# An Estimation of the Price Impact of Electricity Retail Competition

By Alex Hill*

*Since high electricity prices contributed to the adoption of retail competition in the U.S., its effectiveness in lowering electricity prices has been an open question in the literature. Utilizing synthetic control to construct the counterfactual, I find retail competition reduced prices across all sectors by an average of $4/MWh. On average, prices fell for residential and commercial users and rose for industrial users. The price differential is consistent with changes in the price of natural gas. After testing for alternative hypotheses, retail competition is found to have increased electricity price sensitivity to gas prices. (JEL L51, L94, Q41, Q48)*

Electricity market restructuring transformed an industry that had previously been dominated by vertically-integrated utilities. One of the most significant changes was creating competition among retail suppliers by breaking apart these utilities. It was expected that increased competition would raise efficiency in both the generation and sale of electricity, which would then be passed through to consumers in the form of lower prices (Joskow 1997). Surprisingly, the restructuring literature has had difficulty finding an effect of restructuring on electricity prices. Attributing this result to a common support failure and improper estimation methods, this paper uses synthetic control to estimate the impact of restructuring on electricity prices.

The welfare effects of electricity market restructuring are a broad and important subject of study that have attracted attention in the economics literature

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over the last two decades. A large number of papers have addressed various parts of the welfare calculation, covering areas such as market power (Borenstein et al 2002; Mansur 2008), investment (Ishii and Yan 2007; Hill 2019), and plant efficiency (Fabrizio et al 2007; Davis and Wolfram 2012; Cicala 2015). However, the overarching question centers on whether or not retail competition brought electricity prices down compared to their counterfactual outcome. Numerous papers have attempted to answer this question, with most finding insignificant effects. Apt (2005) and Fagan (2006) find insignificant effects for industrial consumers, Su (2015) finds insignificant effects except for residential customers in the short run, and Borenstein and Bushnell (2015) find no significant effect after controlling for gas prices.[1] This paper contributes to this literature by finding a significant effect of restructuring on electricity prices. Furthermore, the hoped for change in sensitivity of electricity prices to gas prices is confirmed.

In each of these empirical studies, the primary challenge is constructing the counterfactual electricity price for restructured markets. In particular, the question to be answered is whether the price gap that existed between restructured and no-restructured states prior to restructuring was reduced. Previous studies rely largely on the states that didn't restructure as a counterfactual, using OLS as an empirical strategy that controls for any factors which might bias their result. The approach taken by these papers faces two problems. First, OLS poorly estimates the counterfactual price trend for restructured states due to a common support failure, as states have very different supply and demand factors.[2] In particular, the OLS approach relies heavily on the Northeast in the sample, largely because almost half of the restructured states are located in this region. While their inclusion does increase the power of the test, it also requires the construction of their

[1] For a further review of the literature, see Bushnell et al (2017)
[2] It would be inappropriate, for example, to use a large coal state as a counterfactual for a small gas state.

counterfactual. Unfortunately, there is no counterfactual for the Northeast. Due to its heavy reliance on oil in this period, unique climate, and regional environmental initiatives, there is no counterfactual region match for the Northeast.[3] Second, the impact of restructuring on electricity prices is likely to interact with the price of natural gas, so any empirical model should have this effect included. These problems lead to spurious results, which can be seen in the lack of significance in many of these papers' results.

These problems are addressed in three ways. First, synthetic control is used as an estimation method, in place of OLS, to construct the counterfactual. The advantage of this technique is in the creation, through weighted, unique factors, of counterfactual restructured states that match the pre-treatment price trend and identify the exogenous effect of restructuring on electricity prices. Second, the Northeast states and DC are eliminated from the analysis. While this limits the sample, it is necessary in order to obtain a valid counterfactual. Third, the relationship with the price of natural gas is explored, as competitive retail markets are likely to be more sensitive to changes in the price of natural gas.

The impact of retail competition on electricity prices is estimated by sector using the staggered adoption of restructuring as an identification strategy. Prices are found to have been reduced overall from restructuring by \$4.06/megawatt hour (MWh), with residential (\$7.04/MWh) and commercial users (\$3.98/MWh) experiencing the largest price drops and industrial users (\$2.76/MWh) facing higher prices. For the average residential customer, this meant an average saving of approximately \$77 per year. These gains are attributed entirely to price cuts and freezes, as removing those observations from the study shows that prices were actually higher for states that adopted retail competition. The price differential between retail competition states and their counterfactual follows the path of natural

[3] Vermont is the only Northeast state to not restructure and its capacity mix and pre-trend price do not match the other states.

gas prices, which peaked in 2008 and subsequently fell by more than 50 percent. Their effect on the electricity price differential is attributed to a higher pass-through rate of natural gas prices in retail competition states.

These results highlight several important facets of the impact of restructuring on electricity prices. First, the residential price effect identified in Joskow (2006) and Su (2015) is entirely the result of states fixing prices following the introduction of restructuring. The lifting of these price caps led to several years of above average price increases, showing prices had been held below market. Second, the impact of restructuring on price is heterogeneous, with industrial users having lost some of their cost advantage. Third, there is substantial evidence that electricity prices in retail competition states are much more closely linked to wholesale markets, which was a goal of restructuring (Bushnell et al 2017). Finally, this analysis highlights the importance of common support, as variable controls in an OLS regression are only a substitute for an RCT in rare cases.

Section 1 presents the empirical methodology for this paper. Section 2 introduces the data and provides background statistics on the states and the empirical approach. Section 3 displays the main results of this paper. Section 4 tests several hypotheses for the link between natural gas prices and the electricity price differential. Section 5 concludes.

## 1. Methodology

A primary goal of restructuring was to reduce electricity prices, which had risen due to slower than expected demand growth in the 1980s and nuclear cost overruns (EIA Annual Energy Outlook (AEO) 1995). Previous attempts to create generation competition (Public Utility Regulatory Policies Act of 1978, Energy Policy Act of 1992, FERC Orders 888 and 889) and change cost saving incentives by utilities (incentive regulation in the 1980s) had failed to bring prices down. Therefore, beginning in the mid-1990s, states began to break apart vertically integrated utilities to spur innovation at both the generation and retail levels. Generation competition was encouraged by transferring control of transmission networks to independent system operators (ISOs), which would allow for more entry of IPPs, and through asset divestiture by utilities, which would spread ownership of power plants across a wider number of firms. It was hoped this would incentivize innovation in both daily operation, with firms reducing expenditures on labor, maintenance, and fuel, and in investment, with firms selecting more cost-effective plant options. Competition at the retail level would allow consumers to seek out alternative sellers of electricity, increasing incentives in delivery innovation (real time pricing, choice of carbon content of delivered electricity, reduction in customer connection costs) and eliminating utility monopsony power.[4]

While it was hoped that these market changes would reduce electricity prices, the impact was unclear, as there are several effects operating in different directions. For example, eliminating price regulation did allow firms with market power to use it to influence wholesale prices, which were passed to consumers through higher retail prices (Mansur 2008). However, increased pressure on power plants to compete in well-functioning wholesale markets reduced the cost of providing electricity, which lowers retail prices (Fabrizio et al 2007). With the overall effect unclear from these differing factors, this paper quantifies the total effect through the use of synthetic control to precisely estimate the counterfactual outcome for restructured states.

### 1.1 Estimation

Comparisons in the restructuring literature are typically between states with restructured electricity markets and those which kept price regulation. The

[4] Note that there were also reasons to expect an increase in the cost of providing service, as delivery of electricity is a natural monopoly and the introduction of competition also introduces marketing costs.

assumption is, after controlling for enough supply and demand factors, the analysis will approach the gold standard of econometric analyses: a natural experiment. In the context of retail competition and electricity prices, this would involve taking two states that are identical in every way, give one the treatment (restructuring), and estimate the effect on average electricity prices. There are a number of econometric methods that attempt to mimic this process, with panel OLS the most popular in this area of the literature. However, papers using this methodology, such as Su (2015), have had difficulty identifying an effect of retail competition on electricity prices, leading them to suggest the effect is inconclusive. Their primary problem, which this paper addresses, lies in the lack of a counterfactual outcome.

One popular method for estimating the effect of policy changes is synthetic control (Abadie and Gardeazabal 2003; Abadie et al 2010; Acemoglu et al (2016)). While this method retains certain technical advantages over OLS through its selection process, the most important reason for its use is, like matching techniques, it forces the researcher to confront problems of common support. To see how critical this problem is in electricity market comparisons between states, consider how synthetic control estimates electricity prices.

States are divided into those which received the treatment (restructured) and those that didn't (donor).[5] The method creates, using a weighted mixture of donor states and important electricity price-determining factors, the counterfactual for each restructured state. The price differential between the restructured states and their newly created counterfactual outcome, $\alpha$, is then estimated using the notation in equation 1:

[5] For internal consistency, multiple states were excluded due to partial restructuring (Virginia, Arizona, California), remoteness (Alaska, Hawaii) and uniqueness (Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, DC). This is covered in more detail later in this section.

$$\Delta p_{st}^{E} = \Delta p_{st}^{Esynth} + \alpha_{st} Z_{st} \quad (1)$$

where $\Delta p^{E}$ is the change in the price of electricity in a restructured state, compared to 1990, $\Delta p^{Esynth}$ is the change in the price of electricity in the restructured state if they hadn't restructured, compared to 1990, and Z is the treatment (restructuring). Prices were differenced from their 1990 level in order to match treatment states with their synthetic counterfactual. High electricity prices were a major cause of restructuring, which makes it difficult to find a match among states that didn't restructure. Differencing from the initial year not only solves this problem but also reduces endogeneity concerns from the correlation between high electricity prices and restructuring.[6]

Following Abadie et al 2010, synthetic control creates the counterfactual state through a weighted combination of the donor states. For example, picture a market with four states (A,B,C,D) and state A receives the treatment. It may be the case that none of the three states B, C, or D fit state A by themselves, but by taking parts of each, a counterfactual state for A can be created. The selection of weights for each of these states, therefore, is critical to the success of synthetic control. It selects weights to most closely match the important electricity price-determining factors between the donor states and the treatment state. In this particular estimation, an example would be ensuring natural gas prices were similar in the treatment and counterfactual states. The remaining step in this process is to select weights for each of these electricity price-determining factors, which synthetic control does by approximating the pre-period electricity price trends between the treatment state and the newly formed counterfactual state. The sign of a good synthetic control match, therefore, is one that approximates both the pre-treatment price trend and electricity price-determining factor values in the restructured state.

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[6] Endogeneity concerns, typically the highest hurdle in empirical papers, are eliminated by creating a synthetic state that is similar in every way except market regulation.

Once the weights and their importance has been assigned, the counterfactual state is created and $\alpha$ can be measured.

### 1.2 Factor Selection

The previous section highlights the primary input in a successful synthetic control estimation, which is the selection of important factors. In the case of estimating electricity prices, these would be the factors which have the greatest influence on state-level, annual electricity prices. Since the estimation strategy of this paper differences the observations from their 1990 level, the focus is on factors influencing electricity prices during the observation period of 1990-2016. Upon review of both the academic and industrial literatures, and consulting with the AEO publications of the EIA, the most important factors were found to be the state generation mix, variance of electricity demand, and fuel prices. [7] Given the difficulty in obtaining reliable state-level estimates of demand variance for the sample period in this paper, cooling degree days (CDD) are used to substitute for demand variance. Weather is the largest factor in determining demand variance in states and CDDs provide a reasonable proxy measure for the impact of weather on electricity demand.

**Table 1. State Factor Differences**

| Years | GasCOV | CoalCOV | NucCOV | OilCOV | CDDCOV |
|---|---|---|---|---|---|
| 1990-1999 | 166% | 65% | 107% | 259% | 73% |
| 2000-2008 | 122% | 65% | 108% | 308% | 69% |
| 2009-2015 | 96% | 77% | 109% | 431% | 70% |

Source: EIA (2019) and Author's Calculations

[7] Factors such as construction costs (CC), labor differences (w) and plant age do not vary widely enough between states to significantly impact prices, nor do they contribute greatly to the cost of plants. Therefore, they are left out as determining factors.

Of the electricity price-determinants listed above, fuel prices are eliminated as, while they have a significant impact on electricity prices across the country, any differences between states are eliminated by differencing value from their 1990 levels. This leaves the generation mix and weather as the most influential factors that show differences between states since 1990. Table 1 highlights the variation in these factors. Columns 1-4 present the coefficient of variation (COV) for the four major fuel types, showing substantial differences among states. This is particularly true in gas and oil, making generation mixes and fuel prices significant determinants of electricity prices. Column 5 shows that, while cooling degree day variation among states didn't change substantially over time, the wide spread among states will affect which states pay higher prices for demand variance.

While it appears from this determination of factors that there are only two (generation mix and CDD), the estimation is actually performed using multiple variables for the generation mix (coal %, nuclear %, natural gas %, oil %, and hydro %). Not all of these factors are used when creating a synthetic control for each state, as some are more impactful for some states than others.[8] The reason for matching on a select few factors is the size of the dataset, which does not have enough observations to match all potential values of the factors. The larger the number of factors, the less precise the match will be with each factor and the pre-treatment price trend line. [9]

This highlights two important estimating advantages of the strategy in this paper. First, synthetic control has more flexibility, in comparison to OLS, allowing

[8] For example, Michigan's reliance on coal drives changes in its electricity price, not its small hydro sector or low number of cooling degree days. Therefore, CDD and hydro percentage were excluded from its synthetic control.

[9] In DID papers, authors often select comparison regions that have similar pre-treatment slopes. By taking the change from the beginning year, this can be seen as a similar strategy. The change from 1990 was chosen, as opposed to annual changes, for the easier graphical interpretation of the price impact. Percentage changes were not chosen, as consumers are concerned with overall price changes (i.e. A 1 unit increase in electricity prices will be smaller in percentage terms in high price states compared to low price states, but impact both consumers the same).

for a closer fit of the counterfactual to the treatment state. Second, the choice to estimate each state individually and average the results, as opposed to averaging the states and then estimating, doesn't impose the same factor choice on all states, leading to improved counterfactual estimation.

## 2. Data and Summary Statistics

The approach of this paper requires comprehensive annual data on a number of electricity market factors for 39 states over the years 1990-2016. Average electricity prices, delivered fuel prices to the electricity sector and electricity retail sales (ERS) by sector are reported by the EIA. State generation statistics by fuel are available from EIA form 923 and capacity and operation statistics from EIA form 860. Cooling degree day data are assembled from the National Oceanic and Atmospheric Administration (NOAA).

Generation mix is separated by fuel, with hydro, gas, and oil percentages of generation as individual variables and coal and nuclear combined into a base load variable.[10] Coal and nuclear are combined due to the advantage of matching on less variables. With both being high use, high capital cost, low variable cost generation sources, it's assumed coal-heavy and nuclear-light states will have a similar effect on prices over time as coal-light and nuclear-heavy states. Oil and gas were not combined, as the trend in prices for the two split in the 2000s (Brown and Yucel 2008). Each of these statistics are not a perfect match for states, as there is cross-state trading. However, in each of these states, the amount is a small percentage of ERS and would only threaten the estimation strategy if there were large changes over time, which are not observed.[11]

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[10] Generation is chosen instead of capacity as it more closely approximates what states use. Low capacity plants may distort differences among states.

[11] For example, Wyoming exports coal-fired power to its neighbors in a similar quantity each year. By differencing electricity prices from 1990, the effect of this cross-state electricity transfer is negated.

The observation level of year-state was chosen due to the availability of data for all the factors necessary for identification. Electricity price data are available on a finer time level (daily or monthly), but fuel price and generation data are only available for all states annually. The state was chosen as the regional observational level, as opposed to the utility level or North American Electric Reliability Council (NERC) level, for two reasons. First, the policy level is the state, making it the natural observation level. Second, the utility level creates a series of problems after restructuring altered the role of utilities and the NERC level lacks sufficient power to provide results.

### 2.1 State Selection

Footnote 5 notes that 11 states and DC were excluded from the analysis.[12] This included six states and DC that fully restructured their markets, three that partially restructured and two that did not. Alaska and Hawaii are the two non-restructure states excluded. Their distance from the continental US and unique weather leave them open to factors that don't fit any of the other states. The partially restructured states were excluded because the nature of this exercise is a long run comparison. In each state, the market lasted for less than five years, and in Arizona and Virginia, very little switching actually occurred prior to the end of restructuring.[13] DC was excluded, as it receives the majority of its electricity from outside the area, making a counterfactual match difficult to find. This leaves six states that fully restructured as being left out of the analysis. These states are typically included in restructuring analyses, as more observations lead to more

[12] Oregon is only included in the industrial and commercial analyses, as residential was not opened to competition.
[13] Arizona and California also suspended restructuring during the period of price freezing, which is at odds with what this paper is testing (the effect of market competition on electricity prices).

robust results. However, as this section shows, the inclusion of these states, all in the Northeastern US, leads to spurious results.

To see the effect the inclusion of these states would have on the results, consider first the ideal state restructuring dataset. It would consist of significant diversity in both restructured and regulated states in terms of geography, weather, generation choice, and other factors, so that treatment assignment would approach random. Following this logic, including the Northeast states in a panel analysis on electricity prices requires that there exist other states that share electricity price traits with the Northeast. In particular, for a difference-in-difference analysis on electricity prices, the trend in prices pre-treatment should be very similar between the Northeast and its control group of states.

**Table 2. Factor Comparison between the Northeast and Rest of U.S.**

| Region | Price1990 | PriceΔ | Capratio | Oil% | Coal% | Nuc% |
|---|---|---|---|---|---|---|
| NE | $9.12 | 2.7% | 1.73 | 18.7% | 18.4% | 27.5% |
| Non-NE | $6.33 | 0.6% | 1.83 | 3.0% | 53.7% | 19.2% |

*Source: EIA (2019) and Author's Calculations*

As Table 2 shows, the Northeast region is unique in comparison to the rest of the states. Not only were prices much higher in the Northeast in 1990 (see Column 1), but they continued to rise at a faster pace than the rest of the US during the 1990s pre-treatment period (Column 2). This makes it difficult for an econometric technique to find a counterfactual whose trend matches the treatment group. Columns 3-6 highlight the problem, which is the supply shortage and oil dependence of the Northeast. This region, partly due to the fallout from nuclear generation cost problems, was chronically short of supply (see Column 3 and EIA AEO 1996). This forces the Northeast to operate old, expensive plants that use various types of petroleum products as fuel (Column 4). The rest of the country experienced less growth in prices, largely due to their use of coal (Column 5) and lower investment in nuclear (Column 6).

Table 3 shows the problem faced in constructing a DID for electricity prices for the Northeast in more detail. There is only one state in the US which didn't restructure and faced a similar sized price increase as the rest of the Northeast from 1990-1997 (Vermont) and Vermont is not a good match on many of the other characteristics. Therefore, there is no valid counterfactual for electricity prices in the Northeastern US after 1990.

**Table 3. Northeast State Factor Comparison**

| State | Coal% | Gas% | Oil% | Nuc% | Res% | CDD |
|---|---|---|---|---|---|---|
| Connecticut | 10.0% | 23.4% | 12.6% | 47.1% | 38.5% | 633 |
| Maine | 2.6% | 26.3% | 10.4% | 7.9% | 32.1% | 239 |
| Massachusetts | 22.3% | 42.6% | 15.7% | 13.0% | 34.5% | 554 |
| New Hampshire | 17.1% | 14.0% | 5.1% | 48.6% | 37.6% | 345 |
| New York | 13.5% | 30.0% | 8.1% | 26.8% | 30.4% | 650 |
| Rhode Island | 0.0% | 96.0% | 1.6% | 0.0% | 37.1% | 626 |
| Vermont | 0.0% | 0.3% | 0.2% | 67.8% | 37.7% | 353 |

Source: EIA (2019)

There are two options available to a researcher at this point: sacrifice external validity or internal validity. Many papers have opted for the latter by including the Northeast, with the hope of answering the question of how restructuring impacted electricity prices across the entire U.S. With the advent of techniques like regression discontinuity, the economics literature has focused more on internal validity and that focus continues here. This paper analyzes the impact of retail competition on electricity prices for non-Northeast restructured states.

## 2.2 Synthetic Control Match

The primary argument for using synthetic control in place of panel OLS as an estimation strategy is its ability produce a better counterfactual. As shown in Table 3, the average restructured state is very different from the average non-restructured state, which limits the ability of OLS to create a valid comparison group. In order for synthetic control to provide a better counterfactual, there must be a group of states which, when weights are applied, can approximate the factors of the restructured states.

**Table 4. Group Factor Comparison**

| Factor | Treated | Synth | Avg. Non |
|---|---|---|---|
| Δprice-7 | $0.33 | $0.27 | $0.12 |
| Δprice-4 | $0.54 | $0.50 | $0.22 |
| Δprice-1 | $0.64 | $0.63 | $0.16 |
| Genbase | 77.9% | 77.7% | 70.3% |
| Gengas | 12.3% | 12.6% | 9.0% |
| Genhydro | 6.8% | 8.2% | 13.2% |
| CDD | 1,007 | 957 | 1131 |

Source: EIA (2019) & Author's Calculations

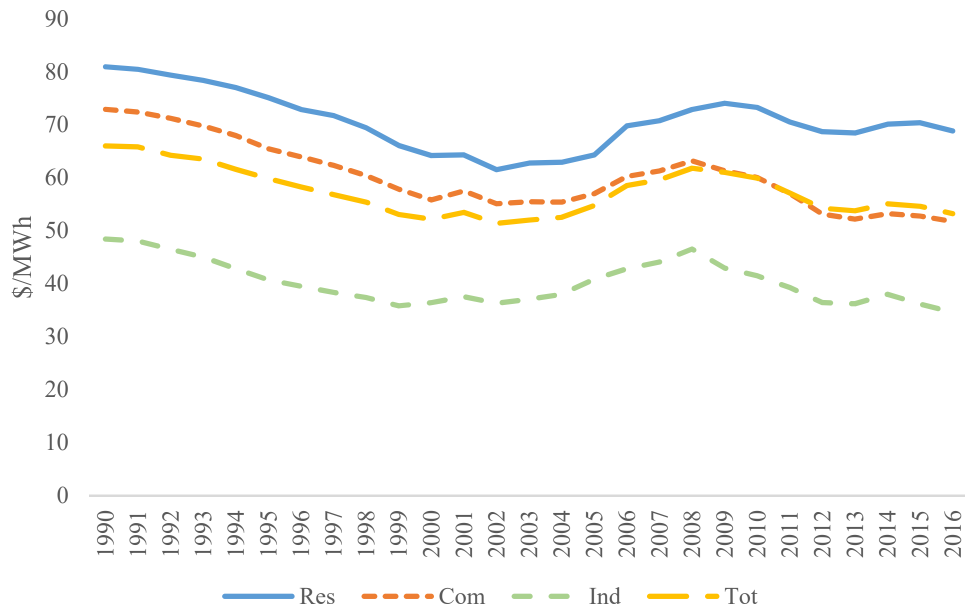
Table 3 shows the average counterfactual state approximates restructured state outcomes in the pre-period better than an average of non-restructured states. The pre-treatment price trend in the first three rows is very similar for the average treated and synthetic states, while the average non-restructured price change was far lower. This suggests there are different factors in these states which are impacting electricity prices. The next three rows show the percentage of generation from each fuel source, showing largely similar generation mixes between the treated and synthetic states. This increase the likelihood that a shock to electricity factors, like the sharp rise in natural gas prices in the mid-2000s, and the subsequent fall after, would affect both states similarly. The reliance of the average non-restructured states on more hydro and less gas will lead to lower price volatility, particularly in the period of rising gas prices. There is not a lot of difference in the final row, as all three groups have similar average weather.[14] The one key difference, therefore, between the restructured states and their synthetic counterfactual is that one received the treatment and one didn't, which is the goal of difference in difference analysis.

### 2.3 Group Electricity Prices

Figure 1 shows the price path of sector-specific electricity prices for the 9 states in this sample. Throughout the 1990s and early 2000s, real electricity prices fell across all sectors in these states. This trend reversed in the mid-2000s before prices stabilized post 2010. The primary culprit of these price changes is the path of natural gas prices, which fell, in real terms, at the beginning and end of this period, and rose sharply in the mid-2000s. The pattern of residential prices being the highest and industrial prices the lowest continued throughout the period. The price impact of natural gas is important in explaining the results of Section 3.

[14] The difference in cooling degree days between the treated and synthetic groups is approximately the same as that between New Hampshire and Vermont.

**Figure 1. Electricity Prices by Sector for Select States ($ 2016)[15]**




Source: EIA (2019) and Author's Calculations

## 3. Data Analysis

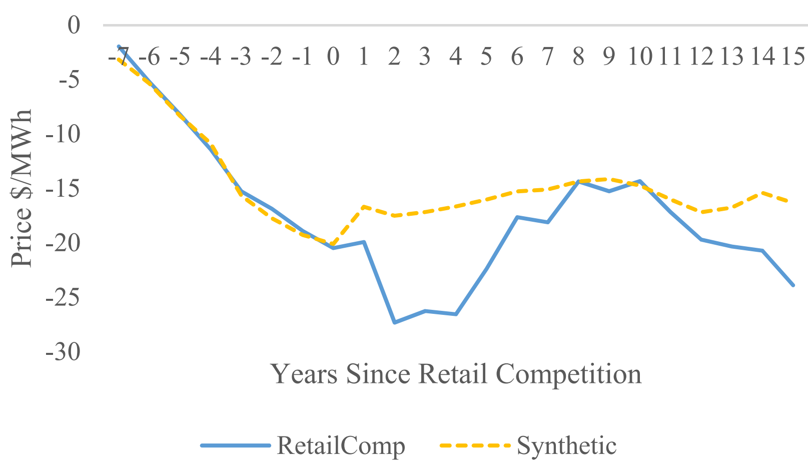
The effect of retail competition on electricity prices, differenced from their 1990 value, is reported for the average total price across all sectors (3.1), and for the three sectors individually (3.2-3.4). Price effects are presented in 2016 dollars, showing real electricity prices have declined over time. As shown in Figure 1, there is substantial variation in prices by sector in the retail competition states, so an analysis by sector is informative. In each section, the price differential is the average of the difference between restructured states and their synthetic match, as opposed to the difference between the average retail competition state and the average synthetic state.

[15] Prices are weighted by state ERS.

### 3.1 Total Price Effect

Figure 2 shows the impact of retail competition on the average total electricity price for 8 states. These states opened all sectors to retail competition and were matched to a counterfactual outcome through synthetic control. In the period prior to retail competition, both the states that opened to retail competition and their synthetic counterparts experienced a similar fall in real electricity prices, compared to 1990. However, once retail competition opened, prices diverged substantially. In the initial period following restructuring (0-6 years), real electricity prices in retail competition states fell compared to their counterfactual, with a moderate reversal in the next period (7-11 years). This trend then reversed again, with prices falling in the post 11-year period.

**Figure 2. Avg. Total Price Impact of Retail Competition**[16]




Notes: Price change compared to 1990 and average of 8 states that opened to competition.

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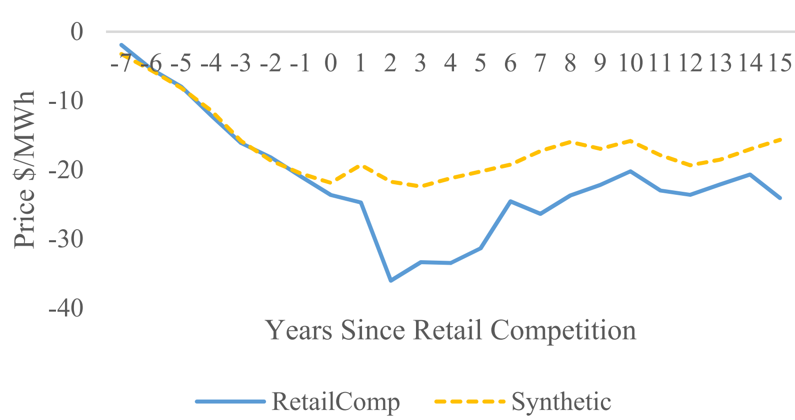
[16] A running variable of years since retail competition opened is used instead of years due to states restructuring in different years.

The explanation for price lagging the counterfactual in the first period is states mandating electricity price reductions or freezes, particularly for residential users, for a number of years after retail competition opened. Although this was not universal, with Texas an important exception, this mandate kept electricity prices below their counterfactual for years after retail competition opened. Once the price mandates ended, electricity prices rose quickly across the states. The reason behind this rapid price increase, and subsequent fall again, is explored in Section 4.

### 3.2 Residential Price Effect

Figure 3 shows the impact of retail competition on residential prices for 8 states. The pre-treatment period is almost identical, suggesting that the price paths of the retail competition and synthetic states would have continued to be the same if retail competition hadn't happened. Once retail competition began, prices dropped in the treatment states, with their counterfactual outcome slightly rising. This gap began to close as prices rose substantially for residential customers, but never caught back up to the counterfactual.

**Figure 3. Avg. Residential Price Impact of Retail Competition**



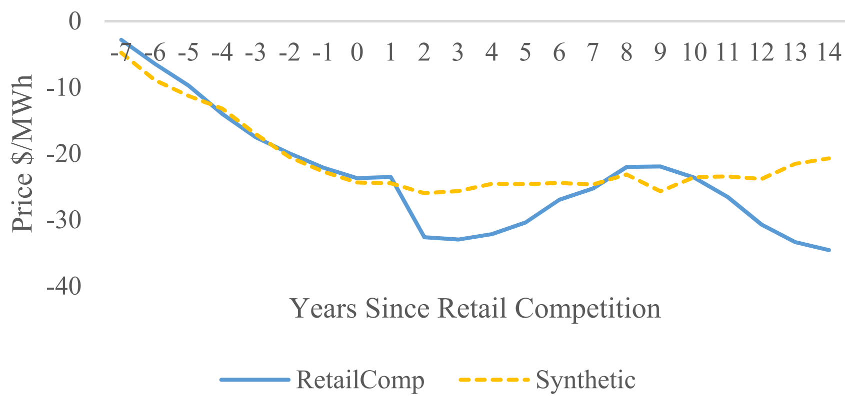

Notes: Price change compared to 1990 and average of 8 states that opened to competition.

This price path is consistent with state utility commission attempts to shield residential customers from high electricity prices. They accomplished this, initially, with price drop and freezes, which contributed to prices remaining well below the counterfactual for five years. The failure of prices to return to their counterfactual level reflects continued efforts by state utility commissions to keep residential rates low. Given that residential customers faced the highest prices prior to retail competition, this is a reasonable assumption.

### 3.3 Commercial Price Effect

Figure 4 shows the impact of retail competition on commercial prices for 9 states, with Oregon added to the other 8 states that restructured their residential sectors. As with residential prices, the pre-treatment period prices for the retail competition states, differenced from 1990, are similar to their counterfactual. This trend breaks with retail competition, as retail competition state prices fall below their counterfactual. Prices then rise rapidly, exceeding their counterfactual level before flipping again after 10 years of retail competition. The increase coincides with the end of the price freeze period.

**Figure 4. Avg. Commercial Price Impact of Retail Competition**

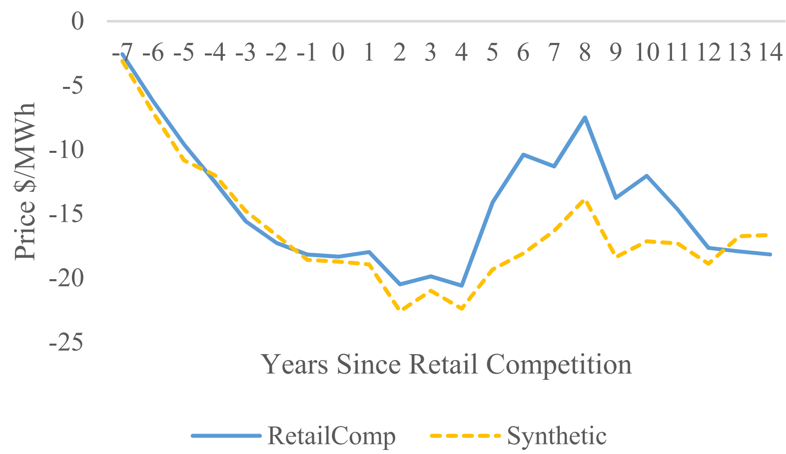



Notes: Price change compared to 1990 and average of 9 states that opened to competition. Running variable ends at 14 due to inclusion of Oregon.

### 3.4. Industrial Price Effect

Figure 5 shows the impact of retail competition on industrial prices for 9 states. There are two important trends in this graph. First, industrial users did not receive the same discount residential and commercial users did after retail competition. Therefore, the substantial decline in prices for residential and commercial users after retail competition began is not present for industrial users. Second, industrial users paid substantially higher prices after retail competition commenced, relative to the counterfactual. In both of these trends, an important component is that industrial users came into the period paying significantly lower prices than residential and commercial users, due both to their size and availability of on-site generation for many. While this sector price differential continued after retail competition, it’s a primary reason why the focus of restructuring was on lowering prices, mainly for residential and commercial users.

**Figure 5. Avg. Industrial Price Impact of Retail Competition**




Notes: Price change compared to 1990 and average of 9 states that opened to retail competition. Running variable ends at 14 due to inclusion of Oregon.

### 3.5 Discussion

Electricity market restructuring was proposed primarily to correct high electricity prices in a number of US state markets, particularly for residential customers. As Table 5 shows, there has been significant variation between sectors. Residential users have benefited most from the switch to competitive markets, with users paying an average of $7.04/MWh less than the counterfactual during the entire period. The largest benefits were early, due to price intervention by utility commissions. Commercial users also benefited, paying almost $4/MWh less during the period. Industrial users have been hurt by the change, particularly during the period 6-11 years after restructuring, as their bills increased by an average of $2.76/MWh during the entire period.

**Table 5. Retail Competition Price Effect by Period**

| Period | Total | Res | Com | Ind |
|---|---|---|---|---|
| Pre-Treat | $ 0.28 | $ (0.13) | $ 0.81 | $ 0.19 |
| 1-5 | $ (7.68) | $ (10.82) | $ (5.28) | $ 2.23 |
| 6-11 | $ (1.21) | $ (6.14) | $ (0.24) | $ 5.23 |
| Post | $ (4.74) | $ (4.99) | $ (10.84) | $ (0.49) |
| Total | $ (4.06) | $ (7.04) | $ (3.98) | $ 2.76 |

Notes: Shows average difference in electricity prices ($/MWh) for period.

To understand the magnitude of these price differences, Table 6 shows the effect on the average user's bill for the sample states. Column 1 (Avg. Price) is the average price of electricity by sector during the retail competition years. Column 2 (Use Per) is the average number of MWh consumed by individual users by sector over the retail competition period. Column 3 (User Effect) is the average annual benefit or cost to individual users in each sector from retail competition, measured in 2016 dollars. Column 4 (PostFreeze) is the dollar change in price per MWh over the entire period after states stopped freezing prices.

**Table 6. Overall Impact of Retail Competition on Consumers**

| Sector | Avg. Price | Use Per | User Effect | PostFreeze |
|---|---|---|---|---|
| Res | $127.42 | 11.19 | $ (76.83) | $ 10.85 |
| Com | $104.50 | 81.96 | $ (353.57) | $ 0.72 |
| Ind | $ 72.40 | 2497 | $ 6,548.01 | $ 6.64 |
| Total | $103.64 | 27.14 | $ (111.59) | $ 4.86 |

Notes: Avg. Price is in 2016 $/MWh. Usage per in MWh. User Effect in 2016 $.

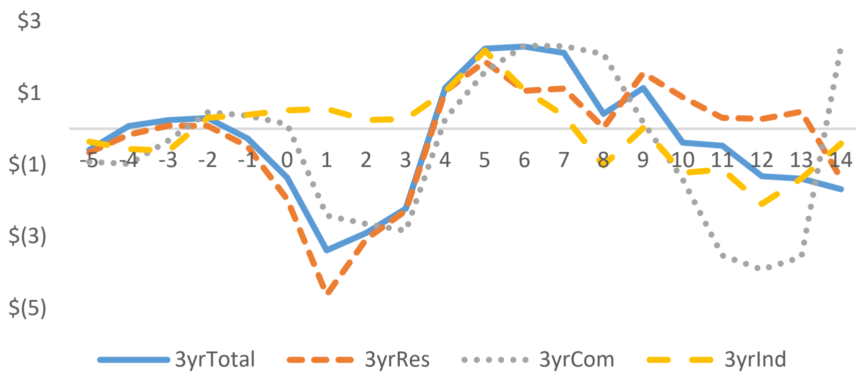
There are substantial differences between sectors in both average price and usage per customer. Throughout the period, industrial users continued to pay the lowest price for electricity, while residential paid the highest. The largest beneficiaries of retail competition were residential users on a per MWh basis, but, due to the much higher usage of commercial customers, they received the largest overall benefit each year. Industrial users paid significantly more each year as a result of retail competition, largely due to their size. In most states, the residential and commercial sectors are the largest, so the huge usage number of industrial customers is tempered by there being many fewer users.

The impact in column 3 is over the entire period of retail competition, which could be considered misleading. Since prices were reduced and then frozen in most states, the effect of retail competition may have been to increase prices but this effect was hidden by the price intervention. Column 4 shows this is in fact the case by looking only at what happened to prices after the freeze period. Total price increased, relative to the counterfactual, with residential users paying the most. Therefore, it should be considered that, in the period where the market was free to operate without any price intervention, retail competition increased prices.

## 4. Market Power and Gas Capacity

The results presented in Section 3 suggest retail competition only reduced prices due to state price freezes. As Table 6 showed, prices increased, compared to the counterfactual, after the freezes were lifted. The reason behind this increase in the differential can be seen in Figure 6. The freeze period coincided roughly with years 0-4, with prices below the counterfactual. Following year 4 prices rose dramatically for several years before falling again. This holds for each sector, with industrial showing the least variance and commercial the most.

**Figure 6. Price Differential Path for Retail Competition States**



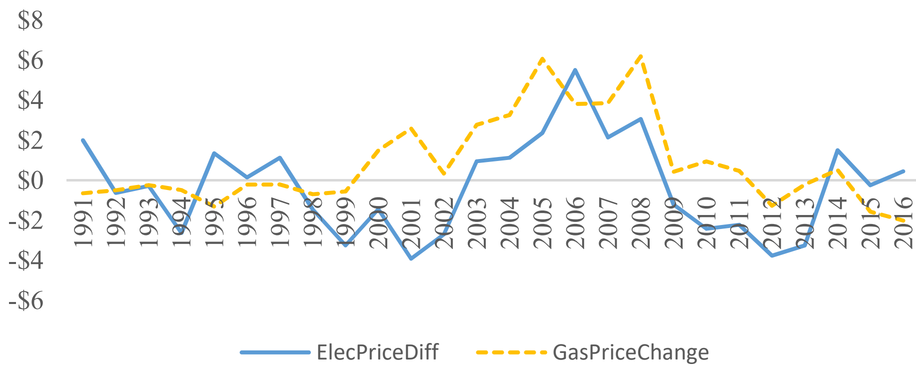

Notes: Price differential is shown annually, rather than the cumulative total in Section 3. Data smoothed into 3-year averages and split by sector.

This price path suggests that prices in these retail competition states were subject to a factor that rose during the middle period and then fell later. If this was not the case, the price effect of retail competition should have been stable. Using variation across sectors and states, this section will uncover the causes behind the time path of the price effects from retail competition.

### 4.1 The Gas Price Boom and Bust

From 1990-1999, the real price of natural gas for the 9 states in this sample averaged $4/mmBtu (2016 dollars). By 2008, that price had peaked at $10.67 before falling to a historic low of $2.46. While there was some variance in natural gas prices between states, all US states experienced a similar pattern. Since this boom affected all states, it should have caused a rise in the level of electricity prices in the 9 states, but not in the price differential with their counterfactual. As Figure 7 shows, there appears to be a strong correlation between the time path of the price differential and natural gas prices. This is especially true once you eliminate the period from 1998 to 2003, as this is when there were price freezes and cuts in most states that enacted retail competition.

**Figure 7. Time Path of Electricity and Gas Price Changes**




Notes: The electricity price series is the annual difference between prices in retail competition states and their counterfactual. 1998 is the first year a state opened to retail competition. The gas series is the difference in natural gas prices from their 1990 level.

The rise and fall in gas prices from 2003-2016 appears to move in tandem with the price differential, leading to the possibility that the change in natural gas prices is responsible for the change in the differential. The elasticity of electricity prices, with respect to natural gas prices, appears to be higher in retail competition states than in regulated states. Other potential explanations for the change in the price differential, such as market power or cost efficiency, are less likely to explain this pattern. They would have had to change in a similar pattern as gas prices, while the most likely path for these factors is constant.[17]

There are three potential channels for gas price changes to cause this price differential to change. The first is, as found in Hill (2019), restructuring led to a large increase in natural gas capacity. With restructured states more reliant on gas

[17] For example, it is unlikely that generators in retail competition states were less cost effective than those in regulated states from 2003-2008 and then more cost effective after.

to generate electricity, their prices would be impacted more by changes in gas prices. A second channel is that natural gas prices were more variable in retail competition states than in their synthetic counterpart. A third channel is the gas pass-through rate is different in states that rely on market mechanisms rather than price regulations. This was, in fact, one of the goals of restructuring, as wholesale prices change daily, while rate cases occur only a few times a year. The remaining part of this section is devoted to clarifying the impact of these effects on the relationship between the price differential and gas prices.

### 4.2 Changes in Gas Capacity

The first channel linking gas prices to the price differential between retail competition and synthetic states assumes that retail competition states built more gas capacity than their synthetic counterparts. As a result of their reliance on gas, electricity prices in those states would fluctuate more than in states with less gas capacity. While synthetic control matched states based on their generation mix, this is done pre-treatment. Therefore, if restructuring led to retail competition states building more gas than their counterfactual, this would not be controlled for by synthetic control and could lead to the relationship observed in Figure 7. Table 7 shows the difference in gas-fired generation and capacity between the eight restructured states and their synthetic counterparts before restructuring, during the price freeze, and after the price freeze. As the table shows, the difference in capacity was slightly positive and negative in generation. The small size of both suggests the retail competition states were not reliant on natural gas to a greater degree after retail competition than if they hadn’t restructured. Therefore, the impact of gas prices on the price differential was not due to greater gas reliance.

**Table 7. Gas Generation and Capacity Differential between States**

| Period | Generation | Capacity |
|---|---|---|
| 0 | 0.026 | 0.026 |
| 1 | (0.011) | 0.002 |
| 2 | (0.051) | 0.012 |

Notes: Period 0 is pre-retail competition. Period 1 is the price freeze period. Period 2 is post-freeze. Number is restructured gas share of generation mix minus synthetic value.

### 4.3 Changes in Gas Prices

Retail competition states added almost exactly the amount of gas capacity after restructuring as if they hadn't restructured. Therefore, this did not leave them any more vulnerable than they otherwise would have. Another possible explanation is that gas prices changed in the retail competition states by more than their counterfactual. This could be due to improper fit in the synthetic control or is possibly a feature of competitive markets. However, in order to fit the time path of the electricity price differential, gas prices would have to overshoot on both the upswing of prices and the downswing. If prices are simply higher in the retail competition states, this would not explain the dramatic drop post-2008.

**Table 8. Natural Gas Price Comparison by Period**

| Variable | Pre-Comp | Post-Comp | Post-2008 |
|---|---|---|---|
| PriceDiff | $ (0.234) | $ 0.084 | $ (0.381) |
| PriceGas | $ 2.583 | $ 6.277 | $ 3.926 |

Notes: Pre-Comp is the period before retail competition began. Post-Comp is the period after retail competition began before 2009. PriceDiff is the difference in natural gas prices between each state and its counterfactual. PriceGas is the price of natural gas in each period. All numbers are weighted to account for differences in state sizes and years.

Table 8 shows there is not a large difference in any of the three periods between the price of natural gas in retail competition states and the counterfactual. The difference in the first and third periods is approximately 9 percent of prices during the period, with the difference in the middle period slightly over 1 percent. These results suggest that it was not a deviation in the price of natural gas in these markets that led to the large price differential observed in Figure 7.

### 4.4 Pass-Through of Gas Prices

Sections 4.2 and 4.3 show the linkage between gas prices and the electricity price differential due to retail competition is not explained by differences in gas prices nor gas capacity. What this implies is the cost of producing electricity through natural gas that is to be passed through to electricity prices is very similar in the retail competition states and their counterfactual. Therefore, there must be a difference in how natural gas prices are passed through in retail competition markets. This is not a surprising result, as linking wholesale and retail prices was seen as desirable prior to restructuring and retail prices in regulated states were known to lag behind wholesale price changes (Joskow 1997). In fact, the price path shown in Figure 7, of prices initially rising above the counterfactual and then falling below it, is exactly what would be expected of regulated rates that smooth market fluctuations over time.

### 4.5 Industrial Users

Section 3 suggested retail competition initiated a transfer from the large, industrial users to the smaller, commercial and residential users. Retail competition appears to raise industrial prices substantially, compared to their counterfactual. Initially, this appears to be a confusing result. Market power theory predicts that when a firm with market power switches purchasing from a monopoly-dominated market to a competitive environment, the firm should be able to take advantage of its market position and obtain lower prices. Therefore, if industrial users were larger and had some market power, they should have been able to use this change to lower their paid price. However, this leaves out the role of the regulator and what may be occurring is the elimination of regulatory capture. Joskow (1997) notes that one of the reasons for restructuring was to reduce the influence of large users on the regulators. It's plausible that large, industrial users were successful in lobbying regulators for low industrial rates at the expense of commercial and residential users, but, once rates were market-determined, this influence dissipated. Further research in this area is needed, but this is one plausible explanation for the rise in industrial prices relative to their counterfactual.

## 5. Conclusion

When the first states opened to retail competition, one of the primary goals was to lower electricity prices. This was particularly true for residential prices, which were double the price for industrial users. Lower prices were supposed to be achieved through competition both in generation and retail. A number of studies have shown that retail competition led to reductions in short-run plant costs, yet the literature concerning the impact on overall electricity prices is mixed. There are two reasons identified in this paper for the identification problems in the literature.

The first problem addressed in this paper is the inclusion of states for which there is no valid counterfactual. The six Northeastern states and DC do not have a match in terms of generation mix and pre-retail competition price trends. Therefore, these states and DC are omitted from this study. Of the remaining 9 states that restructured most or all of their sectors fully, the failure of standard OLS models with fixed effects to present a valid counterfactual is a second problem. In order to better construct a counterfactual, this paper uses the synthetic control method, matching on both supply and demand factors, as well as pre-competition price trends, to provide a valid counterfactual.

Eliminating these concerns, this paper was able to provide a clear picture of the effect of retail competition on prices. While there was some variation by sector, there are three broad trends identified through synthetic control. First, the introduction of retail competition reduced prices substantially due to the imposition of price cuts and freezes by the states. Second, prices rose rapidly once the price freezes were lifted, compared to the counterfactual. This lasted until the end of 2008, when the price differential between retail competition state and its counterfactual fell. The overall effect of retail competition was to reduce prices, but this was due to the imposition of price cuts and freezes. Ignoring these, retail competition increased prices across all sectors.

This intriguing pattern mirrors the run up, and subsequent fall, of natural gas prices, presenting a link between the price of natural gas and the impact of retail competition on prices. This effect is attributed to the pass-through rate of natural gas prices being different in competitive markets, as no other factor was found to be consistent with the pattern of electricity prices. This has important implications for the future of electricity markets, as those with retail competition should expect to be reliant on the price of natural gas to a greater extent than regulated markets.

These findings suggest that, while retail competition didn't necessarily reduce electricity prices permanently, it was able to link the price of electricity more closely with wholesale prices. The next wave of research should more closely investigate this link and what effect the rise of renewable generation will have. Wholesale markets have already experienced periods of below zero bids due to increased renewable generation on the grid, which affects both the functioning of the market and the profitability of large, non-renewable plant owners. The results of this paper suggest the effect of more renewable generation on the grid will increase price volatility and how this is handled and passed onto consumers is an interesting problem for future work.

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