Horizontal Mergers, Prices, and Productivity[1]

Robert Kulick

While empirical research into the price effects horizontal mergers has expanded rapidly over the last decade, analysis of productivity effects has lagged behind, and empirical research considering price and productivity simultaneously is scant. I evaluate the price and productivity consequences of horizontal mergers, focusing in particular on the interaction of these effects. Despite being associated with substantial productivity increases, horizontal mergers are also associated with substantial price increases. There is a significant negative relationship between productivity and price; however, the rate at which productivity increases translate into price decreases is modest. My results provide strong evidence that these price increases are caused by market power: Price increases are associated solely with horizontal mergers and are associated with decreases in output. Price increases are restricted to mergers occurring after the period of strict regulation ending in the mid-1980s and to mergers involving plants in close geographic proximity. Finally, prices rise at nearby plants rise in response to the price increases associated with local merger activity.

1. The results presented here have been screened to ensure that no confidential information is released in accordance with the policy of the Bureau of the Census. The results and conclusions expressed here are those of the author and do not reflect the opinions of the Bureau of the Census or the Center for Economic Studies. I am deeply indebted to John Haltiwanger and Andrew Sweeting for their guidance and support for this research. I also thank Ginger Jin, Chad Syverson, Allan Collard-Wexler, Orley Ashenfelter, Matthew Weinberg, Nathan Miller, Einer Elhauge, Ethan Kaplan, Ryan Decker, Javier Miranda, and Emek Basker as well as seminar participants at the Department of Justice and IIOC Rising Stars Session for their helpful comments and suggestions. Email: kulick@econ.umd.edu.

In recent years, research into the empirical consequences of horizontal mergers has been a burgeoning area of inquiry and there has been significant progress in the retrospective analysis of price effects. A large body of research provides systematic evidence that horizontal mergers are often associated with price increases (Ashenfelter, Hosken, and Weinberg 2014). Yet, research on the productivity consequences of horizontal mergers has lagged behind. Over a decade ago, Michael Whinston averred in his *Lectures on Antitrust Economics* (2006) that "remarkably little has been done examining the effects of horizontal mergers on productive efficiency." However, unlike the retrospective study of price effects, the response to this gap in the literature has been muted. Furthermore, literature on the empirical relationship between the price and productivity effects is virtually non-existent, even though the nature of the tradeoff between price effects and efficiencies is one of the oldest and most important questions in the economic analysis of horizontal mergers (Ashenfelter, Hosken, and Weinberg 2015).

Using data on the ready-mix concrete industry from the Census of Manufacturers as a laboratory, this study seeks to fill the gap by simultaneously evaluating the price and productivity effects of horizontal mergers. Despite being associated with substantial productivity increases, horizontal mergers in the ready-mix concrete industry are also associated with substantial productivity increases. I then examine the nature of the interaction between prices and productivity and consider whether the observed price increases can be attributed to market power. After a careful examination, I conclude there is strong evidence that the price increases are driven by market power and consider how acquisition dynamics impel and perpetuate this outcome. The empirical investigation then concludes by examining how the interaction of price and productivity effects results in significant distortion of total factor productivity measured with respect to revenue (TFPR) relative to total factor productivity measured with respect to quantity

(TFPQ). Finally, to assess total welfare effects, I estimate a simple logit demand system and simulate welfare changes based on my empirical results. For acquired plants, the aggregate effect of this tradeoff is negative across a wide range of specifications and, based on my preferred estimates, contributed to welfare losses of between -$137,000 and -$223,000 per acquired plant. When combined with evidence of inflated prices without productivity increases at both acquiring plants and non-merging plants located near merging plants, the results strongly suggest that total welfare declined.

This paper lies at the nexus of two major strands of economic research: the literature on the retrospective analysis of the price effects of horizontal mergers and the literature on the relationship between productivity and mergers in general. In terms of the horizontal merger retrospective literature, this research is part of the nascent empirical literature considering the relationship between prices and efficiencies. The retrospective empirical literature on the subject is currently restricted to the study of a single merger in the beer industry, (Ashenfelter, Hosken, and Weinberg 2015; Miller and Weinberg 2015) and considers only efficiencies limited to changes in transportation costs.

In terms of the relationship of this study to the horizontal merger retrospective literature more generally, a number of recent commentaries have emphasized the potential for serious methodological problems to undermine the validity of the program evaluation techniques typically employed in the literature (Ashenfelter, Hosken, and Weinberg 2009; Carlton 2009; Werden 2015). In particular, these commentaries argue that as a result of data limitations, identification of merger specific price effects will potentially be confounded by demand shocks and/or selection effects correlated with merger activity. Furthermore, even if merger specific effects are identified, to attribute price increases to market power requires an identification strategy that can distinguish between market power effects and other potential merger specific reasons for price increases like increases in product quality or changes in customer base. Finally, Carlton (2009) argues that because any observed set of mergers is necessarily the sample of mergers permitted by the regulatory authorities, this selection effect presents an added difficulty for estimating informative price effects.

While the ready-mix concreted data available through the CM is also subject to imperfections and is not a panacea, the rich nature of the data provides an opportunity to make substantial progress. The foundation of my control strategy is the detailed variables available on plant characteristics available in the data. When combined with the large number of plants and mergers in the sample, these variables allow for a methodologically appealing implementation of the program evaluation techniques that are standard in the literature. Furthermore, the nature of demand for ready-mix concrete is well-studied and highly effective controls for demand shocks are available for the industry (Syverson 2004a; Collard-Wexler 2013; Backus 2016). The ready-mix concrete data also allow for a number of comparisons that serve both to verify that the observed price increases are not the result of methodological flaws and to distinguish price increases resulting from market power from alternative explanations.

First and foremost, because I observe the quantity sold for each plant in my sample, the same basic methodology can be used to estimate the effects on changes in quantity as for changes in price. Because concrete is a physically homogenous product, to the extent that mergers are associated with increases in product quality, the major opportunity for differentiation is in terms of service quality. Thus, increases in quality resulting from merger activity should result in unchanged or increased plant level quantity sold.

In addition, I take advantage of three sources of potential heterogeneity in merger outcomes to supplement the primary control strategy. First, because of the highly localized nature of competition in the ready-mix concrete industry, price increases associated with market power effects should occur primarily in response to mergers involving plants located in close geographic proximity. Second, I compare horizontal mergers to non-horizontal mergers as market power effects are only likely to be associated with horizontal mergers.[2]

Finally, due the time period which the data span, I am able to compare outcomes before and after the change in regulatory standards of merger review evolving over the course of the 1980s. A large body of research suggests that antitrust policy became less restrictive towards horizontal mergers during the mid-1980s (Krattenmaker and Pitofsky 1988; Baker and Shapiro 2008) following a period of tight regulation in the 1970s. This potential source of heterogeneity is useful for a number of reasons. First, to the extent that price increases are observed for the time period before 1982, it is unlikely that these would be associated with systematic changes in market power due to the relative strictness of policy towards horizontal mergers at that time. Second, as noted in Carlton (2009), by examining the effect of changes in the regulatory regime in the context of merger retrospective studies, the price effects estimated by merger retrospective studies will be more informative from a consumer welfare standpoint.

In terms of productivity, there is a substantial and venerable body of research considering the productivity effects for mergers as a whole (Lichtenberg and Siegel 1987; McGuckin and Nguyen 1995; Maskimovic and Phillips 2001; Hortacsu and Syverson 2007; Braguinsky et al. 2015; Blonigen and Pierce 2016). Despite its size, this literature does not involve any studies

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2. Hortacsu and Syverson (2007) have provided compelling empirical evidence that vertical integration in the ready-mix concrete industry does not enhance market power and there is little basis in economic theory for conglomerate mergers directly resulting in the exercise of market power.

comparing the productivity consequences of horizontal mergers to other types of mergers. This lack of focus on specifically horizontal mergers is potentially problematic for two reasons. First, the productivity consequences of horizontal mergers may fundamentally differ from other types of mergers (Whinston 2006). Second, much of the literature considering the relationship between mergers and productivity relies on TFPR. This standard for measuring productivity has been justified by assuming that antitrust enforcement is sufficient to eliminate systematic bias due to price increases (McGuckin and Nguyen 1995). However, to date this assumption has not been tested in the productivity literature. And, while a few recent papers have examined the productivity effects of mergers in general using TFPQ or using structural techniques to adjust revenue based measured of productivity (Hortacsu and Syverson 2007; Braguinsky et al. 2015; Blonigen and Pierce 2015), the relationship between horizontal mergers, TFPQ, and TFPR is not well understood.

II. Data and Measurement

A. Ready-Mix Concrete

The ready-mix concrete industry has become popular for economic research due to its unique characteristics and because of the detailed data collected for the industry through the Census of Manufactures (CM). The CM occurs every 5 years as part of the Economic Census and collects detailed data on inputs used by plants in the production process. For 1977, 1982, 1987, and 1992, the CM also collected physical quantity data from plants in the ready-mix concrete industry. These data have been used extensively in the economic literature on productivity to calculate TFPQ (Syverson 2004a, 2004b; Hortacsu and Syverson 2007; Foster, Haltiwanger, Syverson 2008; Collard-Wexler 2013; Backus 2016) and serve as the basis for this study.

Ready-mix concrete is a mixture of water, cement, gravel, and other chemical admixtures. The vast majority of ready-mix concrete, over 97 percent according to the BEA's 1987 Benchmark Input-Output data, is purchased by the construction sector (Syverson 2004a). The ingredients of ready-mix concrete are typically mixed at a central plant and then transported to construction sites. The American Society for Testing and Materials (ASTM) standards specify that ready-mix concrete should be transported and discharged within 1.5 hours of initial mixing. Although this stipulation can be waived by the purchaser, the perishability of the product and high cost of transporting it result in a highly localized market for ready-mix concrete (Collard-Wexler 2012). Data from the 1977 Commodity Transportation Survey indicate that ready-mix concrete plants ship approximately 95 percent out their output by weight less than 100 miles (Syverson 2004a). The economic literature suggests that the primary market of an urban ready-mix concrete plant will fall within 20 to 45 minutes of the plant (Syverson 2004a, Collard-Wexler 2013).

Following Syverson (2004a), ready-mix concrete markets are often defined in the economic literature in terms of the BEA's 1995 Component Economic Areas (CEAs). CEAs partition all 3,141 counties in the United States into 348 market areas designed to capture linked economic activity (Backus 2016). CEAs are then combined by the BEA to form 172 Economic Areas or EAs. CEAs have the benefit of providing a contiguous, relatively compact market definition for the ready-mix concrete industry. However, for the purposes of assessing the market power effects of horizontal mergers, CEAs are potentially problematic. First, plants on opposite ends of a CEA will often be too geographically distant to be directly competitive. Second, because CEAs partition the United States into contiguous geographic entities, two plants on the edges of different CEAs may be in much closer geographic proximity than either plant is to other plants within the CEA. Thus, for the purposes of my empirical analysis of market power, I define an alternative geographic area: the Adjacent County Block (ACB). For a given plant, an ACB constitutes the county in which the plant is located and the immediately adjacent counties. While CEAs contain over 9 counties on average, ACBs in my sample have an average of 6 counties. Furthermore, because ACBs are drawn with respect to each plant, this market definition essentially amounts to defining markets in terms of a small circle around each plant. Finally, ACBs represent a convenient unit of analysis because the constituent units of CEAs and EAs are also counties, facilitating direct comparison of the different market definitions. However, because ACBs are necessarily overlapping, in my demand estimation and welfare estimates, I use CEAs to define markets.

B. Sample

The basis for the sample is the Foster, Haltiwanger, Syerson (2008) [FHS] set of ready-mix concrete plants with price and quantity data. As the focus of this study is pricing and productivity changes, the sample is restricted to FHS plant observations spanning at least two consecutive CM years. However, the sample I employ differs from the original FHS sample in one important way. In some instances, where the Census Bureau was unable to collect product level price or quantity data for a plant, it imputed data, but the flags distinguishing the imputed data from the reported data were lost. Previous studies made various attempts to identify imputed data, but were unable to identify the full set of imputations. White, Reiter, and Petrin (2015) have since recovered the missing impute flags. I apply these impute flags to the FHS data to ensure that all revenues and quantities represent reported values rather than imputations. White, Reiter, and Petrin show that imputed observations account for approximately half of the FHS sample. Because of the substantial amount of missing data, after presenting my analysis, I consider the robustness of the results by developing a propensity score model to control for possible systematic patterns created by missing data in Appendix A. The results remain quantitatively and qualitatively similar across all specifications of the propensity score model.

C. Mergers

I identify merger activity by linking the CM to the Census Bureau's Longitudinal Business Database (LBD). The LBD contains a high quality firm identification variable (Firm ID), which I use to track ownership changes and to distinguish horizontal mergers from other types of mergers. Table 1 provides some basic information on the frequency of mergers within the data to help clarify the distinctions between the different categories of plants involved in merger activity.[3]

Table 1

	Plants
TOTAL	1,980
MERGING ALL	540
ACQUIRED ALL	320
ACQUIRED HORIZONTAL	200
ACQUIRING	220

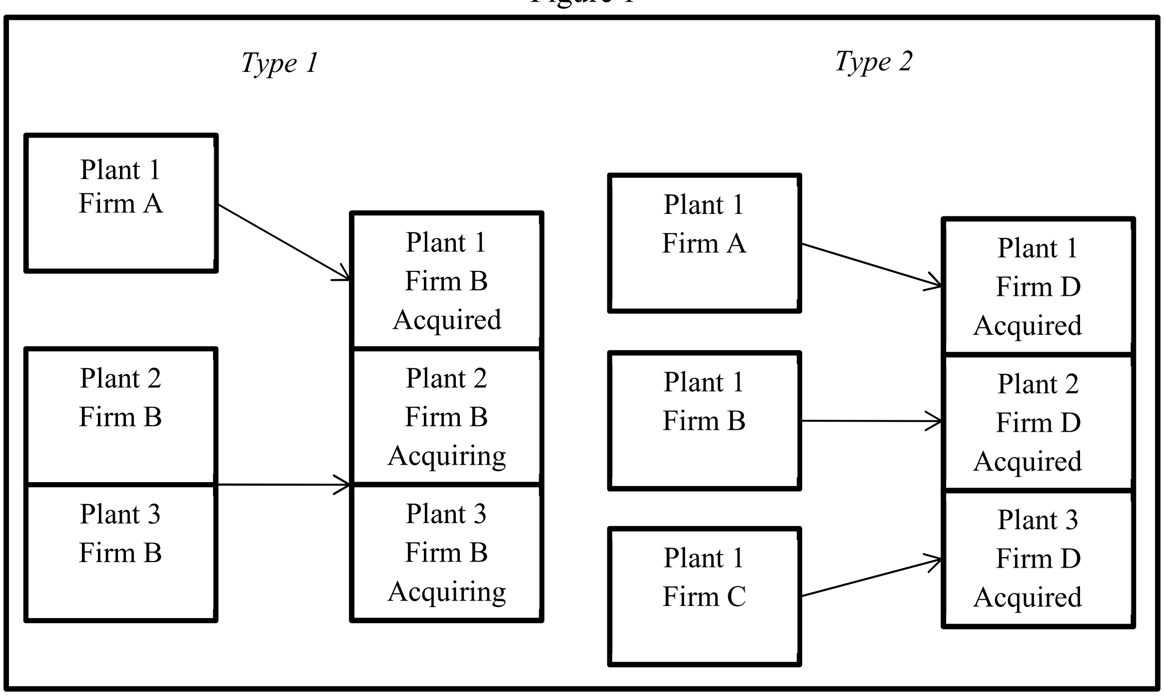
The sample includes 1,980 plant observations over the period from 1977 to 1992. Since changes in price and productivity are the dependent variables of interest, the sample is limited to plants with both price and quantity in year t and year $t + 5$ (denoted as t'). The variable labeled *MERGING ALL* in Table 1 refers to all ready-mix concrete plants in the sample that are part of a firm that was engaged in any type of merger activity. The next variable, *ACQUIRED ALL,* refers to the total number of plants undergoing an identifiable ownership change as indicated by the

3. Given the preliminary nature of these results, to facilitate the disclosure of updated results in the future I have rounded all counts to the nearest multiple of 20.

Firm ID variable. By definition, the *ACQUIRED ALL* variable includes plants acquired through all forms of mergers.

The variable *ACQUIRED HORIZONTAL* is a subset of the *ACQUIRED ALL* variable. An acquired plant is defined as being part of a horizontal merger if and only if it is acquired by a firm with at least one other plant participating in the ready-mix concrete industry pre-merger (at time t). As is evident from Table 1, there are many acquisitions of plants producing ready-mix concrete that involve no horizontal component. The last variable, *ACQUIRING*, refers to those plants that are not subject to direct ownership changes but are affiliated with firms involved in the acquisition of another ready-mix concrete plant. Note that because the sample includes only firms actively participating in the ready-mix concrete industry, the plants represented by the *ACQUIRING* variable are by definition horizontally linked to an acquired plant. This definition of horizontal merger activity gives rise to two "types" of horizontal mergers in the data, which are depicted schematically in Figure 1.

Figure 1



In the *Type 1* merger, Firm B exists both before and after the merger. When Plant 1 is purchased, it takes on the Firm ID "B," while Plant 2 and Plant 3 maintain the Firm ID "B." Thus, Plant 1 is labeled as an "acquired" because its Firm ID changes. Plant 2 and Plant 3 are clearly involved in the merger but do not experience a change in Firm ID and are consequently labeled "acquiring" plants. In the *Type 2* merger, no plant is labeled as an "acquiring" plant because all of the plants involved experience a change in Firm ID. Whether this distinction between acquiring and acquired plants has any economic meaning or simply an artifact of Census processing is explored below. For now, I emphasize, that some (in fact, many) horizontal mergers in the data do not have an acquiring plant associated with the merger.

Table 2 provides counts of the number of *ACQUIRED HORIZONTAL*, *ACQUIRING,* and *TOTAL* plants in the sample over the three 5-year time periods spanned by the data.

Table 2

	ACQUIRED HORIZONTAL	*ACQUIRING*	*TOTAL*
1977-1982	20	40	720
1982-1987	80	80	680
1987-1992	100	120	580

Table 2 suggests that there is a substantial increase in the amount of horizontal merger activity in the ready-mix concrete industry in the latter part of the sample.

Table 3 provides some counts of the number of *ACQUIRED HORIZONTAL* and *ACQUIRING* plants by the various geographic designations discussed in the previous section.

Table 3

	ALL	EA	CEA	ACB
ACQUIRED HORIZONTAL	200	180	160	160
ACQUIRING	220	80	60	20

A number of patterns are evident in Table 3. First, the results indicate, that ready-mix concrete acquisitions are highly clustered within relatively small geographic areas with the vast majority of acquired plants being located in at least the same EA as another plant involved in the merger. Indeed, most acquired plants are even more locally situated. On the other hand, most acquiring plants lie outside of the areas where merger activity is taking place. Taken together, these patterns provide some initial evidence that ready-mix concrete firms engage in carefully selected, highly targeted merger behavior.

D. Productivity

TFP is calculated from the typical index form as set forth by FHS. Specifically, for each plant i, TFP takes the form:

$$TFP_i = y_i - \alpha_l l_i - \alpha_k k_i - \alpha_m m_i - \alpha_e e_i$$

where the lower-case letters indicate the (log) values of, gross output, labor input, capital stock, materials, and energy inputs and the coefficients are the factor elasticities for the respective inputs.

Labor inputs are measured, following Baily, Hulten, and Campbell (1992), as production-worker hours multiplied by the ratio of total payroll to payroll for production workers. Capital inputs are the book values reported by plants for their structural and equipment capital stocks deflated to 1987 levels using sector-specific deflators from the BEA. Materials and energy inputs are plants' reported expenditures deflated using the corresponding input price indices from the NBER Productivity Database. The input elasticities are industry-level cost shares. The labor, materials, and energy cost shares are calculated using reported expenditures from the CM. Capital cost shares are the reported equipment and building stocks multiplied by the capital rental rates matched to ready mix-concrete's two-digit industry code. As discussed above, I consider two measures of TFP in this study: TFPQ and TFPR. For TFPQ, y_i in the equation above is simply each plants' physical output of concrete measured in thousands of cubic yards.

For TFPR, y_i is the nominal revenue from product sales deflated by the revenue weighted geometric mean price across the ready-mix concrete plants in the sample for a given year.

III. Methodology and Identification

Following the discussion of horizontal mergers from the previous section, I distinguish between three mutually exclusive groups of plants: acquired plants—plants experiencing a direct change in ownership—acquiring plants—plants that are part of firms involved in the acquisition of another plant—and non-merging plants. The outcome variables of interest are changes in price or TFPQ defined as the difference between the logarithm of the variable in year t' and the logarithm of the variable in year t. For each plant, I define a potential outcome of $Y_{i\Delta\mathrm{t}}^{0}$ for no merger activity, $Y_{i\Delta\mathrm{t}}^{1}$ for being acquired, and $Y_{i\Delta\mathrm{t}}^{2}$ for acting as an acquiring plant. For a given plant i, I also define an observed merger status variable which takes on the values $M_i = 0$, $M_i = 1$, and $M_i = 2$ for each respective category.

A variety of factors may drive horizontal merger activity including but not limited to market power, productivity, financial distress, managerial incentives, diversification, financial speculation, empire building, etc. As such, in retrospectively determining the extent to which mergers cause price increases due to enhanced market power, I start by acknowledging that I both cannot and do not desire to eliminate selection on the potential outcome variables $Y_{i\Delta\mathrm{t}}^{1}$ or $Y_{i\Delta\mathrm{t}}^{2}$ as the ability to raise prices is always predicated on the strategic circumstances surrounding a particular acquisition. In other words, a merger in a purely experimental setting would not necessarily have any of the effects I seek to identify; rather, it is precisely the mergers that are selected into for their price increasing potential that are of interest. However, to the extent that the potential outcome variable $Y_{i\Delta\mathrm{t}}^{0}$ is independent of the error term, a causal merger-specific price effect in the form of the average treatment effect on the treated (ATET) can still be identified. The average treatment effect on the treated for both acquired and acquiring plants is then given, for $j = \{1,2\}$, by:

$$ATET_j = E\left[Y_{\Delta t}^{j} - Y_{\Delta t}^{0} \middle| M = j\right] = E\left[Y_{\Delta t}^{j} \middle| M = j\right] - E\left[Y_{\Delta t}^{0} \middle| M = j\right]$$

The quantities $E[Y_{\Delta t}^{0}|M = 1]$ and $E[Y_{\Delta t}^{0}|M = 2]$ are not observed. Independence of $Y_{i\Delta t}^{0}$ thus allows us to use the observed quantity $E[Y_{\Delta t}^{0}|M = 0]$ in the formula above.

This condition implies that to achieve identification, the control group of non-merging plants must be an accurate representation of the experience of the plants involved in horizontal mergers had they not engaged in merger activity. However, it is quite possible that there is selection into the control group based on plant characteristics that may affect both the propensity to merge and pricing changes over time. In particular, factors like service or product unreliability, managerial neglect, poor equipment or facilities, or other factors rendering plants unsuitable merger partners may undermine the assumption that $Y_{i\Delta t}^{0}$ is independent of the error term. Although problems such as this are common in the merger retrospective literature, the detailed data available for plants in the CM provides us with a particularly useful set of variables with which to implement the selection on observables identification strategy that is standard in the literature. Plant characteristics affecting both the propensity to merge and prices will very likely be reflected in initial (log) TFPQ, capital equipment stock, structural capital stock, labor input, materials input, energy input, in addition to multi-unit firm status and plant age.

Another identification problem often cited in critiques of the merger retrospective literature is the potentially confounding role of demand shocks. If demand shocks systematically differ across the treatment and control groups, the estimated price effects may represent these differences rather than merger specific changes. Here again, the ready-mix concrete data provides an attractive opportunity to control for demand shocks. In all analyses, I control for EA-year effects and also include the following time-varying CEA level measures of demand: (log) change in construction employment, population density, and average income.

Treatment effects are estimated based on a linear model where the treatment groups of interest are the relevant *ACQUIRED* and *ACQUIRING* variables. The baseline specification is:

$$\Delta Y_{i\Delta \mathrm{t}} = \alpha + \beta_1 ACQUIRED_{i\Delta \mathrm{t}} + \beta_2 ACQUIRING_{i\Delta \mathrm{t}} + X_{it}\gamma + Z_{t'c}\theta + \lambda_{\mathrm{e}\Delta \mathrm{t}} + \varepsilon_{i\Delta \mathrm{t}}.$$

$\Delta Y_{i\Delta \mathrm{t}}$ represents the change in price for plant i, across time period Δt. X_{it} represents the vector of plant specific controls listed above for the initial time t. $Z_{t'c}$ contains the CEA level demand controls measured at time t'. $\lambda_{\mathrm{e}\Delta \mathrm{t}}$ is an EA-year effect, and $\varepsilon_{i\Delta \mathrm{t}}$ is the error term. As in Hortacsu and Syverson (2007), standard errors are clustered at the CEA level. Because evaluating the consequences of mergers for consumers is the focus of this study, the primary results are quantity weighted. Specifically, I use Davis, Haltiwanger, Schuh (1996) activity weights which are calculated as the average of the year t and year t' quantity sold for each plant. In Appendix B, I present unweighted results as a point of comparison. The pattern of results in both the weighted and unweighted analyses is economically very similar, although the coefficient estimates and significance levels tend to be larger for the weighted results.

I supplement this identification strategy by examining three potential sources of heterogeneity in merger pricing outcomes that are likely to be helpful in distinguishing market power effects from other explanations for price increases like merger specific changes in quality, logistics, customer base, or management. Specifically, I examine variation in pricing outcomes before and after the 1982 Merger Guidelines, between horizontal and non-horizontal mergers, and between horizontal mergers involving within ACB merger activity and horizontal mergers that do not involve another plant in the same ACB.

In Table 4, I provide summary statistics for the sample as a whole, the sample of horizontally acquired plants, and the sample of acquiring plants.

Table 4

Variable	Label	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
		TOTAL		*ACQUIRED HORIZONTAL*		*ACQUIRING*	
Change in log(Price)	*ΔP*	-0.022	0.171	-0.001	0.151	-0.039	0.182
Change in log(Quantity)	*ΔQ*	-0.023	0.664	-0.035	0.821	-0.048	0.736
Change in log(TFPQ)	*ΔTFPQ*	0.012	0.260	0.111	0.297	0.048	0.238
Change in log(TFPR)	*ΔTFPR*	0.009	0.272	0.127	0.316	0.025	0.264
Initial log(Price)	*P*	3.828	0.153	3.785	0.169	3.808	0.166
Initial log(Quantity)	*Q*	3.788	0.976	3.970	0.920	3.865	0.914
Initial log(TFPQ)	*TFPQ*	-2.279	0.230	-2.272	0.249	-2.215	0.220
Initial log(TFPR)	*TFPR*	1.518	0.222	1.493	0.250	1.571	0.209
Initial log(Capital Equipment Stock)	*KEQ*	6.550	1.073	6.715	0.993	6.409	1.217
Initial log(Capital Structure Stock)	*KST*	4.534	1.188	4.714	1.096	4.500	1.296
Initial log(Labor Input)	*L*	3.636	0.988	3.694	0.927	3.404	1.001
Initial log(Materials Input)	*M*	7.176	1.009	7.383	0.918	7.220	0.934
Initial log(Energy Input)	*E*	3.311	1.259	3.018	1.224	3.202	1.117
Current Plant Age	*AGE*	5.571	3.899	6.773	4.202	6.295	4.123

Before delving into the main results, it is instructive to examine the extent to which plants differ between the benchmark treatment groups and the control group controlling only for EA-year effects.

Table 5

	[1]	[2]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Input	*Q*	*KEQ*	*KST*	*L*	*M*	*E*	*TFPQ*	*AGE*	*P*
ACQUIRED HORIZONTAL	0.044 (0.098)	-0.131 (0.101)	-0.051 (0.105)	-0.032 (0.095)	-0.007 (0.103)	-0.324** (0.138)	0.007 (0.024)	-0.575* (0.293)	-0.029** (0.014)
ACQUIRING	0.068 (0.091)	-0.276* (0.145)	-0.141 (0.157)	-0.250* (0.133)	-0.015 (0.106)	-0.197 (0.163)	0.084*** (0.026)	-0.781** (0.342)	-0.013 (0.018)
R-Squared	0.401	0.304	0.269	0.357	0.400	0.318	0.350	0.717	0.407
N	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980

*** significant at the 99% level, ** significant at the 95% level, * significant at the 90% level. Dependent variables are *Q*, *KEQ*, *KST*, *L*, *M*, *E*, *TFPQ*, *AGE*, and *P* respectively. Standard errors are clustered by CEA. Regressions control for EA-year effects.

In Table 5, the columns are regressions on the initial values of quantity, capital equipment stock, structural capital stock, labor input, materials input, energy input, TFPQ, plant age, and price.

The most salient results are those from regressions [5.8], [5.9], and [5.10]. These regressions indicate that acquiring plants have significantly higher TFPQ and are significantly younger than plants in the control group and that plants acquired in horizontal mergers are younger and have lower initial prices than the control group. Regressions [5.2] through [5.7] reveal that to the extent the treatment groups differ significantly from the control group in terms of input usage, input usage is lower in the treatment groups. Regression [5.1] indicates that there are no significant differences across groups in terms of initial output

IV. Results

A. Benchmark Results

Table 6 presents the benchmark results for productivity effects where the dependent variable is the change in (log) TFPQ.

Table 6

	[1]	[2]	[3]
Dep. Var.	*ΔTFPQ*	*ΔTFPQ*	*ΔTFPQ*
ACQUIRED ALL	0.087*** (0.029)		
ACQUIRED HORIZONTAL		0.081*** (0.029)	0.096*** (0.031)
ACQUIRED NON-HORIZONTAL			0.076* (0.044)
ACQUIRING	0.049 (0.040)	0.034 (0.038)	0.050 (0.040)
R-Squared	0.356	0.352	0.356
N	1,980	1,980	1,980

Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

Regression [6.1] considers plant-level productivity results for the set of all acquired plants regardless of the type of merger. The coefficient estimate on the *ACQUIRED ALL* variable indicates an increase in TFPQ of 9.1% (e^0.087 = 0.091) for the set of all acquired plants and is significant at the 99% level. Regression [6.2] restricts attention to the *ACQUIRED*

HORIZONTAL treatment group and indicates that horizontally acquired plants are associated with an 8.4% increase in TFPQ or over one-third of a standard deviation of the $\Delta TFPQ$ variable. Finally, regression [6.3] contains separate variables for horizontally acquired and non-horizontally acquired plants. The estimated increases in TFPQ for each group are 10.1% and 7.9% respectively. A test for the equality of these coefficients fails to reject the null hypothesis. Taken as a whole these results suggest substantial increases in productivity at acquired plants that are statistically indistinguishable for horizontal mergers versus non-horizontal mergers. On the other hand, across all three specifications there are no statistically significant effects for acquiring plants, indicating that productivity increases are restricted to plants that experience a direct change in ownership.

Table 7 presents the benchmark results where the dependent variable is change in (log) price.

Table 7

	[1]	[2]	[3]	[4]
Dep. Var.	*ΔP*	*ΔP*	*ΔP*	*ΔP*
ACQUIRED ALL	0.006 (0.019)			
ACQUIRED HORIZONTAL		0.064*** (0.021)	0.078*** (0.022)	0.071*** (0.022)
ACQUIRED NON-HORIZONTAL				-0.035 (0.026)
ACQUIRING	-0.017 (0.023)	-0.001 (0.023)	0.012 (0.023)	0.005 (0.023)
ΔTFPQ			-0.217*** (0.046)	-0.212*** (0.045)
R-Squared	0.390	0.397	0.434	0.436
N	1,980	1,980	1,980	1,980

Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *TFPQ*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

In regression [7.1] the coefficient estimate on the *ACQUIRED ALL* variable is not statistically significant and the point estimate is essentially zero. In contrast to productivity, however, restricting attention to horizontally acquired plants produces a very different result. Regression [7.2] indicates that horizontal mergers are associated with a 6.6% increase in price at acquired plants significant at the 99% level. Regression [7.3] repeats the analysis from regression [7.2], but now includes a control for the change in productivity, $\Delta TFPQ$. Inclusion of this variable allows us to estimate a gross price effect of horizontal mergers controlling for changes in productivity, and to the extent that market power is established as the driving force behind the price effects, provides an estimate of the market power effect of horizontal mergers holding efficiencies constant. Controlling for the change in TFPQ increases the estimated price increase associated with horizontally acquired plants. Regression [7.3] indicates a point estimate of 8.1%—an increase of 1.5 percentage points from the estimate in regression [7.2] and almost half of a standard deviation of the ΔP variable. These results indicate that despite the productivity increases documented in Table 6, increased efficiency associated with horizontal mergers was not sufficient to negate price increases. The results including controls for changes in TFPQ also indicate that while increased efficiency has the price reducing effect predicted by economic theory, the effect is modest relative to the magnitude of the productivity increases. Finally, regression [7.4] includes variables for both horizontally acquired and non-horizontally acquired plants. Unlike the productivity results, equality of the coefficients is rejected at the 99% level.

B. Market Power

I proceed by refining the analysis to further assess the underlying cause of the observed price increases. Table 8 extends the analysis above by examining the differences between the price effects of horizontal over the period from 1977 to 1982 versus the period from 1982 to

1992. These time periods correspond to CM years that conveniently line up with the promulgation of the 1982 Merger Guidelines, which marked the beginning of a period of significant change in antitrust regulation. By the mid-1980s, enforcement patterns indicate that antitrust regulators became substantially more permissive of merger activity.[4]

Table 8

	[1]	[2]	[3]	[4]	[5]	[6]
Dep. Var.	*ΔP*	*ΔP*	*ΔP*	*ΔQ*	*ΔQ*	*ΔQ*
ACQUIRED ALL	0.030 (0.024)			-0.075 (0.073)		
*ACQUIRED ALL*PRE*	-0.034 (0.038)			0.038 (0.128)		
ACQUIRED HORIZONTAL		0.096*** (0.024)	0.082*** (0.024)		-0.154* (0.081)	-0.142* (0.083)
*ACQUIRED HORIZONTAL*PRE*		-0.159*** (0.043)	-0.144*** (0.045)		0.070 (0.174)	0.058 (0.173)
ACQUIRED NON-HORIZONTAL			-0.068** (0.034)			0.055 (0.091)
*ACQUIRED NON-HORIZONTAL*PRE*			0.086** (0.041)			-0.069 (0.178)
ACQUIRING	-0.020 (0.019)	-0.002 (0.018)	-0.018 (0.018)	-0.046 (0.093)	-0.061 (0.089)	-0.048 (0.093)
*ACQUIRING*PRE*	0.090 (0.067)	0.072 (0.067)	0.089 (0.067)	0.040 (0.130)	0.055 (0.130)	0.041 (0.130)
ΔTFPQ	-0.213*** (0.047)	-0.222*** (0.046)	-0.216*** (0.045)	0.639*** (0.106)	0.643*** (0.106)	0.638*** (0.105)
R-Squared	0.428	0.442	0.446	0.619	0.621	0.621
N	1,980	1,980	1,980	1,980	1,980	1,980

Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *TFPQ*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

In each regression in Table 8, interaction variables with suffix **PRE* are added to the treatment variables of interest. These variables indicate the interaction between the treatment variable and

4. It is beyond the scope of this paper whether policy towards horizontal mergers started changing in 1982 following the promulgation of the 1982 Merger Guidelines or in the middle of the decade. Here, what is important is that there is broad evidence of a change in enforcement patterns by the mid-1980s and that this change started in or after 1982.

the period from 1977-1982. Accordingly, the coefficient on the *ACQUIRED HORIZONTAL* variable now reflects the change in prices at horizontally acquired plants for the period from 1982 to 1992. The effect for the period from 1977 to 1982 is then given by the addition of the coefficients on the *ACQUIRED HORIZONTAL* and the *ACQUIRED HORIZONTAL*PRE* variables.

Just as in Table 7, regression [8.1] indicates that there is no significant change for either time period for the *ACQUIRED ALL* treatment group. However, regression [8.2] indicates that the gross price effect associated with the period from 1982 to 1992 rises to an estimated increase of 10.1% (relative to the pooled effect of 8.1% for the comparable regression above). Furthermore, regression [8.2] indicates that horizontal mergers over the period from 1977 to 1982 were of a very different nature with a negative price effect significant at the 90% level. Regression [8.3] adds variables for non-horizontal mergers for the period before and after 1982. The most salient result from regression [8.3] is the stark difference between price effects for horizontal versus non-horizontal mergers for the period from 1982 to 1992. Here, the coefficient for non-horizontal mergers from 1982 to 1992 is negative and statistically significant.

These results suggest that the price increases are driven by market power. The price effects associated with horizontal mergers are associated only with mergers occurring after the period of tighter regulation from 1977 to 1982. Furthermore, price increases over this period are associated only with horizontal mergers. Indeed, other types of mergers are associated with a price lowering, pro-competitive effect. The market power hypothesis is further strengthened by regressions [8.4] through [8.6], which conduct the same analysis using the change in (log) quantity as the dependent variable. Although quantity changes are less precisely estimated, the pattern of quantity reductions follows the same pattern as that for price increases. There are no significant quantity effects associated with the *ALL ACQUIRED* variable in regression [8.4]. However, horizontally acquired plants are associated with quantity reductions in regression [8.5], and, in regression [8.6], the equality of the coefficients on the horizontal and non-horizontal acquired plant variables is rejected.

Table 9 examines the question of market power in terms of the geographic distribution of the price and quantity effects of horizontal mergers. Because of the highly local nature of markets in the ready-mix concrete industry, to the extent that merger activity increases prices through market power, it is likely that price increases will be concentrated in areas with local merger activity.

Table 9

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	ΔP	*ΔP*	*ΔP*	*ΔP*	*ΔP*	*ΔQ*	*ΔQ*
ACQUIRED HORIZONTAL ACB	0.080*** (0.020)	0.093*** (0.021)	0.095*** (0.023)	0.105*** (0.026)	0.120*** (0.026)	-0.126* (0.076)	-0.172** (0.072)
ACQUIRED HORIZONTAL OUT			-0.004 (0.035)	-0.015 (0.034)	-0.012 (0.036)	-0.041 (0.182)	-0.050 (0.192)
NON-MERGING ACB				0.032* (0.018)	0.031* (0.16)	-0.017 (0.067)	-0.014 (0.065)
ACQUIRING ACB	0.060 (0.070)	0.065 (0.071)	0.068 (0.072)	0.081 (0.074)	0.089 (0.073)	-0.137 (0.153)	-0.161 (0.146)
ACQUIRING OUT			0.009 (0.022)	-0.004 (0.021)	0.011 (0.022)	0.005 (0.076)	-0.038 (0.076)
ΔTFPQ		-0.218*** (0.046)	-0.219*** (0.046)		-0.219*** (0.046)		0.642*** (0.107)
R-Squared	0.400	0.438	0.438	0.402	0.439	0.599	0.621
N	1,980	1,980	1,980	1,980	1,980	1,980	1,980

Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *TFPQ*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

In Table 9, mergers within an Adjacent County Block are indicated by the label *ACB* and plants involved in mergers where the plant is the lone entity associated with the merging firm in the Adjacent County Block are labeled *OUT*. Regressions [9.1] and [9.2] indicate that there are substantial net and gross price increases associated with within ACB merger activity estimated at 8.3% and 9.7% respectively. In regression [9.3], the coefficient on the *ACQUIRED HORIZONTAL OUT* variable is not significant and is close to zero. The equality of the coefficients on the *ACQUIRED HORIZONTAL ACB* and *ACQUIRED HORIZONTAL OUT* variables is rejected at the 99% level, indicating that price effects from horizontal mergers are restricted to mergers involving highly localized interactions. Regressions [9.4] and [9.5] include an additional variable *NON-MERGING ACB*, which includes all of the plants located within an ACB with horizontal merger activity that are not involved in any merger. These regressions indicate that local plants not directly involved in mergers raise their prices by over 3% in response to horizontal merger activity, providing evidence of strategic complementarity in the pricing behavior of non-merging plants. Controlling for this variable also increases the price effects for acquired plants associated with within ACB mergers, with net and gross increases estimated at 11.1% and 12.7% respectively. Regressions [9.6] and [9.7] provide evidence of large, statistically significant net and gross quantity reductions associated with the *ACQUIRED HORIZONTAL ACB* plants. Although the standard errors on the *ACQUIRED HORIZONTAL OUT* variables are too large to reject equality of the coefficients in either [9.6] or [9.7], the estimated quantity changes for non-local mergers are substantially smaller and individually insignificant, indicating that quantity reductions are primarily associated with horizontal mergers involving plants in close proximity.

In the analyses presented thus far, the results have not controlled for initial price. The reason for not including initial price in the benchmark results is simple: holding initial price constant may obscure the true extent of changes in prices due to merger activity. Now, both as a robustness check and to learn more about the role of pricing dynamics, in Table 10 we repeat the price regressions from Table 9 including a control for initial price.

Table 10

	[1]	[2]	[3]	[4]
Dep. Var.	*ΔP*	*ΔP*	*ΔP*	*ΔP*
ACQUIRED HORIZONTAL ACB	0.068*** (0.023)	0.079*** (0.022)	0.069*** (0.025)	0.086*** (0.024)
ACQUIRED HORIZONTAL OUT			0.006 (0.029)	0.011 (0.030)
ACQUIRING ACB	0.062* (0.033)	0.066** (0.033)	0.063* (0.034)	0.072** (0.033)
ACQUIRING OUT			0.005 (0.021)	0.022 (0.019)
ΔTFPQ		-0.255*** (0.039)		-0.258*** (0.039)
R-Squared	0.559	0.609	0.559	0.610
N	1,980	1,980	1,980	1,980

Regressions control for *P*, *KST*, *KEQ*, *L*, *M*, *E*, *TFPQ*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

Up to this point, while there has been evidence of substantial price increases at horizontally acquired plants, the results have not indicated a similar effect at acquiring plants. However, in Table 10, indicates substantial price increases at acquiring plants as well, after controlling for initial price. And just as with the acquired plant results, the results indicate that the acquiring plant price effects are restricted to horizontal mergers involving local mergers. In regressions [9.3] and [9.4] equality of the *ACQUIRING ACB* and *ACQUIRING OUT* coefficients is rejected at the 90% level. Another interesting result from Table 10 is that although the price increase for acquired plant remains substantial and highly significant, the estimates fall relative to the results from Table 9 so that the effects for acquired and acquiring plants are of a similar magnitude.

To help understand exactly how initial pricing conditions drive the results indicated in Table 10, we now consider results where the dependent is initial (log) price in Table 11.

Table 11

	[1]	[2]
Dep. Var.	*P*	*P*
ACQUIRED HORIZONTAL 1982-1992	-0.030 (0.022)	
ACQUIRED HORIZONTAL ACB 1982-1992		-0.042** (0.020)
ACQUIRING 1982-1992	0.037* (0.022)	
ACQURING ACB 1982-1992		0.067** (0.027)
R-Squared	0.556	0.555
N	1,980	1,980

Regressions control for *P*, *KST*, *KEQ*, *L*, *M*, *E*, *TFPQ*, *AGE*, an indicator of multi-unit status, initial (log) construction employment, initial (log) population density, and initial (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

For confidentiality purposes, the variables presented are restricted to the period from 1982 to 1992 and the coefficients for the period from 1977 to 1982 are suppressed. Regression [11.1] considers initial prices without restricting the geographic range of the merger variables, while regression [11.2] restricts the treatment groups to within ACB mergers. Regression [11.2] indicates a pattern of initial pricing results that sheds light on the results from Tables 9 and 10. Horizontally acquired plants associated with within ACB mergers have statistically significant below average prices while acquiring plants associated with within ACB mergers have statistically significant above average prices. Thus, the particularly large coefficient estimates associated with horizontally acquired plants in Table 9 reflect the full effect of acquired plants starting from initially low prices and being brought up to a pricing level consistent with increased market power.

C. TFPQ versus TFPR

Having found evidence of price increases induced by market power, Table 12 considers the potential mismeasurement of productivity resulting from the use of TFPR instead of TFPQ.

Table 12

	[1]	[2]	[3]	[4]
Dep. Var.	*ΔTFPQ*	*ΔTFPR*	*ΔTFPQ*	*ΔTFPR*
ACQUIRED HORIZONTAL	0.082*** (0.029)	0.143*** (0.035)	0.116*** (0.029)	0.187*** (0.034)
*ACQUIRED*PRE HORIZONTAL*			-0.252*** (0.064)	-0.361*** (0.081)
ACQUIRING	0.037 (0.038)	0.038 (0.042)	0.052 (0.047)	0.035 (0.045)
*ACQUIRING*PRE*			-0.043 (0.074)	0.040 (0.096)
R-Squared	0.351	0.360	0.358	0.373
N	1,980	1,980	1,980	1,980

Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

Regression [12.1] is identical to [6.2] and is presented again here to provide a convenient point of comparison with [12.2]. Regression [12.1] indicates that the estimated increase in TFPQ as a result of horizontal mergers for acquired plants is 8.5% while regression [12.2] indicates an increase in TFPR of 15.4%. Thus, using TFPR instead of TFPQ exaggerates the productivity increases from horizontal merger activity. Regressions [12.3] and [12.4] indicate that this exaggeration is magnified for the years from 1982 to 1992 as a result of the increased price effects associated with this time period. Regression [12.3] indicates an increase in TFPQ for acquired plants over the period from 1982 to 1992 of 12.3% while regression [12.4] indicates an increase of TFPR of 20.6%.

Regression [12.3] also indicates that for the period from 1977 to 1982 mergers were associated with decreased TFPQ rather than increased TFPQ. This result is intriguing in light of the fact that one of the limited justifications for horizontal merger activity during the period of tight regulation during the 1960s and 1970s was the potential failure of one of the merging parties absent consummation of the merger. In *International Shoe Co. v. FTC* (1930) the

Supreme Court first recognized what is often known as "Failing Firm Defense," which under certain circumstances exempts firms having financial difficulties from the typical legal scrutiny exerted upon horizontal mergers.

Table 13 examines the exaggeration of productivity outcomes resulting from the use of TFPR in the context of within ACB merger activity.

Table 13

	[1]	[2]	[3]	[4]
Dep. Var.	*ΔTFPQ*	*ΔTFPR*	*ΔTFPQ*	*ΔTFPR*
ACQUIRED HORIZONTAL ACB	0.087*** (0.031)	0.162*** (0.033)	0.094*** (0.029)	0.170*** (0.033)
ACQUIRED HORIZONTAL OUT			0.018 (0.080)	0.010 (0.088)
ACQUIRING ACB	0.099 (0.083)	0.147 (0.111)	0.107 (0.085)	0.155 (0.111)
ACQUIRING OUT			0.028 (0.038)	0.028 (0.041)
R-Squared	0.353	0.364	0.353	0.365
N	1,980	1,980	1,980	1,980

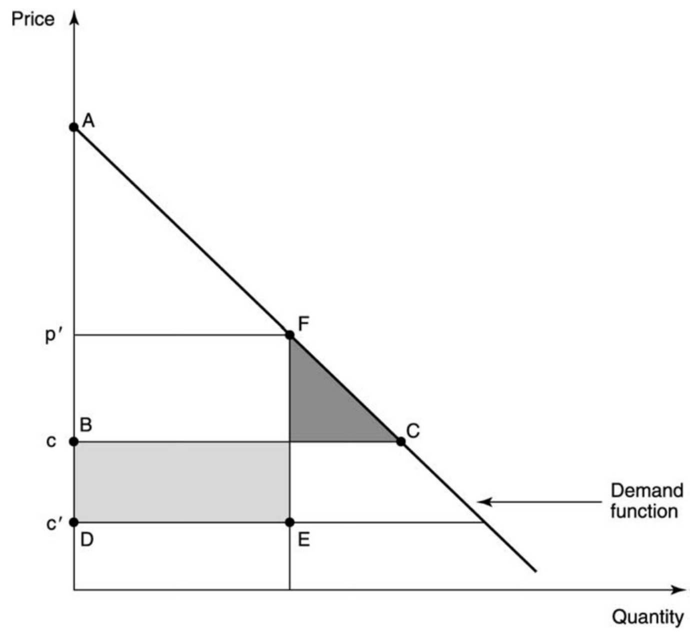
Regressions control for *KST*, *KEQ*, *L*, *M*, *E*, *AGE*, an indicator of multi-unit status, the (log) change in construction employment, the (log) level of population density, and (log) average income by CEA. Standard errors are clustered by CEA. All regressions include EA-year effects.

Regressions [13.1] and [13.2] indicate that the distortion is very pronounced in the presence of the large price effects associated with within ACB mergers. The increase in TFPQ from regression [13.1] is 9.1% while the increase in TFPR from [13.2] is 17.6%. Regression [13.3] indicates that productivity increases are also associated primarily with local mergers. Finally, regression [13.4] implies that although price effects create substantial distortion for local mergers, because price effects are limited to within ACB mergers, there is no such exaggeration for the *ACQUIRED HORIZONTAL OUT* treatment group.

V. Demand Estimation and Welfare Analysis

The above results provide strong evidence that consumer surplus decreased as a consequence of horizontal mergers. However, because there are simultaneous increases in both prices and productivity at horizontally acquired plants, total welfare cannot be assessed without evaluating the tradeoff between these countervailing forces. Williamson (1968) provides a framework for evaluating this tradeoff which can be understood in terms of the following simple diagram taken from Whinston (2007).

Figure 2



In the Williamson model, the change in welfare is determined by size of the shaded rectangle, the increase in producer surplus enjoyed by the firm as a result of merger efficiencies, relative to the size of the shaded triangle, which is the deadweight loss in consumer surplus created by the increase in market power. The thrust of this argument is that proportionally large changes in prices will be needed to outweigh the welfare gains achieved through increases in efficiency. More formally, the increase in total welfare from increased efficiency is first order while the loss of welfare resulting from the increase in market power is second order (Whinston 2007).

However, casual application of the Williamson logic to the results presented above for the ready-mix concrete industry does not provide clear intuition as to the direction of the total welfare effect. While the relatively close magnitudes of the percentage increases in prices and productivity for acquired plants would suggest welfare gains along this dimension, the price effects at acquiring plants and nearby plants not engaged in merger activity with no concomitant productivity gains are unambiguous welfare losses. Determining the sum of these effects requires additional structure. Furthermore, in the context of an oligopolistic industry, there are two primary reasons the Williamson model may underestimate the loss of consumer surplus from mergers. First, in an oligopolistic industry, pricing is above marginal cost. But when pre-merger prices are above marginal cost, the loss to consumers becomes first order. Second, in a differentiated product market when the post-merger industry remains oligopolistic and there are multiple mergers, mergers may have broader consumer welfare effects than those anticipated by the simple Williamson model.

Consequently, I proceed by estimating a simple logit demand system to facilitate the calculation of welfare effects based on the reduced-form estimates from the previous section. As is standard, it is assumed that there are $j = 0,1, \ldots, J$ products in $t = 1, \ldots, T$ markets each with $I = 1, \ldots, I_t$ consumers. Products $j = 1, \ldots, J$ represent competing differentiated ready-mix concrete options corresponding to each plant in a market. The alternative zero, represents an outside option corresponding to not purchasing any of the J products. Markets are defined as CEA-year combinations of size M_t. The non-random portion of utility is determined by a plant level fixed effect x_j^{fe} and the price charged by the plant p_{jt}. Indirect utility for consumer *i* is:

$$u_{ijt} = x_j^{\text{fe}} - \alpha p_{jt} + \xi_{jt} + \varepsilon_{ijt} = V_{jt} + \varepsilon_{ijt}$$

Although we do not observe the transportation costs associated with each plant, the plant fixed effect is included in the indirect utility function to allow for the fact that some plants are located in superior locations with better access to customers. For products $j = 1, \ldots, J$ shares are defined as $s_{jt} = \frac{q_{jt}}{M_t}$. The share of the outside option is then given by $s_{ot} = \frac{M_t - Q_t}{M_t}$ where $Q_t = \sum_{j=1}^{J} q_{jt}$.

Since there are no random effects, assuming the standard specification of the error term allows us to estimate alpha using the equation

$$\ln(s_{jt}) - \ln(s_{0t}) = x_j^{\mathrm{fe}} - \alpha p_{jt} + \xi_{jt}.$$

Because of the potential for correlation between p_j and ξ_{jt}, this equation is estimated using two-staged least squares. Following FHS (2008), I use $\ln(TFPQ_{jt})$ as an instrument and control for CEA-level average income and year effects.

To deal with the challenge of specifying the share of the outside good, I employ three different methodologies. Method 1 involves calculating the maximum ratio of the total physical output of concrete sold to the number of construction workers in each CEA, scaling this figure up by 5%, and then multiplying this by the total number of construction workers for the remaining CEA-year observations. The scaling is introduced so that all observations in the data can be used and so that the minimum share of the outside good is 5%. Method 2 simply specifies the maximum quantity of concrete sold in a CEA across all years scaled by 5% as the total market size for each CEA-year. Finally, in Method 3 the share of the outside good is specified as a fixed percentage for all observations. The benchmark value I set for this methodology is 15%, but I also examine the effects at the value of 5%, the minimum share under the scaling employed in Method 1 and Method 2. Table 14 presents the results of estimating the logit demand system across the three methodologies.

Table 14

	N	α	μ_η	μ_{mc}	μ_s	η_Q
method 1	8,500	0.097	-4.18	34.4	0.422	-8.74
method 2	8,500	0.108	-4.60	35.4	0.288	-6.80
method 3	8,500	0.088	-3.68	32.8	0.150	-4.49

In Table 14, μ_η represents the average elasticity of demand, μ_{mc} represents the average marginal cost, μ_s represents the average share of the outside good, and η_Q represents the elasticity of Q_t

with a respect to a 1% increase in the price of each product simultaneously. Elasticity of demand in the logit model is given by $\eta_{jt} = -\alpha p_{jt}(1 - s_{jt})$. Rearranging the first order condition yields the following expression for each plant's marginal cost:

$$c_{jt} = p_{jt}\left(1 + \frac{1}{\eta_{jt}}\right).$$

As far as the average elasticity of demand and marginal cost are concerned, each of the methodologies produces estimates of a similar nature. However, each methodology differs substantially in the average share of the outside good, providing a broad spectrum of values for simulating the welfare effects of merger activity.

To incorporate my reduced form estimates into the welfare analysis, after estimating demand, I simulate the effects of mergers by adjusting price and marginal cost for the relevant acquired plants by the average values indicated by my reduced form estimates. I limit the simulation of merger activity to within ACB acquired plants to ensure that the price effects are likely to be caused by market power. I begin by using the price increase from regression [10.4] of 9.0% and the decrease in marginal cost (increase in productivity) from regression [13.1] of 9.1%. As the observed prices include the price increases due to mergers, I simulate the change in consumer surplus by mechanically reducing the prices charged by within ACB acquired plants. Thus, the change in consumer surplus is given by applying the "logsum" formula:

$$\Delta CV_t = \frac{M_t}{\alpha}\left\{\ln\left[\sum_{j=1}^{J_t} exp\left(V_{jt}\right)\right] - \ln\left[\sum_{j=1}^{J_t} exp\left(V'_{jt}\right)\right]\right\}$$

where V'_{jt} represents the simulated non-random component of utility. The change in producer surplus is calculated simply by adjusting price and marginal cost following the geometry of Williamson tradeoff model. The change in welfare is then given by:

$$\Delta W = \Delta PS + \Delta CS.$$

Table 15 presents the results of this simulation exercise:

Table 15

	ΔP	ΔPS	ΔCS	ΔW	ΔQ
method 1	9.0%	\$536,000	-\$1,175,000	-\$639,000	-114,000
method 2	9.0%	\$540,000	-\$589,000	-\$49,000	-64,000
method 3	9.0%	\$523,000	-\$527,000	-\$4,000	-46,000

Across all of the methodologies, the net change in welfare is negative, suggesting that even at acquired plants, the consumer surplus losses outweigh the increases in producer surplus. Of course, as these estimates are based on Table 10 which includes a control for initial price, they do not include the full size of the price increases accounting for the initially lower prices charged by acquired plants. Thus, in Table 16 the analysis is repeated holding the efficiency gain constant but allowing for the full change in price estimated in Table 9 of 12.7%.

Table 16

	ΔP	ΔPS	ΔCS	ΔW	ΔQ
method 1	12.7%	\$660,000	-\$1,758,000	-\$1,098,000	-171,000
method 2	12.7%	\$664,000	-\$887,000	-\$223,000	-96,000
method 3	12.7%	\$648,000	-\$785,000	-\$137,000	-69,000
method 3'	12.7%	\$649,000	-\$707,000	-\$58,000	-62,000

The welfare reduction under the original methodologies are now all associated with substantial welfare losses per acquisition. Given that the average share of the outside good is somewhat extreme for Method 1, my preferred estimates are those from Method 2 and Method 3. In the final row, Method 3 is adjusted so that the share of the outside good is fixed at 5%. The result remains negative. Thus, the conclusion that arises from this analysis is that even at acquired plants, productivity increases were not sufficient to negate the loss in allocative efficiency associated with increased prices. Given that the price effects at acquiring plants and plants located in close proximity to within ACB mergers are not accompanied by productivity increases, these results strongly suggest that the overall effect of merger activity in the ready-mix concrete industry was to reduce both consumer and total welfare.

The analysis above is useful as it provides a range of estimates for the net welfare effect at acquired plants taking into account the tradeoff between high prices and increased efficiency. However, imposing a logit demand system and estimating welfare changes requires strong assumptions, some of which present a challenge to justify in this context. For instance:

- Ready-mix concrete is not purchased in the manner envisioned by the discrete choice model.
- Consumer surplus estimation is sensitive to how the share of the outside good is specified.
- Reduced form estimates do not fit neatly into structural models and must be introduced artificially.

Nevertheless, it is unlikely that any demand system would be totally satisfying in this context and logit demand has the advantage of capturing competitive interactions between plants in a market within a simple demand structure. In light of these concerns, these calculations should be interpreted as "back of the envelope" in nature and no individual estimate should be treated as definitive. Rather, the primary purpose of demand estimation in this setting is to provide insight into the direction of the welfare results and a rough idea of the potential range of consequences.

VI. Conclusion

This paper provides compelling evidence that both market power and productivity increased as result of horizontal merger activity. As far as productivity is concerned, this is one of the first studies to distinguish the productivity effects of horizontal mergers from other types of mergers. The similarity of the productivity results across merger types provides new support for the growing literature that emphasizes the potential for mergers to enhance productivity through improved management and logistical coordination. This management based story is further enhanced by the results regarding acquisition dynamics: acquiring plants have above average initial productivity and productivity increases are restricted to acquired plants.

Although there is a much larger literature on the price effects of horizontal mergers, because of the rich nature of the CM ready-mix concrete data, I am able to make a number of contributions to this literature as well. Productivity increases have the expected consequence of reducing price effects. However, the sizable productivity increases associated with horizontal mergers are not sufficient to eliminate the price increasing effects of horizontal mergers. Furthermore, while this result is of great interest as the relationship between price and productivity effects is of central interest in antirust policy, perhaps even more interesting are the results with regard to the relationship between allocative efficiency and productivity. Demand estimation allowing for oligopolistic interaction in the ready-mix concrete industry suggests that contrary to the effects that would be expected based on a simple application of the Williamson tradeoff model, increased productivity is not sufficient to eliminate the deadweight loss associated with horizontal merger activity.

The price increases observed for merger activity in the data follow a very distinctive pattern. They are observed only for horizontal mergers, only over the period from 1982-1992, and only for mergers involving local plants. The pattern of price increases is matched by a very similar pattern of decreases in output, and price increases associated with local merger activity are accompanied by price increases at nearby plants not engaged in merger activity. Although my benchmark specification finds evidence of price increases restricted to acquired plants, after controlling for initial price, the price increases estimated for both acquired and acquiring plants are substantial and of a similar magnitude. The benchmark results are driven by an interesting pair of acquisition dynamics: acquired plants tend to charge below average initial prices while acquiring plants tend to charge above average initial prices. This result is notable as it provides direct evidence that firms engaged in horizontal mergers target "maverick" firms—firms that challenge prevailing price levels and increase competition through aggressive undercutting of rival firms. Taken as a whole, these results strongly suggest that the observed increases in prices were driven by market power and, consequently consumer welfare declined. The demand estimation results further suggest that despite the productivity increases, total welfare declined as well.

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