Dynamic Effects of Price Controls and Deregulation Policies: Evidence from the Indian Cement Industry*

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Abstract

Price controls are frequently implemented in many key industries, especially in developing countries. Meanwhile, deregulation of these industries remains challenging due to a mix of political and economic factors. This raises questions about the long-run effects of price controls on the development of these industries, as well as the design of deregulation policies. We study these questions in the context of the Indian cement industry which was subject to price controls until the early 1980s, and then gradually liberalized between 1982 and 1989. To evaluate these price controls and the gradual decontrol policy, we develop a non-stationary, dynamic, oligopolistic model of production and investment, and estimate it using plant-level data on cement output and capacity. The estimates show that price controls had a significant impact on the size of the industry; in their absence, the industry would have had three times the capacity it had in 1980. A comparison of a swift or "big-bang" deregulation with the gradual deregulation policy indicates negligible differences in consumer welfare as well as in the growth trajectory of the industry post-1982.

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I. Introduction

According to textbook models, price controls could stifle long-run growth of an industry by suppressing firm profits and disincentivizing investment. Yet, price controls remain a popular policy tool for regulating output prices, especially in developing countries (Guenette 2020). The vast majority of developing countries use price controls in critical sectors like agriculture, energy, and construction materials, often as a means of redistribution or of limiting market power (Garg and Saxena 2022; MacKay and Mercadal 2023). Meanwhile, deregulation is typically challenging due to a rapid increase in prices during the transition out of controls, spurring political and economic disruptions. This has led governments to experiment with the pace of deregulation. However, the empirical evidence concerning both regulation and deregulation is limited; the quantitative importance of price controls for long-term industrial development is not well established, and empirical evaluations of alternative deregulation strategies are scarce.

We provide this empirical evidence by examining two questions. First, *how do price controls affect firm dynamics and the overall growth of an industry?* Understanding the long-run consequences of lower investment induced by price controls may be particularly important for developing countries with nascent industries. Second, *what is the impact of the speed of deregulation on firm and consumer outcomes during the transition out of price controls?* In a swift ("big-bang") reform, price controls are completely eliminated in one go, while in a gradual reform industries are slowly liberalized.[1] The gradual reform allows government more control over price increases, but could prolong the transition to a market equilibrium. This may reduce investment, output, and consumer welfare during the transition. A theoretical literature also advocates for a big-bang reform, absent political constraints such as concerns about reversibility of reforms. However, the theoretical arguments for favoring different deregulation strategies remain untested.

We study these questions in the Indian cement industry. The industry operated under price controls for four decades until 1982. Cement was among several "core industries" such as iron and steel, fertilizers, and aluminum where the government regulated prices and distribution.[2] Under

[1]Examples of big-bang deregulation include the liberalization of centrally planned economies in Eastern Europe during the 1990s, the removal of price controls in the USA after World War II, and deregulation of financial market in the UK in 1986. Examples of gradual deregulation include the "dual-track" strategy adopted by China in the 1970s and 1980s as well as the gradual lifting of price controls in the UK after World War II.

[2]Even today, the Indian government continues to intervene in the pricing of fertilizers, agricultural output, electricity, coal, and natural gas. Over the past decade, policymakers have removed price controls in the petrol and diesel industry, and are currently debating deregulation in the natural gas industry.

the policy, the government set the price received by the producers and oversaw the distribution of cement. Roughly 40% of the output was directly procured by the government for public projects and priority industries, and the rest was sold through a network of retailers. These controls were gradually phased out between 1982 and 1989. In 1982, firms were allowed to sell a third of their output at market prices. This fraction was increased over time, culminating in complete deregulation by 1989.

For our analysis, we construct a panel of all the large cement plants in the country, with information on their capacity and production starting in 1969. We complement this with the Annual Survey of Industries (ASI) which provides information on cost and revenue, at the plant level, for all manufacturing sectors. This data is available from 1974. Finally, we obtain data on state-level cement consumption and prices from IndiaStat.

To answer the research questions, we build and estimate a structural model of the cement industry. Before discussing the model, we look at the impact of deregulation on the cement industry and on downstream users. Using the plant-level data from the ASI, we find that prior to deregulation in 1982, the cement industry had similar profit margins and growth as other manufacturing industries. After partial deregulation, profit margins increased substantially before gradually declining over the span of a decade. At the same time investment went up in the industry, increasing growth relative to other manufacturing industries. These dynamics suggest that the controls constrained growth during the 1970s. We also find that relative cement use in residential construction fell during the transition, likely due to higher prices. The drop was especially pronounced for low-income households and in regions with lower production capacity. This suggests that market based allocation of cement might differ from the government allocation, and the difference is important for evaluating the welfare consequences of price controls.

We model the industry as a dynamic game of oligopolistic competition. Incumbent firms are characterized by their installed production capacity. Incumbent firms make capacity expansion and production decisions, while potential entrants make entry decisions. Firms choose output to maximize current period profits, based on either government-set prices or market prices determined by demand and supply conditions. Investment decisions by incumbents and potential entrants are driven by firms' beliefs about future profitability, which depend on government policy, demand conditions, and the evolving industry structure.

We first outline the estimation of the supply side of the model. It depends on parameters governing production costs, and investment and entry costs.

In the model, production costs for firms depend on their capacity utilization, with marginal costs increasing as firms use more of their installed capacity. We also allow for an idiosyncratic cost shock to capture variation arising due to production issues such as mechanical failures. Estimation relies on the method of simulated moments. Given a guess of cost parameters, we can solve for optimal production choices at observed capacities. We match model predictions with three moments in the data. These include annual production in different regions of the country, the revenue to cost ratio of the industry, and the standard deviation of capacity utilization across firms.

Investment and entry costs are estimated from observed capacity expansions and entry decisions during the 1970s, when the industry was under price controls. Using the estimated cost function and the observed government prices, we can construct the path of expected profits. For a given guess of investment and entry cost parameters, we can then solve for equilibrium strategies and compute the likelihood of the observed state transitions. We pick parameters to maximize the likelihood.

Next, we outline the estimation of demand. Demand in a location depends on the retail price and demand shifters such as urban population. Since market clearing prices are not observed under price controls, we use data from the period after deregulation to estimate demand. To address the price endogeneity due to unobserved demand shocks, we construct instruments based on the cost of production from ASI. We highlight two additional details. First, the retail price of cement differed from the price received by the producers due to taxes, freight, and retail markups. We take these values from the data. Second, under price controls, demand may not equal supply. Distribution and allocation of cement to end users was overseen by the government. We provide suggestive evidence that *pro rata* allocation, i.e., allocation that affords all interested consumers an equal chance of being able to purchase cement, serves as a good approximation and assume that in our counterfactuals.

We use our model to quantify the impact of price controls on long-term industrial development and to evaluate alternative deregulation policies through two counterfactuals.

In the first counterfactual, we compare the price control regime during the 1970s to a market equilibrium with no government intervention. In both cases the industry starts in the state observed in 1969. At the control prices set during the 1970s, demand substantially exceeds supply. If we keep output fixed at the level under price controls, market clearing prices would be 48% higher. However, accounting for the supply response under the market equilibrium narrows the gap. Prices are initially 30% higher under the market equilibrium, and settle at a level only 10% higher than the control price by the end of the decade. Higher prices under the market equilibrium result in a higher capacity utilization, pushing up the average cost of production. Despite higher costs, prices are high enough to deliver a higher profit, per unit of output, under the market equilibrium. Higher profits incentivize more investment and entry under the market equilibrium. By the end of the decade, industry capacity and output are three times higher under the market equilibrium relative to the level under price controls. This significant expansion mirrors the high growth seen in the industry after deregulation.[3]

The impact on consumer welfare is ambiguous *ex-ante*. Lower prices through price controls increase consumer welfare, but this may be offset by reduced supply and *pro rata* allocation by the government. *Pro rata* allocation is not efficient as some users who have a high willingness to pay are rationed out. Taking all these into account, we find that consumer welfare is substantially higher in the market equilibrium. If we assume that the government can allocate cement efficiently instead of *pro rata*, we still find that the welfare is higher under the market equilibrium after the first few years.

In the second counterfactual, we assess the deregulation policy. Starting in 1982, producers were allowed to sell a third of their output at market prices. This fraction increased over time, culminating in complete deregulation in 1989. Did this gradual reform adversely affect growth or consumer welfare? We answer this question by comparing the gradual reform to a "big-bang" reform, where producers are allowed to sell all their output in the market starting in 1982.

Under the gradual reform, cement is available at two prices: the controlled price and the market price. The controlled price is substantially lower than the market price. The price under the big-bang reform is in between these two. The market price under the gradual reform is higher than the price under big-bang reform due to *pro rata* allocation. Consumers with a high willingness to pay, who are not allocated cement at the controlled price, turn to the market and drive up the price. Surprisingly, we also find that output and capacity growth are virtually identical in the two scenarios. This is driven by two factors. First, the higher market prices under the gradual reform

[3] In the two decades after deregulation in 1982, the industry capacity increased by almost four times.

partially compensates for the lower control price. Industry profits are only slightly lower under the gradual reform. Further, when making investment decisions firms care about the full path of future profits. Under the gradual reform, higher expected profits after liberalization generate investment during the transition.

Consumer welfare is also similar under the two policies. Three factors drive consumer welfare: output, allocation, and prices. Output is similar under the two policies. Although a fraction of output is inefficiently allocated *pro rata*, consumers have the option to turn to the market. Unlike the first counterfactual, this allows consumers with a high willingness to pay to purchase cement. Finally, while market prices are higher under the gradual reform, they are partially offset by the lower control prices.

Our results have two main policy implications. First, the dynamic effects of price controls, through their impact on investment can offset static gains from lower prices. This might be especially relevant for developing countries with industries in early stages of development. Second, a credible gradual reform can deliver similar outcomes as a big-bang reform. This suggests the choice of deregulation policy can be aligned with other considerations such as political feasibility.

Related Literature. This paper is primarily related to empirical work on the impact of price controls. Some of the older literature studied the impact of price controls in the US during World War II (Evans 1982) and in Poland before its transition to a market-based economy in the 1990s (Tarr 1994). More recent work has shown the negative impact of pharmaceutical price regulation on the introduction of new drugs (Danzon, Y. R. Wang, and L. Wang 2005; Kyle 2007) and on equilibrium drug prices (Dubois, Gandhi, and Vasserman 2022). In addition, a number of papers have examined the impact of cost-of-service regulation in the electricity sector in the US. These papers have shown that while deregulation has led to lower costs (Fabrizio, Rose, and Wolfram 2007; Cicala 2015, 2022), it has also led to higher prices due to higher market power in the absence of price regulation (MacKay and Mercadal 2023). In a developing country setting, Garg and Saxena (2022) show that price regulation in the Indian agricultural sector is regressive and largely benefits richer farmers.

However, empirical work on the *dynamic* effects of price controls is limited. We note two exceptions here. First, Carranza, Clark, and Houde (2015) study the impact of price floors to ensure "fair trade" in gasoline markets in Canada and find evidence for reduced entry by low marginal cost retailers, leading to lower productivity in regulated markets. Second, Filson (2012) uses a parameterized dynamic oligopoly model to show that the introduction of pharmaceutical price controls in the US would temper R&D spending and reduce flow of new drugs. In a similar vein, our paper studies the impact of price controls on dynamic decisions such as investment in physical capital and entry of new firms, and captures the long-run impact of such regulation on the size of the industry.

Our work builds on the literature debating the optimal speed of economic reforms in transition economies during the 1990s, and points to its continued relevance in developing countries today. One camp advocated a "big bang" approach, rapidly removing price controls and state ownership across sectors, arguing this would prevent distortions and rent-seeking that could arise under partial deregulation (Lipton and Sachs 1990; Murphy, Shleifer, and Vishny 1992; Young 2000). Others promoted a gradual, sequenced strategy to make reforms more politically feasible and manageable (Dewatripont and Roland 1995; Fischer and Gelb 1991; Wei 1997). Unlike much of the existing theoretical literature that focuses on economy-wide transitions, our work provides empirical evidence on deregulation in a specific industry context. The results may be more relevant for developing countries today, especially those that are deregulating sectors still under price controls.

Lastly, our paper adds to a long line of work on empirical models of dynamic games, starting with Ericson and Pakes (1995). The dynamic model we propose features a non-stationary environment with a finite-horizon, appropriate for an emerging market such as India in the 1970s, and extends earlier work by Pakes (1986) and Igami (2017, 2018). Further, we build upon work by Doraszelski and Judd (2019) and Igami and Uetake (2020) by incorporating stochastic sequential moves to avoid multiple equilibria. Our approach differs slightly from earlier work as we allow multiple players to move within a single discrete time period. Finally, for estimation, we rely on a full-solution approach as in Rust (1987) and Benkard (2004).

II. Industry Background

Cement is a mineral powder, used as a binding agent in the construction of buildings, dams, and other infrastructure projects. The production of cement requires two main inputs: limestone and heat. In India, limestone is available from domestic sources and heat is derived from coal. Production typically takes place in large-scale cement plants, with each plant producing a few hundred thousand tons of cement per year. Between 1974 and 1994, the cement industry accounted for 1.6% of India's industrial output and 2.3% of its industrial capital stock.[4]

The Indian cement industry was under price and distribution controls up until 1982. Under the policy, government set the price that producers received for their output. The government also oversaw the distribution of cement. The output was divided into two categories, reserved and free-sale. Reserved category included use by government and priority industries, and accounted for 40% of the output. This was directly procured from the factory at the control price. The rest, under the free-sale category, was sold through retail channels for uses such as residential construction. Each manufacturer was allocated a marketing area in which to supply under the free-sale category. The retail price included the control price, freight costs, and various national and state taxes.

The policy in the sector, including the control price, was revised periodically through government committees.[5] We plot the control price over time in Figure A.1a. Between 1969 and 1979, all plants received a single control price. The policy was revised in 1979, with multiple prices based on the cost of production.

The government gradually dismantled the price control regime between 1982 and 1989. Starting in 1982, firms were allowed to sell a third of their output at market prices.[6] The proportion sold at control prices gradually fell, culminating in complete liberalization in 1989. The proportion to be sold at control prices is plotted in Figure A.1b.[7]

III. Data & Descriptive Evidence

We gather data from several sources that allow us to study the production and consumption patterns in the Indian cement industry in the last few decades of the 20th century. These data are crucial for estimating the parameters of our structural model, and we also use these to document the changes in the industry as the industry transitioned from price controls to a market economy.

[4] These statistics are derived from reported revenues and capital stock in Annual Survey of Industries between 1974 and 1994. Cement ranked as the 8$^{\text{th}}$ largest industry by revenue during this period.

[5] The control prices were set to balance consumer welfare and industry profits. A Tariff Commission (1974) report, responsible for setting prices for the period 1974 to 1979, stated that *"our objective is to ensure a fair price to the industry that would not cost an unreasonable burden on the consumers and yet be such as would help in the rapid development of the industry and attract fresh capital for expansion of the existing units and establishment of new ones"*.

[6] Plants established after 1982 needed to sell a smaller proportion of their output at control prices.

[7] For a historical account of price controls in the Indian cement industry and the transition, see Chakravarty (1989), Das (1987), Gadhok (2000a,b), and Mittal (1994).

A. Data

Our first dataset, spanning from 1969 to 2001, provides annual data on capacity and production at the plant level.[8] We compile these data by digitizing records from several books and statistical tables, the details of which can be found in Appendix B. In addition to plant capacity and production each year, the data also include variables such as plant location, the identity of the firm that owns the plant, and the plant's entry or commissioning date. We use this dataset to infer investments by both incumbents, observed through capacity expansions, and by new entrants.

Our second dataset, sourced from the Annual Survey of Industries (ASI), provides annual plant-level data on revenues, capital expenditures, and input cost expenditures from 1974 to 2017. ASI is an annual survey of manufacturing plants in India. All large plants and a sample of small plants are surveyed about their production process.[9] These plant-level data are anonymized and cannot be mapped to the first dataset. However, ASI covers all manufacturing plants in India, allowing us to compare the cement industry to other industries in the country over this period.

Lastly, to capture the demand side of this industry, we use a dataset from Indiastat on cement consumption and prices.[10] In these data, we observe cement consumption at the state-level from 1992 to 2011. The dataset also offers consumer cement prices for major cities in a subset of these years. We calculate the state-level price by taking an average of these city-level prices for all cities within a state.

B. Supply-Side: Descriptive Evidence on Cement Production

In this section, we document the state of the cement industry in India during the regime of price controls and after deregulation.

We begin by providing a snapshot of the industry in two years: 1971, when price controls were in effect, and 1998, long after the industry was deregulated. We divide the country into four regions – North, South, East, and West – and present our findings in Table 1.[11]

Across regions, in 1971, the cement industry was characterized by a few large firms. In the North, East, and West, the top four firms accounted for over 90% of all installed capacity. In the South,

[8] Production data are missing for some years in this period.

[9] The definition of large plants varies over time. Typically, a plant over 50 or 100 employees will be classified as a large plant.

[10] URL: https://www.indiastat.com/

[11] These regions correspond to the boundaries defined by the government for administration of price controls. Each region had an office for overseeing the implementation of price controls.

Table 1: *Snapshot of the Indian Cement Industry: Pre- and Post-Deregulation*

Region	(1) Year	(2) Capacity	(3) Production	(4) Number of Firms	(5) Number of Plants	(6) C4 (capacity)	(7) HHI
West	1971	5,550	4,262	5	13	96.4	3645
	1998	44,750	33,690	12	38	68.2	1579
North	1971	3,418	2,322	5	8	94.1	2576
	1998	24,755	17,793	12	29	62.3	1259
South	1971	7,198	5,946	12	18	67.6	1538
	1998	31,632	24,839	17	39	62.2	1320
East	1971	3,294	2,144	5	9	97.4	3065
	1998	8,811	5,345	9	14	69.8	1523

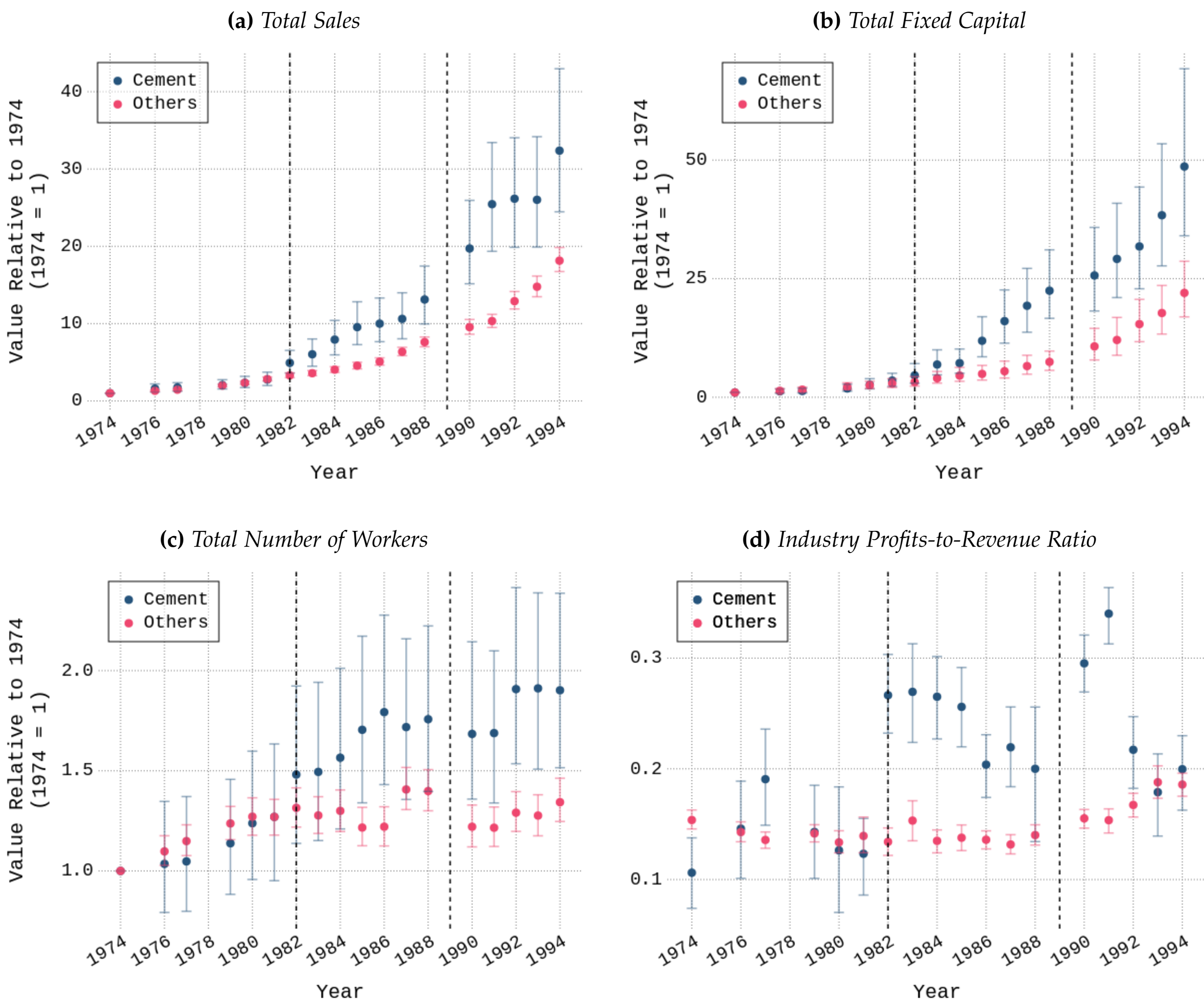
Notes. This table shows various summary statistics for the cement industry in the years 1971 and 1998. The country is divided into four regions, North, South, East, and West. Column (2) and (3) are capacity and production in thousand tonnes. Column (4) and (5) are the number of firms and number of plants respectively. Column (6) is the capacity owned by the four largest firms. Column (7) is the Herfindahl-Hirschman Index (HHI) of capacity.

hosting the highest number of firms, still had a moderately concentrated industry with top four firms controlling 67% of installed capacity. By 1998, the total installed capacity and production had increased in all regions, with an increase of 500% in the country as a whole. This increase was driven by both the entry of new firms and the expansion by incumbents. The industry remained fairly concentrated, with the top four firms accounting for at least 60% of installed capacity in all the markets.

Next, we document the evolution of the cement industry as it transitioned from being under government-imposed price controls to functioning under a market economy. This transition commenced in 1982 when the government began to gradually deregulate the industry. In 1982, firms were allowed to sell a third of their output at market prices. This fraction was increased over time, culminating in complete deregulation by 1989.

Using data from the Annual Survey of Industries (ASI), we track the trajectory of the cement industry during this transition period. In Figure 1a, we compare the revenue growth of the cement industry to that of all other manufacturing industries, using 1974 as the base year. Until 1982, the two series grew at the same pace. However, starting 1982, we observe a noticeable gap as the cement industry began outstripping the rest of the manufacturing industries in revenue growth. This gap widened further after 1989. By 1994, total reported revenue in the cement industry was over 30 times its level in 1974, while revenue in all other manufacturing industries

Figure 1: *Industry-level outcomes during transition of the cement industry from price controls to market economy*



Notes. This figure shows the evolution of industry-level outcomes during the transition of the cement industry from price controls to a market economy. Others include all manufacturing industries except cement. Data comes from various rounds of Annual Survey of Industries. Panel (a) plots the total sales of the cement industry and all other manufacturing industries, normalized by their levels in 1974. Panel (b) plots the total fixed capital of the cement industry and all other manufacturing industries, normalized by their levels in 1974. Panel (c) plots the total number of workers in the cement industry and all other manufacturing industries, normalized by their levels in 1974. Panel (d) plots the industry profits-to-revenue ratio for the cement industry and all other manufacturing industries.

only reached about 18 times its 1974 level.

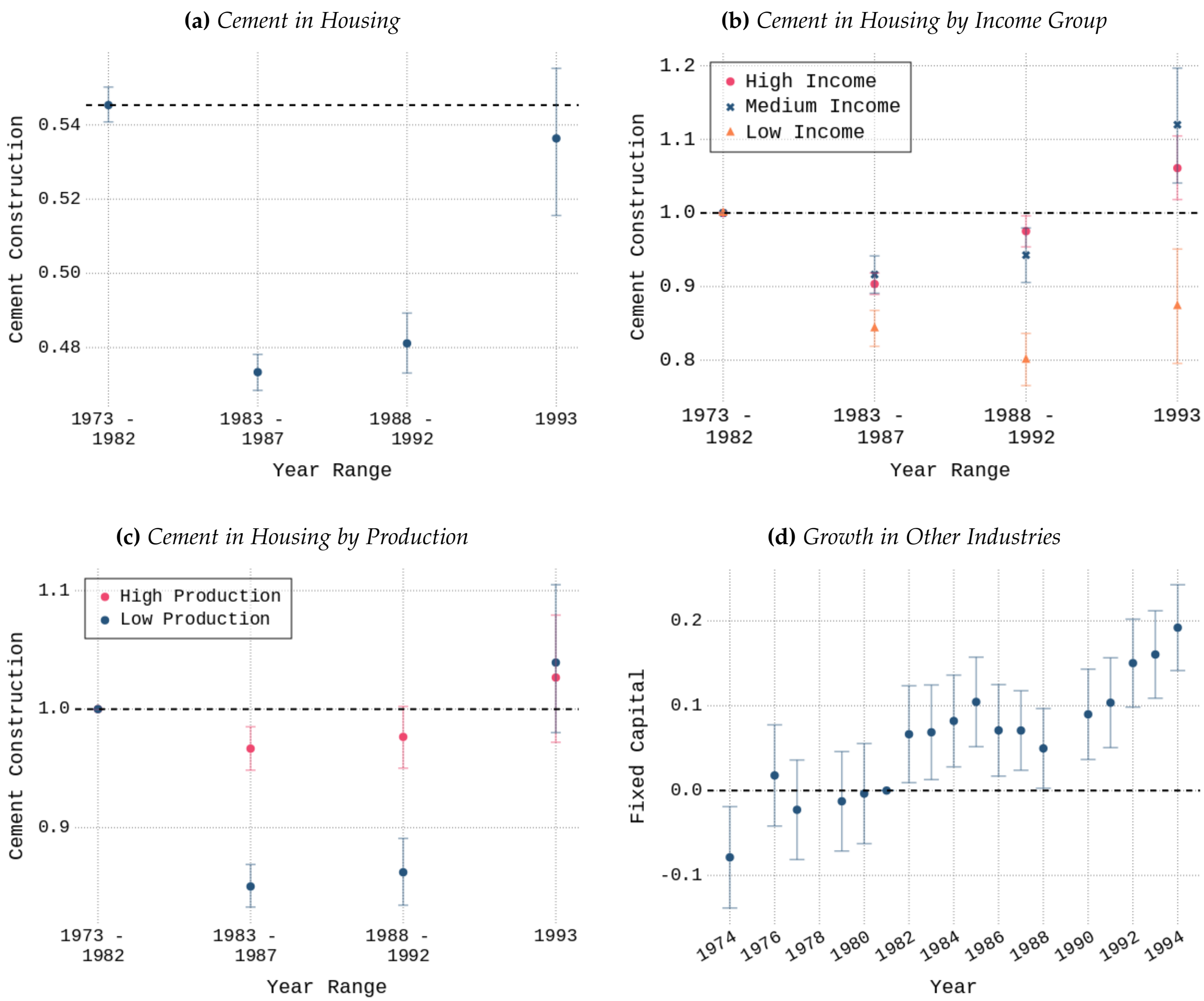
This surge in revenues within the cement industry was accompanied by a similar pattern in investment, as reflected by the growth in *fixed capital* (Figure 1b). Fixed capital is the total value of all assets owned by the plants, such as land, buildings, and machinery. Prior to 1982, all manufacturing industries experienced comparable growth in fixed capital. However, following the partial liberalization of the cement sector, the cement industry saw a faster growth in fixed capital, a trend that became even more pronounced after 1989. By 1994, the industry-level fixed capital in the cement industry was about fifty times its 1974 level; in contrast, fixed capital in the rest of the manufacturing sector only reached about twenty times the 1974 level.

We also examine other plant-level variables during this transition period. In Figure 1c, we plot the total number of workers in the cement industry and all other industries, normalized by their levels in 1974. Again, we see that the number of workers in the cement industry grew faster than in other manufacturing industries, especially during the period of partial decontrol from 1982 to 1989. This growth pattern sharply differs from the pre-1982 era, when the cement industry's employment growth was slower than that in the rest of the manufacturing sector.

Lastly, in Figure 1d, we examine how profits changed relative to revenues during this period. This *profit margin* gives us the share of revenue that was retained by firms. We find that there is a noticeable spike in cement industry profit margins starting in 1982, the year when the government rolled out partial deregulation. Profit margins in the cement industry jumped from below 15% to over 25%. This contrasts with the profit margins in all other manufacturing industries which remained relatively stable around 15% during this period. Note that profit margins could also go up if costs were falling over this period. However, our findings in Figure A.2 suggest otherwise, showing that total costs in the cement industry actually rose faster than in other sectors of the manufacturing industry, likely due to more inputs needed for increased output.

In summary, our data suggests that the deregulation of the cement industry starting in 1982 stimulated substantial growth in the industry. This growth outpaced the rest of the manufacturing sector in terms of revenue, investment in fixed capital, and the size of the workforce. Simultaneously, profit margins in the cement industry also rose significantly, despite increasing costs, suggesting that decontrolled market prices were substantially higher than the previously regulated prices. These descriptive findings motivate our structural model of the cement industry, which we use to quantify the role of government policy on industry growth and welfare. The model also provides insights on the trade-offs associated with various deregulation policies which might be of policy interest in other settings.

Figure 2: *Impact of deregulation on housing and other industries*



Notes. This figure documents the impact of liberalization on housing and other industries. Panel (a) plots the proportion of houses that use cement in construction. Panel (b) plots the proportion of houses that use cement in construction, broken down by income group. For Panel (c), we divide states in two production groups, high production and low production. High production states had above median per-capita production during price controls. Panel (c) plots the proportion of houses that use cement by production group. Panel (d) reports coefficients from a regression of fixed capital, in industries other than manufacturing, on per-capita production in the price control period. Data for Panels (a), (b), and (c) comes from the National Sample Survey Round 49, Housing Condition and Migration. Data for Panel (d) comes from various rounds of Annual Survey of Industries.

C. Demand-Side: Descriptive Evidence on Cement Consumption

In this section, we explore the impact of deregulation on cement consumption, focusing on how deregulation affected access to cement for different groups of consumers and industries.

To study the impact on housing, we leverage a nationally representative household survey conducted in 1993 that collected information on when the house was built and the materials used in construction.[12] In Figure 2a, we plot the proportion of houses that were constructed using cement. During the control period, between 1974 and 1982, approximately 55% of houses were constructed using cement. This proportion falls to 47% during the gradual deregulation from 1983–1987. It remained at 48% after complete liberalization, before increasing back to 54% by 1993. We break this down by income group in Figure 2b. For medium- and high-income households, the proportion of houses built using cement falls but then recovers to a level above the control period level by 1993. In contrast, the proportion of households built using cement by low-income households falls sharply once price controls are removed and remains below the control period level by 1993.

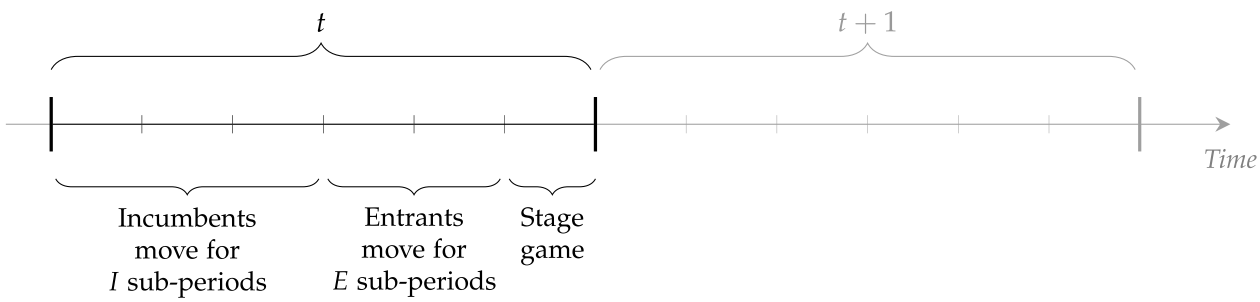
We also decompose the impact on usage of cement by household location. Government reports from the control period suggest that the allocation scheme under price controls tried to balance cement availability across the country. Post-deregulation, we find that the initial drop in proportion of households using cement is concentrated in cement deficit areas, defined as areas with below median production per-capita during the control period (Figure 2c).

Finally, we look at the impact of deregulation on construction in non-cement manufacturing industries. To proxy for construction, we use plant-level data on fixed capital from the Annual Survey of Industries (ASI), which includes the value of buildings. With fixed capital as the outcome variable, we estimate a dynamic difference-in-differences model, setting plants located in states with above median per-capita cement production as the treatment group. In Figure 2d, we plot the coefficient from this regression. Our estimates suggest that fixed capital in other manufacturing industries was higher post-liberalization in states with higher cement availability.

The above set of results on the impact on cement consumption, taken jointly, suggest that deregulation led to a reallocation of cement away from households, particularly low-income households, and towards industrial construction. Even amongst industries, the reallocation was towards industries that were located in cement surplus areas. One interpretation of these findings is that the allocation of cement under price controls differs from the allocation under a market equilibrium, which we account for in our structural analysis.

[12] National Sample Survey Round 49, Housing Condition and Migration.

Figure 3: *Timeline of the Investment, Entry, and Production Game*



Notes. This figure shows the timeline of the dynamic oligopoly game. Time is divided into discrete periods, denoted by t, and ends in period T. Each period is further divided into M sub-periods, denoted by t^m, where $m \in \{1, 2, \ldots, M\}$. In the first I sub-periods of each period t, incumbents make investment decisions. In the next E sub-periods, potential entrants make entry and investment decisions. In the final sub-period, denoted by M, all active firms produce cement and realize profits. The industry then transitions to the next period, $t + 1$, and the within-period game resumes.

IV. Model

In this section, we introduce an empirical model of the cement industry, tailored for the Indian context, that allows us to study the production and investment decisions of forward-looking firms under different policy regimes. The primary purpose of this model is to help us characterize the impact of price controls on the long-run growth of the cement industry in India. Additionally, our goal here is to develop a model that allows for non-stationary dynamics, so we can study industry outcomes during the transition from price controls to market economy under different deregulation policies.

A. *Setup*

Time is discrete and finite, and ends in period T.[13] Each period t corresponds to one year, and is further divided into M sub-periods, denoted by t^m, where $m = \{1, 2, \ldots, M\}$.

The agents in the model are cement firms – incumbents and potential entrants. As shown in Figure 3, the events within each year unfold sequentially. In each of the first I sub-periods of period t, nature selects an incumbent firm to move and decide whether to *expand* its capacity or stay *idle*. In each of the next E sub-periods, nature selects a potential entrant to move and decide

[13]Our data starts in 1969, and we set $T = 2050$, so that the choice of terminal payoffs does not significantly influence our estimation results during the years under study.

whether to *enter* or *stay out*. Finally, in the last sub-period, denoted by M, all active firms produce cement and realize their period profits. The industry then transitions to the next period, and the within-period set of sequential moves repeats.

Firms are denoted by j and differentiated by their production capacity. The production capacity of firm j in sub-period m, denoted by K_{jt^m}, can belong to one of H levels, i.e.,

$$K_{jt^m} \in \{K_1, K_2, \ldots, K_h, \ldots, K_H\}.$$

Thus, firms can also be identified by their type: firm j is of type h if it has capacity K_h.[14] Let $n^h(t^m)$ be the number of firms of type h in the industry in sub-period t^m, and let $\boldsymbol{N}(t^m)$ be a vector that tracks the number of firms of each type at any point in time, given by,

$$\boldsymbol{N}(t^m) = \left\{n^1(t^m), n^2(t^m), \ldots, n^h(t^m), \ldots, n^H(t^M)\right\}.$$

Two additional state variables are needed to characterize the industry state in sub-period t^m: a set of variables that impact demand, $\boldsymbol{D}_t$, and the beliefs of agents about the future path of government policy, $\{G_\tau\}_{\tau=t}^T$. The latter is important because firms' actions will depend not only on the current policy, but also the expected path of future policy.

We are now ready to define the industry state. Industry state in subperiod m of period t is denoted by $\boldsymbol{s}(t^m)$ and given by

$$\boldsymbol{s}(t^m) = \left\{\boldsymbol{N}(t^m), \{G_\tau\}_{\tau=t}^T, \boldsymbol{D}_t\right\}.$$

In the following sections, we provide specifics of how firms make production and investment decisions.

B. Stage Game

In the final sub-period M of each period t, all active firms make production decisions and realize static profits for the period. These production decisions – and the resulting profits – are a function of the industry state $s(t^M)$ and depend crucially on the policy regime: price controls, market economy, or a combination of the two. Below we outline how this stage game unfolds.

[14] For example, in our empirical specification, K_1 is 160 thousand tonnes.

We begin by describing the demand side of the market. The aggregate demand in period t is given by $\boldsymbol{Q}(P_t, \boldsymbol{D}_t)$, where P_t is the price of cement in period t, and $\boldsymbol{D}_t$ is a vector of demand shifters. Under price controls, the price of cement is set by the policymaker, i.e., $P_t = P_t^{gov}$, so this demand function does not have any bearing on a firm's production decision.[15] In contrast, under a market economy, this demand function characterizes the price impact of the production decisions of all firms in the market, i.e., $P_t = \boldsymbol{Q}^{-1}(Q_t, \boldsymbol{D}_t)$, where Q_t is the total quantity of cement supplied. The oligopolistic firms in our model, therefore, take the price as given under price controls, but consider the price as a function of their own and their competitors' production decisions under a market economy.

On the supply side, we assume that each active firm j faces a total cost function, $C(q_j, K_{jt^M})$, which depends on the production level q_j and the firm's total production capacity in the final sub-period K_{jt^M}. This cost function is invariant to the policy regime, G_t.

Firm j chooses production level q_j to maximize period profits given by

$$\pi_j(\boldsymbol{s}(t^M)) = \max_{q_j} \left\{ P_t \cdot q_j - C(q_j, K_{jt^M}) \right\} \tag{1}$$

In the above expression, output price P_t is given by

$$P_t = \begin{cases} P_t^{gov} & \text{if output sold to the government} \\ \boldsymbol{Q}^{-1}(Q_t, \boldsymbol{D}_t) & \text{if output sold in the market.} \end{cases}$$

where Q_t is the total output of all firms sold in the market.[16]

C. *Investment & Entry Game*

In each period, incumbents decide whether to invest in additional capacity, and entrants decide whether to enter the market. These decisions are made sequentially, with nature selecting the order and identity of firms that decide to invest or enter.

[15] The price that producers receive differs from the retail price due to taxes and transportation costs. We do not directly model transportation and rely on industry estimates. More details can be found in **??**.

[16] The government can also implement a partial price control, where only a fraction of output is under price controls. Under such a policy, the government announces both the fraction under control and the retention price. Consumers first try to purchase the controlled cement, and the residual demand is met in the market. Firms choose production level to maximize period profits.

For the first I sub-periods of period t, nature selects one incumbent firm per sub-period which decides to either (1) invest in additional capacity, i.e., *expand* or (2) not invest, i.e., *idle*. If the chosen firm chooses to expand, its type transitions from h to $h+1$. Note that the number of incumbent movers may be less than the number of incumbent firms in the market, and nature selects firms at random *with replacement*. As such, not all incumbents may have the opportunity to invest in a given period. Additionally, the same incumbent firm can be selected multiple times in a period. The probability of being selected in a sub-period m is denoted by ρ^I, and given by $\rho^I = \frac{I}{N_{t^m}}$ where $N_{t^m} = \sum_{h=1}^{H} n^h(t^m)$.

In each of the next E sub-periods, nature selects one potential entrant of type $h \in \{1, 2, \ldots, H\}$ that decides between one of two actions: (1) enter the market, or (2) not enter the market. If the chosen potential entrant decides to enter, it enters with capacity K_h. Again, nature picks potential entrants at random and with replacement, and the number of chosen potential entrants, E, may be less than the total number of potential entrants, H. The probability of an entrant being chosen is given by $\rho^E = \frac{1}{H}$.

Let us first consider the discrete choice problem of an *incumbent* firm j of type h that is selected to move in sub-period m of period t. Once selected to move, the incumbent firm draws choice-specific idiosyncratic investment cost shocks, $\varepsilon_j = \left\{\varepsilon_j^{idle}, \varepsilon_j^{expand}\right\}$. If it chooses to expand, its capacity goes from K_h to K_{h+1}. The cost of this expansion is given by,

$$\Phi_{jh} = \kappa \cdot (K_{h+1} - K_h) + \varepsilon_j^{expand},$$

where, κ is the per-unit cost of building capacity. If the incumbent chooses to idle, its capacity remains at K_h. The cost of this idling is given by ε_j^{idle}. The value function of this selected incumbent firm is given by,

$$V_h^I\left(\boldsymbol{s}\left(t^m\right), \varepsilon_j\right) = \max\left\{\underbrace{-\Phi_{jh} + \Lambda^{h+1}\left(\boldsymbol{s}\left(t^{m+1}\right)\middle|\boldsymbol{s}\left(t^m\right), expand\right)}_{\text{if expand}}, \underbrace{-\varepsilon_j^{idle} + \Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right)\middle|\boldsymbol{s}\left(t^m\right), idle\right)}_{\text{if stay idle}}\right\},$$

where, $\Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right)\right)$ is the expected value of starting out in sub-period t^{m+1} with type h and industry state $\boldsymbol{s}\left(t^{m+1}\right)$. This is the value before nature has chosen the next firm to move, and is given by,

$$\Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right)\right)=\underbrace{\rho^I\cdot\mathbb{E}\,V_h^I\left(\boldsymbol{s}\left(t^{m+1}\right)\right)}_{\text{firm } j \text{ selected again}}+\underbrace{\sum_{k\neq j}\rho^I\cdot W_{h'}^h\left(\boldsymbol{s}\left(t^{m+1}\right)\right)}_{\text{firm } k\neq j \text{ is selected}},$$

where, $W_{h'}^h\left(\boldsymbol{s}\left(t^m\right)\right)$ is the value to firm of type h if a firm of type h' is selected to move in sub-period m. This expected value for a non-selected incumbent firm h depends on the probability of the selected incumbent expanding and idling, and the resulting state transition. It is given by,

$$\begin{aligned}W_{h'}^h\left(\boldsymbol{s}\left(t^m\right)\right)=\Pr\big(h'\ \textit{expands}\big)\cdot\Lambda^h&\left(\boldsymbol{s}\left(t^{m+1}\right)\middle|\,\boldsymbol{s}\left(t^m\right),h'\ \textit{expands}\right)\\&+\Pr\big(h'\ \textit{stays idle}\big)\cdot\Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right)\middle|\,\boldsymbol{s}\left(t^m\right),h'\ \textit{stays idle}\right).\end{aligned}$$

Once I sub-periods have elapsed, nature turns to selecting potential entrants for each of the next E sub-periods.

Let us now consider the choice problem of a selected *potential entrant* of type h. Once selected, this potential entrant draws choice-specific idiosyncratic entry cost shocks, $\varepsilon_j^e=\left\{\varepsilon_j^{not\ enter},\varepsilon_j^{enter}\right\}$. If the potential entrant chooses to enter, it enters with capacity K_h and pays

$$\Phi_{jh}^E=\kappa_0^E+\kappa_1^E\cdot K_h+\varepsilon_j^{enter},$$

where, κ_0^E and κ_1^E are the fixed cost of entry and the per-unit cost of building capacity, respectively. Once in the market, the entrant starts the next sub-period as an incumbent of type h. If the potential entrant chooses not to enter, it pays $\varepsilon_j^{not\ enter}$. The value function of this selected potential entrant is given by,

$$V_h^E\left(\boldsymbol{s}\left(t^m\right),\varepsilon_j^e\right)=\max\left\{-\Phi_{jh}^E+\Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right)\middle|\,\boldsymbol{s}\left(t^m\right),enter\right),-\varepsilon_j^{not\ enter}\right\}.$$

In the final sub-period M of period t, all incumbent firms make production decisions. They realize period profits, following which the industry transitions to the first sub-period of the next period, $t+1$. For a firm of type h, the expected value in the final sub-period M can be expressed as,

$$\Lambda^h\left(\boldsymbol{s}(t^M)\right) = \pi^h(\boldsymbol{s}(t^M)) + \beta \cdot \Lambda^h\left(\boldsymbol{s}\left(t+1^1\right)|\boldsymbol{s}(t^M)\right),$$

where, β is the discount factor used to discount future value.

Finally, to close the model, we need to define the payoff in the terminal period T. We assume that the state stops evolving after T, and all firms continue to receive the stage game payoff in perpetuity for all $t > T$. The terminal value is then the net present value of the stage game payoff, given by,

$$\Lambda^h\left(\boldsymbol{s}(T^M)\right) = \frac{\pi^h(\boldsymbol{s}(T^M))}{1-\beta}.$$

D. Equilibrium

We can solve this finite-horizon, sequential-move game by backward induction. Given that firms are only differentiated by their types, the model yields type-symmetric equilibrium strategies. The presence of idiosyncratic investment and entry cost shocks simplifies computation as firms only need to compute state- and type-contingent choice probabilities for investment and entry decisions.

V. Estimation & Results

In this section, we describe how we estimate the structural parameters governing demand for cement, and the production and investment costs of cement firms in our empirical model.

A. Demand

We let aggregate demand for cement in each location l and year t be a function of the price of cement, P_{lt}, and the size of the urban population in that location, UP_{lt}.[17] Urban population is a demand shifter; greater the urban population, greater are the needs for housing and infrastruc-

[17] A location corresponds to an Indian state.

ture, and hence the greater is the demand for cement. Rural housing, during this period, did not rely primarily on cement as a construction material.

We write location-level (log) demand as

$$\log(Q_{lt}) = \delta_0 + \delta_p \cdot \log(P_{lt}) + \delta_{pop} \cdot \log(UP_{lt}) + \nu_{lt}, \tag{2}$$

where, ν_{lt} is a location-specific error term. When computing market-level demand, we sum over the quantity demanded in each location in that market.

In the above expression, the price P_{lt} is the *retail* price of cement, inclusive of distribution costs.[18] To address potential endogeneity of prices, we use prices of raw materials in the location as instruments. We observe these input costs in the ASI data, reported by cement plants themselves. To construct our instrument, we average the cost of raw materials over all the cement plants in a location. Note that for estimation, we use data from after complete liberalization (1996 to 2009), and assume that the structural demand parameters $\boldsymbol{\delta} = \{\delta_0, \delta_p, \delta_{pop}\}$ remain constant over time.

We present the estimated demand parameters in Table 2. Column (1) presents results from the first stage regression, where we regress the (log) retail price of cement on the (log) average cost of raw materials in the location. The coefficient on the cost of raw materials is positive and statistically significant, and the f-statistic is large, indicating that the instrument is strong. In columns (2) and (3), we present our estimates from the second stage where we regress (log) cement consumption on (log) price of cement. Our preferred specification is given in column (3) where we control for the size of the urban population in the location. From this specification, we obtain a price elasticity of -2.48. This is comparable to the price elasticity of demand for cement of -2.96 estimated in Ryan (2012).

Cement Allocation. Our data do not include details on how the price-controlled cement was allocated to consumers. However, we can use the estimated demand parameters and the data from the period of gradual reform, 1982 to 1989, to infer the allocation mechanism. During this period, the government required cement producers to sell a fraction of their output at controlled prices, while the remaining cement was sold at market prices. We observe the quantities and

[18]The retention price received by producers differs from the retail price paid by consumers. The difference includes various taxes, transportation costs, and retail markups. We observe the taxes paid over the years. We obtain other cost estimates from an industry report in 1988 and assume they remain the same in real terms. These assumptions on distribution costs do not directly affect our parameter estimates. They are held constant across counterfactuals.

Table 2: *Cement Demand Parameters*

	Price	Quantity	Quantity
Intercept	1.85	16.7	2.43
	(0.03)	(1.75)	(1.21)
Materials Price	0.227		
	(0.03)		
Cement Price		-3.98	-2.48
		(0.83)	(0.42)
Urban Population			0.689
			(0.03)
N	178	178	178
R^2		0.082	0.797
F	63.4		

Notes. This table contains the demand parameter estimates. Column (1) is the first stage. Column (2) and (3) are the second stage results. Column (3) controls for urban population. Cement Price, Cement Quantity, Materials Price, and Urban Population are in logs.

the market prices during this period. Suppose the price-controlled cement was allocated to the highest valuation consumers. Then, using our estimated demand model, we can compute the market-clearing price of remaining cement and the "remaining" consumers in the market. Similarly, we can repeat this exercise assuming the price-controlled cement was allocated to the lowest valuation consumers. We plot yearly implied market prices under these two allocations, along with the observed market price between 1982 and 1989 in Figure A.4. The observed price series lies in between the two price series implied by the most-efficient and the least-efficient allocation mechanisms. If we assume a *pro rata* allocation, and repeat the exercise, the implied market price lies close to the observed market price (Figure A.4). Under a *pro rata* allocation all consumers that want to purchase cement have an equal probability of being able to buy it. Based on this exercise, we assume a *pro rata* allocation in our counterfactuals.

B. *Production Costs*

The total cost of producing q_j units of cement by firm j with capacity K_j is given by,

$$C(q_j, K_j) = q_j \cdot \left(\gamma_0 + \gamma_{1j} \cdot \left(\frac{q_j}{K_j} \right)^{\gamma_2} \right),$$

where, q_j/K_j gives capacity utilization at firm j. In the above specification, γ_0 is the fixed cost per unit of production, while parameters γ_{1j} and γ_2 govern how costs change as firm j approaches its capacity limit.

The associated marginal cost of production is given by,

$$mc(q_j, K_j) = \gamma_0 + \gamma_{1j} \cdot (1 + \gamma_2) \cdot \left(\frac{q_j}{K_j}\right)^{\gamma_2},$$

which is increasing in capacity utilization, q_j/K_j, for positive values of γ_{1j} and γ_2.

In the data, firms exhibit substantial variation in their capacity utilization. Industry surveys attribute this to reasons such as mechanical failures, power cuts, lack of raw materials, labor strikes, etc. In our model, we incorporate these as firm-specific idiosyncratic shocks which change the costs associated with using the available capacity. Specifically, we assume that

$$\gamma_{1j} = \gamma_1 \cdot \exp(\eta_j),$$
$$\eta_j \sim \mathcal{N}(0, \sigma_c^2),$$

where, η_j is a firm-specific shock.

The production cost parameters to be estimated are $\gamma = \{\gamma_0, \gamma_1, \gamma_2, \sigma_c\}$. To estimate these, we match model-generated moments with empirical moments from the data. Specifically, for each guess of parameters $\hat{\gamma}$, we draw firm-specific marginal cost shocks from $\mathcal{N}(0, \hat{\sigma}_c^2)$. Holding capacity at the level observed in the data, we solve for production, revenue, and total cost for each firm. Using the simulated choices, we construct three moments, (1) total output at the region-year level, (2) standard deviation of capacity utilization across firms at an annual level, and (3) revenue to cost ratio at an annual level.[19] To construct their empirical counterparts, we use data from the period during which the cement industry was under price controls. For (1) and (2) we rely on the plant-level dataset, and for (3) we use the Annual Survey of Industries.

The estimated production cost parameters are given in Table 3. Both γ_1 and γ_2 are positive, indicating that marginal costs rise with capacity utilization in a convex manner. This suggests that capacity constraints significantly influence production.

[19]The standard deviation of capacity utilization informs σ_c, the variance in production cost shocks across firms. The revenue to cost ratio informs the intercept γ_0, as the intercept governs the profit earned on the inframarginal units. Finally, production choices inform γ_1 and γ_2, as firms vary their marginal production decisions with changes in price.

C. *Investment & Entry Costs*

For incumbents, investment costs depend on κ, the per-unit cost of building capacity, and ε_j, an idiosyncratic shock to the cost of investment. Entrants pay a fixed cost of entry κ_0^E, and an investment costs determined by their type h – an entrant of type h must invest in a plant of capacity K_h. We assume the per-unit cost of building capacity is the same for entrants and incumbents, i.e., $\kappa_1^E = \kappa$. Moreover, both incumbents and entrants draw investment cost shocks from the same distribution.

Idiosyncratic investment cost shocks are drawn from a Type-I Extreme Value (T1EV) distribution, with scale parameter σ^h, where h indexes the type of the firm. This scale parameter is a function of firm capacity, $\sigma^h = \sigma \cdot K^h$. As such, we have three dynamic parameters to estimate, $\boldsymbol{\theta}^\kappa = \{\kappa, \sigma, \kappa^E\}$.[20]

Since the idiosyncratic investment shock is drawn from a T1EV distribution, we can derive an analytical expression for the probability of action by an incumbent and an entrant conditional on being selected by nature. Consider an incumbent, of type h, that is selected by nature but has yet to draw the investment cost shock. The probability that it will choose to expand is given by,

$$\Pr^h(a = expand | \boldsymbol{s}(t^m)) = \frac{\exp\left(U^h(\boldsymbol{s}(t^m), expand)/\sigma^h\right)}{\exp(U^h(\boldsymbol{s}(t^m), expand)/\sigma^h) + \exp(U^h(\boldsymbol{s}(t^m), idle)/\sigma^h)},$$

where $U^h(\boldsymbol{s}(t^m), expand)$ and $U^h(\boldsymbol{s}(t^m), idle)$ are the payoffs associated with expanding and idling, respectively. These are given by,

$$\begin{aligned} U^h(\boldsymbol{s}(t^m), expand) &= -\kappa \cdot (K_{h+1} - K_h) + \Lambda^{h+1}\left(\boldsymbol{s}\left(t^{m+1}\right) \middle| \boldsymbol{s}(t^m), expand\right), \\ U^h(\boldsymbol{s}(t^m), idle) &= \Lambda^h\left(\boldsymbol{s}\left(t^{m+1}\right) \middle| \boldsymbol{s}(t^m), idle\right). \end{aligned}$$

Similarly, the probability that a potential entrant of type h enters, before drawing the entry cost shock is,

$$\Pr^h(a = enter | \boldsymbol{s}(t^m)) = \frac{\exp\left(U^h(\boldsymbol{s}(t^m), enter)/\sigma^h\right)}{\exp(U^h(\boldsymbol{s}(t^m), enter)/\sigma^h) + 1},$$

[20] We set the discount factor, β, at 0.9.

where, $U^h(\boldsymbol{s}(t^m), enter)$ is the payoff associated with entering. This is given by,

$$U^h(\boldsymbol{s}(t^m), enter) = -\kappa \times K_h + \Lambda^h \left(\boldsymbol{s}\left(t^{m+1}\right) \middle| \boldsymbol{s}(t^m), enter \right).$$

We estimate these dynamic parameters using the investment and entry decisions made by firms under the single retention price policy, spanning from 1969 to 1979. Given a guess of parameter values, we solve for the equilibrium, and compute the probability of the state transitions observed in the data. We pick the parameters that maximize the likelihood of the observed state transitions. Further details on each step are provided below.

To solve for an equilibrium, we need to calculate the expected profits for each state and time period until the terminal period T. These profits depend on the beliefs about the path of government policy and control prices. We assume that prior to 1979, firms believed that price controls would continue indefinitely. Figure A.3 shows the nominal and real retention price during the period. Nominal prices were roughly constant until 1974, and then increase. The increase was based on recommendations of the Tariff Commission, a government body responsible for setting prices. In real terms, prices fall till 1974, and then increase. We assume that prior to 1974, firms knew the price path till 1974 and expected prices to stay at that level beyond 1974. After the Tariff Commission report, they update their beliefs and the price path between 1974 and 1978. During this period, they expect the price post-1978 to continue at the level in 1978. With these beliefs and the estimated production cost parameters, we can solve for the optimal production and profits for each state and time period.[21]

Using the expected profits for each state and time periods, we can compute the equilibrium strategy for incumbents and entrants for a given guess of dynamic parameters through backward induction.[22] The equilibrium strategies allow us to compute the probability of state transitions numerically. For example, consider a transition from $\boldsymbol{s}$ in $t-1$ to $\boldsymbol{s}'$ in t. To compute the probability of this transition, we simulate the model starting from $\boldsymbol{s}$ through all the sub-periods of t many times. Across different runs, nature may select different firms and selected firms may

[21] In our baseline specification, we allow for 5 discrete firm capacity levels and a maximum of 20 firms per market. This results in 53,129 different possible industry states. We calculate production and profits for each firm type, in every state, for 75 years from 1969. To average over production cost shocks, we repeat the exercise for multiple draws and take an average. Computation is aided by the fact that under price controls, firms treat price as exogenous.

[22] The sequential ordering of moves within a period simplifies the computation of equilibrium strategies relative to a standard simultaneous move game. For a selected firm, the dynamic decision problem is akin to a single agent problem. This avoids having to compute the expectation over other players' strategies.

Table 3: *Cement Supply Parameters*

		Estimate	95% CI
Production Costs	γ_0	1.74	[0.98, 1.9]
	γ_1	0.54	[0.43, 1.37]
	γ_2	5.04	[3.28, 8.72]
	σ^c	1.08	[0.66, 1.64]
Investment & Entry Costs	κ^E	1.6	[0.18, 3.13]
	σ^c	1.69	[1.09, 3.22]
	κ	15.53	[13.0, 22.55]

Notes. This table reports the static and dynamic parameters which govern the supply-side of the model. The top panel reports parameters associated with the marginal costs of production of cement, while the bottom panel reports parameters governing the costs of entry and capacity expansion.

choose different actions. To compute the probability of transition, we take the proportion of simulations that end in $\boldsymbol{s}'$. We pick parameters that maximize the probability of all the observed state transitions.

We report the estimated dynamic parameters in Table 3. All values are reported in millions of 2015 Indian Rupees (INR). Per our estimates, new entrants must pay a fixed cost of κ^E = INR 1.6 million if they choose to enter. Our estimated per-unit cost of capacity expansion is κ = INR 15.5 million. This lines up with industry estimates from years 1982 and 1985, published in Chakravarty (1989), of INR 12.5 million and INR 14.5 million, respectively.[23]

D. Model Fit

We assess the fit of our estimated model in Figure 4.

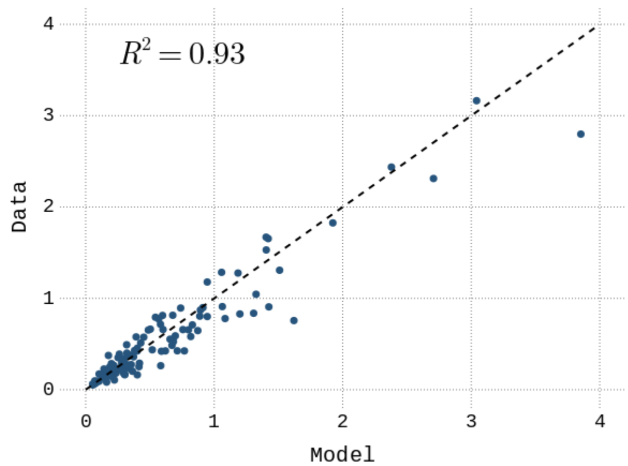
First, holding capacity fixed, we compute the model-predicted production at the firm- and region-level using our estimated production cost and demand parameters. In Figure 4a and Figure 4b, we compare these predictions with actual production observed in the data. At both the firm- and region-level, the model does a good job of replicating the data with an R^2 of 0.93 and 0.99, respectively.

Additionally, in Figure 4c, we plot the distribution of model-predicted capacity utilization against the data, and find these two distributions to be quite similar.

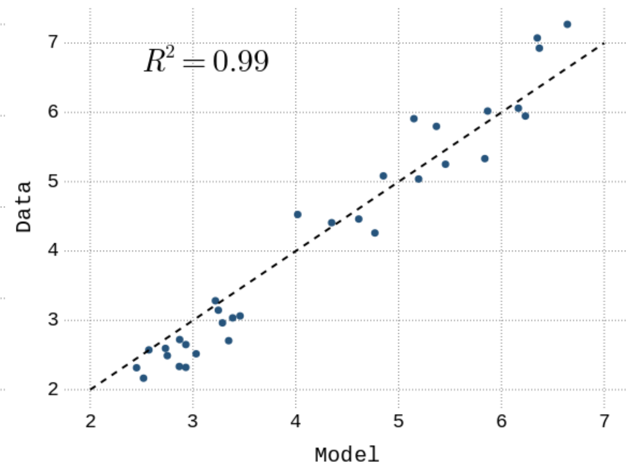
[23] We convert the published numbers to 2015 INR and report those here for ease of comparison.

Figure 4: *Assessing Model Fit*

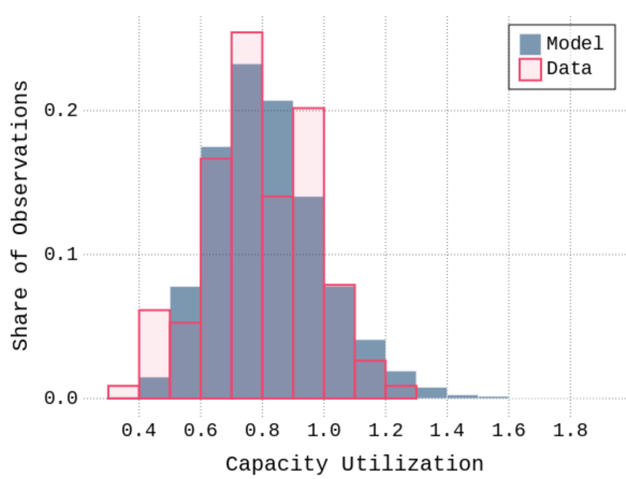
(a) *Firm-level production decisions*



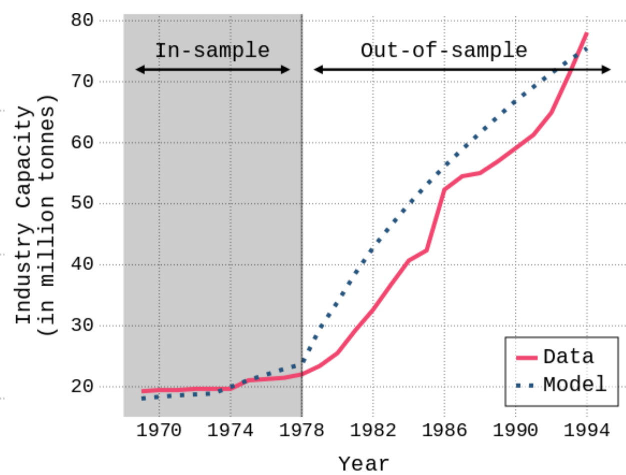
(b) *Region-level production*



(c) *Distribution of capacity utilization*



(d) *Total capacity in the cement industry*



Notes. This figure compares model predictions with data. Panel (a) plots the model predicted production, at an annual-regional level, against the data. Panel (b) plots the model predicted production, at the firm level, against the data. Panel (c) plots the density of capacity utilization in the data and the model. Panel (d) plots the model predicted industry capacity against the data. Data to the left of vertical line in Panel (d) is used in estimation, data to the right shows out-of-sample prediction.

Second, we compare the model-predicted trajectory of total capacity in the cement industry with the observed trajectory of the cement industry in India from 1970s to 1990s. The model is estimated using data prior to 1979, but we predict capacity for years after 1979 as well. We compare these two series in Figure 4d and find that this out-of-sample prediction for industry capacity lines up well with the data.

VI. Counterfactual Analysis

In this section, we use our empirical model to study the effects of India's price control policy on the cement industry. We first examine the impact of these controls on the industry's growth trajectory in the 1970s. To do so, we compare industry outcomes under price controls with a hypothetical scenario where the industry functioned in a regime free from these controls. Next, we evaluate the gradual phase-out policy that was adopted to remove these price controls. Leveraging our nonstationary model, we examine outcomes *during* and after the transition from a regime with price controls to one without them under the implemented strategy, and contrast this with a hypothetical rapid big-bang approach. The first counterfactual highlights the potential adverse effects of price controls on industrial growth. The second offers guidance for policymakers considering the deregulation of industries under price controls.

A. Impact of Price Controls on the Indian Cement Industry

In the first counterfactual, we compare the trajectory of the Indian cement industry under two scenarios – the actual scenario with government price control and a hypothetical scenario without government intervention, where prices are determined by market forces.[24]

For each scenario, we simulate our model forward starting at the industry state observed in 1969. Firms know the future path of government policy, and make production and investment decisions accordingly. Specifically, under price controls, firms assume that price controls will continue indefinitely, while under the scenario with no government intervention, firms do not expect price controls to be introduced in the future.[25]

[24]The results across counterfactual simulations will differ due to variation in the set of firms selected by nature to move, and their investment cost shock draws. For all our results, we run 100 simulations and report the average.

[25]For the scenario with price controls, we also have to make assumptions about firm beliefs about future retention prices. We assume that before 1974, firms know the evolution of the path till 1974, and expect the price to be at the 1974 level beyond 1974. They update their beliefs in 1974 and know the price path between 1974 and 1978. Finally, the expected retention price beyond 1978 is at the level in 1978. These assumptions are motivated by actual changes in the retention price during this period, as shown in Figure A.3.

We begin by looking at the policy's effect on cement prices. As a first step, we consider the case where output is fixed at the level under price controls, and then solve for the price that would result at this output level in a setting without government intervention. We refer to this as the *market clearing price*. We compare this with the price of cement under price controls in Figure 5a. We find that, on average, this market clearing price would be about 48% higher than the controlled price.

However, this comparison is misleading as it does not take into account the equilibrium supply response in the absence of price controls. In Figure 5a, we also show the counterfactual price of cement *while allowing the output to adjust*. We find that in the scenario without price controls, prices initially rise by approximately 30%. But over the following years, they gradually fall. By the end of the decade, in 1979, the counterfactual price is still higher than the controlled price, but only by about 10%. This exercise confirms that price controls were indeed effective in reducing prices over this period, but their impact is muted when one accounts for the counterfactual supply decisions of cement producers.

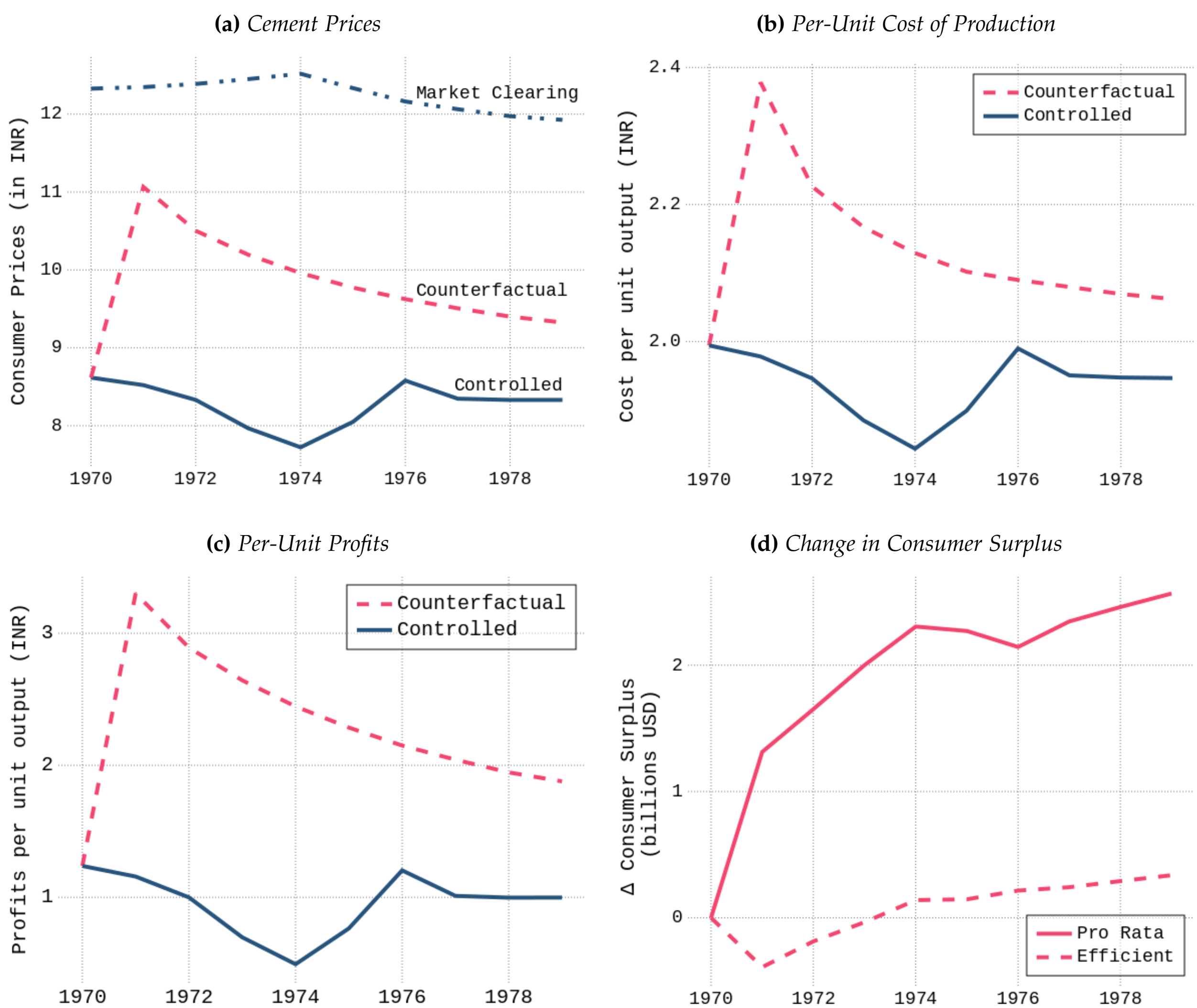
Next, we compare production costs and profits of cement firms. In the absence of price controls, two opposing forces influence the amount of output produced by firms. On one hand, firms may choose to exercise market power by reducing output and raising prices. This force is not present in the case of price controls as additional units of output do not affect output price. On the other hand, higher output prices incentivize firms to produce more. In our simulations, we find that firms not only produce more in the absence of price controls, they also use a greater share of their available capacity. This pushes up the per-unit cost of production, as shown in Figure 5b. However, this is more than offset by the higher price of cement. On net, firm profits are higher under the counterfactual scenario, as shown in Figure 5c.

In Figure 6, we also compare output and industry capacity (investment) under the implemented policy and the hypothetical scenario without government intervention. We find that the industry grows rapidly in the absence of price controls, with output and capacity almost tripling by the end of the decade. In contrast, under price controls, the industry maintains low levels of output and develops capacity at a substantially slower pace during the 1970s.

Finally, we look at consumer welfare in Figure 5d.[26] We plot the difference in consumer surplus in

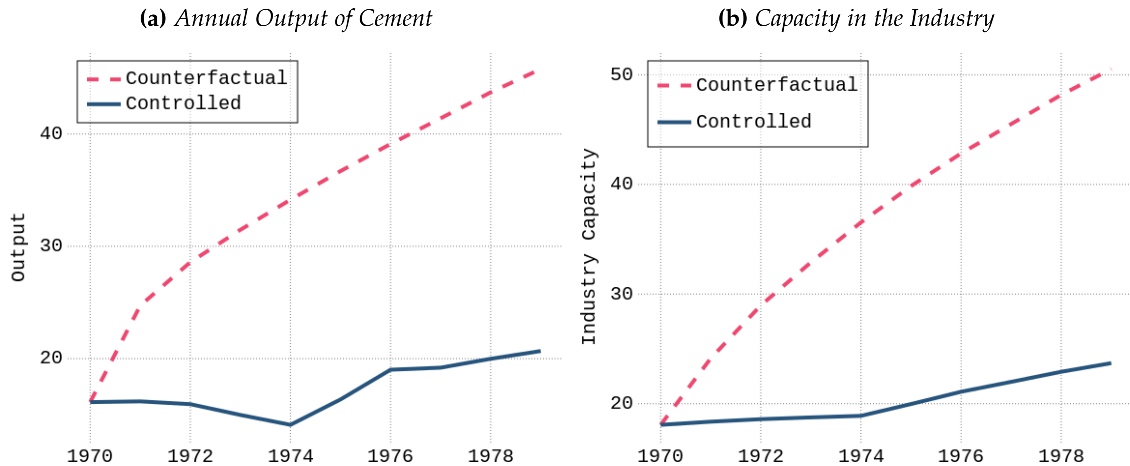
[26] We define consumer surplus as the area under the demand curve. Under price controls, with *pro rata* allocation, we scale consumer surplus to account for rationing. However, this aggregate measure misses some important dimensions

Figure 5: *Firm and Consumer Outcomes With and Without Price Controls*



Notes. Panel (a) plots the consumer prices over the years under price controls ("Controlled"), a hypothetical scenario without price controls where output is fixed at the level under price controls ("Market Clearing"), and a hypothetical scenario without price controls where output is allowed to adjust ("Counterfactual"). Panel (b) plots the per-unit cost of production under price controls and under the counterfactual without price controls. Panel (c) plots firm profits per unit of output under price controls and under the counterfactual without price controls. Panel (d) plots the difference in consumer surplus under the counterfactual without price controls and to the scenario with price controls, under the assumption of pro rata and efficient allocation. All plots present results averaged across 100 simulations.

Figure 6: *Output and Capacity in the Cement Industry*



Notes. *Panel (a) plots the annual output of cement under price controls ("Controlled") and under the counterfactual without price controls ("Counterfactual"). Panel (b) plots the capacity in the industry under price controls and under the counterfactual without price controls. Results are averages across 100 simulations.*

the market equilibrium and under the price control policy, in billions of USD. Consumer surplus is driven by prices, output, and the efficiency of allocation. Lower prices under price controls increase consumer surplus, but this may be offset by lower output and inefficient allocation. Under the baseline assumption of (*pro rata*) allocation by the government, we find that the welfare under the market equilibrium is significantly higher. In contrast, if we assume that cement was allocated efficiently under price controls, the market equilibrium is worse for consumers for the first few years. However, eventually, consumer welfare under price controls falls below the level under the market equilibrium. This is because the industry grows rapidly in the absence of price controls, and the benefits from increased supply outweigh higher prices.

B. *Impact of Implemented Deregulation Policy*

In this section, we study the impact of the implemented deregulation policy. Starting in 1982, the government allowed firms to sell a proportion of their output at market prices. This proportion was increased over time, culminating in complete deregulation by 1989. To evaluate this gradual reform, we compare it with a hypothetical big-bang reform under which price controls are

of welfare. For example, government use of cement for infrastructure may generate externalities. Additionally, Beirne and Kirchberger (2023) show that due to cement's position in the production network, distortions can have large effects on steady-state output of the economy.

completely removed in 1982.[27]

In our simulations, both reforms are announced in 1982. In the big-bang reform, producers are allowed to sell their output at the equilibrium market price starting in 1982. Under the gradual reform, producers sell a fraction of their output at the government-determined retention price. The rest is sold at a market-determined price. The fraction sold at the retention price declines over time, with complete liberalization in 1989. The fraction to be sold at retention price and the level of the retention price are given in Figure A.1. These are known to the producers in 1982.

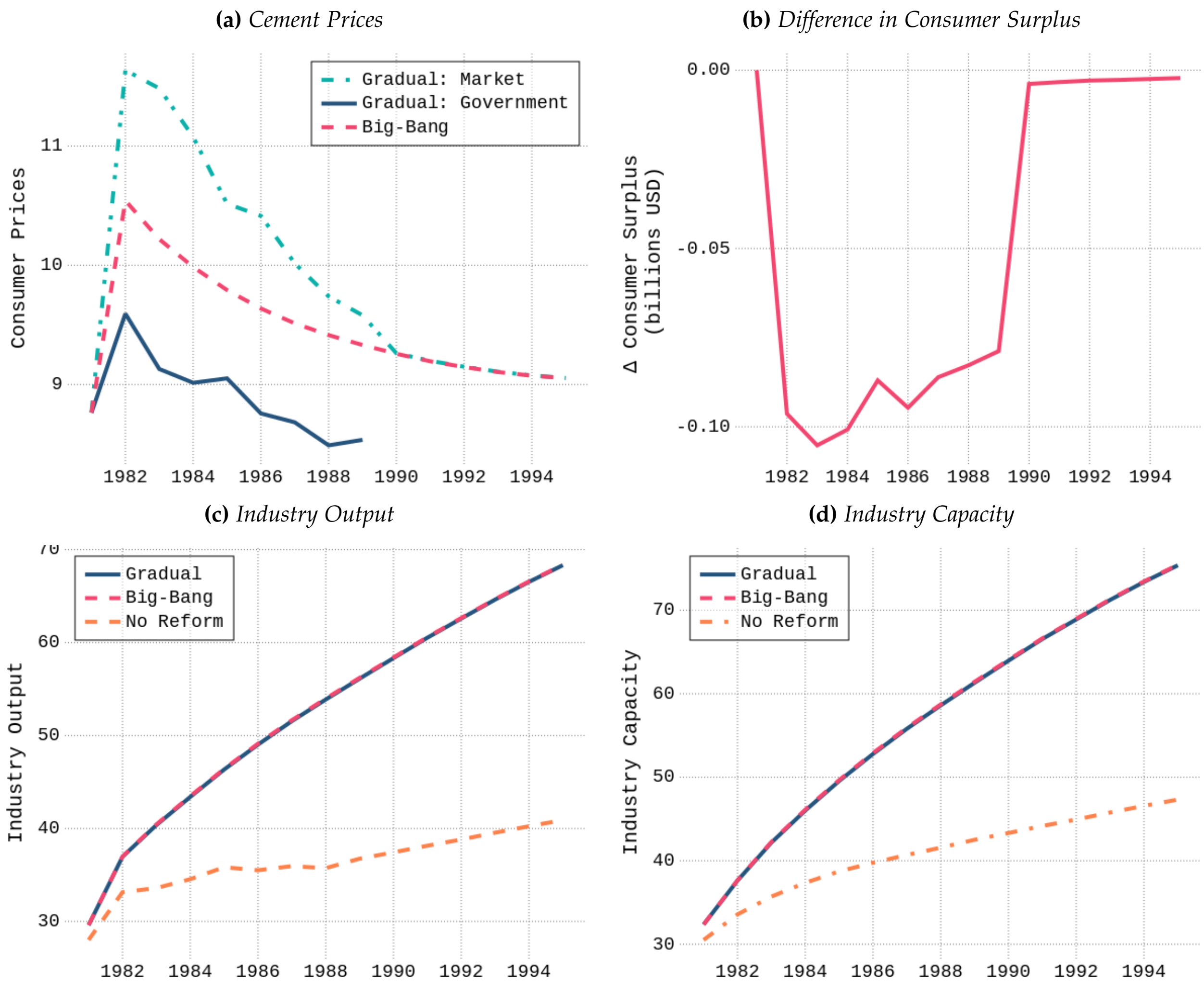
We first look at the impact of the two policies on the price of cement. Under gradual reform, we have two prices: the controlled price and the market-clearing price. These are shown in Figure 7a. Part of the total output is sold to consumers at the controlled price, and the residual consumer demand is met by the market at the market-clearing price. In 1982, when the policy is adopted, the market price is substantially higher than the controlled price. Over the next few years, however, this gap narrows as the government allows producers to sell a larger fraction of their output at the market price and more capacity comes online. Under the big-bang reform, there is a single market clearing price. This price lies in between the two prices under the gradual reform. This is because under the gradual phase-out policy, some consumers with high willingness to pay are rationed out, who turn to the market and drive up the price. As such, the market price under the big-bang reform is lower than the market-price under the gradual reform.

Next, we look at the growth in output and capacity under the two policies (Figure 7c and Figure 7d). Surprisingly, growth in output and capacity is virtually identical in the two scenarios, and significantly higher than if price controls were maintained.

Surprisingly, output and capacity growth is virtually identical in the two scenarios, and is much higher than if price controls were maintained. This is driven by two factors. First, the higher market price under gradual reform partially compensates for the lower retention price. Industry profits are only slightly lower under the gradual reform. Second, when making investment decisions firms care about future profits. Under the gradual reform, expectations of higher profits following complete liberalization generate investment today.

[27] There is substantial policy debate on the speed of transition out of price controls. Both the United States and the United Kingdom implemented price controls during World War II. After the war, economists argued for a slow phase-out in the US. The extension of price controls was rejected by the Truman administration. Rapid phase-out led to a substantial increase in prices and labor unrest. In contrast, a more gradual approach in the UK limited inflation and labor unrest. A similar debate took place when Russia and China phased out price controls. Russia adopted a 'shock-therapy' approach, where controls were rapidly phased out, while China adopted a more gradual policy.

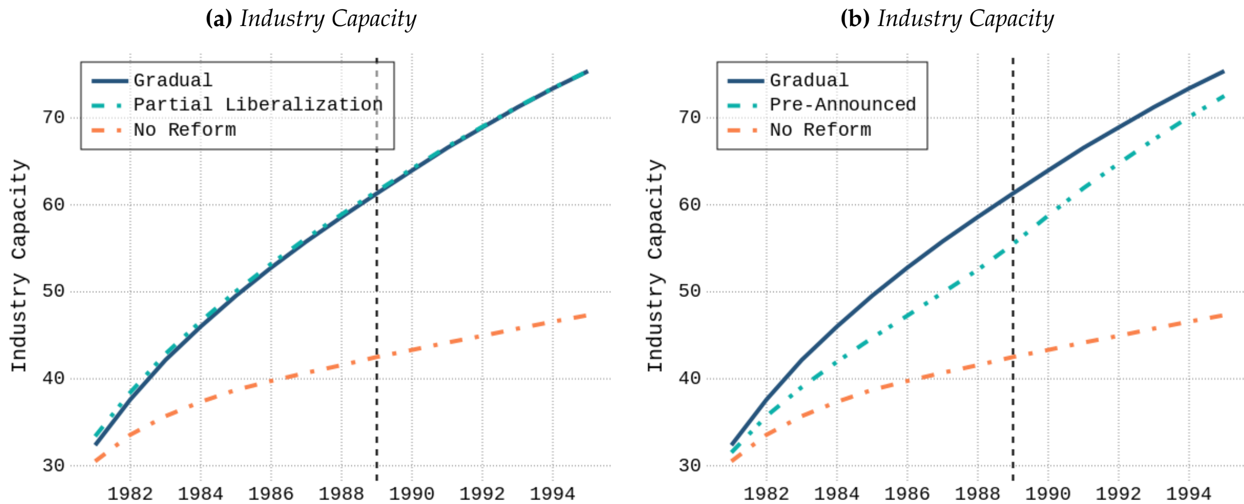
Figure 7: *Comparison of Outcomes Under Gradual and Big-Bang Reform*



(a) *Cement Prices* **(b)** *Difference in Consumer Surplus* **(c)** *Industry Output* **(d)** *Industry Capacity*

Notes. Panel (a) plots the retail price of cement under the gradual and the big-bang reform. "Gradual: Market" is the price of cement sold on the market. "Gradual: Government" is the price of cement sold under price control. Panel (b) plots the difference in consumer surplus under the gradual and the big-bang reform. Panel (c) plots the industry output under the gradual, the big-bang, and under no reform. Panel (d) plots the industry capacity under the gradual, the big-bang reform, and under no reform.

Figure 8



Notes. Panel (a) plots the total industry capacity under the gradual reform, the partial reform, and under no reform. Panel (b) plots the total industry capacity under the gradual reform, the pre-announced reform, and under no reform.

To further understand the impact of each of these, we run two additional simulations. In the first simulation, we look at the impact of a partial reform (Figure 8a). Firms are allowed to sell a third of their output at market prices, and the rest is sold at the retention price. This differs from the gradual reform as the proportion of output sold at market prices is fixed at 33% instead of increasing over time. We find that the industry grows at a similar rate as under the gradual reform. Higher market prices under the partial reform adequately offset lower prices of the regulated cement.[28] The second simulation is a "pre-announced" reform, under which firms know that the sector would be liberalized in 1989 but are not allowed to sell their output at market prices until then. As we show in Figure 8b, changing firms' beliefs about future policy is sufficient to substantially increase investment.

Finally, we consider the impact on consumer welfare under the two policies during the transition period. We plot the difference in consumer surplus under the gradual reform and the big-bang reform in Figure 7b. The difference in surplus is about USD 100 million; consumers are better off under big-bang reform, at least for the first few years. Post-1989, the difference in consumer surplus is negligible. The difference between the two reform policies is quite small compared

[28]This result relies on the allocation mechanism. A *pro rata* allocation increases the market price of the unregulated cement by rationing out some high willingness to pay users. Under a more efficient allocation mechanism, profits and growth would be lower.

to the numbers in the first counterfactual. This is driven by the fact that consumers with a high willingness to pay, who were rationed out under price controls, were able to purchase cement in the market under the gradual reform.

VII. Conclusion

Price controls are ubiquitous and frequently emerge in contemporary policy discussions as a popular tool for regulating prices. Another recurring debate centers on the optimal approach to deregulation: should an industry be deregulated in one go or gradually? In this paper, we study these questions in the context of the Indian cement industry, which was subject to price controls until 1982 and then progressively deregulated by 1989. We develop a non-stationary, dynamic, oligopoly model of the industry and estimate its parameters using historical micro-data.

Our findings indicate that the price control policy had a substantial impact on the size of the cement industry during the 1970s. In the absence of price controls, the industry would have grown to three times its 1980 size. Quantifying the role of price controls on growth and investment may be particularly important in developing countries where industries are in early stages of development. Regarding deregulation, we find that the gradual approach adopted by the government delivered outcomes similar to a big-bang reform. Capacity, output, and consumer welfare evolve similarly under gradual and swift deregulation. This result is driven by two factors. First, under gradual reform, an increasingly larger fraction of cement could be sold at market prices, allowing firms to invest more from increased profits. Second, anticipation of complete deregulation enabled firms to invest more during the period of deregulation. Our findings support gradual approaches to deregulation where political constraints require a measured transition.

Future research could explore alternative interventions, such as production and investment subsidies, and compare them to price controls. Additionally, the study of other distortions common in developing countries, such as collusion or inadequate antitrust enforcement, may be useful for understanding underlying motives for implementing price controls.

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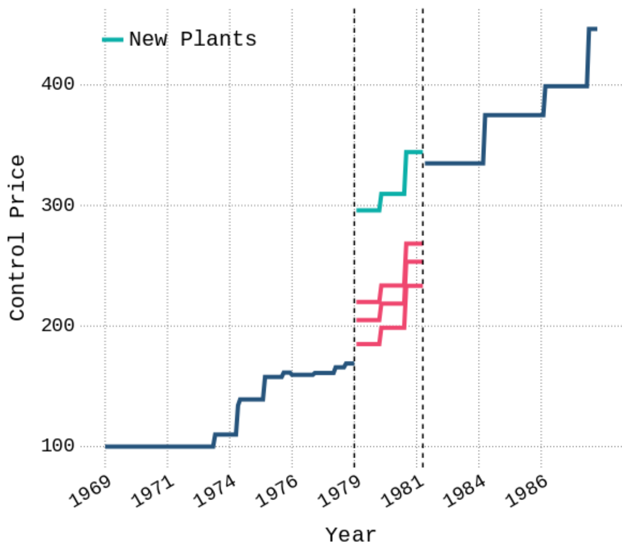
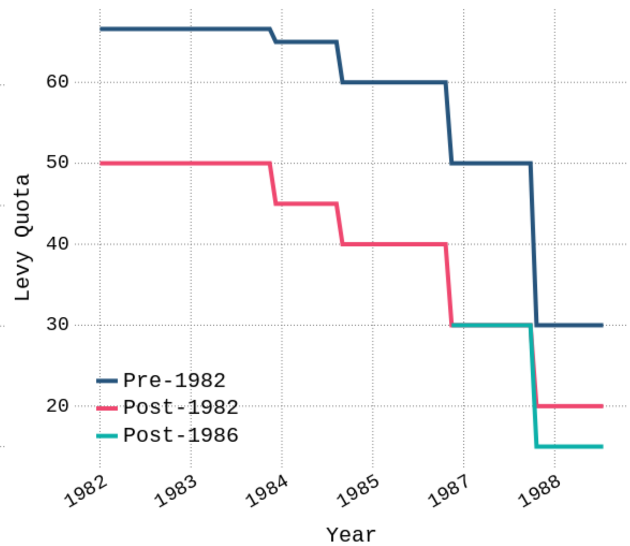
A Additional Figures

Figure A.1

(a) *Retention Price over Time*

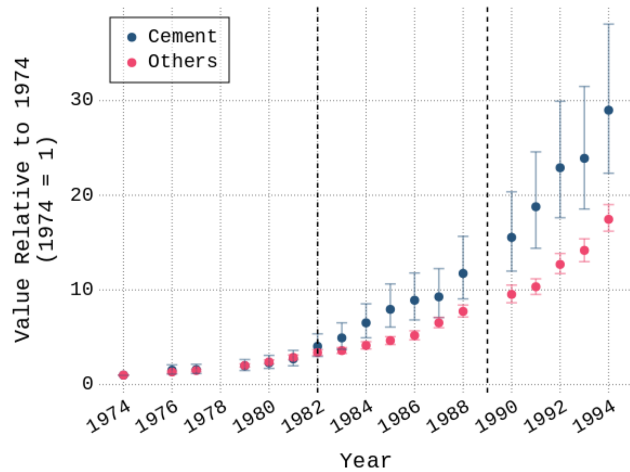


(b) *Levy Quota*



Notes. Panel (a) plots the retention price over time. Retention price is the price that producers receive for their output. The government offered a single retention price between 1969 and 1979. Between 1979 and 1982, the government offered four different prices based on the cost of production. New plants received a significantly higher price. Starting in 1982, the government started offering a single price again. Panel (b) plots the evolution of levy quota during the partial liberalization period, from 1982 to 1969. Under partial liberalization plants were required to sell a proportion of their output, the levy quota, to the government at the retention price. Rest could be sold in the open market.

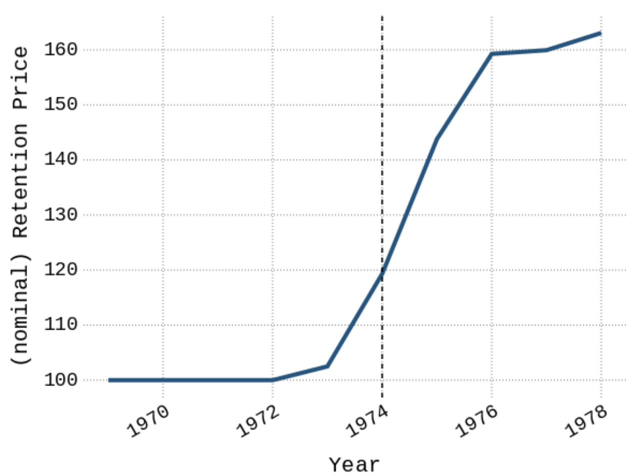
Figure A.2: *Total Reported Costs*



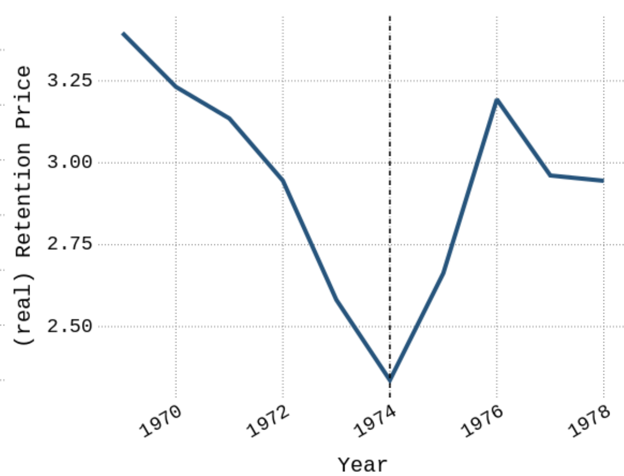
Notes: This figure plots the total cost of production in the cement industry and all other manufacturing industries. The values are normalized to their level in 1974. Data comes from various rounds of the Annual Survey of Industries.

Figure A.3: *Nominal and Real Controlled Price Between 1970 and 1978*

(a) *Nominal Retention Price*

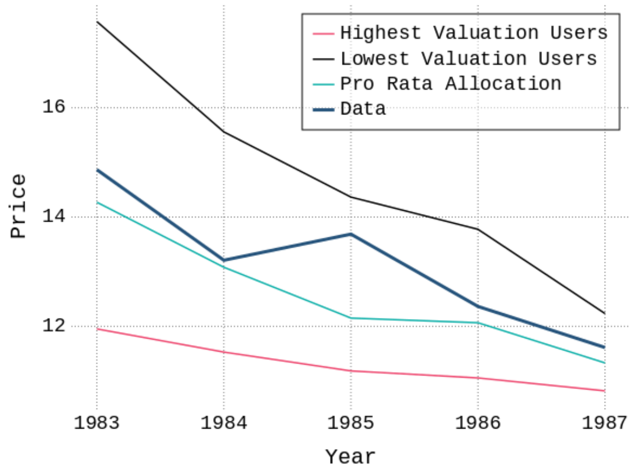


(b) *Real Retention Price*



Notes. Panel (a) plots the nominal control price between 1969 and 1978. Panel (b) plots the real control price.

Figure A.4: *Market-Clearing Price Under Alternative Allocation Mechanisms*



Notes. This figure plots the price series under alternative allocation mechanisms. In "Highest Valuation Users", the government allocates cement to the users who value it the most. In "Lowest Valuation Users" the government allocates cement to the users who value it the least. In "Pro Rata Allocation", the government allocates cement with equal probability to all interested consumers.

B Data Appendix

The production data for our analysis comes primarily from Gadhok (2000a,b), which provides plant-level cement production starting in 1969. The production data is available every alternate year until 1985, after which it is available annually. Gadhok (2000a,b) also contains annual plant capacity data starting in 1982. Additionally, it has capacity and number of plants aggregated at the state level from 1970 onwards. To construct the full plant-level capacity panel, we supplement this with data from Das (1987), which has plant-level capacity in 1971, and Chakravarty (1989), which has plant capacity from 1978 onwards.

For the missing years between 1971 and 1978, we fill in plant capacity as follows. For plants that report the same capacity in 1971 and 1978, we assign the 1971 capacity.[29] For new plants that entered during this period, we confirm the year of entry based on state-level information and set capacity to zero before the entry year. For plants that increased capacity during this period, we verify the exact year of increase using state-level capacity figures. We apply a similar procedure to fill in plant capacity in 1970. Through this process, we are able to construct a plant-level panel on capacity from 1970 onwards.

[29] To rule out an increase and decrease of capacity between 1971 and 1978, note that we never see a reduction in capacity in the plant level capacity data that we have from 1982 onwards.

Table C.1

	(1) Baseline	(2) High E, I	(3) Low T
κ^E	1.6	1.87	0.674
σ	1.69	1.64	1.87
κ	15.5	17.4	16.6

Notes. The table shows estimates of the dynamic parameters under different extensions. Column (1) presents the baseline estimates. Column (2) shows estimates after increasing E and I by one each, respectively. Column (3) displays estimates when T is set to match 2020.

C Robustness and Extensions

A. Increasing I and E

In the baseline specification of our model, we set the number of incumbents (I) that nature selects to 3, and the number of potential entrants (E) to 2. This aligns with the maximum number of firms we observed moving in a given year based on our data. To confirm that our results are not sensitive to this assumption, we increase I and E by 1 and re-estimate the model. The resulting estimates of the dynamic parameters are shown in Table C.1, Column 2. As expected, increasing the assumed number of potential movers increases the estimated cost of building capacity.

We find that the counterfactuals look the quantitatively similar with the new estimates and number of movers. We plot the prices, capacity, output, and consumer welfare for the first counterfactual in Figure C.1.

B. Changing the Share Sold to Government

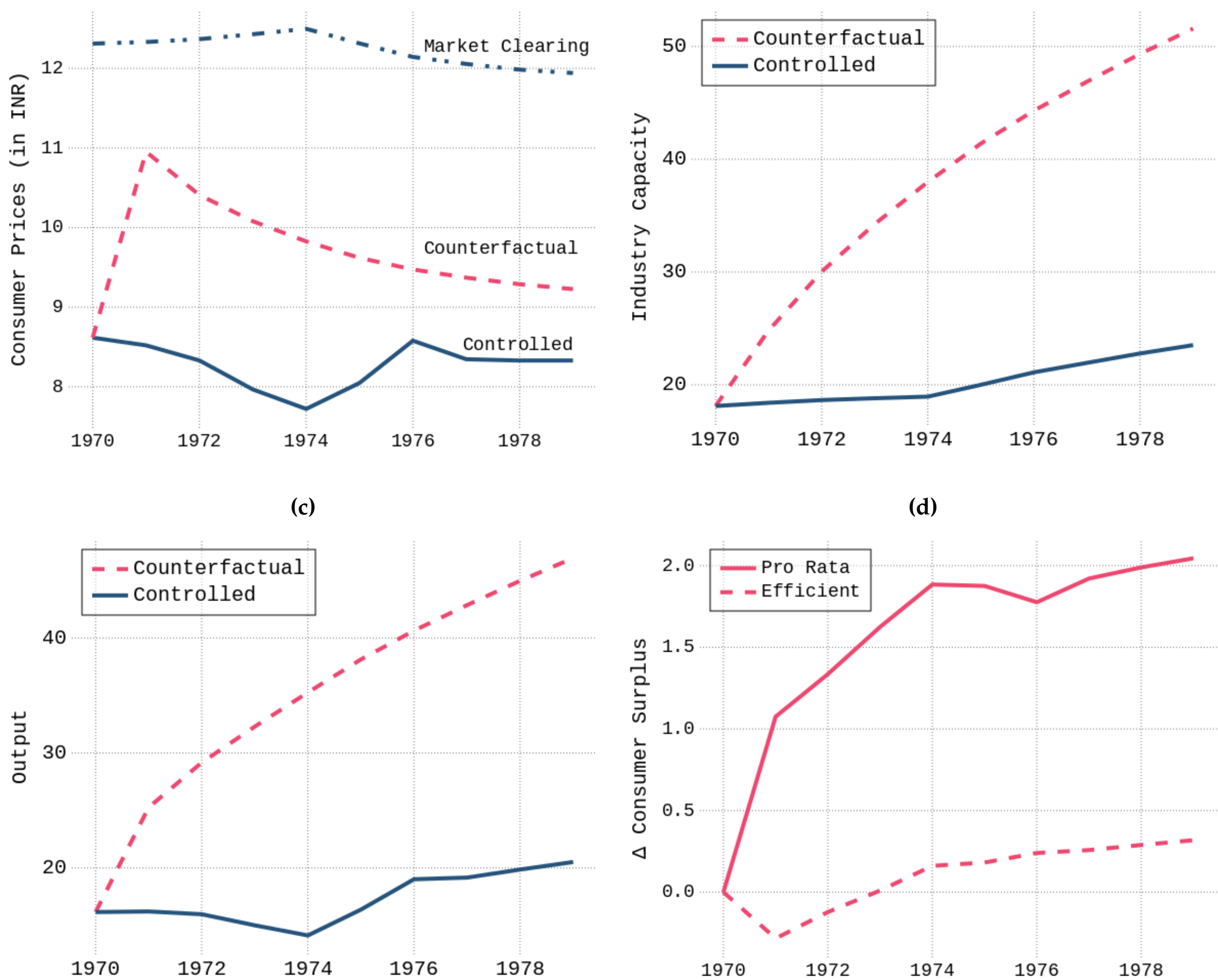
In the second counterfactual, we examined the liberalization policy adopted by the government, allowing the share sold to the government to evolve as it did historically. In this section, we explore the importance of the specific mandated share amount itself. We consider a scenario where firms are required to sell a high portion (90%) of their total output to the government until 1989. The sector is liberalized in 1989 and firms can sell all their output at market prices beyond that.

We plot the output and capacity under the high quota scenario in Figure C.2. The results show that capacity and output are only slightly lower compared to the actual gradual reform. This

Figure C.1

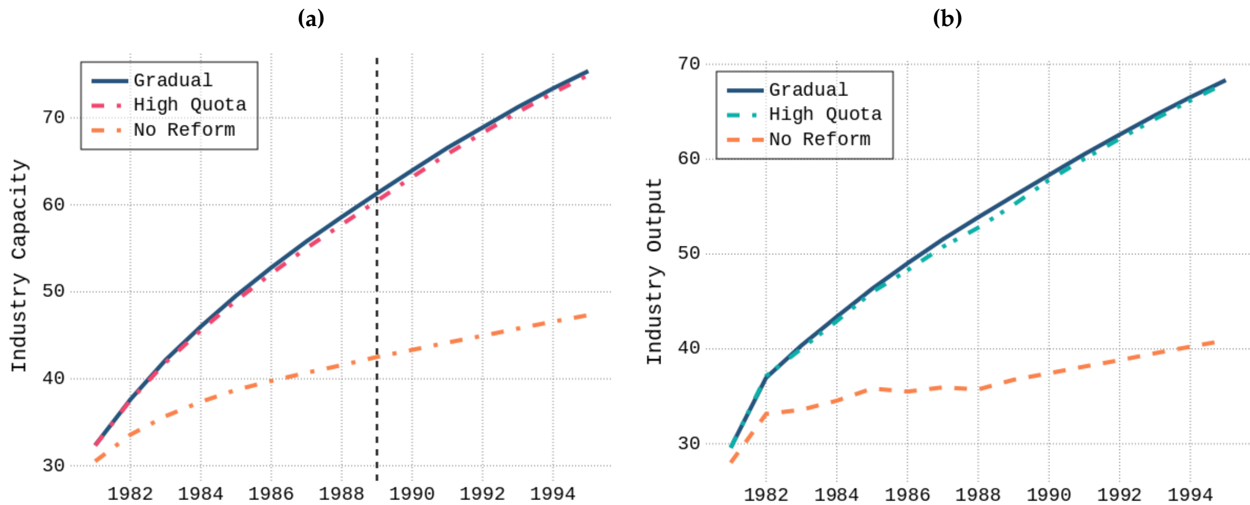
(a) **(b)**

(c) **(d)**



Notes. *Panel (a) plots the consumer prices over the years under price controls ("Controlled"), a hypothetical scenario without price controls where output is fixed at the level under price controls ("Market Clearing"), and a hypothetical scenario without price controls where output is allowed to adjust ("Counterfactual"). Panel (b) plots the industry capacity under price controls and under the counterfactual without price controls. Panel (c) plots the industry output under price controls and under the counterfactual without price controls. Panel (d) plots the difference in consumer surplus under the counterfactual without price controls and to the scenario with price controls, under the assumption of pro rata and of efficient allocation.*

Figure C.2



Notes. *Panel (a) displays industry capacity under the gradual reform, under the high quota scenario, and under the counterfactual without price controls. Panel (b) displays industry output under the gradual reform, under the high quota scenario, and under the counterfactual without price controls.*

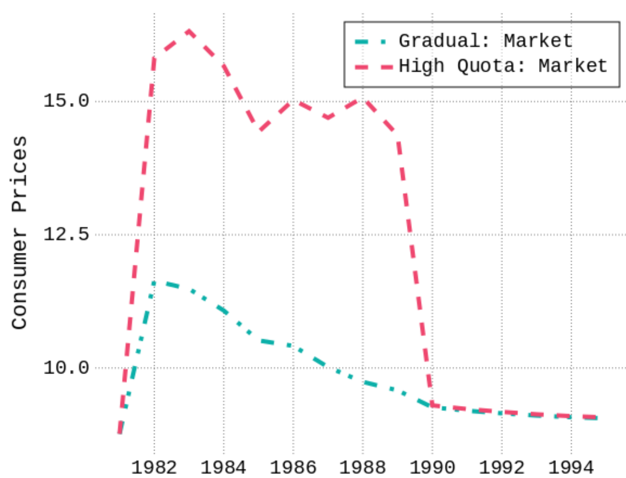
outcome is driven by an adjustment in the price of unregulated cement. As shown in Figure C.3, the market price for unregulated cement is considerably higher under the high quota scenario relative to the price under gradual liberalization. The increase in price counterbalances the lower share that firms can sell on the market.

C. *Changing the Terminal Period T*

In the baseline specification, we set the terminal period T to correspond to 2050. With a discount rate of $\beta = 0.1$, we do not expect the choice of terminal period to significantly impact our main results. In this section, we explore the robustness of our results to this assumption by reducing T. Specifically, we set T to correspond to 2020 and re-estimate the dynamic parameters. The parameters from this robustness check are shown in Column 3 of Table C.1. These parameter estimates are quite similar to the baseline estimates.

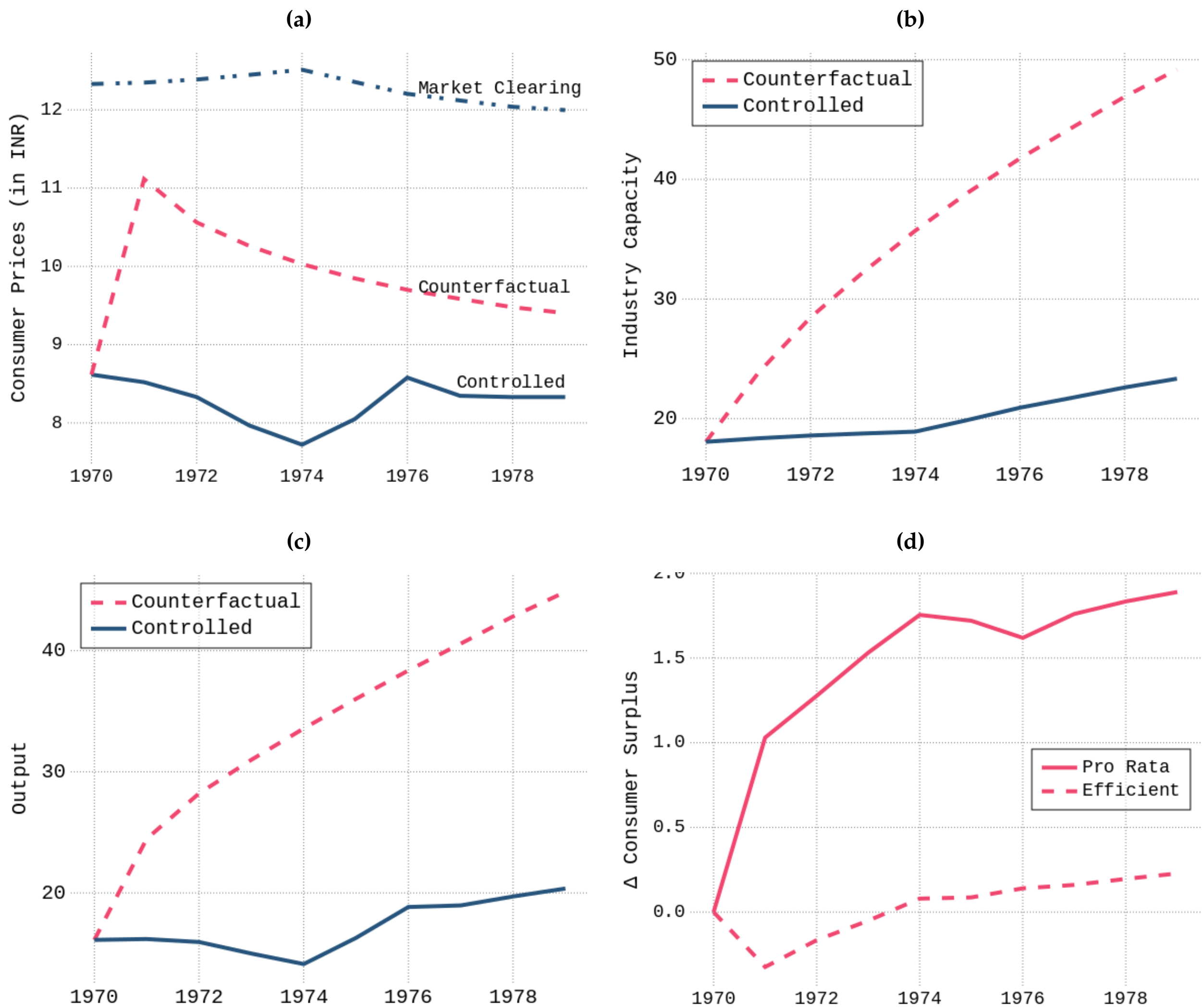
We find that the counterfactuals also look quantitatively similar with the new estimates and lower T. We plot the prices, capacity, output, and consumer welfare for the first counterfactual in Figure C.4.

Figure C.3



Notes. The figure displays the market price under the gradual reform and the high quota scenario.

Figure C.4



Notes. Panel (a) plots the consumer prices over the years under price controls ("Controlled"), a hypothetical scenario without price controls where output is fixed at the level under price controls ("Market Clearing"), and a hypothetical scenario without price controls where output is allowed to adjust ("Counterfactual"). Panel (b) plots the industry capacity under price controls and under the counterfactual without price controls. Panel (c) plots the industry output under price controls and under the counterfactual without price controls. Panel (d) plots the difference in consumer surplus under the counterfactual without price controls and to the scenario with price controls, under the assumption of pro rata and of efficient allocation.