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The Effect of Deregulation on Electricity Prices in the United States

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Abstract

There are different views on whether the regulation of electric utilities is justified. These views relate to the debate between the relative efficiencies of state regulation vs. municipal franchise contracting which historically preceded state regulation. The lack of a consensus in this debate is the impetus for this study. Specifically, the study empirically examines the effect of deregulation on the price per kilowatt hour of electricity in the United States. This study uses a difference-in-difference approach with a panel of US data for 1990 and 2010 to investigate the effect of deregulation of electric utilities as well as natural gas on electricity prices. Contrary to predictions from theory, the simultaneous deregulation of electric utilities and natural gas utilities in the United States did not necessarily result in lower utility prices.

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1.0 Introduction

The electricity industry provides a benchmark for analyzing the role of industry regulation due to its large-scale specialized capital investment; a feature also common in other utility industries such as gas. There is a lack of consensus in the literature on whether the regulation of electric utilities provides economic and social gains to the economy. These views relate to the debate between the relative efficiencies of state regulation against municipal franchise contracting (a market structure that historically preceded state regulation)[1]. In their seminal paper that pioneered empirical study of regulation, Stigler and Friedland (1962) observe that the behaviour of electric utilities subject to state regulation was not significantly different from that of other utilities. Following on this work, Jarrell (1978) investigates the claim that state regulation results in regulatory "capture" by the regulated industry. The author highlights the challenge of trying to discern the effects of regulation on electricity rates (empirically) since utilities that were not subjected to state regulation were still subject to municipal franchise contracting. Moreover, the states that adopted state regulation in the early twentieth century were states with already lower electricity rates relative to their counterparts that were still under the municipal franchise contracting. To this effect, Jarrell (1978) posits that state regulation is a classic example of 'regulatory capture' by the electricity industry.

Other studies (e.g., Knittel, 2006; Neufeld, 2008) strongly refuted the 'regulatory capture' hypothesis and argued that it is the municipal franchise contracting rather than the state

[1] Municipal Franchise Contracting represents an agreement between municipal governments and private electric and gas utilities, originally created to spur municipal economic development. This agreement defines the implementation of franchise fees, and the "rental" price utilities pay to use city-owned property in order to deliver resources to consumers. While utilities own telephone poles and electric wires, they often do not own the majority of property on which these resources are located, and franchise fees are usually the most cost-effective solution for utilities to gain access to this land. Under municipal franchise contracting, consumers end up paying the investor-owned utility's franchise fee instead of sharing in its profits (Hughes, 2002; Troesken, 2006).

regulation that is fraught with inefficiencies. Knittel (2006) and Neufeld (2008) point to the large-scale corruption plaguing municipal franchise contracting regimes as the source of these inefficiencies. The advent of state regulation was primarily to protect the large-scale specialized investment by electric utility companies with the aim to help them improve on generation capacity, hence, the incentive to allow for higher electricity rates in states under state regulation. Knittel (2006) concurs with Jarrell (1978) on the fact that the regions that adopted state regulation early were already facing lower electricity rates. However, the author believes this assertion does not depict a complete picture of the status quo during that time because these states were also facing low capacity[2] and residential electricity penetration rates. These factors were good indicators of a lower price of electricity and a justification for state regulation. Similarly, Neufeld (2008) argue that the early adopting states had a higher level of per capita capacity; this fact indicates that state regulation was adopted to protect existing capacity investments. Hence, Knittel (2006) and Neufeld (2008) are of the view that state regulation promotes efficiency more than municipal franchise contracting.

In contrast, Lyon and Wilson (2012) cast doubt on the assertion by Knittel (2006) and Neufeld (2008) on whether state regulation improves on the existing capacity or preserves current capacity even in the face of higher rates under state regulation. This view is consistent with observations by other studies (Stigler and Friedland, 1962; Peltzman, 1976; Jarrell, 1978; Kalt and Zupan, 1984; Navaro, 1984; Smyth and Söderberg, 2010; Cortese, 2011; DeAngelo et al., 2018). All these studies support the "capture" theory of regulation. In addition, Etzioni (1986) and Emmons (1997) find that state regulation had the intended effect of lowering electric utility rates; results that contrast with Stigler and Friedland's (1962) seminal paper. The lack of a

[2] The term capacity refers to generator capacity, which is the maximum electricity output commonly expressed in megawatts (MW) that generating equipment can supply to system load (adjusted for ambient conditions).

consensus on the validity for the rationale of state regulation in the electric utility industry provides an impetus for this study, which empirically examines the effect of deregulation on the price per kilowatt hour of electricity.

This study examines whether the absence of complete state regulation (deregulation) of electric utilities and/or energy (electricity and natural gas) is effective in reducing electricity prices. If regulation helped to create a more efficient market, then deregulating the same market is likely to lead to higher electricity rates. If this was the case, given that electric utilities exhibit similar cost conditions, as they have persistently decreasing costs, deregulation could mean higher electricity rates as competition could lead to either a single monopolist dominating the market or a few large sellers who together dominate the industry and/or some degree of the imperfectly competitive market (Samuelson, 1964). The process to the new market structure can either be driven by stable changes or through a series of intermittent price wars (Samuelson, 1964). Otherwise, deregulation would be more efficient than regulation.

This study uses state-level data from the United States for the years 1990 and 2010 to empirically investigate the effect of simultaneous deregulation of electric utilities and natural gas on electric utility rates. To ascertain the impact of regulation, a counterfactual is needed to compare the outcome under regulation and that under no regulation (Stigler and Friedland, 1962; Jarrell, 1978; Etzioni, 1986). This approach has become to be known in modern-day econometric terminology as the treatment (regulatory outcome) relative to the control (counterfactual). The control group consists of states that were still under state regulation in both 1990[3] and 2010. On the other hand, the treated group consists of states that were under state regulation in 1990 but

[3] Deregulation only really started in the 1990s when the Energy Policy Act of 1992 eliminated restrictions on the prices of wholesale electricity.

had implemented deregulation by 2010. This approach allows the researcher to use a difference-in-difference methodology. The result from this approach, which is contradictory to theoretical expectations, shows that the deregulation of electric utilities, as well as natural gas in the United States, had an insignificant effect on lowering prices.

Though examining a different dimension, the outcome of this study is consistent with those of Etzioni (1986) and Emmons (1997) which obtained that state regulation of electric utilities did lower electric prices (an outcome in favour of the public interest theory of regulation). In a similar spirit were the findings by Knittel (2006) and Neufeld (2008) that hinged on the argument that state regulation is better suited for efficiency than municipal franchise contracting. They maintained that large-scale specialized investments of electric utility companies help to improve generation capacity. Moreover, the state regulation protects these firms from large-scale corruption plaguing municipal franchise contracting, which allows utilities to charge higher electricity rates. Their argument then is that state regulation of electric utilities is efficient only when it means the protection of existing capacity or expanding private capacity investment. This claim is consistent with the findings in this study; state regulation breeds efficiency.

The rest of the paper is organized as follows. Section 2 presents a brief overview of the economic theories of regulation as well as reviewing empirical studies. Section 3 discusses the data and the econometric method adopted in this study. Section 4 focuses on the empirical specification, and Section 5 presents the results. Finally, Section 6 concludes.

2.0 Literature Review

This section discusses the different theories of state regulation, results from past studies, and the general lack of consensus among these studies. The lack of consensus in literature leaves a need for further research. Thus this study aims to bridge this gap.

2.1 Theoretical Literature

2.1.1 Public Theory of Regulation

The Public Theory of Regulation was proposed on the premise that regulation is adopted to correct the problem of market failure, namely: natural monopolies, externalities, and information asymmetry. Natural monopolies are usually common in markets that are characterized by specialized large-scale production and/or service provision such that production or service provision is effective only if a single firm operates in the market rather than several firms. When this happens, the cost function of the firm is assumed to be sub-additive. Hence the firm becomes a natural monopoly. What makes natural monopolies unique is the fact that they enjoy declining average costs within their entire generational capacity range. However, the proponents of the public interest theory believe that if these firms are left unregulated, they are likely to restrict output to raise prices, which in turn, lower public welfare. These public interest theorists (Etzioni, 1986; Emmons, 1997) amongst others, therefore, propose that rather than being left unregulated, such firms should be regulated. Instead of using the conventional optimization rule (marginal revenue - MR equals marginal cost - MC), these theorists argue that natural monopolies should be forced to use average cost pricing (i.e., P = AR = AC). At this level, more output is produced at lower prices, which maximizes aggregate public welfare. The regulated firms earn zero economic profits (breakeven in accounting terms).

2.1.2 Capture Theory of Regulation

Unlike the public interest theory, the tenet of capture theory of regulation is not to maximize public welfare. In his work on the "theory of economic regulation", Stigler (1971) argue that, as a rule, regulation is acquired by the regulated industry and is designed and operated primarily for the benefit of the industry. This work, the statement, in particular, led to the crystallization of "capture" theory of regulation. However, the origin of capture theory can be traced back to the work of Stigler and Friedland (1962). It is the idea from this study that Stigler later developed using weight limits on trucks and occupational licensing as an illustration. Peltzman (1976) further illustrates how regulation can be captured for the benefit of small interest groups with strong felt preferences at the cost of large interest groups that have weak felt preferences. The author argues in favour of small interest groups as they are more organized and able to foster their interest with minimal possibility of the cost of free riding on the efforts of others and given that the per capita benefits from regulation is higher with small groups. This approach means that the regulator is better able to use regulation as a tool to maximize a majority vote for the politician through the raising of campaign funds and contribution to votes.

2.2 Empirical Literature

Using the United States cross-sectional level data, Stigler and Friedland (1962) examine the effect of electricity regulation on price per kilowatt hour of electricity in the early 20th century. They find the coefficient on the regulatory dummy to be negative but statistically insignificant and thus concluded that electric utility regulation does not reduce prices. Consistent with Stigler and Friedland (1962), Jarrel (1978) argue that the early adopting states had lower electricity rates than their non-adopting counterparts before regulation took effect. Based on this observation, Jarrell (1978) conclude that regulators were "captured" by the interests of the regulated electric utilities as he finds that the early adopting states before 1917 had lower rates than their counterparts before adopting regulation and after regulation even though their rates increased during this period.

Peltzman (1976) use a theoretical model of price and entry regulation to show how the preferences of the regulator will determine what type of theory holds. He argues that although the two theories (public interest theory and right capture theory) are on opposite extremes, both could be used to explain regulation consistently and/or otherwise, the regulator would settle for a tradeoff; a mixture of the two theories. Also consistent with the "capture" theory of regulation is the outcome from Lyon and Wilson (2012) who examine the effect of transitioning from municipal franchise contracting to state regulation on investment propensity. Using a United States level panel data from the U.S. Electrical Censuses of 1902–1937, they find that the shift from municipal franchise contracting to state regulation was associated with a substantial decrease in investment propensity. Though consistent with the capture hypothesis, they argue that the position of Jarrell (1978) in assuming away the potential positive effect of regulation was a flaw in that study. They note that this assumption is costly as the premise is not sufficient to show that state regulation was a case of regulatory capture.

Examining the public interest and regulatory capture hypotheses, as competing rationales for what motivates regulatory behaviour in the context of the Swedish electricity market, Smyth and Söderberg (2010) employ hazard models and some alternative estimators and specifications based on binary and count outcomes. The aim was to investigate why the Swedish Energy Agency (SEA) replaced decision-makers hearing customer complaints in the Swedish electricity market over the period 1996–2008. Their main findings show that the probability that the regulator would replace individual decision–makers over a sequence of the decision made in favour of customers relative to utilities reduces to around one-tenth from one fifth. This argument is consistent with the public interest theory as the regulators tend to favour the public (consumers) over the utilities (producers).

The authors further find that for periods 2–6 years succeeding the market reform, decision-makers who decided in favour of customers over utilities faced a higher probability of replacement. This is supported by the life-cycle theory of regulatory agencies which posits that regulatory agencies are initially set up to protect consumers, and the agency does so because it is subject to close monitoring by the government and the general public. Albeit, with the passage of time, the pressure on the regulator to act in the interests of consumers declines, and the pressure exerted by utilities remains constant, meaning that the regulator becomes more susceptible to being captured by the interests of the utilities it intended to regulate. Hence, in the context of the Swedish electricity market, this suggests that the more extended the period between the regulatory reforms and when the decision is made, the more likely it is that the regulator will replace decision-makers who decide complaints in favour of customers. This shift happens because both the government and the public's attention shifts overtime to other issues, and the day-to-day activities of the regulator are not subjected to the same level of scrutiny (Smyth and Söderberg, 2010).

Using the regulatory capture framework developed by Mitnick (1980), Cortese (2011) survey the failure of the standardization of the oil and gas accounting across states in the US in the 1970s. The historical narrative of the standard-setting process mirrored through the lens of regulatory capture theory revealed that the inadequacy of information, which results from the reliance of the regulator on the regulated (oil and gas) industry for information due to the complexity of the sector and its accounting practices, informed the failure of the standard-setting process. Also, Cortese (2011) finds that lobbying pressure and revolving doors of professional affiliation are also contributing factors to the regulatory capture of the standard-setting process. The reliance by the regulator on the industry resource, which could be information from industry representatives and affiliated experts that have been socialized with the industry either through one of prior employment and promise for future employment and/or business connections, impacted the failure of the efforts of the Financial Accounting Standards Board (FASB) in setting an agreeable accounting standard for the oil and gas industry. This failure reflects the regulatory capture of the accounting process (Cortese, 2011).

In a distinct and more recent study, DeAngelo et al. (2018) investigate the impact of general experience as a referee as well as experience refereeing a particular team on the assignation of penalties in the National Hockey League (NHL) game. With the aid of NHL game level data from the NHL games during the period January 1, 1996, to December 11, 2015, and NHL box scores from espn.com, they were able to obtain a measure of the referee's game experience in seasons. The authors report results as effects of seasons rather than games of experience to facilitate the interpretation of the coefficients. Their findings revealed an inverse statistically significant relationship between referee's game experience in seasons and the number of penalties awarded. Also, they find that for each additional season of experience, the expected number of penalty minutes decreases by 0.262. Given the longevity of some referees, this number is economically significant as well; referee teams with the mean level of experience

(10 years) call 2.6 fewer penalty minutes per game than rookie referee teams or 1 fewer minor penalty. The penalties are even more by a factor of 1.038 for games officiated by a pair of referees. The authors envision this result to mean that a pair of officiating referees is less experience than a lone referee and/or NHL pairing more experience referee with less experience referee. Overall, their findings of significant regulatory capture, that is, a rookie referee calls significantly more penalties than veteran referees are consistent with those of Cortese (2011). Cortese's results hinge on the likelihood of the regulated (players) and the regulator (referees) forming relationships through repeated interactions (revolving doors of professional affiliation).

Conversely, Etzioni (1986) review the work of Stigler and Friedland (1962) using the same data that he obtained from the authors and an employment of a cross-section study approach for two separate time periods, and finds that the result of regulation was consistent with the lowering of electricity rates, a finding that Stigler and Friedland (1962) previously dismissed[4]. Emmons (1997) examines the impact of variations in regulation, ownership, and market structure in the U.S. electric utility industry using a cross-section firm–level and market–level data set collected on utilities serving cities of population 50,000 or more in the periods 1930 and 1942. The period of the study as noted by Emmons (1997) coincides with the period surrounding the New Deal reforms when considerable institutional variation provided a natural experiment for analysis. Employing a simultaneous equations model of electricity supply and demand in estimating the study outcome for each of the periods 1930 and 1942 separately from the other, Emmons (1997) find evidence that regulation, public ownership, and competition served to reduce electricity prices and enhance allocative efficiency during the period under examination. Emmons (1997) argued that his findings suggest that while state regulation reduced

[4] As described in Peltzman (1993), Claire Friedland later found that the paper had underestimated the impact of regulation on prices by an order of magnitude, though the statistical significance of the result remained marginal.

electric rates to a limited extent, prices were even lower when utilities faced competition and/or were publicly owned. This is evident from the empirical analysis of the 1942 sample that revealed a reduction in electric rates of about 9.8% as compared to a 13.0% reduction estimated for 1930 both induced by competition; a 20% reduction from the combined effect of regulation and competition while regulation, public ownership, and competition together appeared to have reduced rates by up to 30% relative to prices charged by the unregulated private monopoly utilities (Emmons, 1997). However, contrary to the suggestion by Stigler and Friedland (1962), he finds that although a wide range of factors may have constrained the effectiveness of state regulation, it was not rendered entirely impotent as state regulation of privately owned monopolies had a downward effect on rates during these years, but only on the order of 6–10%.

Overall, the findings by Emmons (1997) presupposes that competition, and even public ownership, should not be dismissed out of hand as appropriate institutional responses to the organization of industries with natural monopoly characteristics. This is particularly instructive as the results challenge the paradigm of the regulated private monopoly as a second-best solution to the provision of utility services, not only in the United States but also around the world where the privatization movement has increasingly transformed state-owned utilities into privately owned, government-regulated monopolies (Emmons, 1997). Moreover, given that both competition and public ownership further reduces the utility rate in addition to the reduction from the state regulation of utilities.

Knittel (2006) in another work employs an empirical hazard model to ascertain the determinants of early adoption of state regulation, and finds it was not only low rates of electricity, but also capacity shortages and low residential electricity penetration rates that impacted adoption. In a similar study, Neufeld's (2008) reports that states with higher capacity per capita adopted state regulation earlier. Both studies were respectively of the views that state regulation is better suited to grow and/or preserve the already existing capacity.

It is based on the above that this study attempts a careful investigation of the effect of electricity and/or energy deregulation on electric utility rate per kilowatt hour of electricity.

3.0 Data

As stated previously, the study uses a panel of the United States (U.S.) level data on energy, economic and census for the period 1990 and 2010 sourced from the; United States Energy Information Administration (EIA); Bureau of Economic Analysis, United States Department of Commerce (BEA); and United States Census Bureau (UCB). The policy variable which is the variable of interest represents the year deregulation took place in the deregulated state. According to an online blog[5], "deregulation began in the 1970's with the passage of the Public Utilities Regulatory Policy Act, which created an environment and structure for Independent Power (electricity and natural gas) Producers (entities that are not public, that is regulated utilities, but who do own facilities to generate electric power that they can then sell to both other utilities and to end users). However, deregulation did not get started until the 1990s when the Energy Policy Act of 1992 eliminated restrictions on the prices of wholesale electricity. The trend towards deregulation slowed around 2000-2001 during the California energy (electricity and natural gas) crisis that gave many states concerns over the potential for market manipulation if the market became fully deregulated."

Drawing from the above, this study adopts 1990 as the reference year with which the policy change year in this case 2010 will be compared to ascertain the policy impact different

[5] https://www.brightergy.com/how-to-make-sense-of-regulated-deregulated-energy-markets/

from the treatment effect before the policy change since prior to and by 1990, both the electricity industry in all states and natural gas were under state regulation and deregulation have not really began. The year 2010 is chosen as the policy change year because all deregulated states were already deregulated at least three years before 2010 and this resonates with Stigler and Friedland (1962) criteria in choosing their policy change year. In some states, both electricity and natural gas deregulation took place in the same or different time periods, while in others electricity or natural gas was deregulated or there was no deregulation at all. As a result, this study separates deregulation into complete and incomplete by whether a deregulated state has both of its electricity and natural gas or just electricity deregulated.

While the states with deregulation in both electricity and natural gas are considered to be fully deregulated, those with only electricity deregulation are considered partially deregulated. However, it is instructive to note that the usage of complete and incomplete deregulation remains the writer's way of separating between two groups. This is to make sure there is no state with complete energy deregulation[6]. The closest state is Texas with approximately 85% of the state having access to electricity choice as only electricity deregulation took place in the state. With this, we define two controls (comparison) groups as: first, all states without electricity deregulation with corresponding treatment group defined as states with at least (some degree of) electricity deregulation not minding natural gas deregulation. Second, for a robustness check, we

[6] **Regulated electric markets** are home to vertically-integrated utilities that own or control the power plants that generate electricity, as well as all of the transmission and distribution equipment—such as the poles, wires, and transformers—that are used to distribute electricity to homes and businesses. In other words, consumers only have one option for their electric utility, who owns both the energy generated and the means to distribute it, and the rates the utility charges them are approved and regulated. Whereas, in a **deregulated electric market,** utilities are required to divest their ownership in generation and transmission which means they are only responsible for: Distribution, operation, and maintenance from consumers' interconnection to the power grid at their electric meter, Billing the consumers, the ratepayer and acting as their Provider of Last Resort. Same applies to the market for natural gas.

consider only states with neither electricity nor natural gas deregulation as the control group while all states with both electricity and natural gas deregulation as the treatment group.

Besides the variable of interest, the study also controls for demand and supply shifters as in Stigler and Friedland (1962). The demand shifter controlled for includes the log of urban population by state measured in thousands and log of states' per capita real income chained in 1997 dollars. Supply shifter, on the other hand, comprises of the proportion of states' electric output from conventional hydroelectric power and natural gas sources respectively. Included as control covariate variable is the year dummy variable. The *a priori* expectation is that the coefficient on the log of urban population measured in thousands will be negative since the more the urban population, the concentrated the market, and cheaper to provide electricity, which would mean lower prices per kilowatt hour. The log of states' real per capita income is anticipated to have a positive relationship with average revenue per kilowatt hour of electricity. This is so given that a higher per capita real income is indicative of economic prosperity and expansion in the use of electricity which feeds into higher cost of servicing capacity in new investments, thus, higher prices. The proportion of output from conventional hydroelectric and natural gas sources are expected respectively to be negatively and positively correlated with the price per kilowatt hour of electricity. As noted by Stigler and Friedland (1962), hydroelectric power is termed a low-cost power source that means the more of its output as a proportion to total electricity output in a state, the less the price of electricity in that state. Natural gas works in direct opposition to hydropower source.

Of the 102 sample points from a panel of 51 states over two years, about 35.3% are observations from states with at least deregulation in the electric utility, while states with both electric and gas deregulation constitutes 29.4% of the entire sample. Put differently, the percentage contribution of states regulated in both electricity and natural gas to the study observation is about 70.6% as against 64.7% contributed by states with at least electricity regulation. A look at the average price per kilowatt hour of electricity for all sectors measured in cents, which is the dependent variable for the study, reveals that rates were higher in deregulated states ever before deregulation began. In the comparison year (1990), price per kilowatt hour of electricity for all sectors was about 7.45 cents in deregulated states against 5.94 cents in regulated states for states with at least deregulation in electric utility. By 2010 which is the treatment year, prices had gone up to about 12.20 and 8.97 cents respectively for both deregulated and regulated states with the difference in magnitude exceeding the initial difference before the start of deregulation. This is also similar for states with both electricity and natural gas deregulation and will be crucial in analyzing our final result. Table 2 in the Appendix reports the summary statistics of some observations; mean, standard deviation, minimum and maximum of each variable. Also, the table indicates the sources of data. See also Tables 3 and 4 in the Appendix for the analysis of price per kWh for all sectors.

4.0 Methodology

4.1 Model Specification

The study adopts a difference-in-difference approach in evaluating the outcome of deregulation, a different methodology to those followed by Stigler and Friedland (1962) and Jarell (1978). Although the difference-in-difference method became more formal in a regression setting in Card and Krueger (1994), the idea had earlier been conceived in the studies above. This type of methodology not only compares between two groups over two periods but also controls for time and fixed effects. Shannon and Grierson (2004:432) note that "the difference-in-difference approach measures the impact of an event as the change in outcome before and after the event for a treatment group less the change in the same outcome for some appropriate control group." Angrist and Pischke (2015) highlight that the difference-in-difference method can help to identify causal effects in cases where treatment and control groups are different, however, to produce causal effects, the differences must move in parallel in the absence of any policy effect. If this assumption holds, then "divergence of the post-treatment path from the trend established by a comparison group may signal treatment effect" (Angrist and Pischke, 2015:178).

Using states with at least electric utility regulation as the control (comparison) group, the effect of deregulation on price per kilowatt hour of electricity can be evaluated by estimating the following regression:

$$\boldsymbol{P_{it} = \beta_0 + \beta_1 DR_{it} + \beta_2 YEAR_t + \gamma(DR_{it} * YEAR_t) + X'_{it}\delta + \varepsilon_{it}} \text{ .... } \mathbf{(1)}$$

where P_{it} is the price per kilowatt hour of electricity paid by a user in state i at time t, DR_{it} is the deregulation (treatment) dummy variable with the value of one if the state i is deregulated in period t and zero if otherwise, $YEAR_t$ represents the year dummy which controls for time trend with the value of one if the year is 2010 and zero if otherwise; X'_{it} is a vector of control covariate variables, which comprise of the demand and supply shifters mentioned above, and ε_{it} is a random error term.

The coefficient β_1 measures the difference between the treatment and control group before deregulation. The normal expectation is that states with higher electric utility rates are more likely to be deregulated as deregulation is perceived to bring about competitiveness that will reduce prices, thus, β_1 should be positive. The sign of β_2, which is the coefficient on the year dummy controlling for time trend, can either be negative or positive since it is independent of regulation and should capture a general trend in electricity prices over the period in question (for instance, electricity rates could be declining over the period because of an increase in supply across the U.S. and vice-versa). In this study, the parameter of interest is γ (the coefficient on the interaction dummy). It measures the effect of deregulation in state i and in the period after deregulation has taken place (2010), that is, the difference-in-difference. This is expected to be negative if the "capture" hypothesis of regulation was to hold and if deregulation were to be efficient over state regulation, otherwise, the assertion of Samuelson (1964) would be true.

To ensure robustness of estimates, we re-estimate equation (1) using only states with both electricity and natural gas regulation as the control group, with the treatment group being stated with both electricity and natural gas deregulated.

5.0 Empirical Results

The regression results contained in Columns 1 and 2 of Table 1 reveal the effect of deregulation on the average revenue (price) per kWh of electricity by states for all sectors with the control group defined as states with at least electricity regulation. Similarly, Columns 3 and 4 assumed as control group states with both electricity and natural gas regulation for the robustness of parameter estimates. While Columns 2 and 4 controls for supply and demand shifters holding deregulation constant, Columns 1 and 3 do not consider other factors that might influence price differently from the deregulatory policy.

The statistical significance of the interaction effect in all the models controlling and not controlling for demand and supply shifters (covariate variables) is conditional on the standard error clustering. This assumes that adopting a difference-in-difference (DiD) approach to a panel study using a panel (state-year) level data with clustering on the state will amount to regression model errors independent across clusters but correlated within groups (Cameron and Miller, 2015). The correlation of errors within clusters is possible as state observed between two different time periods could be subject to the same unobserved heterogeneity which could result from time-invariant factors.

Table 1

Dependent Variable: Price per kWh of electricity for all sectors in dollars

Variables	1	2	3	4
DR	0.0150*** (0.0044)	0.0105** (0.0042)	0.0193*** (0.0041)	0.0151*** (0.0039)
$YEAR$	0.0302*** (0.0046)	0.0220*** (0.0059)	0.0312*** (0.0042)	0.0227*** (0.0057)
$DR * Year$	0.0173*** (0.0063)	0.0141** (0.0066)	0.0176*** (0.0066)	0.0155** (0.0066)
$Log(Urban\_Population)$		-0.0026 (0.0026)		-0.0030 (0.0023)
$Log(State\_Real\_Per\_Capita\_Inc)$		0.0186* (0.0109)		0.0175 (0.0108)
$Proportion\_of\_Hydro\_Power$		-0.0239** (0.0113)		-0.0192* (0.0100)
$Proportion\_of\_Natural\_Gas$		0.0273** (0.0120)		0.0298** (0.0123)
$Constant$	0.0594*** (0.0024)	0.0209 (0.0378)	0.0590*** (0.0023)	0.0256 (0.0348)
$Number\ of\ Observations$	102	102	102	102
R^2	0.4440	0.5185	0.4771	0.5507

Cluster-robust standard errors in brackets

***** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$**

Cameron and Miller (2015) note that Bertrand et al. (2004) demonstrate the relevance of using cluster-robust standard errors in DiD settings. They argued that clustering should not be done on state–year pairs but on state citing an example that the error in the state in 2010 is likely to be correlated with its error in 2009 (assuming error independence across states). The implication of this is that states are influenced by their (time-invariant) factors, which would imply that observations within a state share frailty characteristic not covered by the explanatory variables. In such settings, default standard errors can either understate or overstate the precision of the coefficient estimate, hence, the standard error clustering (Cameron and Miller, 2015).

Other econometric second order tests such as Ramsey reset test for functional form specification, Woodridge serial autocorrelation test, and white heteroscedasticity test were conducted. All these tests did not indicate any problems with the specification above. The F-values of the Ramsey reset test for functional form specification for the regression results in Columns 2 and 4 with their corresponding probabilities are respectively $F(3, 91) = 1.12$ [$Prob > F = 0.3439$] and $F(3, 91) = 1.42$ [$Prob > F = 0.2407$] indicating that the models are correctly specified. In the same vein, the serial autocorrelation and heteroscedasticity test turned up a high probability value greater than the F statistic value leading to none rejection of the null hypothesis of no serial autocorrelation and heteroscedasticity. However, the regressions with cluster-robust standard errors were reported as it possesses minimum efficient standard errors compared to the OLS (Ordinary Least Squares) estimates.

The regression result contained in Column 1 shows that on average, holding all else equal, price per kWh of electricity in states with deregulation in electric utility exceed those of the regulated states by about 0.015 dollars before deregulation and the coefficient is significant at 1% level. This conforms to expectation and it is consistent with observations from the data. As shown from the data deregulated states tend to have a higher price per kWh of electricity for all sectors before and after deregulation compared to their counterparts. The differences in cost per kWh are consistent when we consider states with at least deregulation in electricity and/or both electricity and natural gas. This difference is captured by the coefficient on the treatment dummy which is argued to be positive as it further lends support to the need for deregulation to ensure competition that would lead to lower prices. Throughout the regressions, this coefficient is positive and significant with a magnitude of 0.0105, 0.0193, and 0.0151 for Columns 2, 3, and 4 respectively. The year dummy in all regressions controlling for the effect of time trend was positive and significant and thus, reveals that electric utility rate increases over time.

Figure 1: Coefficient Plot for Regression Result contained in Column 2 of Table 1

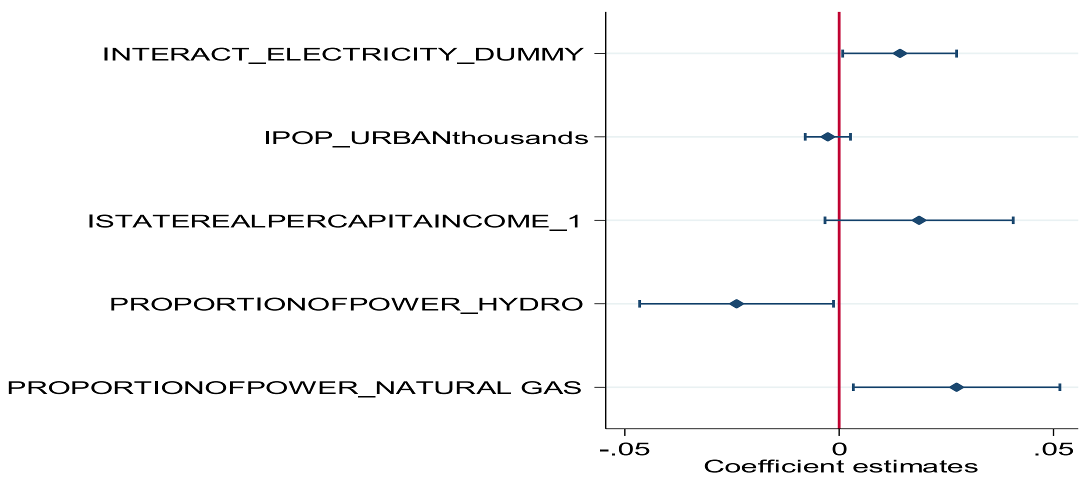
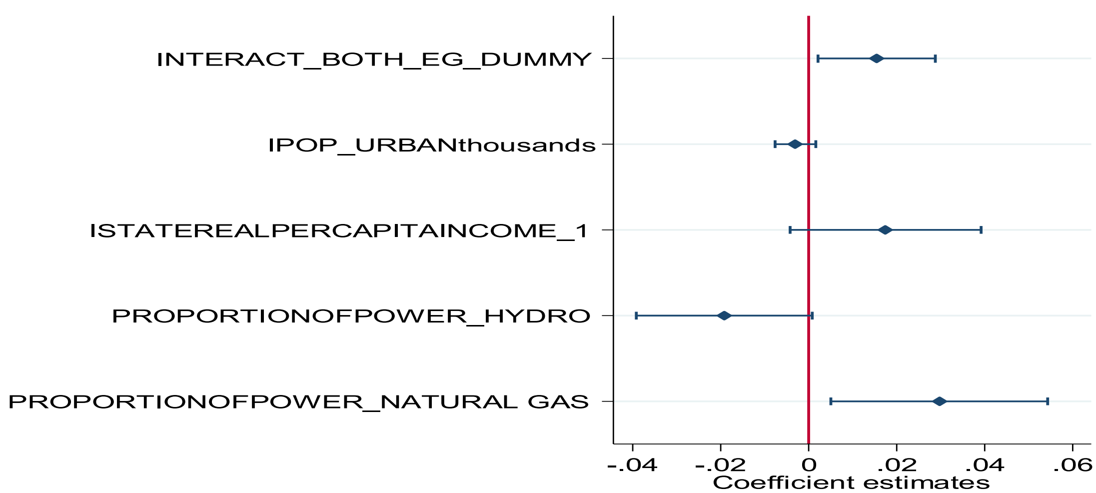


Figure 2: Coefficient Plot for Regression Result Contained in Column 4 of Table 1



The key variable of interest is the interaction dummy whose coefficient captures the average treatment effect of policy change (deregulation). Contrary to expectations, its coefficient is positive and statistically significant with the magnitude of about 0.0173, 0.0141, 0.0176, and 0.0155 for regressions 1, 2, 3, and 4 respectively. Figures 1 and 2 reveal the coefficient plot of this key variable of interest (the interaction dummy) in comparison to other explanatory variables excluding the year and treatment dummies for the regression results contained in Columns 2 and 4 respectively. This is to aid with the visualization of the magnitude of the policy variable's effect vis-à-vis other regressors. The positive value of the coefficient on the interaction dummy is somewhat suggestive that deregulation is less efficient compared to regulation. However, (Lyon and Wilson, 2012) argued that it is insufficient a premise to conclude on whether or not regulation is a "capture" judging from its impact on price alone but rather its impact on private capacity generation as it is better suited to reflect efficiency. This argument was put forward against the assertion by (Jarell, 1978) who concluded that regulation was the case of "capture" evidence from its impact on price alone. Following this, it could be that deregulation is less efficient to regulation in which case, the view of (Samuelson, 1964) holds such that deregulated states have their downstream retail firms compete which could lead to one of natural monopoly, few dominating oligopolies and/or Bertrand kind of price competition with the potential of raising prices. It could also be possible that deregulation is efficient but not correctly done in a manner that will engender competition in lowering rates.

Throughout the regressions controlling for the demand and supply shifters, the coefficient estimates on the control covariate variables had the expected signs but were not all statistically significant. While the supply shifters were significant in both regressions 2 and 4 with the coefficient on the proportion of output from conventional hydroelectric power and that from natural gas at least statistically significant at 1%, the demand shifters, on the other hand, were not all significant. The log of the urban population was not significant in both regressions, and that of state real per capita income was only significant at 10% in regression 2. In regression 2, a unit increase in the proportion of output from hydroelectric power results on an average is about 0.0239 dollar decrease in price per kWh of electricity as a hydroelectric power source is termed a low-cost energy source, (Stigler and Friedland, 1962). This is also consistent with what obtains from regression 4, though there is a fall in magnitude to 0.0192. The proportion of output from natural gas works in the opposite direction as the more output from natural gas the more the price. The urban population following (Stigler and Friedland, 1962) ought to reduce the rate as the higher the population, the concentrated the market which will mean low cost in the provision of electricity. This is also in sharp contrast to state real per capita income, and they are both logged to reduce their sizes.

6.0 Conclusion

Overall, the regression results show that electricity prices in U.S. states with at least deregulation in electric utilities exceeded those of the regulated states for all sectors. The coefficient on the policy variable which is the parameter of interest for all regressions controlling and/or not controlling for other factors turned up positive and significant. This outcome shows that deregulation of electric utilities is somewhat less efficient compared to regulation. This accord with the findings of (Etzioni, 1986; Emmons, 1997) that states with electric utility regulation had lower prices per kWh of electricity as against their counterparts. This result stands in contrast to that of Stigler and Friedland (1962) who found that regulation was not statistically significant about electricity prices. Emmons (1997) by extension found that variations in ownership and market structure further reduced electricity prices relative to rates charged by unregulated private monopoly utilities. Furthermore, the outcome of the study by (Knittel, 2006; Neufeld, 2008) although from a different stance, allude to the fact that state regulation of electric utilities helps minimize the large-scale corruption fraught with municipal franchise contracting that preceded it, hence its efficiency.

Also, with the argument that regulated states typically have vertically integrated utilities that own or control the power plants that generate electricity as well as transmission and distribution equipment, and this structure contrast with deregulated states in which utilities are required to divest ownership in both generation and transmission. It can be inferred that regulation is better suited for efficiency than deregulation. This is so since not every state that deregulated had multiple choices regarding who and where to buy energy from, as some states either have just one or few utilities offering downstream retail services. Also, for the majority of the deregulated states, nothing was said about their energy choices as no comment was made about the availability of choice programs[7]. The lack of choice for some states regarding who and where to buy energy from following deregulation as well as the majority of the deregulated states not reporting energy choice suggest that competition is not an effective constraint on prices. Deregulation works better if average cost functions are U-shaped and there are several competitors at higher demand levels. However, as cost conditions of the electricity industry are that of a natural monopoly with an inverted U-shaped average cost curve and a large private demand for the product, it becomes clear that although a wide range of factors may have constrained the effectiveness of state regulation, it was not rendered entirely impotent, as was suggested by (Stigler and Friedland, 1962).

This result should be interpreted with caution as deregulation might have been intended to reduce prices but for reasons such as corruption, lack of transparency and hidden practices such an outcome was not achieved (Knittel, 2006; Neufeld, 2008). Following (Lyon and Wilson, 2012), the effect of regulation on prices alone is not a sufficient premise to conclude that state regulation is an instrument of "regulatory capture" other than a better contractual means of protecting specialized investments. They instead suggest that the effect of regulation on new private capacity investment should be the basis for such a conclusion since both the capture and contract theories are consistent with an increase in price.

[7] https://www.electricchoice.com/map-deregulated-energy-markets/

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[1]-https://www.renewablechoice.com/blog-municipal-franchise-agreements-14-09-10/

[2] https://www.eia.gov/tools/glossary/index.php?id=Generator%20capacity

[3, 5& 6] https://www.brightergy.com/how-to-make-sense-of-regulated-deregulated-energy-markets/

[7] https://www.electricchoice.com/map-deregulated-energy-markets/

Appendix

Table 2
Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$Price\_per\_kwh\_cents\ \zeta$	102	8.2907	3.2872	3.4000	25.1200
$DR\_Electricity$	102	0.3529	0.4802	0.0000	1.0000
$DR\_Electricity\_NaturlGas$	102	0.2941	0.4579	0.0000	1.0000
$Year$	102	0.5000	0.5025	0.0000	1.0000
$DR\_Electricity * Year$	102	0.1765	0.3831	0.0000	1.0000
$DR\_Electricity\_NaturlGas * Year$	102	0.1471	0.3559	0.0000	1.0000
$Urban\_Population\ \varsigma$	102	4277.5170	5590.6950	181.1490	35373.6100
$State\_Real\_Per\_Capita\_Inc\ \xi$	102	31.7628	12.7209	17.3920	116.1324
$Proportion\_of\_Hydro\_power\ \psi$	102	0.1081	0.1975	0.0000	0.9405
$Proportion\_of\_Natural\_Gas\ \vartheta$	102	0.1613	0.2139	0.0000	0.9799
$Price\_per\_kwh\_dollars\ \tau$	102	0.0829	0.0329	0.0340	0.2512
$Log(Urban\_Population)\ \varphi$	102	7.7404	1.1511	5.1993	10.4737
$Log(State\_Real\_Per\_Capita\_Inc)\ \phi$	102	3.4053	0.3056	2.8560	4.7547

ζ $cents, in\ kwh$ [Source: United States Energy Information Administration (EIA)]
ς $Thousands$ [Source: United States Census Bureau (UCB), 2010 Census – Urban and Rural Classification and Urban Area Criteria, Conversion to thousands done by the author by dividing by 1000]
ξ $Thousands, Chained\ in\ 1997\ dollars$ [Source: Bureau of Economic Analysis (UBEA), U.S. Department of Commerce, Conversion to thousands done by the author by dividing by 1000]
ψ $Output\ from\ Conventional\ Hydro\ Power\ divided\ by\ Total\ Output\ from\ all\ Sources$ [Source: United States Energy Information Administration (EIA), Conversion done by the author]
ϑ $Output\ from\ Natural\ Gas\ divided\ by\ Total\ Output\ from\ all\ Sources$ [Source: United States Energy Information Administration (EIA), Conversion done by the author]
τ $Dollars, in\ kwh, divided\ by\ 100$ [Source: Author's conversion from cents, in kwh to dollars, in kwh by dividing by 100, Thus, Coefficient on the logged regressors are interpreted directly without further division by 100]
φ $Thousands, in\ logarithm$
ϕ $Thousands, Chained\ in\ 1997\ dollars, in\ logarithm$

Table 3
Price per kWh for all Sectors for States considering at least Electricity Regulation/Deregulation, 1990 & 2010

Year	Regulated		Deregulated	
	States	Price_Per_kwh_cents	States	Price_Per_kwh_cents
1990	33	5.94	18	7.45
2010	33	8.97	18	12.20

Source: The author's

Table 4
Price per kWh for all Sectors for States considering both Electricity and Natural Gas Regulation/Deregulation, 1990 & 2010

Year	Regulated		Deregulated	
	States	Price_Per_kwh_cents	States	Price_Per_kwh_cents
1990	36	5.90	15	7.84
2010	36	9.02	15	12.71

Source: The author's