed above as well as through changes in the productivity levels and market shares of surviving plants. Foster, Haltiwanger, and Syverson (forthcoming) show that plant survival is tied to productivity in a dynamic economic setting as well. We take advantage of being able to measure ready-mixed outputs in both revenue and physical units (cubic yards), allowing us to separate revenue-based productivity—the typical measure in the literature—into physical productivity and prices. This allows us to tie both supply- and demand-side measures of producer fundamentals to plant survival. The findings indicate that physical productivity affects plant exit, but demand-side factors (like geographic variation in product demand or differences in "relationship capital" as described above) have a large quantitative impact on survival as well.

A combination of selection-induced productivity growth along with continuing producers experiencing technological progress has led to aggregate productivity gains in the industry. Industry-level data from the NBER Productivity Database (I extended the series after 1997 using data from the Annual Survey of Manufactures and other sources) indicate that real output per hour grew 52 percent between 1958 and 2005. This annualized rate of 0.9 percent was considerably slower than the 2.2 percent seen for the entire nonfarm business economy over the same period. Of course, changes in output-per-hour will be determined by growth in physical capital per worker as well as by technological progress more broadly. The relatively low growth rate of output-per-hour reflects, perhaps in large part, that capital per worker grew more slowly in the ready-mixed concrete industry than in the manufacturing sector as a whole.

The total factor productivity time series indicates 27 percent growth over the same period, an average annual rate of 0.5 percent. In contrast to the industry's under-performance in labor productivity relative to aggregates, this rate is at roughly the 55th percentile (and above the weighted average) of the total factor productivity growth rates Jorgenson and Stiroh (2000) compute for many broad sectors over the same time period. This lends further support to the notion that slow labor productivity growth was driven by slow capital accumulation. The industry did experience the productivity growth slowdown (though at a smaller magnitude) during the 1974-1995 period that was observed in the broader economy. The output per hour and total factor productivity growth series are shown in Figure 1.

Prices

The ready-mixed concrete industry's faster-than-average growth in total factor productivity has been reflected in real ready-mixed concrete prices. The ready-mixed Bureau of Labor Statistics PPI index saw average annual price growth that was 0.2 percentage points lower than annual CPI growth over 1958-2006. Price changes key intermediate inputs also drove ready-mixed price fluctuations, as Figure 2 shows. Concrete prices were more responsive to cement price variation than to sand and gravel prices. This likely reflects the fact that cement's share of the ready-mixed industry's materials costs is about 60 percent higher than sand and gravel's share (U.S. Census Bureau, 2004).

Typical delivered ready-mixed concrete prices are roughly $100 per cubic yard, which is enough concrete to pour about a 20-foot length of four-foot-wide, four-inch-deep sidewalk. (Thus the average concrete truck, even completely full, carries only about $1,000 of product.) Prices do vary across producers, however. Syverson (2007) finds the interquartile range of average prices *across* CEA markets—the dispersion of the average—is 9.5 percent, and the average interquartile range of plant-level prices *within* a market—the average dispersion—is 9.3 percent.

Plant Location as Strategy

Given the importance of spatial differentiation and the continuing evolution of the locations of construction demand (particularly in growing urban markets with active homebuilding on their fringes), plant location can be an important strategic consideration. Lafarge states in its 20-F filing: "We evaluate each micro market in which we operate periodically and dismantle and move plants to locations where they can be used more profitably." Rinker Group Ltd. (2006) discusses a similar action: "Eight new ready-mix plants and five new block plants have been constructed in Florida to meet customer demand in growing regions of that state or to replace facilities to better meet strong demand in existing market areas."

More systematic looks at the data back this anecdotal evidence. Hortaçsu and Syverson (2007) find that integrated concrete firms reshuffle production locations in markets by reducing output at existing plants that they purchase (bought, perhaps, to obtain the relationship capital of the previous owner), and then replacing their output with production from newly built plants located closer to spatially shifting demand within the market. Further, larger firms are more likely than their smaller competitors to locate these new plants in areas within markets where demand is growing fastest.[6]

[6] To draw this last conclusion, I used a sample of all new ready-mixed concrete plants (that is, those appearing for the first time in a Census) from the 1963-1997 Censuses of Manufactures. I regressed an indicator variable for

Collusion

While the empirical patterns observed in the ready-mix industry generally conform well to the predictions of non-cooperative oligopoly theory, the industry is not without its miscreants in particular markets. For example, the FBI devotes a webpage to outlining its investigative focus on the New York area ready-mixed concrete industry because of "its history of being controlled by La Cosa Nostra." The outline describes the kickback scheme, run through the Mafia's control of two unions, where the Colombo family earned between 1 and 2 percent of ready-mixed concrete contracts under $15 million, with contracts larger than this reserved for exclusive control of the Genovese family.[7] Another recent (non-Mafia) case involves price fixing by five firms in the Indianapolis area. This case led to guilty pleas, multiple convictions guilty pleas, considerable fines being levied (a single $29.2 million fine against Irving Materials, Inc. was the largest ever imposed in the U.S. resulting from a domestic cartel investigation), and ten executives sentenced to prison time (Barnett, 2007).[8]

The industry's trend to greater concentration has raised other antitrust concerns. An issue that has received considerable policy attention is the possible market power consequences of vertical mergers between cement and ready-mixed producers (for discussion, see FTC, 1966; Allen, 1971; McBride, 1983; Johnson and Parkman, 1987; Hart and Tirole, 1990; Hortaçsu and Syverson, 2007). After considerable debate and various enforcement actions, competition policy was explicitly eased with regard to allowing such mergers. This move is supported by the findings in Hortaçsu and Syverson (2007), which did not find evidence that the dozens of cement

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entrants from large (multi-plant) firms on contemporaneous (i.e., occurring over the same five-year period in which the plant enters) construction activity growth in the county in which it entered, the lagged level of construction activity in that county, and a set of CEA market fixed effects. The coefficients on both lagged county-level construction employment and its growth were positive, indicating that large firms' new plants are systematically more likely than single-plant firms to enter counties where construction activity and its growth rate are higher than the average values in their markets.

[7] The website address is <http://www.fbi.gov/hq/cid/orgcrime/casestudies/lrconcrete.htm>. Controlling the ready-mixed business also offers the Mafia a secure supply of one of its more infamous intermediate inputs into downstream operations: concrete shoes.

[8] Albæk, Møllgaard, and Overgaard (1997) argue that the decision by the Danish antitrust authority to regularly publish ready-mixed concrete transaction prices—ironically, a policy implemented with hopes of increasing competition—facilitated collusion in Denmark's concrete markets by making it easier for industry firms to coordinate on anticompetitive prices. Prices increased 15-20 percent within a year of the new publication policy in absence of any notable increases in raw materials costs or downstream construction activity.

and ready-mixed concrete mergers over a 34-year sample period enhanced market power. The softer current stance of antitrust authorities toward vertical integration in these industries has been accompanied, probably not coincidentally, by a trend toward many of the largest firms in the industry today also having cement operations.

Concentration has also increased instances where the same firms compete in several markets. As Bernheim and Whinston (1990) point out, multimarket contact can improve firms' abilities to sustain collusive outcomes. I am not aware of any work that has investigated this issue in the cement industry, but it seems sensible for economists to keep this mechanism in mind as the industry's consolidation continues.

Looking Forward: Growth and Consolidation

The prospects for long-run output growth in the ready-mix concrete industry are solid. Obviously, its fortunes will be closely tied to construction activity. The construction sector's value added share of U.S. GDP has been roughly constant over the past 60 years at about 4.5 percent. Thus, in the absence of vigorous growth of substitute products (of which there is no obvious indication in the last few decades), concrete demand should grow at roughly the rate of GDP growth. In the medium-run, the recent housing slowdown may stifle growth somewhat, but counteracting this is the federal highway bill signed in 2005. The law authorizes projects totaling $286 billion, an amount greater than the $185 billion total cost (in 2005 dollars) of building the entire interstate highway system (U.S. Department of Transportation, 2007). Looking beyond the U.S. market, vigorous worldwide growth is likely to continue, driven largely by development in India and China. China alone currently uses roughly 40 percent of the world's cement, most of which is used to make concrete (Watson, 2005).

Long-run employment growth should also be robust in the domestic ready-mixed concrete industry. While some jobs will probably be lost to further consolidation of dispatch operations, the nontradability of ready-mixed shields domestic producers from low-cost foreign manufacturers. In addition, the fact that growth of output per hour worked is slower than the rest of manufacturing also helps to buoy employment growth. The past suggests the future here: while manufacturing employment as a fraction of total nonfarm employment declined from 30 to

10 percent over the past 50 years (in fact, manufacturing employment has fallen back to its 1950 level in absolute terms), the ready-mixed industry's employment grew by 75 percent.

The industry's move toward further consolidation and away from mom-and-pop operations seems destined to continue for some time. Several large mergers are already underway. Cemex, a Mexico-based cement and concrete multinational that is now the largest U.S. ready-mixed producer with roughly 300 plants, completed in July 2007 a $14.2 billion hostile acquisition of Rinker, an Australian construction materials firm that is the second-largest ready-mixed producer in the United States with over 170 plants, mostly in Arizona and Florida (Rinker Group Ltd. 2006; U.S. Concrete 2007). Even this "blockbuster" merger only involves roughly 10 percent of total U.S. production, though of course the combined market shares are considerably larger in particular markets. In August 2007, Vulcan materials—with $250 million in concrete sales in 2005—bought 120-plant Florida Rock for $4.6 billion. Interestingly, a high fraction of the largest firms in the U.S. today, and among those who have been most active in the consolidation movement, are foreign-based multinationals. These include Cemex and Rinker, but also Lafarge (France), Oldcastle (Ireland), and Argos (Colombia).

Many more merger opportunities are still available. Market shares are considerably more diffuse in domestic ready-mixed concrete than for the typical manufacturing industry. Perhaps more tellingly, they are more diffuse than in other developed countries' concrete industries. The five largest firms in the UK, for example, have a 25 percent market share (the data are aggregated to "articles of concrete, stone, etc." level, however). In Denmark, the four largest firms held a 57% market share in 1987 (Albæk, Møllgaard, and Overgaard 1997). I don't know if the U.S. industry's still large (but shrinking) number of single-plant firms is a result of historical accident, past or present aggressive antitrust enforcement, or peculiarities of the domestic industry's technology (though I would bet on a combination of the first two), but regardless of the source, it implies that more consolidations are feasible.

Further consolidation could allow firms to harness more of the logistical efficiency gains that come from owning several plants. From a social welfare standpoint, this would of course have to be balanced against any reduction in spatial competition. Continued changes in the spatial patterns of demand also seem likely to drive production toward larger firms since, as was noted above, big firms are more likely to build plants in the fastest-growing areas within a market. The only obvious barrier counteracting such concentration processes will be antitrust concerns that might arise in certain local markets. The Department of Justice did require the divestiture of 39 plants in seven local markets in the Cemex-Rinker merger, for example. Excepting such local actions, I expect the coming years will see many single-plant firm proprietors sell off their physical and relationship capital, and then drive home from their plant for the last time on the roads they built.

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References

Albæk Svend, Peter Møllgaard, and Per B. Overgaard. "Government-Assisted Oligopoly Coordination? A Concrete Case." *Journal of Industrial Economics*, *45*(4), 1997, 429-43.

Allen, Bruce T. "Vertical Integration and Market Foreclosure: The Case of Cement and Concrete." *Journal of Law and Economics*, *14*(1), 1971, 251-274.

Barnett, Thomas O. "Statement Concerning Oversight of the United States Department of Justice, Antitrust Division." Testimony before the Senate Subcommittee on Antitrust, Competition Policy and Consumer Rights, March 7, 2007.

Bernheim, B. Douglas and Michael D. Whinston. "Multimarket Contact and Collusive Behavior." *RAND Journal of Economics*, *21*(1), 1990, 1-26.

Collard-Wexler, Allan. "Demand Fluctuations and Plant Turnover in the Ready-Mix Concrete Industry." Mimeo, 2006.

Dunne, Timothy, Mark J. Roberts, and Larry Samuelson. "Patterns of Firm Entry and Exit in U.S. Manufacturing Industries." *RAND Journal of Economics*, *19*(4), 1988, 495-515.

Foster, Lucia, John Haltiwanger, and Chad Syverson. "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" American Economic Review, forthcoming.

Hart, Oliver and Jean Tirole. "Vertical Integration and Market Foreclosure." *Brookings Papers on Economic Activity*, *0*(0), 1990, 205-76.

Horowitz, Karen J. and Mark A. Planting. *Concepts and Methods of the U.S. Input-Output Accounts*. Washington, DC: U.S. Bureau of Economic Analysis.

Hortaçsu, Ali and Chad Syverson. "Cementing Relationships: Vertical Integration, Foreclosure, Productivity, and Prices." *Journal of Political Economy*, *115*(2), 2007, 250-301.

Johnson, Ronald N. and Allen M. Parkman. "Spatial Competition and Vertical Integration; Cement and Concrete Revisited: Comment." *American Economic Review*, *77*(4), 1987, 750-53.

Jorgenson, Dale W. and Kevin J. Stiroh. "U.S. Economic Growth at the Industry Level." *American Economic Review*, *90*(2), 2000, 161-167.

Lafarge. "Form 20-F." http://www.lafarge.com/lafarge/PUBLICATION/20050407/04072005-publication_finance-20f_2004-uk.pdf, 2005.

McBride, Mark E. "Spatial Competition and Vertical Integration: Cement and Concrete Revisited." *American Economic Review*, 73(5), 1983, 1011-1022.

National Ready Mixed Concrete Association. “Truck Mixer and Agitator Standards of the Truck Mixer Manufacturers Bureau. Third Revision.” September 1953.

National Ready Mixed Concrete Association. “Panel Discussion of Plant Operating Problems.” NRMCA Publication No. 79, 1958.

Rinker Group Limited. “Form 20-F.” 2006.

Sleets, Gentry and Keith Claxton. “Trump Pump.” *Chicago Tribune,* Sept. 22, 2006.

Syverson, Chad. “Market Structure and Productivity: A Concrete Example.” *Journal of Political Economy, 112*(6), 2004, 1181-1222.

Syverson, Chad. “Prices, Spatial Competition, and Heterogeneous Producers: An Empirical Test.” *Journal of Industrial Economics,* June 2007, 197-222.

U.S. Census Bureau. “Concentration Ratios.” *1958 Economic Census*. Washington: U.S. Government Printing Office, 1963.

U.S. Census Bureau. “Concentration Ratios.” *2002 Economic Census*. Washington: U.S. Government Printing Office, 2006a.

U.S. Census Bureau. “Ready-Mix Concrete Manufacturing: 2002.” *2002 Economic Census*. Washington: U.S. Government Printing Office, 2004.

U.S. Census Bureau. “Statistics for Industry Groups and Industries.” *Annual Survey of Manufactures: 2005*. Washington: U.S. Government Printing Office, 2006b.

U.S. Concrete. “The Wall Street Analyst Forum.” (Presentation Slides.) February 13-15, 2007.

U.S. Department of Transportation. “Dwight D. Eisenhower National System of Interstate and Defense Highways.” http://www.fhwa.dot.gov/programadmin/interstate.cfm, 2007.

U.S. Federal Trade Commission. *Economic Report on Mergers and Vertical Integration in the Cement Industry*. Washington, DC: U.S. Government Printing Office, 1966.

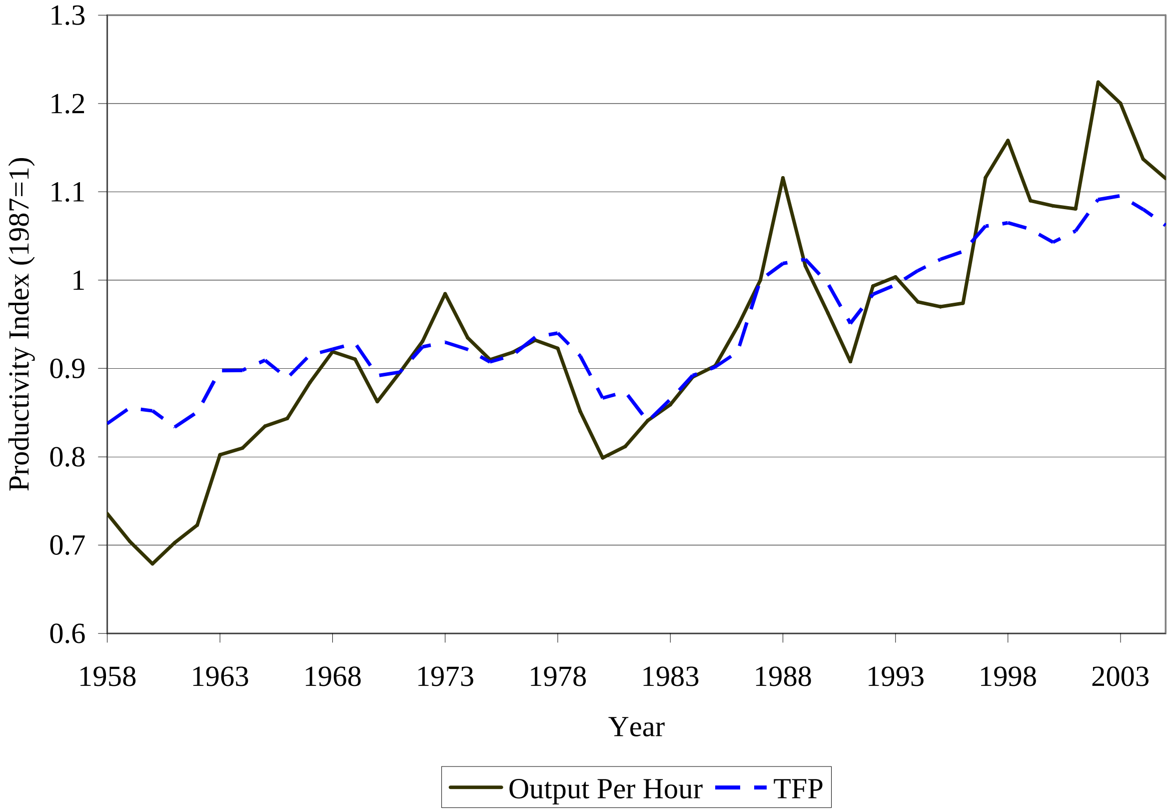
Watson, Jim. “Rising Sun: Technology Transfer in China.” *Harvard International Review,* 26(4), 2005, 46-49.

Table 1. Ready-Mixed Industry Concentration Measures (from Census of Manufactures)

Year	Firms	C_4	C_8	C_{20}	C_{50}
1958	3104	4%	7%	13%	21%
1963	3999	4	7	13	22
1967	4032	6	9	16	24
1972	3978	6	10	16	25
1977	4317	5	8	14	23
1982	4161	6	9	16	24
1987	3749	8	11	18	27
1992	3249	6	11	19	30
1997	2888	7	11	20	33
2002	2614	11	17	28	42

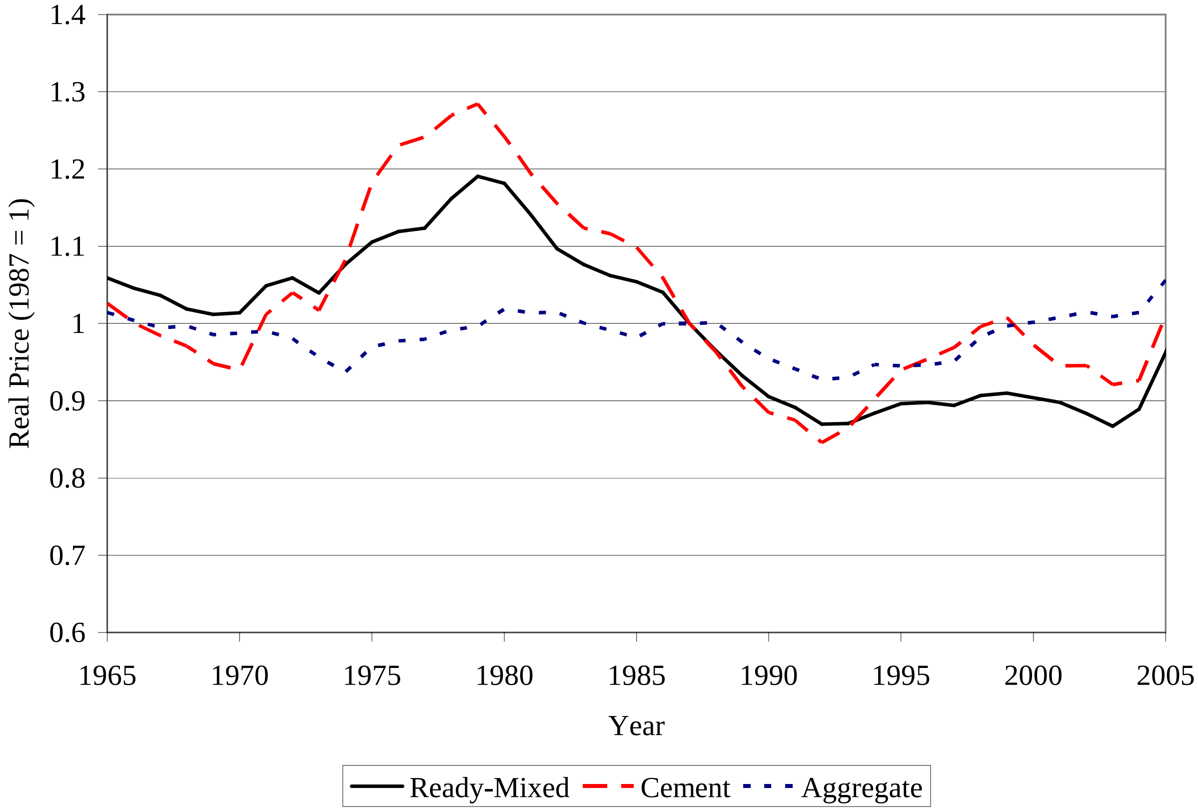
Notes: This table reports firm counts and concentration measures for the ready-mixed concrete industry (SIC 3273) as reported in the various U.S. Census of Manufactures. Concentration measures are the fraction of total industry output accounted for by a given number of firms, added in descending size order; i.e., C_n is the output share of the largest *n* firms.

Figure 1: Aggregate Industry Productivity Indexes (1987 = 1)



Notes: This figure plots industry-wide labor and total factor productivity (TFP) indexes for ready-mixed concrete. Data for 1958-1996 are from the NBER productivity database. For 1997-2005, I construct the numbers using data primarily from the Annual Survey of Manufactures (ASM) and a few other sources for 1997-2005. Labor productivity is computed as real output per worker-hour, where output is deflated using the industry's output price index in the database and hours are computed as production worker hours (reported directly in the database) multiplied by the ratio of total payroll to production worker payroll. TFP is taken directly from the database for 1958-1996 and supplemented afterwards with a five-factor index I compute using ASM data for input expenditures and input deflators from the Bureau of Labor Statistics, Bureau of Economic Analysis, and Energy Information Administration.

Figure 2. Real Prices of Ready-Mixed, Cement, and Aggregate (1987 = 1)



Notes: This figure plots producer price indexes from the Bureau of Labor Statistics for three products: ready-mixed concrete, cement, and aggregate (the composite BLS commodity sand and gravel).