Shades of Integration:
The Restructuring of the U.S. Electricity Markets

Alexander MacKay Harvard University*

Ignacia Mercadal Columbia University†

March 14, 2019

PRELIMINARY AND INCOMPLETE:
NOT FOR GENERAL DISTRIBUTION

Abstract

We use a detailed dataset on electricity transactions to investigate changes in market structure following the deregulation of the electricity sector, as well as the consequences for prices. We show that deregulation was effectively delayed by intermediate degrees of vertical integration, such as long-term contracts and common ownership. To account for these mechanisms, we look at the impact of *effective deregulation*: the portion of a market served by companies not related to the incumbent utility. We find that effective deregulation occurs several years after the initial vertical separation of incumbent utilities, and, when it occurs, prices increase. We examine wholesale market transactions in more detail using contracts for a subset of our data. We find that higher prices appear to be driven by purchases between affiliated companies, pointing to one mechanism by which an intermediate form of vertical integration plays a role.

*Harvard University, Harvard Business School. Email: amackay@hbs.edu.
†Columbia University, School of International and Public Affairs. Email: ignacia.mercadal@columbia.edu.

1 Introduction

The restructuring of the electricity sector started in the 1990s with the objective of bringing down consumer prices by introducing competition into markets that traditionally operated as regulated monopolies. Two and a half decades later, we still do not fully understand the consequences of this effort (Bushnell et al., 2017). Previous studies have found that generation costs went down in deregulated markets, but it is still unclear if this has translated into lower prices for consumers (Fabrizio et al., 2007; Davis and Wolfram, 2012; Borenstein and Bushnell, 2015; Bushnell et al., 2017; Cicala, 2017). In this paper, we exploit a unique dataset on electricity markets in the U.S. to examine the consequences of deregulation.

Using detailed data on electricity transactions from generation to distribution, we obtain two main findings. First, we show that *effective deregulation* was delayed in several states. In particular, rates were frozen, companies kept a high degree of vertical integration through contracts and common ownership, and competition at the retail level was very weak. Second, we find that effective deregulation is correlated with higher prices at both the wholesale and retail levels, which implies that deregulation seems to have not fulfilled the expectations of higher prices that lead states to deregulate.

Traditionally, electric utilities in the U.S. and the world were vertically integrated companies that included generation, transmission from power plants to towns and cities, and distribution to final consumers. Because electricity was considered a natural monopoly, only one company was allowed to serve the market and its rates were regulated under rate of return to avoid monopoly pricing. Following a wave of deregulation that was successful in other sectors, like telecommunications and airlines, the electricity sector started its own process of deregulation in the 1990s.

The deregulation of the sector included a number of changes aimed at introducing competition in the segments that were not natural monopolies, namely generation and retailing. The upstream market was opened to entry by any firm, expecting to have efficiency from competition among generators. To guarantee access, the operation of the transmission grid was put in the hands of an Independent System Operator (ISO), an independent non-profit organization in charge of coordinating the usage of the grid by all parties. Downstream, the former utility kept the monopoly of distribution, since it is a natural monopoly, but retail was open to competition. This means that any company could buy electricity upstream and sell it to final consumers using the utility's distribution grid. Under this scheme, the consumer pays the agreed energy rate to the retailer and a regulated distribution rate distribution to the utility.

Though competitive generation was allowed in the whole United States since 1978 (Public Utility Regulatory Policies Act), electric deregulation was conducted at the state level, and many states chose to stay regulated. We introduce our analysis by focusing on the case of Illinois, where deregulation began formally in 1997. Even though upstream deregulation started early

on by encouraging utilities to sell their generation assets, downstream deregulation was delayed because retail competition was introduced only for large commercial customers. For the rest, retail rates from the utility were lowered and frozen for 10 years. We show that during this early period, incumbent utilities sold their generation assets but still obtained a large share of their purchases from affiliated companies, i.e., companies belonging to the same parent company. Deregulation was therefore effectively delayed for 10 years, since most generation and retail sales were under the control of the incumbent utility.

In 2007, when retail competition was fully introduced, both the incumbent's retail sales and its share of affiliated purchases went down. Interestingly, wholesale prices paid by incumbent utilities went up. As this could have been due to other factors, we compare wholesale prices in Illinois to those in Missouri, a neighboring state that remained regulated and where the largest utility belongs to the same parent company that the largest utility in Illinois. We show that wholesale prices in the two states moved in sync before Illinois was deregulated, and until 2007. In that year, when market structure effectively changed as a consequence of deregulation, prices in Illinois spiked and stayed at higher level than prices in Missouri.

To confirm that this is a general finding and not just a feature of the particular case of Illinois, we use detailed data on (formerly) regulated utilities across the United States to analyze what happened after deregulation. Our findings indicate that, like in Illinois, market structure took many years to change as a result of deregulation measures. In particular, we show that, in the upstream market, effective deregulation lagged apparent deregulation—how much electricity was generated by companies other than the utility—by as much as 10 years. Though utilities divested themselves of their generation assets quickly, companies just split themselves into a downstream utility and a generation firm that continued to sell its output to the affiliated utility.[1] In other words, despite being formally different companies, they were only one step below being completely vertically integrated since they had common ownership and control. Moreover, the affiliated purchases tended to be governed by long-term contracts, which further brought the firms toward vertical integration. At the downstream level, competition also took some time to intensify, since consumers were slow to switch and the incumbent utility kept a high market share for years. Hortaçsu et al. (2017) study the reasons behind this initial inertia in Texas, which we show was the general trend in deregulated states.

After showing the delay in effective deregulation across the U.S., we estimate its effect on prices. Our measures of effective deregulation are the share of non-affiliated resources in the upstream market, and the share of retail sales by independent retailers in the downstream market. We conduct the analysis at the utility level using regulated states as a control group, include utility and year fixed effects, and control for fuel prices at the state level.

Our results indicate that both upstream and downstream prices increased around 35% after deregulation. Though effective upstream deregulation is correlated with lower prices, con-

[1] We use the term "affiliate" as a company belonging to the same parent company.

firming efficiency gains documented in the previous literature (Fabrizio et al., 2007; Davis and Wolfram, 2012), downstream deregulation is associated to higher prices and has effects an order of magnitude higher. Thus, we find that the generation efficiencies arising from upstream deregulation were overwhelmed by the upward pressure on prices brought about by deregulation downstream.

The fact that prices increased after deregulation comes somehow unexpectedly, since arguments to deregulate are typically based on competition bringing down prices. Nonetheless, there are clear market forces that may push prices up when a market introduces retail competition: namely the loss of monopsony power by the incumbent utility. As a monopsonist, the utility had the ability to purchase electricity upstream at the average cost to the generator. With entry into the market of competitive retailers, the utility loses market power and thus pays higher prices, which reflect both the marginal cost of generation (typically higher than average cost) and also the markup earned by the generators. Although in principle this effect could be counterbalanced by efficiency gains, our results indicate that cost reductions are small.

Finally, we use transaction level data on electricity sales from FERC Electric Quarterly Reports (EQR) to analyze the role of vertical integration for the case of Illinois. Here, as in many states, the share of purchases from affiliated companies falls at the time retail competition intensifies, when we also find that prices go up. We show that for the case of Illinois, this increase in prices comes primarily from purchases that occur under long-term contracts with affiliated companies. Most of these contracts were signed in 2007, suggesting it was yet another attempt of incumbents to delay changes in market structure from deregulation, though they might not have been as effective once competitive retailers started to gain larger market shares.

This paper's main contribution is to present the first complete description of how U.S. markets changed after deregulation, including both the upstream and the downstream markets. We are able to do this by exploiting two rich datasets that have not been used before. These are: FERC Form 1, which contains detailed information on (formerly) regulated utilities, including costs and procurement sources, and FERC EQR, which contains contractual details of most electricity sales at the wholesale level, except for those in spot markets.

Combining these data, we are able to introduce a new dimension to the analysis of electricity markets restructuring, namely vertical integration. We show that accounting for intermediate degrees of vertical integration is key to understand how markets responded, since they used them to effectively delay the loss of market control by the incumbent utility.

Bushnell et al. (2008); Mansur (2007) discuss the role of vertical integration in deregulated markets and show that spot wholesale electricity markets are more competitive when generators are vertically integrated because they have fewer incentives to increase prices. Our paper complements these finding by looking at the market as a whole instead of focusing on the spot market, and including intermediate degrees of vertical integration in the analysis.

The existing literature on the consequences of deregulation is surprisingly scarce, given the

importance of the electric sector for the economy and, more recently, for decarbonization. We know that deregulation has brought some gains in productive efficiency (Fabrizio et al., 2007; Davis and Wolfram, 2012; Cicala, 2017), but we still do not know what was the effect on prices (Bushnell et al., 2017). We are the first to document that effective deregulation is correlated to higher prices upstream and downstream.

The next section of the paper describes the data sources used in this paper. The core of the paper is in Section 3, we describe the restructuring process of the United States and analyze the changes it brought to market structure using data for all states. We discuss our findings on the effect of deregulation on prices in Section 4, and conclude in Section 5.

2 Data

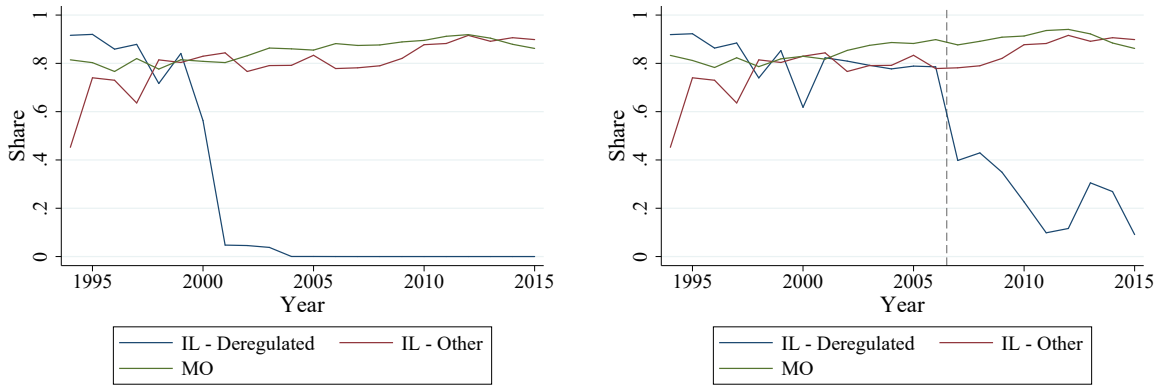
Our dataset is constructed using data from several sources. Data on electric utilities comes from FERC Form 1, which is completed annually by all electric utilities. This dataset contains financial information, as well as data on purchases (how much, from which company, at what price) and sales (retail by type of customer, wholesale), as well as generation costs when applicable. We combine this with data from forms EIA-861 and EIA-923 from the Energy Information Administration (EIA). This dataset is complemented with industry data provided by S&P Global.

A second source of data are the Electric Quarterly Reports (EQR) collected by FERC, where most sellers of electricity are required to report their sales and the details of the contract under which they take place. For each wholesale sale of electricity in the US, firms report the price and quantity, the seller and buyer's name, and the contract terms of the transaction. Independent System Operators (ISOs) are not required to report, so in this dataset we do not observe transactions in which utilities purchase in the spot market organized by the corresponding ISO.

3 Restructuring of the U.S. Electricity Markets

Traditionally, electric utilities have operated as vertically integrated companies, which means that the same firm is in charge of the three segments of electric supply: Generation, transmission or transport from the generating plant to the cities, and distribution or delivery to each household or business. Electricity is a case of what is called a natural monopoly, which is a market where unit costs are significantly lower when there is only one firm due to economies of scale. In this particular case, costs are lower when there is only one transmission and distribution grid instead of several competing firms, each with its own network. For this reason, in most countries it used to be the case that only one firm was allowed to operate in each electric market. In the U.S, electricity firms were typically privately owned and prices were regulated to allow firms to recover investment and earn a "reasonable" return, as determined by the regulator, while staying below monopoly prices.

Figure 1: Share of Electricity Sources



(a) Own Generation (b) Affiliated Sources

Notes: The affiliated sources include both own generation and purchases from companies belonging to the same parent company. The year 2007 is indicated by a vertical dashed line. Source: FERC Form 1 data.

Following successful deregulation stories in other industries like airlines, ground transportation, and telecom, the electricity sector in the United States started to deregulate in the 1990s. This process generally consists in lowering both barriers for firms to enter and constraints on the prices firms can charge. The consequences of deregulation in electricity markets are particularly important given how fundamental this sector is in the economy. Electricity is indispensable both as an input in most production processes and as a component of every household's daily life. Moreover, we need a good understanding of electricity markets function in order to overcome the challenges brought by decarbonization, which will require a deep change in the structure of generation in order to replace fossil fuels and serve a demand that will grow with the electrification of transportation and heating.

3.1 A Case Study: Illinois

In the 1990s, Illinois' electricity rates were among the highest in the United States. Motivated by these high prices, Illinois lawmakers passed the Consumer Choice Act in 1997, which encouraged large investor-owned utilities to divest their generation assets and allowed for independent companies to supply electricity to commercial customers. For residential customers and small businesses, rates were lowered by 15 percent and frozen for 10 years. In 2002, retail choice was extended to residential and small commercial customers, thus allowing for competitive supply in the downstream market.

Within a few years, the investor-owned utilities in Illinois had sold off their complete portfolio of generation assets. This large change to the market is illustrated in panel (a) of Figure 1. The blue line represents the share of sources that investor-owned utilities obtained from their own generation. The remainder is obtained by purchasing electricity from other producers. The

share of electricity sourced from own generation fell from above 80 percent at the time of the restructuring initiatives to 5 percent by 2001.

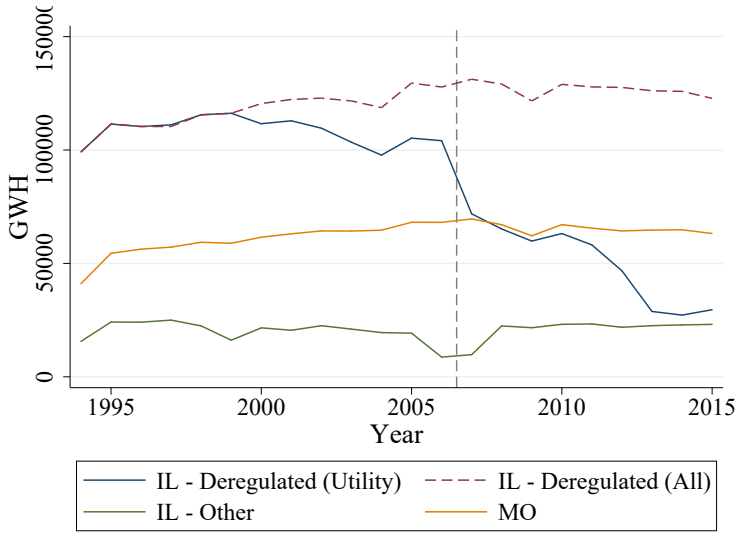
For comparison, we construct two reference groups: (1) other utilities in Illinois that were not affected by deregulation measures (e.g., co-ops), and (2) utilities in Missouri. Missouri is a neighboring state and its largest utility, Union Electric, is part of the Ameren group that owns the utilities serving a large portion of Illinois. Importantly, Missouri did not pass any deregulation measures in this period. Panel (a) of Figure 1 plots the share of own generation for other Illinois utilities in red and for Missouri utilities in green. While deregulated firms in Illinois divested nearly all of their generation assets, the regulated firms in Illinois and Missouri continued to obtain the vast majority of their electricity from own generation.

Even though deregulated firms legally divested themselves of generation assets quickly, the actual restructuring of the upstream market came about more slowly. Indeed, this is one of the key empirical facts of our paper, and can be observed in Figure 1. Panel (b) plots the share of electricity obtained from affiliated companies, which combines both own generation and purchases from companies belonging to the same parent company. The share of purchases from affiliated companies did not fall until 2007, indicated by the vertical dashed line. In practice, the deregulated Illinois utilities split into subsidiary companies and signed long-term purchase agreements with each other, therefore still maintaining a high degree of vertical integration until those contracts expired in 2007. Even at the end of the sample, some fraction of the electricity is still purchased from affiliated companies, raising the possibility that aspects of vertical integration might still be at play in the market.

To examine the effect of the restructuring measures on the downstream market, we consider retail electricity supplied by investor-owned utilities compared to sales from independent power producers and power marketers. As in the upstream market, the conditions in the downstream market changed slowly. From 1997 to 2006, only commercial customers were incentivized to choose electric providers, resulting in a modest decline in sales for incumbent utilities. Figure 2 plots retail sales for the deregulated utilities (blue line) compared to retail sales in the utilities' geographic footprint (red dashed line). Though formally deregulated, during this period the market remained similar to how it was before deregulation started: Incumbent utilities served most of the market and rates were frozen.

In 2007, the price cap on rates was removed and several long-term purchase agreements expired. Figure 2 shows that the incumbents then started to lose their dominant position in the market more rapidly than during the first 10 years of deregulation. Additionally, Illinois began implementing additional incentives to encourage retail choice, such as municipal aggregation (Deryugina et al., 2019). After this point, the share of retail electricity supplied by independent power companies began to grow more quickly, surpassing 50 percent of the market by 2011. Utilities did not change their real purchase patterns until 2007 (Figure 1) and downstream competition did not take off until that year. Thus, effective deregulation, measured by the

Figure 2: Retail Sales



Notes: The blue line represents retail sales by deregulated utilities in Illinois and the red dashed line represents all retail sales in the utilities' geographic footprint. The difference between these two lines are sales by independent retailers. The year 2007 is indicated by a vertical dashed line. Source: FERC Form 1 data.

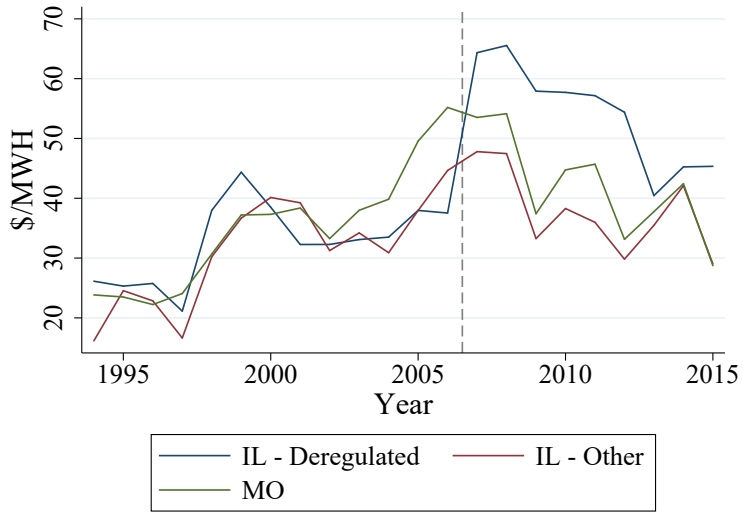
impact on market restructuring, did not occur in Illinois until 2007. Beginning that year, retail choice was much more common and most transactions were between independent parties.

Deregulation was expected to bring down prices by reducing inefficiency and increasing the competitiveness of the sector. Surprisingly, wholesale electricity prices in Illinois increased after 2007, when deregulation had effectively taken place. This is illustrated in Figure 3. Before 2007, the quantity-weighted purchase price for deregulated utilities in Illinois followed a similar path to prices for other Illinois utilities and for Missouri utilities. After effective deregulation (2007), prices in Illinois spiked, and then stayed above prices paid by regulated utilities. Part of the spike in 2007 is likely due to a poorly designed procurement auction for retail customers, but this does not seem to be the whole story since prices remained higher for deregulated utilities even after the auction issues were fixed.

The case study of Illinois illustrates two potentially surprising results for policies intended to deregulate a market. First, firms have access to mechanisms (e.g., contracts and common ownership) to maintain a strong degree of vertical integration even when the legal entities are vertical separated. Second, deregulation could potentially *increase* prices. The economic reasons for price increases resulting from deregulation are standard economic arguments, though they are less frequently discussed than their counterparts. We discuss these arguments and the evidence for them in Section 4.

Though we find this case compelling, there are of course other reasons that might generate (especially) the price patterns we observe in Illinois. In the next section, we expand our analysis

Figure 3: Wholesale Prices



Notes: Purchase prices reflect the quantity-weighted average price of purchased electricity, including long-term contracts and spot-market transactions. Source: FERC Form 1 data.

beyond Illinois and Missouri to examine how systematic are the delays in effective deregulation and whether the prices indeed increased across a broader sample.

3.2 Aggregate Impacts of Electricity Restructuring

In this section, we examine the overall impacts of electricity market deregulation measures on market structure and prices. To do so, we use detailed annual transaction data for major electricity market participants in the United States. As deregulation measures primarily targeted investor-owner utilities (IOUs), we restrict our analysis to electricity delivered by these companies. Prior to deregulation, IOUs generated the majority of electricity in the U.S.

The geographic footprint of investor-owned utilities remained largely unchanged during our sample period, and utilities remain involved in maintaining the power lines even when electricity is supplied by an independent company. Thus, our dataset is best though of as a geographic subset of the United States, where the included area are the areas serviced by investor-owned utilities. We observe all electricity that flows through the utilities' lines. Our dataset includes generation (if owned by the IOU), purchases made by the IOU, sales for resale, and retail sales. We also observe electricity that is delivered by the IOU as a service for an independent power company. Importantly, we observe whether a company that the IOU sells to or purchases from is owned by the same (ultimate) parent company, so we can measure purchases from these affiliated companies.

To estimate the aggregate impact, we divide our states into two groups: a treated group that includes states that passed deregulation measures, and a control group that did not. Four

Table 1: Year of Initial Deregulation Measures

State	Upstream	Downstream
RI	1997	1997
NY	1997	1998
CA	1998	1998
NH	1998	1998
MA	1999	1998
PA	1999	1999
NJ	1999	1999
DE	1999	1999
MD	1999	2000
CT	1999	2000
IL	2000	2000
ME	2000	2000
OH	2001	2001
TX	1995	2002
VA	2002	2002
OR	2002	2002
MI	-	2002

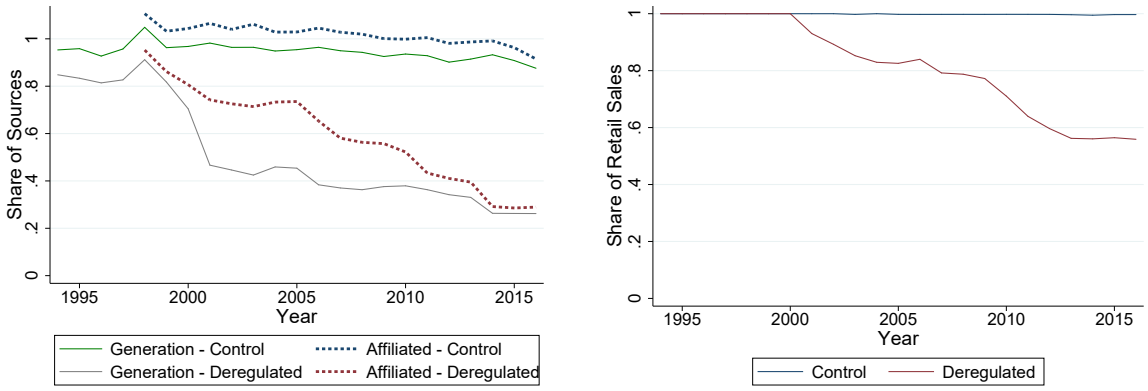
Notes: Table indicates the year initial deregulation measures came into effect for the listed states, by whether they affected the upstream market or the downstream market. Michigan (MI) did not pass a measure to deregulate the upstream market. Four states (AZ, AR, NV, and MT) initially passed deregulation measures but later rescinded them. These four states are omitted from our analysis.

states—Arizona, Arkansas, Nevada, and Montana—initially passed deregulation measures but later rescinded them. These four are omitted from our analysis. We are left with 17 states in our treated group, and 29 states in the control group.

The 17 states that implemented deregulation measures in our period (1994–2016) are reported in Table 1, along with the year the first measure came into effect for the upstream and downstream markets. With the exception of Texas, all of the states implemented these measures between 1997 and 2002. For our current analysis, we generate our plots relative to a benchmark year of 1998, though we may use state-varying implementation dates in a future version.

Figure 4 indicates the degree of market restructuring over time in the aggregate. Panel (a) shows the share of electricity sources obtained from own generation for deregulated states (gray line) and control states (green line). Across the treated states, own generation fell sharply from 1998 to 2002, from roughly 90 percent of sources to less than 50 percent. By contrast, the share of own generation for control states remained roughly constant over the entire sample. The share is reported with electricity demand as the denominator, which is why it is possible for the share to be greater than one (the excess electricity is lost on the lines or exported).

Figure 4: Share of Market Supplied by IOUs (1 – Effective Deregulation)



(a) Upstream

(b) Downstream

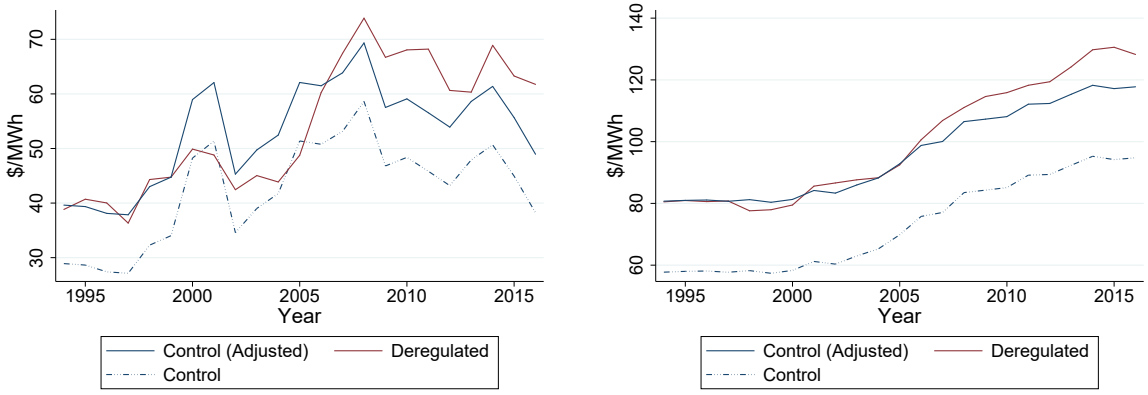
Notes: Source: FERC Form 1.

The thick dotted lines indicate the share of electricity sources obtained from affiliated companies. For deregulated states, the decline in electricity purchased from affiliated companies lagged the decline in own generation by several years. It was not until 2011 that non-affiliated purchases reached the level of *effective deregulation* indicated by generation assets in 2001: more than 50 percent from independent companies. These two measures converge toward the end of our sample, with over 70 percent of the aggregate demand being provided by companies independent from the IOUs. Overall, panel (a) suggests that IOUs were able to delay the effects of market restructuring and maintain effective vertical integration.

Panel (b) of Figure 4 indicates aggregate effective deregulation in the downstream market. Much like the path for affiliated purchases, the transition to a deregulated market occurred gradually over a number of years. In the aggregate, the downstream market realized less deregulation than the upstream market, with independent companies providing less than 50 percent of retail consumption in 2016.

We now examine the aggregate effects on wholesale prices (upstream) and retail prices (downstream). Panel (a) of Figure 5 shows the average wholesale price for the two groups. After accounting for level differences, the plot shows that wholesale prices for deregulated states and control states tracked each other closely from 1994 to 1999. In 2000, wholesale prices in control states rose relative to the treated states, and they remained higher (relative to the baseline) until 2006. In 2007, wholesale prices increased in deregulated states. This timing coincides with effective deregulation exceeding 40 percent of the upstream market (Figure 4), as well the expiration of the rate freeze in Illinois discussed in the previous section. Further, panel (b) in Figure 5 shows that retail prices in treated and control states followed a similar pattern until 2007, at which point retail prices in treated states increased. These time-series pat-

Figure 5: Deregulation and Electricity Prices



(a) Upstream

(b) Downstream

Source: FERC Form 1.

terns show that (effective) deregulation is positively correlated with upstream and downstream prices in the time series, though, at least initially, long-term contracts and other initiatives may have suppressed prices in the deregulated markets.

3.3 Utility-Level Analysis

To generalize the findings in the aggregate data in the previous section, we conduct an analysis at the level of individual utilities. We wish to explore the mean effect of deregulation measures on an individual utility, controlling for other factors.

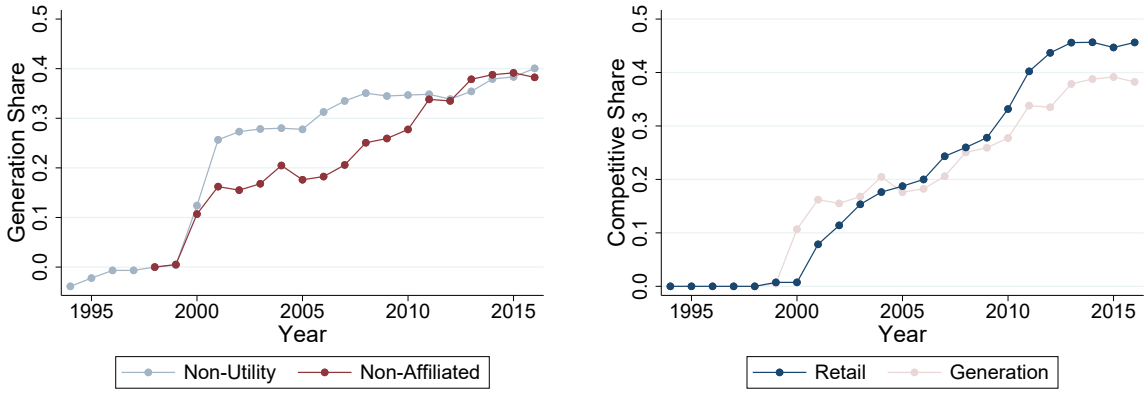
To begin, we use an event-study regression to estimate the following model:

$$y_{it} = D_i \beta_t^y + \xi_i + \phi_t + \varepsilon_{it} \tag{1}$$

Where y is the outcome of interest, i indexes utilities, t indexes years, and D is an indicator for whether or not the utility is in a treated state. We control for utility fixed effects (ξ_i) and yearly fixed effects (ϕ_t). Our coefficients of interest, $\{\beta_t^y\}$, capture the time-varying difference between treated and control utilities in our sample, after accounting for fixed effects.

For our first set of regressions, we calculate effective deregulation compared to apparent deregulation. For the upstream market, we estimate equation (1) where y indicates the share of IOU sources that are purchased (non-utility) and the share of that are purchased from non-affiliated companies. The latter measure corresponds to our notion of effective deregulation. The estimates for β_t^y are plotted in panel (a). Corresponding to our aggregate findings, the average utility divests a substantial portion of its own generation quickly, with over 25 percent

Figure 6: Event Study: Effective Deregulation



(a) Upstream

(b) Downstream

Notes: Source: FERC Form 1.

divested by 2001. However, utilities continue to purchase from affiliated companies, and effective deregulation does not reach 25 percent until 2008, seven years later. Effective deregulation and apparent deregulation converge at 35 percent for the average utility in 2011, roughly 10 years after the wave of deregulation initiatives.

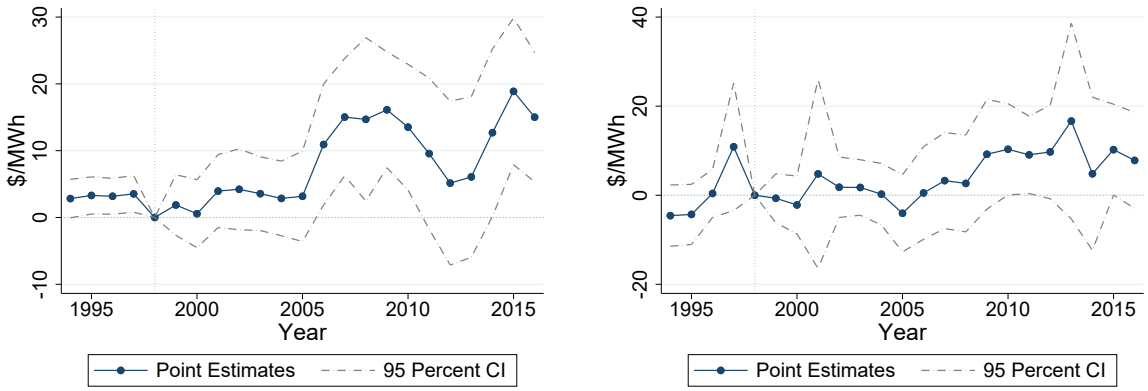
In panel (b), we plot the coefficient estimates for effective deregulation from the downstream market. For comparison, we also plot the upstream measure from panel (a). As in the upstream market, the move toward effective deregulation is gradual for the average utility. In contrast to the aggregate statistics, deregulation in the downstream market exceeds the upstream market for the average utility, reaching roughly 45 percent by 2014. The difference between the upstream market and downstream market compared to Figure 4 indicate that there are some compositional effects arising from differential changes to large individual utilities.

Next, we construct event-study estimates for the effect on prices both upstream and downstream. These estimates are plotted in panels (a) and (b) of Figure 7. For the average utility, we find that wholesale price remain roughly the same for deregulated and control utilities through 2005. Starting in 2006, wholesale prices increase for the deregulated utilities. We observe similar patterns for retail prices, though prices for deregulated states do not separate from the control states until a few years later, around 2009. We find no strong evidence of pre-trends in wholesale prices or retail prices leading up to deregulation.[2]

The event study results thus far described indicate delayed impacts of market restructuring and suggest a positive effect of deregulation on prices. However, we wish to control for the fact that these deregulation measures occur at the same time, as well as for other factors (such as

[2]The estimated confidence intervals are relatively large in the event study plots because they are calculated for each (yearly) coefficient.

Figure 7: Event Study: Upstream and Downstream Prices



(a) Upstream

(b) Downstream

Notes: Source: FERC Form 1.

fuel costs). We construct estimates of the impact of deregulation on prices with variations of the following regression model:

$$price_{it} = \beta^U E^U_{it} + \beta^D E^D_{it} + \gamma X_{it} + \xi_i + \phi_t + \varepsilon_{it} \tag{2}$$

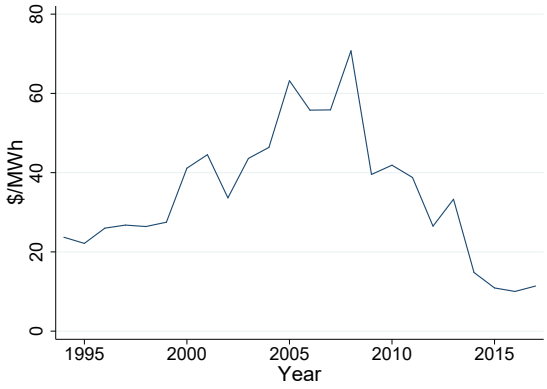
As before, i indexes utilities and t indexes years, and we control for utility fixed effects (ξ_i) and yearly fixed effects (ϕ_t). E^U and E^D measure effective deregulation (the share of supply comping from independent power companies) upstream and downstream, respectively. Thus, our coefficients of interest β^U and β^D capture the net effect of effective deregulation on prices.

We use time-varying controls, X_{it}, to account for differential changes in fuel costs across states. Borenstein and Bushnell (2015) hypothesize that one reason for increased retail prices in restructured states is that they have a higher share of natural gas generation and were therefore more exposed to natural gas prices.[3] To account for this possibility, we include state-level average variable costs of generation[4] as a control in our model. However, an examination of the time series of natural gas prices and fuel costs shows that fuel costs are unlikely to explain the divergence in prices occurring in 2007 and beyond. Panel (a) of Figure 8 plots the time series of the average variable costs for natural gas plants over our sample. Natural gas prices to rise to a peak in 2008, but decline rapidly after that and fall below the 1998 price.

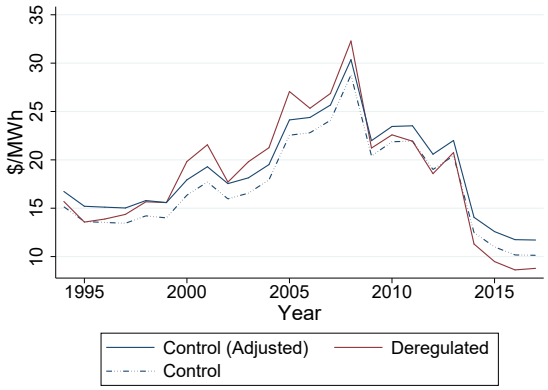
[3]Borenstein and Bushnell (2015) also find different baseline empirical patterns, estimating that retail prices in restructured states did not increase from 2007–2012. We have not yet entirely understood the discrepancy, though we suspect it may be because we only include prices for investor-owned utilities. Our estimates of retail prices are similar for not restructured states and restructured states in 2012, but our estimates of average retail prices are meaningfully lower in 1997 and 2007.

[4]Essentially, fuel costs.

Figure 8: Variable Costs of Generation



(a) Natural Gas Plants



Notes: Source: EIA.

Indeed, the greater exposure to natural gas prices results in a decline in average fuel costs for the deregulated states in our sample, relative to the control states, in 2009 and beyond. Panel (b) plots the average fuel costs for deregulated and control states. Thus, the price increases we observe in restructured states toward the end of our sample move in the opposite direction to the movement in fuel costs.

Table 2 presents our main regression results for the effect of deregulation on upstream prices. We find that downstream deregulation is strongly correlated with higher wholesale prices. The coefficient on our effectively deregulation measures are the linear projection of the impact were a state to go from no effective deregulation ($= 0$) to full deregulation ($= 1$). Thus, in our preferred specification, model (4), the coefficient may be interpreted as: the average IOU territory, which realized an effective downstream deregulation share of 0.45, realized an increase in wholesale prices of $0.45 \times 31.573 = 14.2$ ($/MWh).[5] This is a large number, but it in line with the effects observed in Illinois (see Figure 3). We discuss the economic mechanisms that could account for this increase in the following section. Our estimates are robust to controlling for fuel costs, which have estimated magnitudes that seem reasonable and in line with economic theory (between 0.76 and 0.96).

Though upstream deregulation is correlated with higher prices in the time series, this correlation disappears (and becomes slightly negative) after controlling for downstream deregulation. The slightly negative coefficient is consistent with previous findings that upstream deregulation results in small efficiency gains (Fabrizio et al., 2007; Davis and Wolfram, 2012).

Table 3 presents our main regression results for the effect of deregulation on downstream prices. The estimated coefficients are similar to the estimated coefficients for upstream prices.

[5] On a baseline of 38.7 $/MWh.

Table 2: Dependent Variable: Upstream Prices ($/MWh)

	(1)	(2)	(3)	(4)	(5)
Upstream Deregulation	9.023***		−0.138	−1.108	−1.243
	(3.388)		(3.767)	(3.654)	(3.702)
Downstream Deregulation		24.923***	31.449***	31.573***	31.589***
		(7.315)	(10.555)	(10.405)	(10.454)
Fuel Cost				0.861***	
				(0.218)	
Fuel Cost × Treatment					0.954***
					(0.266)
Fuel Cost × Control					0.765***
					(0.238)
Constant	36.766***	27.208***	38.684***	26.197***	26.188***
	(2.004)	(1.852)	(1.957)	(3.727)	(3.726)
Year FEs	X	X	X	X	X
Utility FEs	X	X	X	X	X
Observations	2,145	2,688	2,145	2,145	2,145
R^2	0.45	0.45	0.47	0.48	0.48

Cluster-robust standard errors are calculated at the utility level and displayed in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In particular, the coefficient on downstream deregulation in model (4) of 30.650 is close to the analogous coefficient of 31.573 for upstream prices. One notable difference between the two estimates is that the coefficient on upstream deregulation is more negative. We interpret these results as indicating that the downstream prices do reflect the increased efficiency from deregulation the upstream market. These efficiency gains are not fully realized in the upstream prices, because they reflect only marginal electricity sold on the wholesale market and not the inframarginal gains.

Finally, we note that the differential coefficient on fuel costs in model (5) may be consistent with the presence of market power in the deregulated markets. Pass-through of fuel costs to resale prices appears to be lower for deregulated markets, which is consistent with the presence of market power.

3.4 Contract-Level analysis

In this section, we extend the previous utility-level analysis to contract-level data for the largest investor owned utilities in deregulated states, which are utilities in the states of California,

Table 3: Dependent Variable: Downstream Prices ($/MWh)

	(1)	(2)	(3)	(4)	(5)
Upstream Deregulation	2.250		−4.836	−5.131	−4.675
	(4.036)		(4.218)	(4.035)	(3.891)
Downstream Deregulation		25.041***	30.799***	30.650***	30.593***
		(7.835)	(8.018)	(8.306)	(8.136)
Fuel Cost				1.052***	
				(0.312)	
Fuel Cost × Treatment					0.729***
					(0.218)
Fuel Cost × Control					1.260***
					(0.299)
Constant	70.647***	72.512***	72.395***	56.549***	57.380***
	(1.908)	(1.320)	(1.980)	(5.298)	(4.324)
Year FEs	X	X	X	X	X
Utility FEs	X	X	X	X	X
Observations	2,457	3,009	2,457	2,457	2,457
R^2	0.88	0.88	0.89	0.90	0.90

Cluster-robust standard errors are calculated at the utility level and displayed in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Illinois, Maryland, New Jersey, New York, Ohio, Pennsylvania, Texas, and Virginia.[6] This sample includes wholesale level transactions reported to FERC in the Electric Quarterly Reports (EQRs) by the seller. Each observation includes the buyer, the seller, whether they are affiliated, the quantity, the price, and the terms of the contract under which each transaction took place. Though there are typically multiple transactions for each contract, we aggregate all transactions under a given contract in a year and compute the sum of the quantity traded and the average price weighted by quantity.

This sample only includes part of the transactions in spot market organized by ISOs. ISOs are not required to report sales of electricity that take place in the markets organized by them, so we do not observe these transactions. We do observe transactions in which a company sells energy in the market organized by the ISO, since individual sellers are required to report. For the purpose of this analysis, this implies that we do not observe purchases from ISO markets by utilities in the EQR data, though from the Form 1 data we know how much the utility buys in these markets each year.

We start by estimating the impact of deregulation on contract prices using variations of the model in equation 2:

[6]We are working on a larger sample that includes investor owned utilities in all states.

Table 4: Dependent Variable: Wholesale Contract Prices (log($/MWh))

	(1)	(2)	(3)	(4)	(5)	(6)
Downstream deregulation	0.382**	0.379**	0.330**	0.332**	0.288*	0.360**
	(0.160)	(0.156)	(0.146)	(0.144)	(0.150)	(0.170)
Upstream deregulation	−0.232**	−0.233**	−0.197*	−0.189*	−0.134	−0.178*
	(0.104)	(0.102)	(0.102)	(0.099)	(0.099)	(0.103)
Share ISO		−0.178	−0.163	−0.161	−0.260	−0.301*
		(0.195)	(0.194)	(0.196)	(0.196)	(0.181)
log(quantity)			−0.021**	−0.025***	−0.028***	−0.034***
			(0.009)	(0.009)	(0.007)	(0.006)
LT				0.064*	0.052	0.025
				(0.037)	(0.041)	(0.039)
Constant	3.380***	3.422***	3.644***	3.649***	3.115***	3.156***
	(0.077)	(0.104)	(0.130)	(0.130)	(0.130)	(0.206)
Utility FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
BA FE	N	N	N	N	Y	Y
Contract chars	N	N	N	N	N	Y
Observations	25,331	25,303	25,179	25,152	24,846	22,636
R^2	0.239	0.240	0.250	0.252	0.306	0.348
Adjusted R^2	0.237	0.238	0.248	0.250	0.300	0.341
Note:						*p<0.1; **p<0.05; ***p<0.01

$$price_{it} = \beta^U E^U_{it} + \beta^D E^D_{it} + \gamma X_{it} + \xi_i + \phi_t + \varepsilon_{it} \tag{3}$$

As before, i indexes utilities and t indexes years, and we control for utility fixed effects (ξ_i) and yearly fixed effects (ϕ_t). E^U and E^D measure effective deregulation (the share of supply coming from independent companies) upstream and downstream, respectively. Thus, our coefficients of interest β^U and β^D capture the net effect of effective deregulation on prices.

We control for different sets of contract characteristics to account for differences in contract terms. These include transmission priority, the traded quantity in MWh, the number of consecutive hours to which the terms of the contract apply (e.g. weekly if the price does not vary in a week, hourly if it varies hourly), and whether the rate is subject to regulation (cost-based) or determined independently by the parties (market-based). Additionally, we control for the balancing authority containing the point of delivery, which indicates the area where the electricity is agreed to be delivered. Because transmission lines have limited capacity, transporting electricity is potentially expensive and this could be an important determinant of prices. Lastly, because the contract data does not include utilities' purchases from ISOs, we include the share of purchases from an ISO as a control, which we obtain from the FERC Form 1 data.

Table 4 presents our results for the effect of effective deregulation on contract prices. The

dependent variable is the log of the average price paid in all transactions under a given contract, weighted by quantity. The coefficients represent the percentage change in price that is associated with a utility moving from no effective deregulation to full effective deregulation. In 2016, the average utility in this sample had effective upstream and downstream deregulation shares of 0.71 and 0.47, respectively. Thus, we can interpret the coefficients in our preferred specification, (6), as follows: for the average utility, downstream deregulation was correlated with a 17% increase in prices, and upstream deregulation was correlated with a 13% decrease in prices.

The positive correlation between wholesale prices and downstream deregulation is consistent with what we found in the utility-level analysis of Section 3.3. The magnitude of the effect is smaller in the contract sample, potentially because we are only including a subset of utilities that does not include those in regulated states. Additionally, the contract data does not include MISO purchases. Though the utility-level does not show a significant correlation between upstream deregulation and wholesale prices, as we find with the contract data, we do find it between upstream deregulation and retail prices. Overall, our results point out to a tradeoff between efficiency gains and upward pressure on prices.

Our results are consistent with the idea that introducing competition upstream results efficiency gains that lead to lower prices, while downstream competition pushes wholesale prices upwards since it eliminates the utility's monopsony power and may introduce double marginalization. These mechanisms are discussed in more detail in the next section.

We also estimate the following model to investigate the effect of effective deregulation on the share of long-term contracts in utilities' purchases.

$$shareLT_{it} = \beta^U E^U_{it} + \beta^D E^D_{it} + \gamma X_{it} + \xi_i + \phi_t + \varepsilon_{it} \tag{4}$$

We estimate this model using two alternative definitions of deregulation. One is the share of purchases from independent companies, as before, and the other is a dummy indicating that this share is higher than 40%. The unit of observation is now a utility during a given year, so we do not control for contract characteristics. We do control for the share of purchases from an ISO, since these transactions are not part of this dataset because they are not reported in the FERC EQRs.

Results are presented in Table 5. They indicate that the share of long-term contracts is correlated with a higher degree of upstream deregulation, while downstream deregulation has no significant effect. In terms of magnitudes, these coefficients indicate that the average utility increased its share of purchases from long-term contracts by 5.5 percentage points.

Table 5: Dependent Variable: Long-term contracts share

	(1)	(2)	(3)	(4)
Upstream deregulation 40	0.103**		0.110**	
	(0.051)		(0.054)	
Downstream deregulation 40		0.016	−0.021	
		(0.055)	(0.060)	
Upstream deregulation				0.228**
				(0.105)
Downstream deregulation				−0.153
				(0.171)
Share ISO	−0.098	−0.122	−0.093	−0.093
	(0.109)	(0.117)	(0.107)	(0.104)
Constant	0.369***	0.424***	0.370***	0.350***
	(0.079)	(0.081)	(0.080)	(0.091)
Utility FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	520	520	520	520
R^2	0.296	0.289	0.297	0.301
Adjusted R^2	0.205	0.196	0.203	0.208
Note:				*p<0.1; **p<0.05; ***p<0.01

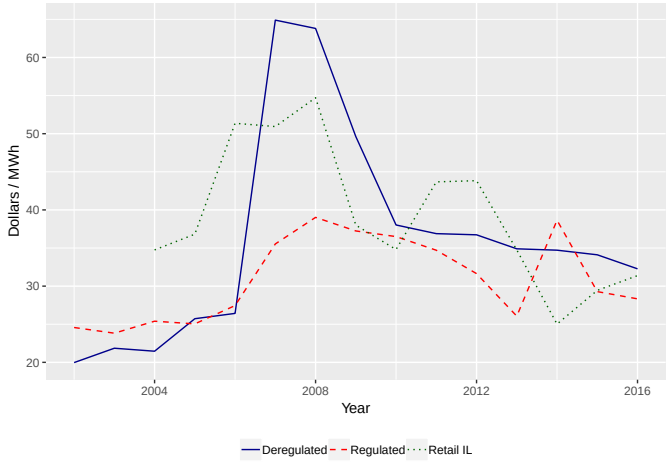
4 Discussion

Why did wholesale prices increase after deregulation? We consider several potential explanations for the increase in prices. The first and most intuitive explanation is the loss of monopsony power by the incumbent. When retail competition becomes stronger, generators may sell their output to several firms, putting them in a stronger position to get a higher price than when there is a unique buyer. This story explains why downstream deregulation is correlated with higher prices in both the upstream and downstream markets. Moreover, our results suggest that though there are efficiency gains from competition, the effect of loss of monopsony power is stronger and results in higher prices.

Effectively, the regulated monopolist faced a purchase price that corresponded to the average cost of generation. In the transition to the deregulated market, the loss of monopsony power eliminates the ability to purchase at average cost, as the generation firms can decide (at the margin) to sell to the competitive market. Further, the deregulated generation firms are free to earn a markup above this marginal costs. Likewise, the downstream competitive firms also earn a markup on their retail sales. Thus, the transition to a deregulated market brought about double marginalization, *in addition to* the move from average-cost pricing to marginal-cost pricing. As marginal costs tend to be upward-sloping for electricity, these features plausibly explain the large increase in prices we observe.

Cream skimming could also explain why prices increase after effective deregulation, since

Figure 9: Quantity weighted average purchase price



Notes: Regulated firms include all IOUs in Missouri and regulated utilities in Illinois. Only Illinois has deregulated utilities and retailers. Source: FERC EQR

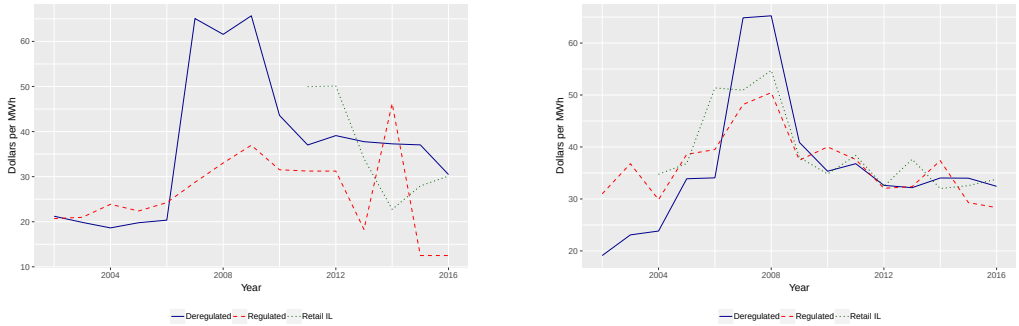
the sample we use only includes the price paid by regulated utilities. If alternative retail suppliers attract the customers that are the cheapest to serve, the most expensive customers are left to the utility, therefore increasing its procurement costs. We explore this possibility using data on power sales from FERC Electric Quarterly Reports (EQR), which includes both incumbent utilities and competitive retailers as buyers. Figure 9 presents the evolution of prices paid by firms using this sample. The solid blue line shows prices paid by deregulated utilities, the dashed red line those paid by regulated utilities, and the dotted green line shows prices paid by retailers. We see from the figure that incumbents did not pay consistently more than competitive retailers, implying that cream skimming does not seem to be a plausible explanation for higher prices after deregulation. Though this sample does not include purchases from the spot markets organized by ISOs, the patterns are similar to those pictured by Figure 3, which suggests that the price differences are not driven by spot purchases.

4.1 Examining transactions for the case of Illinois

In this section, we go back to the case of Illinois using detailed transaction data from FERC Electric Quarterly Reports (EQR) to analyze the transactions that lead to price increases in more detail. EQRs are reports that all sellers of electricity at the wholesale level are required to submit, in which they describe the contractual terms of each transaction: purchasing firm, contract length, price, quantity, hours, location, and other characteristics of the agreement. This allows us to understand better what was behind the increase in prices that followed effective deregulation.

A first thing to notice is that higher prices came from purchases from affiliated sources. Figure 10 shows the evolution of the quantity weighted average price, but now splitting the

Figure 10: Purchase prices by affiliation



(a) Affiliated (b) Unaffiliated

Notes: Source: FERC EQR

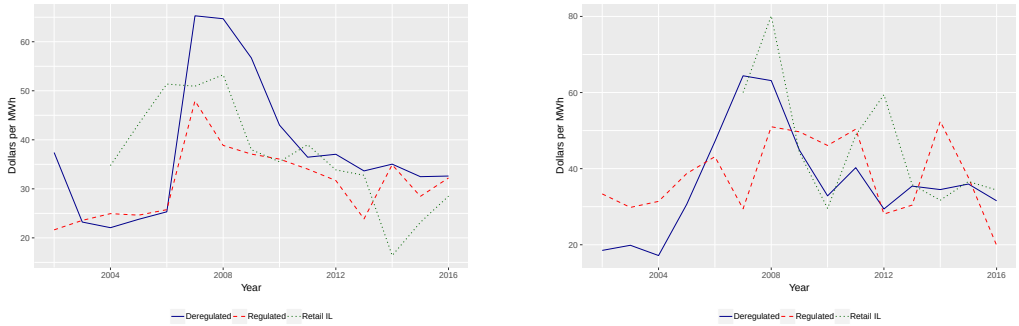
sample between affiliated and unaffiliated purchases. The solid blue line shows prices paid by deregulated utilities, the dashed red line those paid by regulated utilities, and the dotted green line shows prices paid by retailers. Prices paid by deregulated utilities to affiliated sellers, presented in Panel (a), started similar to prices paid by regulated utilities, spiked in 2007 and then went down, but stayed higher than for regulated utilities until the end of the sample. Panel (b) shows prices paid in unaffiliated transactions, which stayed at similar levels for regulated and deregulated utilities with the exception of a spike in 2007 for deregulated firms, which is likely due to a poorly designed auction as explained above.

Second, higher prices are correlated to long-term contracts. Figure 11 also shows quantity weighted average price paid by utilities, but the sample is now split between long-term and short-term contracts, where short-term is defined as a year or less. This figure indicates that the higher prices paid after effective deregulation in 2007 came from long-term contracts, which increased in 2007 and remained higher than prices paid by regulated companies. By contrast, prices paid under short-term contracts stayed at similar levels during the whole period, with the exception of the spike of 2007.

In fact, we find that utilities in Illinois signed high price long-term contracts with affiliated generators in 2007, when many contracts expired and retail competition was introduced for all types of consumers. Utilities may have signed this contracts in an attempt to continue to delay effective deregulation, as they had done it until the moment.

Alternatively, these contracts could have been an attempt to exert market power under the assumption that downstream competition would continue to be weak. Without competition at the retail level, utilities have incentives to buy from generators affiliated to the same parent company at higher prices, increasing generation profits without losing sales since demand for electricity is very inelastic and will not respond much to a higher price. Retail competition is expected to discipline incumbents and prevent them from exerting market power in this way by making demand more elastic, with consumers switching to a cheaper provider when the

Figure 11: Purchase price by contract length



(a) Long term contracts

(b) Short-term contracts

Notes: Source: FERC EQR

incumbent raises its prices. Toward the end of our sample period, wholesale prices did decline and moved closer to the prices in regulated Missouri. It is unclear whether this decline reflected an increase in upstream competition, and increase in downstream competition, or the steady state arising after a temporary transition period for restructuring.

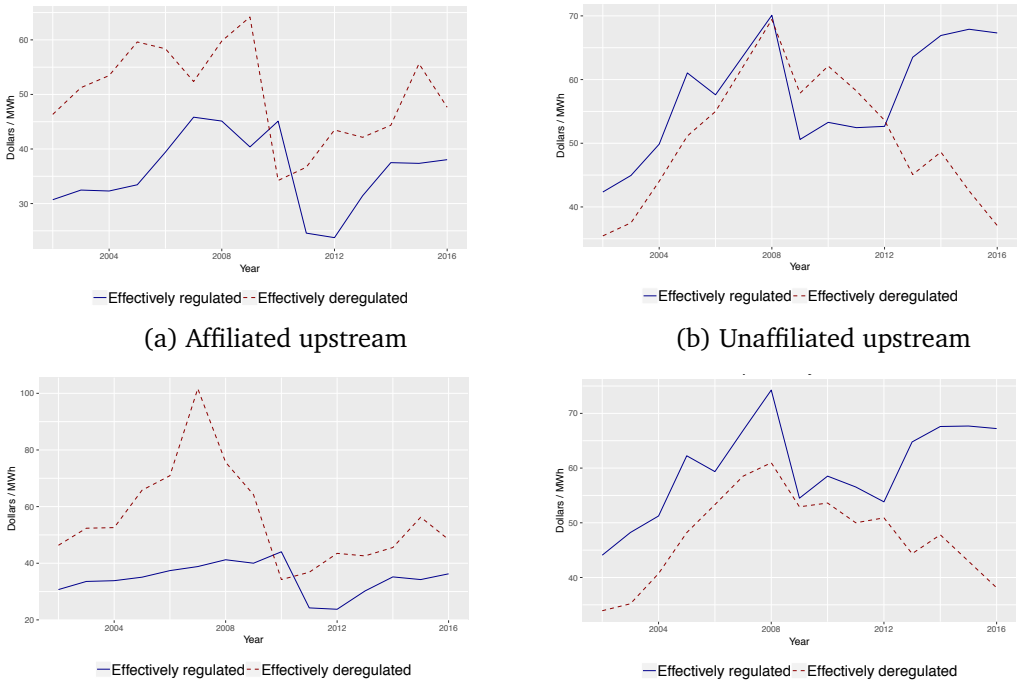
4.2 Examining transactions for deregulated utilities

In this section, we conduct a similar analysis to that of Illinois, but including all the largest investor-owned utilities in a subset of the deregulated states, namely California, Illinois, Maryland, New Jersey, New York, Ohio, Pennsylvania, Texas, and Virginia. Since this sample includes only utilities in deregulated states, we construct a measure of deregulation to have a control group. We define the treatment group as the set of utilities with a share of purchases from independent firms that is higher than 40%. Though this is an arbitrary threshold, results are fairly similar when we use 30% and 50%.

Figure 12 shows the evolution of quantity weighted average contract price, splitting the sample between effectively regulated and effectively deregulated companies, as well as between affiliated and unaffiliated transactions. The solid blue line shows prices paid by effectively regulated utilities, and the dashed red line the price paid by effectively deregulated companies. Panels (a) and (c), on the left, include only transactions with affiliated sellers, while panels (b) and (d), on the right, include transactions with unaffiliated sellers. The top panels split the sample according to effective upstream deregulation, and the bottom panels split it according to effective downstream deregulation. Both sets show that companies in effectively deregulated markets paid higher prices to affiliated sellers than those in effectively regulated markets, while prices are similar for unaffiliated transactions.

Figure 13 shows the evolution of quantity weighted average contract price, splitting the sample between effectively regulated and effectively deregulated companies, as well as be-

Figure 12: Purchase prices by affiliation



(a) Affiliated upstream

(b) Unaffiliated upstream

(c) Affiliated downstream

(d) Unaffiliated downstream

Notes: Source: FERC EQR

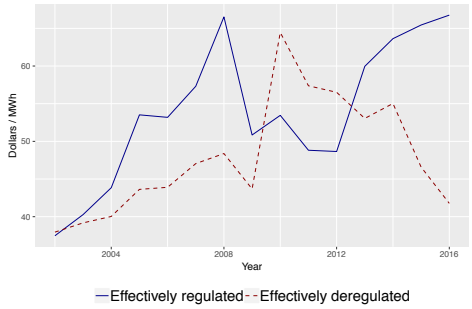
tween long-term (more than a year) and short-term contracts. As before, the solid blue line shows prices paid by effectively regulated utilities, and the dashed red line the price paid by effectively deregulated companies. Panels (a) and (c), on the left, include only long-term contracts, while panels (b) and (d) on the right include only short-term contracts. The top panels split the sample according to effective upstream deregulation, while the bottom panels splits it by effective downstream deregulation. Consistent with the findings in Table 4, the graphs do not suggest significant price differences between long-term and short-term contracts.

Our analysis in this section suggests that the higher prices paid by effectively deregulated utilities in the wholesale market come from contracts with affiliated sellers, just like in the case of Illinois. Further exploration of the differences in the deregulation process and market structure across states may be necessary in order to understand the mechanism that resulted in these higher prices.

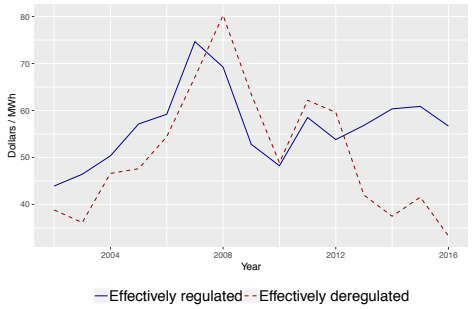
5 Conclusion

We show that accounting for intermediate degrees of vertical integration—brought about by contracts and common ownership—is essential to analyze changes to market structure and the effect of market structure on prices. In the U.S. electricity sector, deregulation was effec-

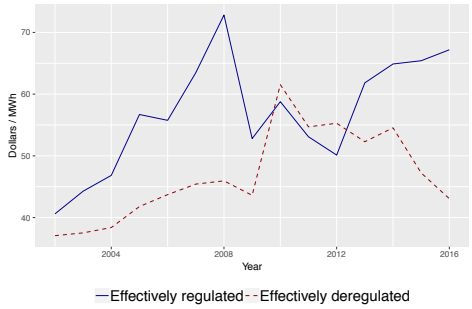
Figure 13: Purchase price by contract length



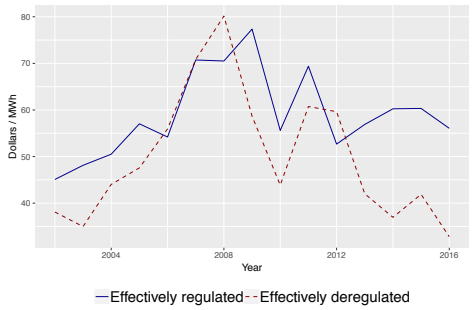
(a) Long term contracts upstream



(b) Short-term contracts upstream



(c) Long term contracts downstream



(d) Short-term contracts downstream

Notes: Source: FERC EQR

tively delayed for years by vertical arrangements that kept market structure similar to what it was before deregulation. When incumbents finally started to lose market share upstream and downstream, wholesale and retail prices increased. We argue that this was most likely due to reasons connected to market power. First, utilities lost monopsony power when they had to compete with others for the energy sold by generators. Second, double marginalization, combined with the loss of monopsony power, seems to have outweighed any generation efficiencies occurring upstream. Third, at least in the case of Illinois, it seems that firms attempted to use contracts with affiliated firms to exert market power and charge higher prices.

References

Borenstein, S. and J. Bushnell (2015). The US electricity industry after 20 years of restructuring. *Annual Review of Economics 7*(1), 437–463.

Bushnell, J., E. Mansur, and K. Novan (2017). Review of the economics literature on US electricity restructuring.

Bushnell, J. B., E. T. Mansur, and C. Saravia (2008). Vertical arrangements, market structure, and competition: An analysis of restructured US electricity markets. *American Economic Review 98*(1), 237–66.

Cicala, S. (2017). Imperfect markets versus imperfect regulation in u.s. electricity generation. Working Paper 23053, National Bureau of Economic Research.

Davis, L. W. and C. Wolfram (2012). Deregulation, consolidation, and efficiency: Evidence from US nuclear power. *American Economic Journal: Applied Economics 4*(4), 194–225.

Deryugina, T., A. MacKay, and J. Reif (2019). The Long-Run Dynamics of Electricity Demand: Evidence from Municipal Aggregation. *American Economic Journal: Applied Economics*. Forthcoming.

Fabrizio, K. R., N. L. Rose, and C. D. Wolfram (2007). Do markets reduce costs? assessing the impact of regulatory restructuring on US electric generation efficiency. *American Economic Review 97*(4), 1250–1277.

Hortaçsu, A., S. A. Madanizadeh, and S. L. Puller (2017). Power to choose? an analysis of consumer inertia in the residential electricity market. *American Economic Journal: Economic Policy 9*(4), 192–226.

Mansur, E. T. (2007). Upstream competition and vertical integration in electricity markets. *The Journal of Law and Economics 50*(1), 125–156.