Cementing the Case for Collusion under the National Recovery Administration

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Abstract

Macroeconomists have long debated the aggregate effects of anti-competitive provisions under the "Codes of Fair Conduct" promulgated by the National Industrial Recovery Act. Despite this disagreement, there is only limited evidence documenting any actual effects at the micro level. We use a combination of narrative evidence and a novel plant-level dataset from 1929, 1931, 1933, and 1935 to study the effects of the NRA in the cement industry. We develop a test for collusion specific to this particular industry. We find strong evidence that before the NRA, the costs of a plant's nearest neighbor had a positive effect on a plant's own price, suggesting competition. After the NRA, this effect is completely eliminated with no correlation between a plant's own price and its neighbor's cost. We argue that this work provides some of the strongest evidence yet for the collusive effects of the NRA.

1 Introduction

For a brief period during the Great Depression, American industrial policy actively promoted cartelization of much of the economy. This goal was codified in the National Industrial Recovery Act of 1933 (NRA), which had the stated intention of "eliminat[ing] cut throat competition" and promoting "fair competition." President Franklin Roosevelt and his advisers argued that price cutting drove out businesses, led to ruinous deflation, and caused low wages that led to a vicious cycle of underconsumption and further wage cuts. Their solution was greater national planning and coordination within industries.[1] This meant that in consultation with government officials,

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[1] At the beginning of the Depression, President Herbert Hoover actually supported many of these ideas through the strengthening of voluntary trade associations. Ohanian (2009) points to these policies of artificially inflating wages and prices as a major cause of the Depression itself. Rose (2010) argues that these policies were ineffectual.

industries drew up codes of conduct to regulate competitive behavior. By the end of 1933, a large part of the American economy, including the cement industry, was operating under a code of fair conduct. In addition, hundreds of other industries were seeking approval of codes they had submitted.

Though the ramifications of this law could have been huge, there is little consensus on its effects at the micro (or macro) level. Part of the reason for disagreement is the level of aggregation in the data which previous studies use. Plant or firm-level is the natural level at which to study collusion, but the literature on this question, with the exception of Alexander and Libecap (2000), has relied on industry-level data. In this paper, we contribute to the literature by examining the cement industry using newly digitized plant-level records from the Census of Manufactures in 1929, 1931, 1933, and 1935. We first provide narrative evidence from contemporaneous trade journals that is suggestive of collusion and close adherence to the code. We then develop a test for collusion motivated by the particular features of the industry. Cement is a local product with almost no physical product differentiation. Because of this geographic segmentation, the costs of a plant's nearest neighbor play a key role in disciplining the pricing choice of a plant in a competitive market. Under collusion, the costs of the nearest neighbor have no effect. The plant charges its monopoly price, which depends solely on its own cost. We formalize this logic in a Hotelling framework and then test it using our plant-level data. Our regression results imply that before the NRA, in line with the theory, the average price a plant charges is strongly correlated with the costs of its nearest neighbor, controlling for the plant's own costs. After the NRA comes into force, this correlation between own price and neighbor's cost disappears, though own cost still has a strong positive effect on price. Our test provides strong evidence for the collusive impact of the NRA.

This paper joins the literature stretching back to Bellush (1975) that highlights evidence for collusion under the NRA. Besides this earlier work, Alexander (1994) finds that the critical concentration ratio falls after the introduction of the NRA, which is evidence that the codes facilitated collusion. More recently, Taylor (2002) uses an index of durable good output for a few different industries at a monthly frequency. He finds that output falls after the codes come into force, which is consistent with a cartelization story.[2] Vickers and Ziebarth (2011) reexamine the macaroni in-

[2] In subsequent work, Taylor (2007) identifies features of the codes that made them particularly effective in fostering collusion.

dustry with plant-level data from the source employed here and find evidence for collusive activity, in contrast to Alexander (1997).

On the other hand, many authors have suggested that these codes had little effect on promoting collusive behavior. Alexander (1997), Krepps (1997), and Alexander and Libecap (2000) all argue that these codes were not uniformly effective. Alexander suggests that the reason for the failure of the codes is due to intra-industry heterogeneity. Low cost plants have a much higher return to cheating on a collusive agreement then high cost plants. This means that small shifts in exogenous circumstances can push low cost firms to exploit their advantage and undercut the agreement. Both Hawley (1974) and Brand (1988) make similar arguments regarding the sources of conflict with the added contention that these codes were drawn up to benefit small firms. Using some limited firm-level data, Alexander and Libecap (2000) argue that because of productivity differences, firms were not able to collude despite being given a ripe opportunity. Responding to Alexander (1994), Krepps (1997) finds no evidence that the critical concentration ratio actually changed once a consistent set of industries are used.[3]

2 Data

The data used for this paper come from the Census of Manufactures (CoM) collected by the Census Bureau in one form or another since 1810. This was initially done in conjunction with the decennial population census. In the beginning of the 20th century, the census began to be collected every five years. Then in 1921, Congress authorized a Census of Manufactures to be taken biannually. This biannual timing persisted through 1940 when there was a shift to every seven years before returning to the current quinquennial enumeration. For reasons unknown, the schedules for 1929, 1931, 1933, and 1935,[4] the first half of the Great Depression, were kept and are housed at the National Archives.[5] Between 1880 and 1929, after tabulations were made, the schedules were either

[3] Though he like Taylor points to some aspects of the codes that do seem to be correlated with a decline in the critical concentration ratio.

[4] There can be confusion with the dating of the censuses. The year convention we will use refers to the year the data are meant to cover. The Archives usually employs a convention where the year refers to the year in which the data are collected, which is one year subsequent. For example, the data in the 1929 census cover things that occurred in calendar year 1929, while the data was collected during the calendar year 1930. The Archives is not altogether consistent in how they record the years.

[5] For years 1929 and 1935, the schedules are on microfilm while 1931 and 1933 are on paper. These are in Record Group 29, Entries 307, 307-A, 309, 309-A.

destroyed intentionally by an Act of Congress or through a combination of fire and bureaucratic neglect (for example, the Census of 1890). The questions on the schedules include revenue, quantity of output, total wage bill, cost of intermediate goods, and number of wage earners employed at a monthly frequency. There is other information about whether the plant is incorporated and, if unincorporated, who the owner is. This latter piece of information allows us to link plants to their parent company.

Besides this data from the Census, we obtained data on plant capacities from a court case regarding the legality of base point pricing, *FTC v. Cement Institute* (1948). Capacities were reported in the exhibits that formed a major part of the case.[6] Note that these are *not* production based capacity numbers where capacity is based on the highest output averaged over some period of time. We have cross-checked these capacities against the Pit and Quarry Handbook, which among other things contains a directory of all cement plants in any given year and has capacities, though often only at the *firm*-level. For the cases where capacities were reported at the plant-level, the correspondence between the directory and the FTC sources is quite good. We have also cross-checked these capacities against the American Cement Directory, another source for capacities. We note that capacities from the court case exhibits are daily rates. To annualize the capacities, we multiply by $.91 \times 365$, which assumes that the plants could not run at their maximum daily capacity for more than 91% of the year.[7]

The plant-level data from the CoM have been previously used in limited applications. Bresnahan and Raff (1991)use data from the motor vehicles industry to examine the evolution of production heterogeneity over the Depression. They find that differences in production technologies predict whether inefficient plants exit the industry. Bertin et al. (1996) study blast furnaces as another case of the impact of heterogeneity on industry behavior. Some recent work using the data, besides that on the macaroni industry, is Ziebarth (2011a) and Ziebarth (2011b). The first studies the effects of the banking crisis that enveloped Mississippi while the latter work addresses the decline in productivity over the first 4 years of the Depression.

A worry in working with the schedules is the completeness of the data. Raff (1998) suggests

[6] Stephen Karlson transcribed these capacities and he has graciously shared those data.

[7] This figure is derived from commentary in industry publications which indicates that this is approximately the level at which plants can no longer expand production and shortages occur. Moreover, it corresponds in practice to the average rate at which our daily capacities convert to figures in sources reporting annual capacities.

that the records are more or less complete. In our own experience, we have noted whole states missing for certain industries, such as the manufactured ice industry in Texas. Luckily, unlike many other industries, there exist numerous other sources with which we can check the validity of the Census data for cement. First, to check for completeness of the list of firms, the 1929 Census data was compared to the listing of portland cement producers as of Oct 31, 1929 published in the 1928 issue of Minerals Resources.[8] The discrepancies between their listings and our own, which are not large to begin with, can be entirely accounted for by a number of factors. First, there are inclusions in the census of non-portland cement producers, such as producers of masonry cement, or in two cases, grinding plants. There are plants included in the Minerals Resources list which, while still in existence, are idle. In addition, the Minerals Resources list appears to include several plants which, according to other trade sources, are closed down. Second, we have compared our production and revenue totals from the plant-level data to the totals reported by the Census itself. Coverage seems excellent with very minor differences between our totals and the published ones.

There is a second worry regarding the quality of the data reported on the forms. The returns are self-reported and considering the complexity of the form (see Figure 1), it does not seem implausible that data quality could have been low. Again the cement industry provides a number of opportunities for independent checks. First, we use the Minerals Yearbook which provides independent estimates of production at a much higher frequency derived separately from the Census. We find very good correspondence between the Minerals Yearbook and our totals. There appears to be no systematic bias between the two sources and the largest divergences are not more than a few percent. Another source for output data is from an FTC court case brought against the Cement Institute in 1948.[9] Here too we find very close agreement at the plant-level between the FTC production numbers and those reported on Census schedules. We have also compared some calculated statistics from our dataset to other published values. For one, the NBER macrohistory database (Series m04076b) has information on cement prices during this time period. We find a relatively stable discount of 17% for our prices relative to the NBER prices. This is not surprising as the NBER prices include any commission to the dealer in addition to the free on board (f.o.b.)

[8] The 1928 issue is published long after 1928, but generally concerns 1928 data and events. In this case, the plant information was collected close to the publication date. Minerals Resources, known as the Minerals Yearbook from 1932 onwards, is the annual publication of the United States government giving summary statistics and annual reviews for a whole range of minerals industries, including cement.

[9] These data were graciously given to us by Stephen Karlson who transcribed them from the court exhibits.

price while our prices only include the latter component.

3 Background on the Portland Cement Industry

Portland cement, often known by its shorthand as 'cement', is a fine powder that is typically mixed with water and sand or gravel ('aggregate') to make concrete. Cement is a very cheap and versatile construction material used in everything from roads and dams to piping. Once dried, portland cement becomes very hard and strongly binds the aggregate together. Because of its strength, it can be used not only as a filler material but also in the construction of load-bearing architectural structures.

The portland cement industry is popular in the economics literature because of several key features.[10] First, the product is essentially homogeneous, so that for a buyer the identity of the plant offering the product is of limited relevance. By far the main consideration is the price offered by that plant. Second, there are numerous relatively isolated markets due to geographical segmentation in the industry, providing useful variation in the cross-section. Portland cement is both relatively cheap to produce and particularly heavy: a cubic foot weighs about 100 pounds. For this reason, shipping costs are a nontrivial component of cement prices, and it is uneconomical to ship cement long distances. For any given plant, its practical market lies within a relatively short distance. In fact, the 1963 Census of Transportation[11] reports that 82% of shipments are under 200 miles with 49.9% of shipments by commercial truck, and 25.5% by rail. The remaining modes of transportation are private truck (9.6%) and water (15%). With the road network not nearly as advanced in the 1930s, this distance from the 1963 Census is almost surely an upper bound for the period of time in question.

There are some additional features that make the industry particularly attractive to economists. First, markets are relatively concentrated, making them ideal settings to study strategic behavior. Second, the production technology is relatively straightforward, allowing for adequate modeling of the production function itself. On the demand side, cement is a key component of many construction activities, though the cost of cement only accounts for on average 2 to 5 per cent of construction

[10] Dumez and Jeunemaître (2000) provide a comprehensive overview of the economic characteristics of the portland cement industry.

[11] This is the earliest such census that we are aware of.

costs (Dumez and Jeunemaître, 2000). Because of its essential nature, it has few substitutes, making demand relatively insensitive to price fluctuations. Hence, the overall level of demand is well approximated by the the level of building and highway construction, which in a typical year comprise more than 95% of cement's use (Minerals Yearbook).

We now summarize the structure of the industry at the time. Figure 2 displays the spatial distribution of the plants for 1929 with the size of the circle representing the plant's output. Table 1 offers some summary statistics of key variables in our dataset. It is interesting to note that there is a fair amount of turnover at the plant-level, with 18 plants leaving over the period, or a 4% probability of exit over a given two year period. A single plant entered the industry in our sample, in 1935.[12] The top 10 firms control around half of the plants in the United States, suggesting some scope for coordination on pricing and output decisions.

4 Narrative Evidence

There is substantial documentary evidence that the NRA had anti-competitive effects in the cement industry. In this section we provide a narrative account of collusive activities under the NRA code. In particular, we study the unique role of the Cement Institute in coordinating industry activity. One reason we do so is to show that contemporaries observing the industry thought that the law had anti-competitive effects. More importantly, the narrative evidence shows mechanisms in place which plausibly could have enforced collusive agreements. To our knowledge, there no longer exists direct evidence of exactly what mechanisms were used by the cement industry to maintain collusion.[13] Therefore, we rely on information from industry trade publications to highlight possible coordinating mechanisms.

It is important for the purpose of context to note that there were allegations of noncompetitive

[12]Exit here means that we were not able to locate a plant in a subsequent census. Similarly, entry means that a plant had no antecedent record. We do not use a master manifest of plants presumably employed by the Census to canvass the plants.

[13]In particular, the "business sharing plans" discussed below do not appear to have survived.

behavior before the introduction of the code.[14] Bids for government contracts were thought to be particularly vulnerable to collusion. According to Loescher (1959), government agencies receiving bids for cement "have nearly always received identical bids of delivered prices" except for a period between 1929 and 1931. Nevertheless, there is substantial evidence that the industry became even less competitive after the NRA was introduced. A crucial role in formulating the code as well as enforcing collusion was played by the Cement Institute. Founded in August 1929, its initial function was to support the base point pricing scheme in operation at the time. To facilitate this system, the Institute published freight rate books, which helped standardize the freight charges applied by plants for shipping cement to various locations. This enabled the reduction of competition between its member firms who could in principle more easily coordinate on delivered prices of cement. This cooperation was the basis of the allegations in the *FTC v. Cement Institute* case in 1948. In general, cement companies submitted identical bids for delivered prices when bidding for government contracts rather than quoting f.o.b. mill prices (Loescher, 1959).

The Code of Fair Competition for the Cement Industry was approved by the federal government on November 27, 1933, after having first been submitted by the Cement Institute on July 19, 1933. Its first stated aim was to "stabilize the industry and prevent economic disturbances due to price wars." The code included provisions to limit capacity investment, restrict pricing below marginal cost, create guidelines for announcing price changes, prohibit certain competitive practices such as gifts to producers, standardize sales and marketing methods, and stipulate acceptable terms and conditions of sale. A majority of the provisions regarding sales and marketing were suspended soon after the approval of the code because of complaints from industry participants. Still, much of the code remained intact, in particular provisions regarding pricing behavior.

The cement code did not explicitly mandate that prices should be kept at some high level. As the code was first being drafted, the intention was to avoid directly fixing prices and limiting capacity. Industry officials stated that prohibiting sales below cost, together with a unified cost-accounting system, would suffice to limit harmful competition (*Rock Products*, August 1933). However, these

[14] For example, the Chicago municipal government complained about being overcharged for cement in 1932:

> "Cement was $1.28 a barrel last year," said [Commissioner of Public Works Oscar] Hewitt. "This year it's $2.10 a barrel. I called the companies in and asked them why the identical bids. They told me they had lost money last year on the city business because they fought for it. They admitted they had got together." (*Rock Products*, 1932).

principles were later abandoned as the code was being drafted. Feasibly, a market with highly competitive prices could be following the letter of the code. However, the effect of the code was to prevent deviations from the collusive outcome by outlawing the aggressive cutting of prices or deviating by offering, for example, price cuts after an initial price had been set. Thus, the code added to the disincentives from deviating from a collusive outcome.

One code provision was considered by the industry trade publication *Rock Products* to be in some respects "the most radical of any industry's code yet signed by the President" (December 1933). This was the explicit business-sharing provisions seldom seen in other codes. Article VI of the code authorized and required the Board of Trustees of the Cement Institute to institute a plan "for the equitable allocation of available business among all members of the industry" within thirty days of the code being approved. Article VII of the code restricted increases in productive capacity. Specifically, the Cement Institute was tasked to scrutinize proposed new plants or increases in the capacity of existing plants. If they concluded that more capacity would exacerbate "the problem of over-production and over-capacity," the Institute could petition the president of the United States to prohibit the increase. Furthermore, the institute could study permanent overcapacity and recommend closing less economical plants.

Several principles were articulated in the code which theoretically could have served to protect consumers from anticompetitive activity, but the details of how the protections were to operate were left unclear. The code mandated that the business-sharing plan "shall in no way reduce the total production of all plants below what is necessary amply to supply demand." At what price level demand was to be satisfied was left unexplained. Moreover, the law states that it was not meant to "promote monopoly or monopolistic practices," although this would seem to conflict with the existence of business sharing plans.

The cement industry began to follow much of what later would be put into law even before the codes themselves were ratified, particularly those provisions regarding labor relations. Charles Conn, the president of the Cement Institute, sent a letter to President Roosevelt on July 13, 1933, noting that a minimum wage of 40 cents per hour and a maximum work week of 36 hours was to be in place in the industry by August 1 of that year, supporting the President's Reemployment Agreement (see Taylor (2011) for a discussion of this policy). Numerous organizations objected to the proposed code. The American Federation of Labor wanted a shorter, 30 hour work week.

E. M. Tisdale made a statement for the Consumers' Advisory Board of the NRA objecting on behalf of consumers to provisions which allowed the allocation of productive capacity (*Pit and Quarry*, October 1933). However, these complaints did not result in those clauses being modified, and President Roosevelt approved the code for the cement industry on November 27, 1933.[15]

After the Supreme Court invalidated the NRA law in May 1935, various industry groups expressed hope that the code would still be followed by the industry. In one headline, *Rock Products* suggested that the "Cement Industry's NRA Code Could Be Enforced Without NRA" (June 1935). On June 11, 1935, the board of trustees of the Cement Institute voted unanimously to retain the NRA hours and wages provisions. The trade publication *Concrete* said that "few cement manufacturers have any desire to return to that unbridled and destructive competition" that characterized the industry prior to the introduction of the code. What mechanism they thought could accomplish this feat is unclear, besides their suggestion of using the NRA as a "code of honor" rather than one of law. In reality, firms began to disregard the labor provisions of the code almost as soon as the law was struck down (*Concrete*, July 1935). Numerous establishments had already reduced wages and increased work hours in the month after the Supreme Court decision. However, there does not seem to be much evidence that plants ignored the restrictions on price cutting and output controls, which favors an interpretation of continued collusion. This outcome is especially likely to have been the case for government contracts, as the Federal Trade commission was "besieged with complaints from the President, the secretary of interior, and state governors and highway department officials concerning identical sealed bids" after a letup of complaints during the time that the NRA was in force (Loescher, 1959).

4.1 Enforcement and Collusion

For the codes to be effective in maintaining collusion, there needed to be mechanisms to enforce agreements. Although membership in the Cement Institute was not necessary for the code to bind, the organization appears to have played a key role. There was a large surge in Cement Institute membership in mid-1933, as firms presumably wanted to provide input to the drafting of the code

[15]Due to some of these complaints, a revised code for the industry became effective on May 21, 1935, although as the law was struck down six days later, the effects of these changes were minimal. Changes made including eliminating provisions regarding the allocation of output, prohibitions on sales below cost, control of increases in capacity and new plant construction, and customer classification (*Concrete*, June 1935).

and mediation of disputes under the code. At the time that the National Industrial Recovery Act was signed, the membership spiked from 20 firms to 73 firms out of a total of about 85, with several others joining soon after (see Figure 5). By the end of 1933, the Cement Institute represented 97 percent of the productive capacity of the industry (*Concrete*, August 1933). What also made the Cement Institute particularly powerful was that it was the sole representative of the industry, unlike other industries that were often represented by multiple trade associations.[16]

There were worries in the industry that the code was not enforceable. *Rock Products* at one point complained that enforcement of codes was useless. For example, the federal government would only interfere with selling below cost when it was done with the express purpose to injure a competitor, because prohibiting it in all cases would be inconsistent with the antitrust laws. Smaller firms were considered particularly damaging to the effort to maintain higher prices, with one editorial in *Rock Products* referring to them as "the greatest menace to stability and recovery."[17] The Department of Justice and the Federal Trade Commission were tasked with enforcing the codes. Donald R. Richberg, general counsel of the NRA, said that:

> The NIRA does provide that any action complying with the provisions of a code shall be exempt from the provisions of the anti-trust laws. This does not mean two things: First, this does not mean that a code can be written to authorize monopolistic practices. Second, this does not mean that, under the protections of a code, industrial groups can organize and then, without regard to the requirements of the code, proceed to fix prices, or to carry out other operations in restraint of trade, free from the penalties of the anti-trust laws."

The NIRA did not define "monopolistic practices" (*Rock Products*, February 1934). Otto M. Graves, the chairman of the 1934 Code Authority for the crushed stone and slag industries, told a January 28, 1935, meeting of the 1935 Code Authority that code provisions designed to prevent increases in capacity for existing plants could not legally be enforced (*Pit and Quarry*, February 1935).

However, because of the nature of the cement industry, court action was not necessary to enforce cartel decisions. Instead, the government could use its position as a major purchaser of cement to force compliance with the codes. A March 20, 1934, proclamation by President Roosevelt required bidders for federal contracts to sign certificates certifying their compliance with NRA codes (*Rock*

[16] The other organization affiliated with the industry was the Portland Cement Association, which at the time was more concerned with the engineering and technical aspects of the cement industry. Today, and following the disbanding of the Cement Institute, the Portland Cement Association assumes both roles.

[17] This is an interesting point of comparison with Alexander (1997) who argues that in the macaroni industry, the largest firms used the code against smaller firms.

Products, April 1934). According to *Rock Products*, the codes were thus being enforced because "nearly all construction today involves the use of [Public Works Administration] money, and the Government can and does refuse contracts to those who fail to comply with codes." Indeed, public spending as a fraction of new construction increased from 23 percent in 1929 to 57 percent in 1933 (Maxwell, 1952). A further method of maintaining cooperation was the exclusion of foreign cement. In order to prevent imports from entering the market, the American firms organized a collective boycott of dealers who handled imported cement in New York and Boston. From 1933 to 1935, there was even a "rotating system of espionage of manufacturers' representatives" organized to check dealers' trucks for foreign cement (Loescher, 1959).[18]

The trade publication literature gives some anecdotal evidence for collusion in the cement industry after the introduction of the NRA. One example of alleged collusion came from the federal government. On June 28, 1934, Secretary of War George Dern complained about rigged bids from cement firms working to gain contracts for the construction of the Fort Peck dam. He alleged that all the bids were at an identical level of $2.70 a barrel regardless of the transport distance involved and denounced the collusion. However, he bought the cement at the "outrageous price" because it was needed immediately (*Rock Products*, August 1934). Various groups expressed concern that the cement NRA code was being used to restrict competition. An article in the September 1934 edition of the *Illinois Journal of Commerce*, reprinted in *Rock Products*, suggested that legal price fixing was implicit in the NRA law, with price fixing not forbidden "provided it does not lead to 'monopolies or monopolistic practices'." Also, the Consumers' Advisory Board of the NRA brought complaints against the price control provisions of the cement code. The federal government investigated allegations of collusive behavior in the cement industry. Barton Murray, the deputy NRA administrator, cleared the industry (*Concrete*, August 1934).[19]

[18] There is other evidence that American cement firms coordinated in matters regarding international trade. For example, a document dated May 3, 1932, in records from the Board of Trade in the United Kingdom said that "an arrangement had been in force for some time with the Americans in which the English manufacturers undertook not to market grey cement in Canada on condition that the United States kept out of the West Indian market."

[19] A separate issue regarding compliance that remains completely unstudied is the degree to which state laws could contribute to enforcing codes. By July 1934, eighteen states had introduced laws allowing the state governments to bring various sanctions against code violators. Pennsylvania, however, a key state with numerous cement producers, never passed one of these laws (*Rock Products*, July 1934). Theoretically, these laws circumvented the constitutional issues involved in the federal governments intensive regulation of commerce in the codes. However, most of them contained clauses rendering the laws operative only so long as the NRA remained in effect. These laws often contained criminal sanctions for NRA code violators. For example, the California law provided for up to six months imprisonment for violations.

The balance of the narrative evidence suggests that the cement industry became less competitive after the NRA was introduced. On the one hand, the industry was already viewed as collusive even before the law, and it would later be the subject of antitrust legal actions. Despite this, there is substantial anecdotal evidence that the industry became even more collusive under the code, in addition to the quantitative evidence we provide below. Moreover, there were a number of mechanisms by which the code could plausibly have enforced cooperation. Enforcement was especially likely in the cement industry because the federal government was such a major consumer and required firms to follow the code. Theoretically, the government could have used its monopsony power in the industry to attempt to force prices down, but doing so would have contradicted the explicit goals of the NRA. To our knowledge, government purchases were done at the local level and not coordinated among government agencies. We have not uncovered instances of cement producers complaining about government action to drive prices down.

5 Theory

In this section, we develop a simple spatial pricing theory to motivate our test for collusion. The model here is a simplified version of a structural model of the cement industry in Chicu (2012). We assume a basic Hotelling setup where there is a market of unit length, with uniform density of consumers N. There are two firms,[20] one located at either end of the market. Suppose that each atomistic consumer has valuation v for a unit of cement, where $v \sim F_v$. This effectively defines a demand curve since it dictates the probability a consumer will buy at a given price and location. This distribution of values is important if we want to assume that consumers are not constrained to buy only from one of the firms, but may consider some outside good: a substitute like stone or lumber, or not purchasing at all.

There are two dimensions over which firms fight for consumers. First, for any given price level, they fight over the marginal consumers (or the location of the marginal consumer) since they want a bigger fraction of the market. Second, for any given fraction of the market, the proportion of consumers they capture depends on how high their price is. A higher price means lower probability that any consumer will want to buy, conditional on the firm's price being the

[20] We use "firm" here for ease of exposition, though the data and tests are done at the plant-level. Our empirical work is careful to define competitors as plants

lowest net of transportation costs. In addition, we assume that firms can price discriminate between consumers. This assumption is consistent with anecdotal evidence from the industry which suggests that via public and secret discounts, firms have the ability to charge unique prices to individual consumers (see United States Federal Trade Commission, 1966).

5.1 Pricing Strategies under Competition

The choice of consumer i located at x_i is a choice between the outside good and purchasing a unit of cement from whichever firm $j \in \{1, 2\}$ offers a lower value of $p_j(x_i) + td_{ij}$. Here, t is the cost of transportation per unit of distance, $p_j(x_i)$ is the 'mill price' exclusive of transportation costs, and d_{ij} is the distance of consumer i from firm j. Given our assumptions, $d_{i1} = x_i$ and $d_{i2} = (1 - x_i)$. We assume throughout that firms have a constant marginal cost c_j, motivated by the observation that capacity utilization rates are quite low for the time period in question.

A firm targeting a particular consumer has two constraints. The first constraint is imposed by F_v. The distribution of a consumer's (private) valuation dictates the probability that they will buy from the firm given some price plus transportation cost and implies that there may be some optimal price for the firm to charge even if there are no other competitors. We denote this as the monopoly price, $p_j^m(x_i)$. The second constraint is imposed by the competing firm, and arises from the fact that at any given price above the rival's marginal cost, that rival would be willing to undercut and steal consumers. Firms will only charge $p_j^m(x_i)$ when it is lower than the maximum price they could charge *without* being undercut by their rival. This intuition forms the basis of the optimal pricing strategies.

We first describe the equilibrium pricing when firms are constrained by their competitors' ability to steal consumers. If for a consumer located at x, $p_1 + tx > c_2 + t\,(1 - x)$, firm 2 can profitably undercut by charging some $p_2 > c_2$ and stealing that consumer. The identity of the consumers at x does not matter, so we drop the indexing by i. An equilibrium price is found by setting the undercutting condition to equality. We can perform a similar analysis for firm 2 to reach the equilibrium (Hotelling) prices

$$\begin{aligned} p_1^H(x) &= \max\{t - 2tx + c_2, c_1\}, \text{ and} \\ p_2^H(x) &= \max\{t - 2t\,(1 - x) + c_1, c_2\}. \end{aligned}$$

Firm 1's equilibrium price dictates that the marginal consumer $\tilde{x}$ is given by

$$\begin{aligned} t - 2tx + c_2 &= c_1 \\ \Rightarrow \tilde{x} &= \frac{1}{2} + \frac{c_2 - c_1}{2t}. \end{aligned}$$

The same condition holds when calculating the price and marginal consumer for firm 2 as above. Firms' relative market shares are thus, in part, dictated by their marginal costs (competitiveness).

So far, the analysis does not make use of F_v. Given that firms cannot charge the monopoly price, it is optimal to charge the highest price feasible that is less than monopoly price. Conditional on being less than monopoly price, the pricing decision does not depend on the consumer's outside option. Where the distribution matters is in the monopoly pricing problem. The monopoly profit maximization problem for firm 1 selling a consumer located at x is given by

$$\max_{p_x} \pi_1^x = (p_x - c_1)\left(1 - F_v\left(p_x + tx\right)\right),$$

with the first order condition for optimal pricing

$$\frac{\partial \pi_1^x}{\partial p_x} = -\left(p_x - c_1\right) f_v\left(p_x + tx\right) + \left(1 - F_v\left(p_x + tx\right)\right) = 0. \tag{1}$$

This implicitly defines the optimal monopoly price $p_1^m(x)$. It is useful to rewrite these expressions in terms of the hazard rate associated with f_v. The hazard rate of a distribution f is defined by

$$h(z) = \frac{f(z)}{1 - F(z)},$$

so that the monopoly price solves

$$h(p_1^m(x) + tx)(p_1^m(x) - c_1) = 1.$$

This equation has a simple economic intuition. A monopolist who raises its price suffers from the cost of a higher "failure" rate of customers: a greater rate of consumers not purchasing the good. This cost is balanced against the direct benefits of selling at a higher price. We make the following assumption.

Assumption 1. *F_v is distributed exponentially with rate parameter λ.*

Assumption 1 makes the analysis more tractable because the hazard rate of the exponential distribution is constant and equal to the rate parameter λ. Under Assumption 1, the monopoly pricing expression simplifies to

$$p_1^m(x) = \frac{1}{\lambda} + c_1.$$

In this case the monopoly price does not depend on the marginal cost of the rival firm. It is clear that $\frac{\partial p_1^m}{\partial c_1} = 1$, and that p_1^m is independent of x. Neither of these facts need be true for more general distributions, however.

The optimal pricing strategy in a competitive environment is given by:

$$\begin{aligned} p_1^*(x) &= \min\left\{p_1^H(x), p_1^m(x)\right\}, \\ p_2^*(x) &= \min\left\{p_2^H(x), p_2^m(x)\right\}. \end{aligned}$$

Figure 3 shows how the equilibrium pricing schedules depend on distance. Firms will charge the monopoly price if it is less than the 'competitive' price. This occurs towards where firms are located—where they have more market power over consumers and are less constrained by their opponents willingness to undercut. Once opponents are able to profitably undercut, firms are forced to charge the diagonal constrained price, which they are willing to do until they reach their own marginal cost, which they set for all remaining locations (though do not actively charge as this is after $\tilde{x}$).

With firm strategies outlined, it is useful to state the following result.

Proposition 1. *It is not a competitive equilibrium for both firms to be charging their monopoly price at the marginal consumer $\tilde{x}$.*

Proof. See Appendix A. □

The implication of this proposition is that for at least some of their consumers, under competition, firm i will charge the competitive Hotelling price p_i^H.

5.2 Pricing Strategies under Collusion

We have now fully characterized the pricing strategies under competition. Optimal collusion will be characterized by firm i charging its own monopoly price to each of its customers $p_i^m(x)$. What has to be decided is how the firms will divide up the market. The joint profit maximizing problem that determines the market split is given by

$$\max_z \int_0^z \left(p_1^m\left(x\right) - c_1\right)\left(1 - F_v\left(p_1^m\left(x\right) + tx\right)\right) dx \\ + \int_z^1 \left(p_2^m\left(x\right) - c_2\right)\left(1 - F_v\left(p_2^m\left(x\right) + t\left(1 - x\right)\right)\right) dx.$$

Denote the optimal choice of z above by x^*. Assuming the first order condition holds, meaning that there exists $\tilde{x} \in [0, 1]$, we can write the first order condition of the above problem as

$$\frac{1 - F_v(p_1^m(x^*) + tx^*)}{1 - F_v(p_2^m(x^*) + t(1 - x^*))} = \frac{h(p_1^m(x^*) + tx^*)}{h(p_2^m(x^*) + t(1 - x^*))}. \tag{2}$$

By Assumption 1, the hazard rate of the distribution is constant, which implies that $p_1^m(x^*) + tx^* = p_2^m(x^*) + t(1 - x^*)$. Substituting the expression for monopoly price and rearranging, we find that

$$x^* = \frac{1}{2} + \frac{c_2 - c_1}{2t}.$$

In this case the market distribution under collusion is the same as in the competitive Hotelling case, but this need not be generically true. In Section 7, we provide some empirical evidence testing this implication of the exponential assumption.

5.3 Testable Predictions of the Theory

The test for collusion compares the pass through of a competitor's cost onto own price under collusion and competition. To bring the theory closer to the data, it is important to specify how the data we observe maps into our theoretical constructs. In general, the model predicts a different price for each consumer depending on their location. All we observe in our data are average prices:

total revenue divided by total output. Total output for firm 1 is given by

$$Q_1(w) = \int_0^w (1 - F_v(p_1(z) + tz))dz,$$

where w and $p_1(z)$ denote an arbitrary market share and pricing schedule. Total revenue is given by

$$R_1(w) = \int_0^w p_1(z)\left(1 - F_v\left(p_1(z) + tz\right)\right)dz.$$

What we observe in the data for price of the firm 1 is

$$P_1 = \frac{R_1}{Q_1}.$$

This is the unit price calculated as total revenue divided by total output. Generally, this will not have a closed form expression under competition or collusion. We now state the central proposition.

Proposition 2. *Suppose that firms act competitively. First,*

$$\frac{\partial P_1}{\partial c_1} > 0,$$

and under certain conditions,

$$\frac{\partial P_1}{\partial c_2} > 0.$$

Proof. See Appendix A. □

Figure 4 illustrates the comparative statics on firm 1's pricing schedule when firm 2's costs increase. The conditions required for Proposition 2 are discussed in the Appendix, and amount to a (sufficiently) inelastic market-level demand for cement. The conditions rule out what we consider to be a pathological case. The pathology arises because while the firm increases its price for all of its *original* customers when its competitor's cost rises, it may additionally serve a relatively large new pool of low value customers. If the mass of this new pool is sufficiently large relative to the mass of consumers receiving the higher prices (some of whom may, in principle, now stop buying), the average price across all consumers may go down. We prevent this by ensuring that market-level demand is sufficiently inelastic that small price changes cannot drastically change the mass of consumers choosing to buy. Both Chicu (2012), as well as Miller and Osborne (2011) in a related model of the cement industry, find such inelastic market-level demand. Our conditions are also consistent with anecdotal discussion of the cement industry (see Dumez and Jeunemaître, 2000).

Proposition 2 forms the basis of our first prediction regarding own cost pass through.

Prediction 1. *Firms' average price P_1 is increasing in own marginal cost regardless of whether the regime is competitive or collusive.*

This prediction does not provide a way to distinguish between competition and collusion. Hence, we consider pass-through of a competitor's cost under competition and collusion. Above we showed that other's cost pass through $\frac{\partial P_1}{\partial c_2}$ can be positive under competition and reasonable assumptions. Crucially, in the exponential case, there is no pass through of other's costs to own price under collusion. Since $p_1^m(x^*) = P_1^m$ for the exponential distribution, the derivative with respect to c_2 is 0, implying no effect of other's cost on own average price under collusion. From this, we obtain a testable prediction for collusion.

Prediction 2. *Under a competitive environment, firms' pricing will depend positively on the marginal cost of their competitor, so that $\frac{\partial P_1}{\partial c_2} > 0$. Under a collusive environment, there will be no dependence of price on competitors' marginal cost: $\frac{\partial P_1^m}{\partial c_2} = 0$.*

The latter part of Prediction 2 would also be true if firms had decided to split the market without recourse to marginal costs in some sub-optimal though perhaps more practically implementable way. Examples here include market divisions based on previous marginal costs or some other exogenous factor. We take this as more than a qualitative prediction that the correlation should fall. Instead we look for quantitative evidence that the correlation falls to 0 after the NRA.[21]

6 Empirical Specification

Our basic specification estimates the impact of own average variable cost $\log AVC_{it}^O$ and average cost of nearest neighbor not jointly owned by the same parent firm, $\log AVC_{it}^N$, on a plant's average

[21] Our result depends on the realism of allowing consumers an outside good. In Appendix B, we show the theoretical implications for the simplification of our model where there is no outside good. In this case, the testable predictions are starkly different, with $\frac{\partial P_1^m}{\partial c_2} < 0$.

price $\log p_{it}$. We are interested in how the effect of the neighbor's cost changes after the NRA. In particular, we specify

$$\log p_{it} = \alpha_0 + \alpha_1 Dist_{it} + \alpha_2 \log AVC_{it}^O + \alpha_3 \log AVC_{it}^N + \alpha_4 NRA_t \cdot \log AVC_{it}^N + \sum_t \alpha_t Year_t + \epsilon_{it} \quad (3)$$

where $Year_t$ are a full set of time dummies and $Dist_{it}$ is the distance to the nearest neighboring plant that is not owned by the same firm. Because of worries about measurement error in the variables, we choose to trim the 1% tails of $\log AVC^O$ and $\log AVC^N$. Results are robust to the fraction we trim. We also cluster the standard errors at the plant-level.

Following our theory, we do not include market fixed effects, instead treating the relevant variables for summarizing the competitive environment for a particular plant as the distance to nearest neighbor and the neighbor's costs. The distance variable attempts to capture the other crucial implication of our model, which is that distance matters, as it serves to segregate customers from plants. We experiment with including some market fixed effects where the markets are based on broad geographic groupings, but find no material difference in outcomes.

A question is whether to treat the data from 1933 as under the NRA or not. The law itself was passed in May 1933 and the code for the cement industry was approved towards the end of the year. There is reason to believe from the narrative evidence that cement plants began operating under the code even before it was approved. Therefore, we treat all of 1933 as an NRA year. While these narrative reports only highlight some of the labor provisions, it is suggestive that there is a sharp increase in the average price-cost margin between 1931 and 1933. The effects of treating all of 1933 as under NRA, if anything, would bias our estimates towards a null result.

Our test for collusion has two parts: $\alpha_3 > 0$ and $\alpha_3 + \alpha_4 = 0$. The first part asks whether, in the pre-NRA period, plants' pricing decisions were constrained by the costs of their nearest neighbor. A significant finding of $\alpha_3 > 0$ would justify our basic theoretical structure and motivate our test for collusion, which forms the second part of the test. If the second claim cannot be rejected, this implies that under the NRA plants' pricing strategies are no longer constrained by their competitors. Under our model, this is positive evidence of collusion.

A feature of this test is that there is no reason to believe that it is sensitive to external business cycle factors. There is a major worry in simply examining margins before and after the NRA because the period of the NRA coincides with one of the strongest expansions in the history of the American economy. Furthermore, there is extensive evidence that margins and profits are procyclical (Floetotto and Jaimovich, 2008), making inference using those variables fragile. In fact, our simple theoretical model would predict a similar effect on margins if there was a shock to demand that raised every consumer's probability of purchase: a drop in λ . But there is no theoretical prediction that external demand factors should increase collusion as measured by our test.

7 Results

7.1 Effect of Neighbor's Cost on Pricing Decisions

Table 2 displays our initial regression results. Our baseline specification in column 1 includes year and firm fixed effects, and shows strong evidence for our theory of how competition operates in the industry. It also shows strong evidence for collusion under the NRA. Before the NRA, a 1% increase in own average variable cost leads to an increase in the price of 0.2%, while a similar increase in the cost of the nearest neighbor leads to half that increase in own price, still a sizable fraction. What is striking is that after the NRA comes into effect, there is in total no effect of nearest neighbor's cost on own price, both statistically and economically. This conforms closely to our theory that suggests under collusion, there should be no effect. We note that there is much less than perfect pass through of costs into prices, which is in tension with our basic theory, though is perfectly consistent with a 2-dimensional extension of our model. Our results are robust to other choices of what fixed effects to include, as evidenced by columns 2 and 3, where we add plant fixed effects in one and drop firm fixed effects in the other. The overall significance of the cost terms is decreased in the regression with plant fixed effects.

In columns 4 through 8, we consider some other robustness checks. First in column 4, we include an indicator for whether the plant has spare capacity of over 10%. Our model assumed constant marginal cost and, therefore, no capacity constraints. However, if plants are sufficiently close to their capacity constraint, it might be unreasonable to assume this pricing structure. Controlling for this possibility does not affect the results at all, suggesting our pricing model is sensible. This is not surprising in a time period in which spare capacity is plentiful. In column 5, we modify the definition of the NRA variable by dropping the observations from 1933. This allows us to not take a stand on how to treat that year. The broad pattern of a strong positive effect of neighbor's price on own price in the pre-NRA years is still present. The sum of the coefficients is not statistically significant at standard significance levels. We take this as evidence that the results are robust to how 1933 is treated. It is feasible that the results are sensitive to changing neighbors over time, due to entry and exit. This would induce changes in the market definitions for a set of plants that survive. In column 7, we consider a regression on plants which were active from 1929 to 1935, and for whom the same nearest neighbor was also present for all years in our sample. Considering only these plants has no meaningful impact on our results.

We have also experimented with excluding plants that are effectively monopolies. In particular, we reran the regressions eliminating any plants whose nearest neighbor is more than 200 miles away, which is the maximum distance cement is shipped normally. This cut of the data does not affect the main results that the NRA dampens competition. In addition, it serves as a falsification test. Examining the results for the group of local monopolists in the final column, there is no effect of the NRA on how they set their price. If there had been an effect here, this would have suggested that there was some unobserved trend that was potentially driving the results. The fact that plants who *ex ante* were monopolists continue to exercise their monopoly power in a similar way after the NRA is reassuring.

7.2 Robustness Check 1: More Neighbors

Our existing regression approach only considers the closest neighbor to any given plant as the relevant competitor, consistent with our theoretical assumption. However, plants may compete with several plants located nearby. Indeed, if plants ship up to 200 miles, they may feasibly compete with other plants up to 400 miles away. To account for this competition with multiple neighbors, we try several alternative specifications of the 'neighbor's' marginal cost. Currently, $\log AVC_{it}^N$ concerns the average variable cost (marginal cost) of the nearest neighbor. Let m be a particular physical distance cutoff. In all of these measures, to keep notation simple, it is implicit that we do not consider plants that are commonly owned with i.

1. 'Simple' average of all plants not commonly owned within m miles of plant: $AVC^S_{it,m}$

$$AVC^S_{it,m} = \frac{1}{n} \sum_{j:d_{ij}<m} AVC^O_{jt},$$

where d_{ij} denotes the distance between plants i and j in miles, and $n = |\{j : d_{ij} < m\}|$.

2. The 'capacity-weighted' average: $AVC^C_{it,m}$

$$AVC^C_{it,m} = \left(\sum_{j:d_{ij}<m} CAP_{jt} \right)^{-1} \sum_{j:d_{ij}<m} CAP_{jt} \cdot AVC^O_{jt}.$$

This measure suggests that larger plants pose a greater competitive threat than smaller plants.

3. The 'distance-weighted' average: $AVC^D_{it,m}$

$$AVC^D_{it,m} = \left(\sum_{j:d_{ij}<m} \frac{1}{d_{ij}} \right)^{-1} \sum_{j:d_{ij}<m} \frac{AVC^O_{jt}}{d_{ij}},$$

where rival plants j are weighted by the inverse of their distance from plant i. An exception occurs when $d_{ij} = 0$, which occurs occasionally for plants located next door to each other. In this case, the measure is the simple average for *only* the next door plants.

We choose $m = 200$ as our baseline though we experiment with cutoffs of 100 and 400 miles.

The results from these regressions are presented in Table 3. While the results show less significance than the baseline regressions, this is not unexpected. For any value of m that we might choose, there are two conflicting effects that will add noise to the data. First, as m gets larger, it will include more plants that are not direct competitors. Second, for smaller m, and especially for plants in sparse areas, relevant competitors are likely to be omitted. We note that the economic significance of the estimated coefficients is relatively unchanged compared to the baseline. The effect of own cost is consistent across all specifications. The point estimates for the effect of competitor costs are very similar to our baseline specification and in two of specifications, we retain statistical significance. What is also similar to the baseline specification is that after the NRA comes into force, the effect of neighbor's cost disappears. This is not just in a statistical sense. The point estimates for the effect after the NRA are usually quite close to 0.

7.3 Robustness Check 2: Separate Estimates by Year

We run a number of regressions which allow for the effects of the nearest neighbor's marginal cost to vary over time. In Table 4 we run the baseline model on data from each individual year including firm fixed effects in each. This allows the values of all the coefficients to be different in each of the years. The results are quite similar with the effect of own average variable cost basically unchanged over the 4 years. While there is less statistical significance to the neighbor effects in 1931 and 1933, the point estimates and economic significance thereof are nearly identical and stands in sharp contrast to the estimate in 1935, which is nearly 0.

7.4 Robustness Check 3: Effects on Market Shares

Our theory makes predictions about how costs affect market share both in terms of the relative effects of own versus competitor's cost and when the NRA comes into effect. In particular, the theory predicts that the effect on market share of an increase in a plant's competitor's cost should be equal in absolute value to the effect of an increase in its own cost. Market share is defined as the amount of output for a particular plant relative to its nearest neighbor's output. Second, the theory at least under the case of exponential demand predicts that the allocation of market share does not change under collusion. The only thing that changes is the pricing decisions of each plant.

Table 5 reports regressions testing these two predictions. In columns 1 and 2, we estimate the effect of own cost and neighbor's cost on market share with and without market fixed effects allowing for this effect to differ with the NRA. Here, we define a market as a particular pair of plants. With regard to the first prediction, we are not able to reject the null that the coefficients are equal in absolute value. The p-value for this hypothesis in the first specification is .55 and .71 in the second specification. Also reassuring is the fact that both variables are strongly significant both economically and statistically. A 10% increase in own costs translates into a 1 percentage point loss in market share. In terms of the second prediction, there is very limited evidence in either specification suggesting that the NRA had much of an effect on how markets were split. In the specification with market fixed effects, the NRA interaction on competitor's cost is marginally significant.

In columns 3 and 4, we combine the cost variables into a cost differential, in effect, presuming that that the effects of each are symmetric. Like the first two specifications, we find a strongly negative effect, statistically and economically speaking. This effect is basically unchanged when the NRA comes into effect, again echoing the prediction of the model that all of the effect of collusion are through pricing. We take all of these specifications as encouraging evidence for the basic predictions of our theory.[22]

7.5 Robustness Check 4: Effects of Cement Institute Membership

In the narrative evidence, we emphasized the role played by membership in the Cement Institute. There is variation over time in who is actually a member. From the exhibits in the *Cement Institute* case, we have information on the identity of each of the members of the Cement Institute, as well as the time period over which they were members. This information is summarized in Figure 5. The membership can be broken down into roughly four groups. The first is a group of 20 firms who joined the Cement Institute within 6 months of its inception, and remained members until after 1935. Call this group the 'founders'. The second is a group of 21 firms who joined the Cement Institute within 6 months of inception, but left by early 1931. It is not clear, from available sources, what caused them to leave. This second group rejoined the Cement Institute in 1933 as the NIRA was passed, remaining members through 1935. The third group is of some 42 separate firms who joined the Cement Institute in 1933 and stayed members through 1935. By our count there are 12 firms that never joined the Cement Institute.

In this section, we consider how firms behave based on the nature and timing of their membership in the Cement Institute. The clearest test revolves around the founders. Since these firms were always part of the Cement Institute, it might be the case that they were always colluding. On the other hand, we would expect firms that joined (or re-joined) in 1933 to show a greater difference in behavior between the pre- and post-NRA periods, colluding only after the NRA was in place. In our model, collusion can only be successful if both firms take part. We account for this in our analysis.

[22] One may wonder why there are 404 observations given the total number of observations in the plant-level regressions was approximately 600. If there was a unique pair of plants defining each market, then there should be 300 observations. However, it need not be the case that if plant A's closest competitor is, say, plant B, that plant B's closest competitor is also A. Consider the case where 3 plants were on a line with A at one end and B in the middle of A and its closest competitor, say C, which is at the other end of the line. While this is slightly in tension with the theory, a majority of plants are in this symmetric relationship.

We consider three regressions in Table 6. In column 1 we consider the basic test run only on cases where at least one of a plant and its nearest neighbor were founding members of the Cement Institute. In column 2, we consider only the case where both the plant and its nearest neighbor are founding members. In these regressions, we expect no dependence of own price on neighbor cost before 1933, and no change in behavior after. We cannot reject this null in the regressions, though in column 2 there are very few observations, making parameter estimates unreliable. In column 3, we consider a regression in which both a plant and its nearest neighbor are not founding members. Here, if our hypothesis about sustained collusion of Cement Institute members is true, we would expect stronger effects than in the original regressions (Table 2). The relationship between own price and rival costs pre-NRA appears stronger as expected, and again is insignificant after 1933. It appears that the nature of Cement Institute membership did have some effect on behavior. Accounting for membership differences yields results that accord with our theory.

7.6 Robustness Check 5: Non-Classical Measurement Error

A final worry that we consider is one of measurement error of a non-classical sort. In our basic specification, both the left hand side variable and one of the right hand side variables are derived from the same "source." More specifically, the price and cost variable are calculated by dividing revenue and total cost, respectively, by total output. If output were mismeasured, then the mismeasurement would drive a spurious positive correlation between price and cost even when there is no "true" relationship. This worry could not explain why a *neighbor*'s cost should be correlated with *own* price. The neighbor's cost is not generated by the same potentially contaminated data as own price and cost. Hence, there is no reason to expect the baseline positive correlation to be spurious let alone the null relationship after the NRA. That being said, when one regression coefficient is biased, this has the potential to bias the other estimates.

A priori, we have no evidence that quantities were reported incorrectly by the plants. As discussed in Section 2, the numbers reported in the court case against the *Cement Institute* line up quite well with those on the Census forms. Still, to check for the severity of this issue, we use an instrumental variables procedure discussed in Blau et al. (2003). The basic idea of their strategy is to use a particular quantile of the contaminated variable as an instrument for the contaminated variable itself. This instrument will be correlated with the regressor in the first stage.

The suggestion for why it is valid is that variation across, say, deciles, reflects true differences in the regressor.[23]

Our analysis uses deciles of the average cost variable as an instrument. We do not report the results in the paper because they are in fact nearly identical to the baseline results. After correcting for measurement error, the correlation between own cost and price is 0.19 as compared to 0.2 in the uncorrected case. The correlation with neighbor's cost before the NRA is 0.09, effectively unchanged. Not surprisingly as well, the correlation after the NRA is a precisely estimated 0. We conclude from this that none of our results are being driven by non-classical measurement error of this sort.

8 Conclusion

To date, there has been little microeconomic evidence about the impact of the NRA's "Codes of Fair Conduct" on firm behavior. We have developed new evidence of how the NRA affected competition with a study of the cement industry. Qualitatively, we show substantial anecdotal evidence from the trade literature that the law led to more anti-competitive behavior. We complement that anecdotal evidence with quantitative evidence based on newly collect plant-level data from the Census of Manufactures. Based on a theoretical test for collusion derived here, we confirm empirically that collusion increased. Before the NRA, a cement plant's pricing decisions were at least constrained by the pricing behavior of its nearest neighbor. After the NRA, plants were free to choose whatever price they liked.

At the macro-level, economists have long debated the effect of the NRA on the economy during the early part of the Roosevelt administration. Cole and Ohanian (2004) have argued that the NRA helps to explain the sluggish recovery from the depths of the Depression. On the other hand, Eggertsson (2011) has suggested that in a liquidity trap, which arguably prevailed at the time, policies that push up inflation expectations, like the NRA, could serve to break the deflationary spiral. Unfortunately, the data do not stretch far enough to consider whether collusion and cooperation continued well after the NRA was struck down in 1935, as Cole and Ohanian (2004) suggest. Given

[23]The choice of which quantile to use depends on the degree of measurement error thought to be present. More measurement error means using coarser quantiles as instruments. In the limit, when measurement error goes to 0, then we return to the basic OLS case where the regressor can serve as an instrument for itself.

the *Schechter* decision invalidated the NRA in May 1935, the fact that effects are still detectable indicates some persistence. We also highlight some narrative evidence that hints at continued collusion even after the Supreme Court's decision. We remain agnostic on the macroeconomic question of how the NRA affected the recovery in the larger economy. We simply note that the effect at the micro-level is a necessary input into any aggregate model of the NRA's effects.

Crucially for the macro question, to what extent do the results here apply to other industries? Admittedly, our industry is more likely to be collusive than most, especially when it is given an additional push in that direction from the government. The narrative evidence suggests that the industry was far from perfectly competitive before the NRA, although it also provides evidence for a further increase in collusion after the NRA. For this reason, caution should be exercised in extending these findings to the broader economy. With that said, many large industries in the economy during the 1930s were similarly concentrated and ripe for a "nudge" by the government.

In a slightly broader context, this study provides a relatively rare direct empirical test for collusion. Much of the empirical industrial organization literature on collusion, largely for the reason that explicit cooperation is generally illegal, has been plagued by a dearth of detailed plant-level data. Given that the Census of Manufactures records are publicly available, the time period seems well suited for further empirical study of collusion. We conclude by suggesting that more case studies of individual industries might be particularly useful not simply for economic historians attempting to gauge the extent of the collusion under the NRA, but also for those interested in industrial organization and how collusion actually occurs, tacit or otherwise.

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A Appendix: Proofs

A.1 Proof of Proposition 1

From the first order condition in equation (1), it must be that $p_1^m > c$. If this does not hold, the condition fails by the fact that $f_v > 0$ and $1 - F_v > 0$. Since firms are observed to serve a positive measure of consumers, then there must exist a marginal consumer. If firms charge monopoly price at the marginal consumer, it means that both firms are charging more than marginal cost, and that consumers are indifferent between the two firms. This means that one firm can deviate and profitably steal consumers from the other firm at the margin. As soon as such a deviation is feasible, we do not have an equilibrium.

A.2 Proof of Pass Through Results for P_1 for Exponential Distribution

There are two cases to consider depending on $p_1(0)$. The first case is when $p_1(0) = t + c_2$, which happens when $\frac{1}{2t\lambda} \geq \tilde{x}$. In this case, prices will be the Hotelling prices for all consumers. We focus on this case for the remainder of the proof, and will discuss extensions of the results to the case where some (or all) prices are the monopoly prices. One can calculate in the pure Hotelling case

$$Q_1 = \frac{\exp(-\lambda(t + c_2))}{\lambda t}[\exp(\lambda t\tilde{x}) - 1].$$

Similarly, one can calculate that

$$R_1 = \exp(-\lambda(t + c_2))\frac{t + c_2}{t\lambda}[\exp(\lambda t\tilde{x}) - 1] - 2t\int_0^{\tilde{x}} x\exp(\lambda tx)dx.$$

Using integration by parts,

$$f(x) = \int x\exp(\lambda tx)dx = \frac{\exp(\lambda tx)}{\lambda t}\left[x - \frac{1}{\lambda t}\right].$$

Now we have

$$\frac{\partial f(\tilde{x})}{\partial c_i} = \frac{\partial \tilde{x}}{\partial c_i}\tilde{x}\exp(\lambda t\tilde{x}), \text{ and}$$

$$\frac{\partial Q_1(\tilde{x})}{\partial c_1} = t\exp(-\lambda(t + c_2))\frac{\partial \tilde{x}}{\partial c_1}\exp(\lambda t\tilde{x}).$$

Furthermore,

$$\frac{\partial Q_1(\tilde{x})}{\partial c_2} = -[\exp(\lambda t\tilde{x}) - 1]\exp(-\lambda(t + c_2)) + t\frac{\partial \tilde{x}}{\partial c_2}\exp(\lambda t\tilde{x})\exp(-\lambda(t + c_2)).$$

This derivative can be rewritten as

$$\frac{\partial Q_1(\tilde{x})}{\partial c_2} = \exp(-\lambda(t + c_2))\left[1 - \frac{\exp(\lambda t\tilde{x})}{2}\right].$$

In general,

$$\frac{\partial P_1}{\partial c_i} = -Q_1(\tilde{x})2t\frac{\partial f}{\partial c_i} - R_1\frac{\partial Q_1}{\partial c_i}.$$

We first consider own cost pass through. In this case, $sgn(\frac{\partial f}{\partial c_1}) = sgn(\frac{\partial \tilde{x}}{\partial c_1}) < 0$ and $sgn(\frac{\partial Q_1}{\partial c_1}) = sgn(\frac{\partial \tilde{x}}{\partial c_1}) < 0$. Therefore,

$$\frac{\partial P_1}{\partial c_1} > 0.$$

Intuitively, since we are considering a situation where there are only Hotelling prices, an increase in c_1 has no effect on the prices charged by the plant. All it serves to do is reduce the market served by firm 1 dropping the customers who were receiving the lowest prices.

In the case where there are some consumers charged a monopoly price, the logic above applies for all consumers that receive Hotelling prices. Those that are paying the monopoly also see an increase of 1 for 1 when the plant's costs rise. Therefore, assuming that the price sensitivity of those receiving the monopoly price is not too high, the average price across all consumers will increase.

Returning to the calculation of other's cost pass through,

$$P_1(\tilde{x}) = t + c_2 + \frac{2\exp(\lambda(t+c_2))}{\lambda}\left[1 - \frac{\lambda t\tilde{x}}{1-\exp(-\lambda t\tilde{x})}\right].$$

To sign the derivative of this expression with respect to c_2, note that $\frac{z}{1-\exp(-z)}$ is increasing in z. So to ensure that pass through is positive, we choose the largest value for $z = \lambda t\tilde{x}$ that is consistent with our maintained assumption of all consumers receiving Hotelling prices, which is

$$\lambda t\tilde{x} = \frac{1}{2}.$$

Substituting this into the expression for $P_1(\tilde{x})$, we find

$$P_1(\tilde{x}) = t + c_2 + \frac{2\exp(\lambda(t+c_2))}{\lambda}\left[1 - \frac{1}{2(1-\exp(-.5))}\right].$$

So if

$$\frac{\partial}{\partial c_2}\left(\frac{2\exp(\lambda(t+c_2))}{\lambda t}\left[1 - \frac{1}{2(1-\exp(-.5))}\right]\right) > -1,$$

then $\frac{\partial P_1(\tilde{x})}{\partial c_2} > 0$. This condition can be re-written as

$$\begin{aligned}\exp(\lambda(t+c_2)) &< \frac{1}{\frac{1}{2(1-\exp(-.5))} - 1}\\ \Rightarrow \lambda &< \frac{0.613}{t+c_2}.\end{aligned}$$

Again, the complication here is that when the other firm's costs rise, that allows for the firm to raise its price to its existing customers. It also starts selling to a new lower value group of customers near its margin. The condition above is a condition on how many new customers the firm sells to, and how many existing customers it loses due to higher inframarginal prices. The condition ensures that overall average price rises, and we have our result for the case of all Hotelling prices. In the context of the exponential distribution and the structure of demand in our model, a condition requiring sufficiently low λ amounts to requiring that market-level demand is sufficiently inelastic.

Consider now the case where the firm is charging its monopoly price to some subset of its customers. First, it is easy to check that in the case where a plant is charging the monopoly price to all of its customers, then there will be no effect of a change in c_2 on price. This is then also true for the subset of consumers being charged the monopoly price. However, the analysis for the subset being charged a Hotelling price is analogous to the above. Thus, an analogous condition on demand will be required for the case where the firm sets its monopoly price for a strict subset of its consumers.[24]

B Appendix: Model Predictions with No Outside Good

Consider a model identical to that discussed in Section 5, but without an outside option, and the assumption that all consumers have valuation v of the good. In this case, $p_1^*(x) = \min\left(p_1^H, v - tx\right)$ and similarly for p_2^*. Assume $c_i < v$ sufficiently so that some consumers are charged p_i^H. Then the marginal consumer is still given by $\tilde{x}$, and without an outside option, it is immediate that $\partial P_1^H / \partial c_2 > 0$.

Suppose now that the firms collude, and that the market is covered. Then we have that

$$\begin{aligned} p_1^m &= v - tx \\ p_2^m &= v - t(1-x) \end{aligned}$$

and the marginal consumer $\tilde{x}$ is such that

$$\begin{aligned} \tilde{x} &= \arg\max_x \pi(x) \\ &= \arg\max_x \left[(v - tx - c_1) x + (v - t(1-x) - c_2)(1-x) \right]. \end{aligned}$$

This optimization yields $\tilde{x} = 1/2 + (c_2 - c_1)/(4t)$. Consider the perspective of firm 1 (by symmetry the conclusion will hold for firm 2 also). Its average price is given by

$$P_1^m = \frac{\int_0^{\tilde{x}} (v - tx)\, dx}{\tilde{x}}$$

so that

$$\frac{\partial P_1^m}{\partial c_2} = \frac{\frac{\partial \tilde{x}}{\partial c_2} \cdot (v - t\tilde{x}) \cdot \tilde{x} - \frac{\partial \tilde{x}}{\partial c_2} \cdot \int_0^{\tilde{x}} (v - tx)\, dx}{\tilde{x}^2} < 0.$$

The final inequality follows since $v - tx$ is strictly downward sloping in x, and so it must be that $\int_0^{\tilde{x}} (v - tx)\, dx > (v - t\tilde{x}) \cdot \tilde{x}$. Thus, the model without an outside good option unambiguously predicts a decrease in one plant's monopoly price for an increase in its rival's cost. Intuitively, this is because as plant 2 becomes more inefficient, plant 1 takes over some consumers at the margin to which it must charge a lower price than for any other of its previous consumers, with inframarginal prices remaining unchanged.

[24] If the conditions we outline above were violated and $\frac{\partial P_1(\tilde{x})}{\partial c_2} < 0$, we could still use this to form the basis of a statistical test. The only case in which we could not form a useful test is if the true parameter values were precisely such that $\frac{\partial P_1(\tilde{x})}{\partial c_2} = 0$. In this proof we have endeavored to show what is required for the most realistic outcome.

C Appendix: Figures and Tables

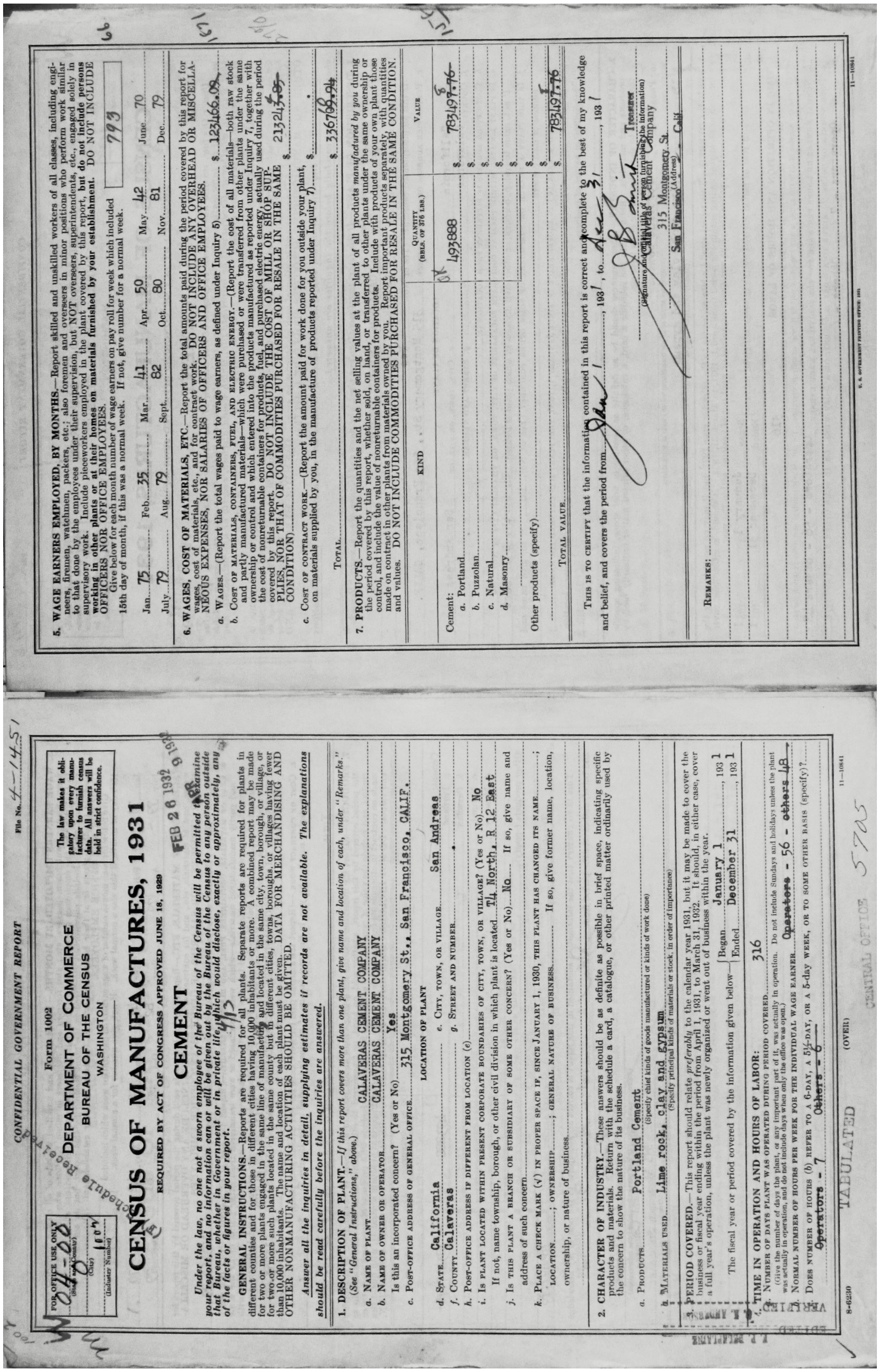

Figure 1: Example of one of the manufacturing schedules for 1931.

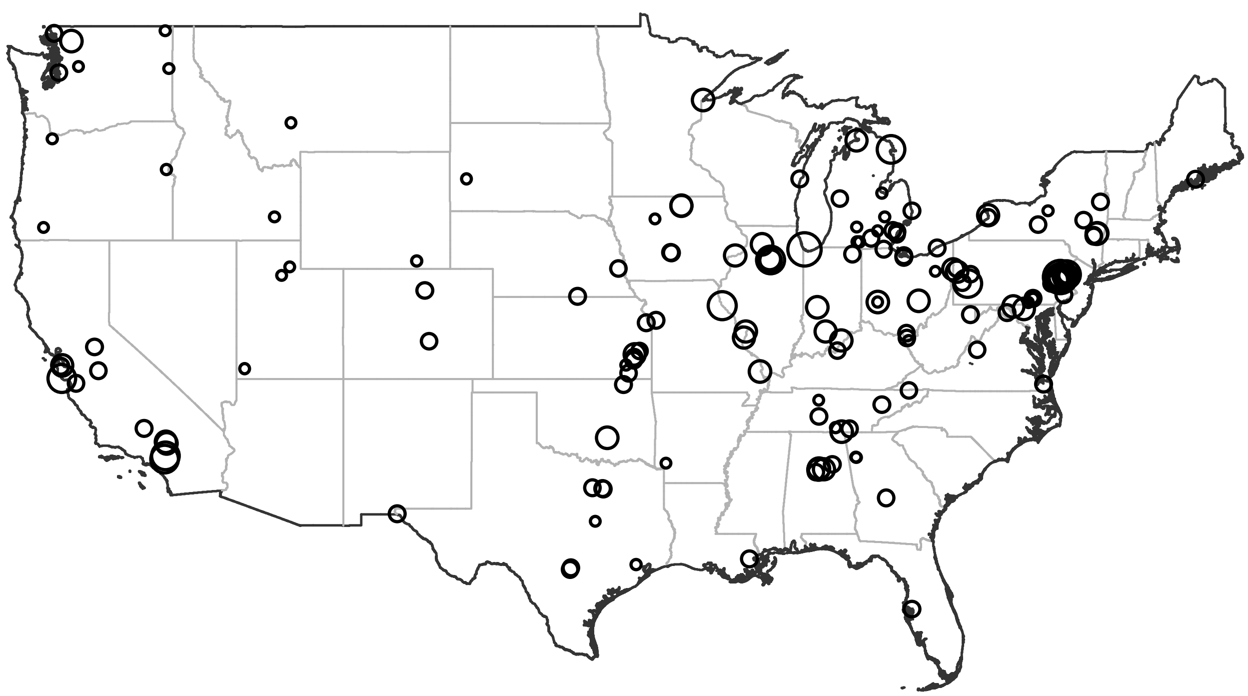

Figure 2: Map showing plant locations for 1929, with circle sizes indicating plant capacity.

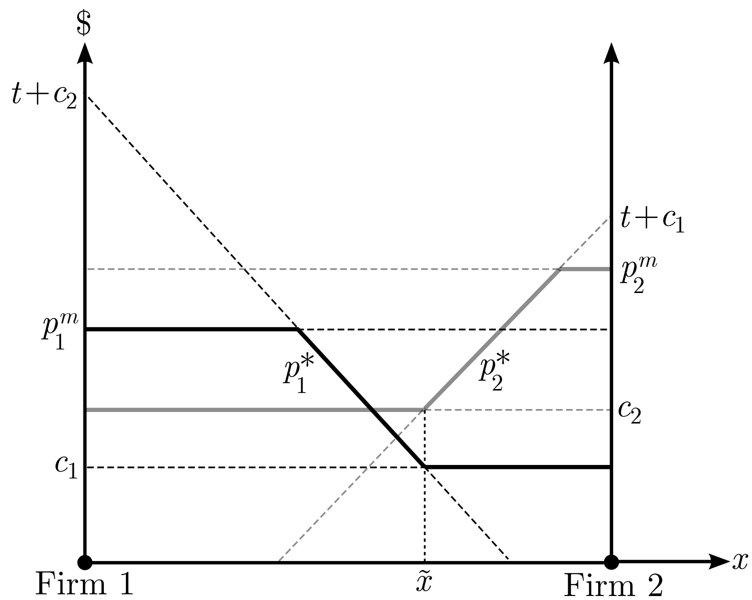

Figure 3: The optimal pricing schedule under the exponential distribution. The pricing functions of firm 1 are shown in black, and those of firm 2 in gray. The bold lines are the prices offered to any given consumer located at x. The diagonal lines are the prices constrained by rival marginal cost ('competitive' prices, $p_1^H(x)$), and monopoly prices are shown as constant in x, in accordance with an exponential distribution of consumer valuations.

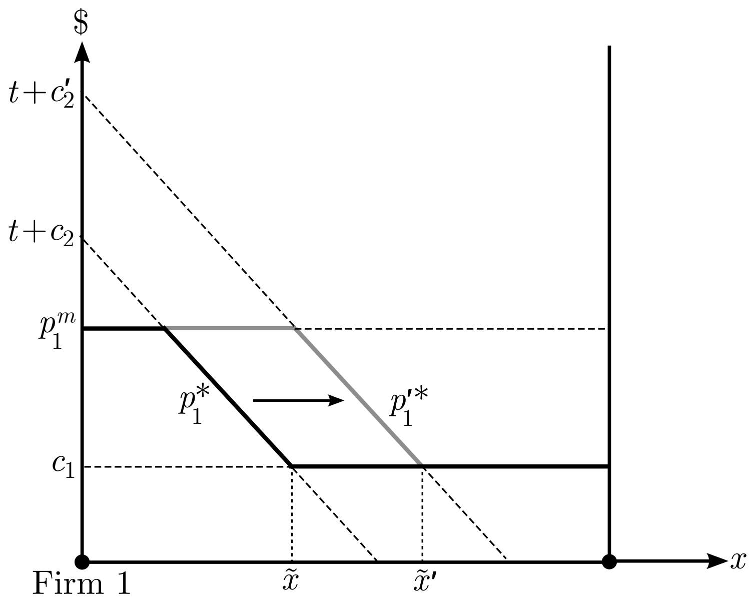

Figure 4: This diagram shows how average price charged by firm 1 can increase if there is an increase in the marginal cost of firm 2, assuming that firms do not collude. When c_2 increases, this shifts outward the line representing 'competitive' prices, $p_1^H(x)$. This means that there is a set of consumers that are now charged a higher price, as the optimal pricing schedule now shifts outwards.

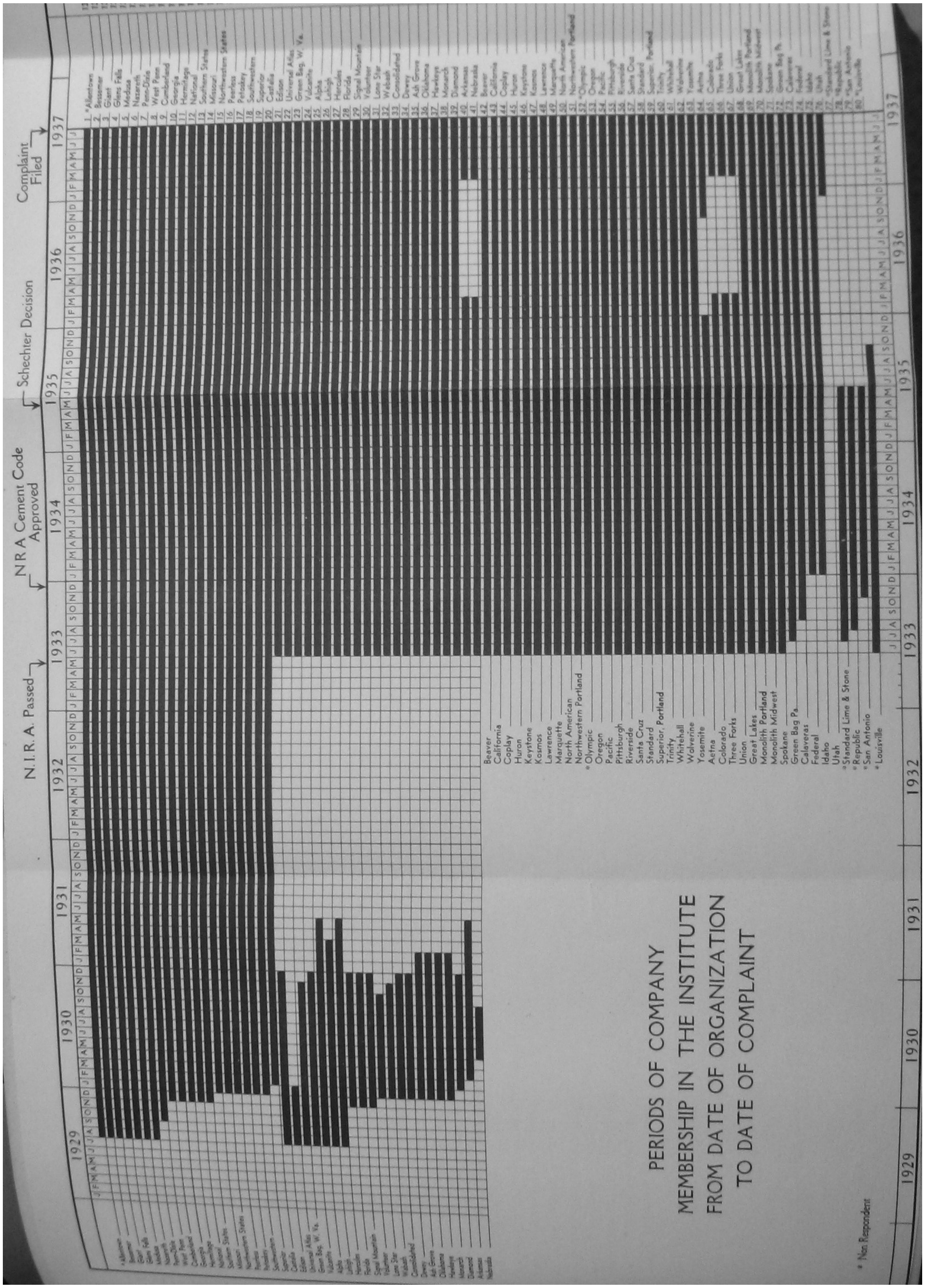

Figure 5: Chart X-B from the case of *FTC v. Cement Institute* (1948). Each row is a different firm, months and years are represented across the x-axis, and black bars represent period of membership of the Cement Institute. Those 12 firms that never joined the Cement Institute are not represented.

	Price	Quantity	Capacity	Wage	Entry	Exit
Mean	1.46	723086	1600906.53	.51	.00	.04
Median	1.44	566659	1168121.73	.48	-	-
Std. Dev.	.35	656973	1328600	.34	-	-
Min	.75	11970	332150	.05	-	-
Max	4.20	7342167	9964500	4.56	-	-
N	598	598	604	451	1	18

Table 1: Summary statistics of a number of variables over all 4 census years. Prices and quantities are for barrels of cement and prices are in nominal dollars. Wages are not available for 1933. Capacities are daily capacities multiplied by $.91 \times 365$ to give our estimates for annual capacities. Entry and exit are indicators for whether a plant enters the sample or exits, and mean gives the expected probability of firm entry/exit in a given year.

	Log Price							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log AVC$	0.204***	0.159**	0.214***	0.207***	0.223***	0.202***	0.221***	0.101
	(0.0429)	(0.0623)	(0.0313)	(0.0433)	(0.0521)	(0.0423)	(0.0489)	(0.117)
Distance	0.0193***	0.0400	0.0229***	0.0195***	0.0181***	0.0196***	0.0203***	1.530***
	(0.00612)	(0.0319)	(0.00579)	(0.00609)	(0.00645)	(0.00608)	(0.0638)	(0.256)
$\log AVC_n$ (a)	0.0934**	0.0650	0.107***	0.0936**	0.0921**	0.0775**	0.115***	0.175*
	(0.0390)	(0.0410)	(0.0360)	(0.0391)	(0.0384)	(0.0367)	(0.0432)	(0.0954)
$\log AVC_n * NRA$ (b)	-0.0953**	-0.100**	-0.0975**	-0.0960**	-0.182***	-0.160***	-0.0897**	-0.0229
	(0.0452)	(0.0485)	(0.0493)	(0.0455)	(0.0564)	(0.0535)	(0.0436)	(0.0863)
Excess capacity				-0.0508				
				(0.0370)				
Firm fixed effects?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Plant fixed effects?	No	Yes	No	No	No	No	No	No
p-value (a) + (b)	0.970	0.503	0.834	0.961	0.105	0.134	0.622	0.152
N	566	566	566	566	445	566	494	41
R^2	0.575	0.616	0.398	0.577	0.584	0.578	0.604	0.698
NRA Definition	1933	1933	1933	1933	Drop 1933	1935	1933	1933
Sample	All	All	All	All	All	All	Balanced	Monopolies

Table 2: Effect of own and neighbor's cost on log price. Standard errors are clustered at the plant-level. Excess capacity is an indicator for whether output is less than 90% of plant's capacity. All regressions include year fixed effects and 1% tails of own and neighbor's AVC are trimmed. The last column restricts attention to plants that are effectively monopolies meaning they have no competitors within 200 miles. $*$ significant at 10%. $**$ significant at 5%. $***$ significant at 1%.

	Log Price				
	(1)	(2)	(3)	(4)	(5)
$\log AVC^O$	0.202***	0.202***	0.202***	0.205***	0.194***
	(0.0445)	(0.0441)	(0.0435)	(0.0456)	(0.0433)
Distance	0.0133**	0.0135**	0.0155**	0.0178**	0.0166***
	(0.00667)	(0.00684)	(0.00673)	(0.00793)	(0.00611)
$\log AVC^S$ (a)	0.0902			0.0379	0.196*
	(0.0903)			(0.0689)	(0.113)
$\log AVC^S \cdot NRA$ (b)	-0.0418			-0.120	-0.0386
	(0.105)			(0.0866)	(0.117)
$\log AVC^C$ (a)		0.107			
		(0.0982)			
$\log AVC^C \cdot NRA$ (b)		-0.0695			
		(0.108)			
$\log AVC^D$ (a)			0.109*		
			(0.654)		
$\log AVC^D \cdot NRA$ (b)			-0.0880		
			(0.0711)		
Distance Cutoff	200	200	200	100	400
p-value (a) + (b)	0.716	0.788	0.817	0.497	0.208
N	525	525	547	490	562
R^2	0.571	0.571	0.568	0.583	0.573

Table 3: Effect of own and neighbor's cost on log price. Standard errors are clustered at the plant-level. All regressions include year and firm fixed effects and 1% tails of own and neighbor's AVC are trimmed. $*$ significant at 10%. $**$ significant at 5%. $***$ significant at 1%.

	Log Price			
	(1)	(2)	(3)	(4)
$\log AVC^O$	0.253**	0.242*	0.196*	0.233***
	(0.126)	(0.125)	(0.106)	(0.0833)
Distance	0.00825	0.0231	0.0203*	0.0185**
	(0.0114)	(0.0152)	(0.0119)	(0.00861)
$\log AVC^N$	0.107**	0.125	0.0778	-0.00302
	(0.0484)	(0.102)	(0.0949)	(0.0756)
Firm fixed effects?	Yes	Yes	Yes	Yes
Plant fixed effects?	No	No	No	No
Years	1929	1931	1933	1935
N	155	150	121	140
R^2	0.756	0.795	0.835	0.783

Table 4: Effect of own and neighbor's cost on log price, separate years and coefficients. Standard errors are clustered at the plant-level. All regressions include year and firm fixed effects and 1% tails of own and neighbor's AVC are trimmed. $*$ significant at 10%. $**$ significant at 5%. $***$ significant at 1%.

	Market Share			
	(1)	(2)	(3)	(4)
$\log AVC^O$	-0.146^{***}	-0.187^{***}		
	(0.0409)	(0.0339)		
$\log AVC^O * NRA$	0.0226	0.0166		
	(0.0500)	(0.0682)		
$\log AVC^N$	0.116^{***}	0.170^{***}		
	(0.0340)	(0.0318)		
$\log AVC^N * NRA$	0.0645^{*}	-0.0562		
	(0.0383)	(0.0557)		
$AVC^O - AVC^N$			-0.142^{***}	-0.210^{***}
			(0.0280)	(0.0213)
$(AVC^O - AVC^N) * NRA$			-0.0205	0.0787
			(0.0384)	(0.0528)
Observations	404	404	404	404
Adjusted R^2	0.769	0.145	0.774	0.186
Market fixed effect	YES	NO	YES	NO

Table 5: Effect of own and neighbor's cost on market share. Standard errors are clustered at the market level. All regressions have 1% tails of own and neighbor's AVC are trimmed. $*$ significant at 10%. $**$ significant at 5%. $***$ significant at 1%.

	Log Price		
	(1)	(2)	(3)
$\log AVC$	0.201**	0.0843	0.147***
	(0.0877)	(0.480)	(0.0475)
Distance	0.0271***	0.0335**	0.0151*
	(0.00875)	(0.0137)	(0.00888)
$\log AVC_n$ (a)	0.0387	0.109	0.148***
	(0.0691)	(0.156)	(0.0462)
$\log AVC_n * NRA$ (b)	-0.0379	0.0504	-0.106**
	(0.0908)	(0.865)	(0.0516)
Firm fixed effects?	Yes	Yes	Yes
Plant fixed effects?	No	No	No
NRA Founding Members?	One	Both	Neither
p-value (a) + (b)	0.992	0.873	0.513
N	230	23	336
R^2	0.622	0.313	0.562

Table 6: Effect of own and neighbor's cost on log price, accounting for NRA membership. Standard errors are clustered at the plant-level. All regressions include year fixed effects and 1% tails of own and neighbor's AVC are trimmed. $*$ significant at 10%. $**$ significant at 5%. $***$ significant at 1%.