

*Senior Project*



*Department of Economics*

**“The Effect of Regional Transmission Operators  
on Price of Electricity in the United States”**

Sam Myers

May 2016

Advisor: *Dr. Francesco Renna*

## Abstract

For over 100 years, the electric industry in the United States was a vertically integrated monopoly. In 1996, the Federal Electric Regulatory Commission (FERC) began taking action to create competition in the United States electricity market. FERC orders 888 and 2000 created Independent System Operators (ISO) and Regional Transmission Organizations (RTO) to make the generation, transmission, and distribution of electricity more efficient and pass the efficiency gains onto consumers. This paper utilizes a panel data set of the years 1990-2014 for the continuous 28 states in order to estimate the effect the creation of a RTO has on the price of electricity. The creation of ISOs and RTOs has resulted in a decrease in the price of electricity by 2.5% in the state which they operate. When ISO and RTOs opened up the wholesale electricity market to competition the price of electricity dropped by 4.4%. Residential and commercial customers saw the majority of the price savings, while industrial customers actually saw an increase in the price of their electricity rates. This paper concludes that ISOs and RTOs have had the desired effect on the electricity market, of lowering the price of electricity for the majority of end use customers.

# Table of Contents

Abstract.....	2
Introduction.....	4
Literature Review.....	5
Theoretical Model Development .....	8
Model Specification & Results .....	9
Interpretation of Results.....	13
Conclusions and Suggestions for Future Study .....	14
Bibliography .....	17
Appendix.....	18
Figure 1: Regional Transmission Organizations and Independent System Operators in the United States .....	18
Table 1: Data descriptions and sources.....	20
Table 2. OLS estimation of LnPrice .....	21
Table 3: Fixed Effect estimates for RTO and RTOW .....	22
Table 4: Fixed Effect Models for Residential, Commercial, and Industrial customer classes.....	23
SAS Data.....	24

## Introduction

The United States electricity market operated as a vertically integrated monopoly for over 100 years. In 1996 the Federal Energy Regulatory Commission, or FERC, created order 888 which implemented new rules that led to the restructure of many electricity markets around the nation. Previously generation, transmission, and distribution was all done by a single utility. By way of order 888, and a later order 2000 in 1999, utilities were asked to divest generation, transmission, or distribution of their electric utility to Independent System Operators (ISO) and Regional Transmission Organizations (RTO). By the year 2000, most utility companies located under RTOs rule ceded control of their transmission assets. Regional Transmission Organizations allowed for all utility companies to share generation and transmission lines, allowing for companies to compete without paying high quasi-rents for participation in transmission. The Federal Energy Regulatory Commission believed that after the creation of RTOs, electricity would be transmitted more efficiently, and prices for the consumer would fall. The economic problem here is whether or not FERC's creation of RTOs has been beneficial to customers by dropping electricity prices or has had little to no effect on prices for electric customers. It is also important to know what type of customer is being affected by the creation of RTOs such as residential, commercial, or industrial customers. A map of these regional transmission organizations can be seen in Figure 1. From Figure 1, one can see all the currently operating RTOs as well as the groupings of states where RTOs have not been implemented.

This paper will examine the effect which the creation of RTOs has had on electricity rates in the United States by estimating the price function for electricity rates. While this is not a full on replication study, inspiration for the topic and econometric model have come from Dr. Kury's paper on the same topic (Kury). In order to estimate the effect a RTO has on the price of

electricity, a fixed effects model will be used with panel data of the 48 continuous United States through the years 1990-2013. The motivation behind this topic comes directly from the FERC's order 2000, and from the theoretical model mentioned above. FERC states in order 2000, "Thus, we believe that appropriate RTOs could successfully address the existing impediments to efficient grid operation and competition and could consequently benefit consumers through lower electricity rates resulting from a wider choice of services and service providers. In addition, substantial cost savings are likely to result from the formation of RTOs." The hypothesis which will be tested in this paper is that Regional Trade Organizations will decrease the price of electricity in the United States for end-use customers. Studies done in the past on this topic have yielded varied results, and the debate continues whether regional transmission organizations have actually decreased the price of electricity for end use customers.

## Literature Review

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

In 2007, Fabrizio, Rose, and Wolfram wrote this paper analyzing the effects on technical efficiency of shifting regulated monopolies to market based environments. The authors found that publically owned plants saw small efficiency gains, while privately owned plants saw larger

efficiency gains. Fabrizio, Rose, and Wolfram concluded that modest efficiency benefits were created by replacing a regulated monopoly with a market based industry structure.

**Greenfield, Daniel, and John Kwoka. "The Cost Structure of Regional Transmission Organizations." *Energy Journal* 32.4 (2011): 159-81.**

In 2011 authors Daniel Greenfield and John Kwoka created a paper to advance the understanding of RTO costs. Using a Cobb Douglas cost function and annual panel data for RTOs operating within the United States from 1998 to 2008, they found that the simulated costs of the average full-service RTO is in the range of \$130 million to \$210 million per year. A RTO simply providing open access transmission will have total costs of approximately \$55 million dollars. The authors also concluded that RTO costs are directly related to the number of market functions performed, such as rate making, price caps, and transmission regulation. The authors state this as unsurprising.

**Kury, Theodore J. "Price effects of independent transmission system operators in the United States electricity market." *Journal of Regulatory Economics* 43.2 (2013): 147-167.**

Theodore Kury, director of Energy Studies at the University of Florida, used panel data from the United States Department of Energy – Energy Information Administration dataset to identify tangible price effects resulting from the formation of regional transmission operators and independent system operators. Kury's used the following econometric model:

$$\begin{aligned} \Delta \ln Price_{it} = & \beta_0 \Delta \ln Sales + \beta_1 \Delta \ln P_{Coal_{it}} + \beta_2 \Delta \ln P_{Gas_{it}} + \beta_3 \Delta \% Hydro_{it} \\ & + \beta_4 \Delta \% Nuclear_{it} + \beta_5 \Delta RTO_{it} + \beta_6 \Delta RTO_{it-1} + \beta_7 \Delta RTO_{it-2} + \mu_{it} \end{aligned}$$

Using this model, Kury found that electricity prices fell 4.8% in the first two years after an ISO or RTO was formed. This 4.8% drop was dependent on a state restructuring their electricity market. When Kury removed states which had reconstructed their electricity market he found that the 4.8% decrease in electricity price actually became indistinguishable from zero. His findings refute part of the efficacy of these federally created RTOs and ISOs that they will reduce the price of electricity for the customer.

**Kwoka, John, Michael Pollitt, and Sanem Sergici. "Divestiture Policy and Operating Efficiency in U.S. Electric Power Distribution." *Journal of Regulatory Economics* 38.1 (2010): 86-109.**

In 2010, authors Kwoka, Pollitt, and Sergici, used time series data from the Department of Energy to find the effect which restructuring has on electricity prices. Using a data envelopment analysis, or DEA, the authors found that states which restructured had electricity prices 1.3% higher than predicted, while states that did not restructure had electricity prices 9.2% higher than predicted. The author states that there was a significant state variation in the data. Two thirds of states that restructured had lower energy prices than predicted, and One fourth of states who did not restructure were lower than predicted. This is important to consider since the variation must have been caused by a few states having a much higher increase in prices than most others.

**Taber, John T., Duane Chapman, and Timothy D. Mount. Examining the Effects of Deregulation on Retail Electricity Prices. Cornell University, Department of Applied Economics and Management, Working Papers: 127082, 2005.**

Researchers at Cornell University used data from the Energy Information Administration to investigate the success of deregulation on lowering retail energy prices. Taber, Chapman, and Mount found that there is no evidence to support the general expectation that deregulation would result in lower electricity prices. Their results showed that customers in deregulated states that saw declines in the real price of electricity were actually paying higher prices relative to customers in still-regulated states.

## Theoretical Model Development

The theoretical model used for this paper is a supply function used for price determination. This model is an inverse supply function which accounts for price as a function of quantity, input prices, and technology.

$$Price = \int (Quantity, input\ prices, technology, \dots)$$

In this instance, the quantity is being measured by the sales of electricity by state. The input prices are prices of electric generating resources such as coal and natural gas. Technology can be determined by the percentage of electricity generation from technology such as hydroelectric power and nuclear power. Since this theoretical model is a supply curve, the predicted coefficients for quantity, input prices, and technology variables will be believed to be positive values which would indicate an upward sloping supply curve.

Further theory involved in the formation of this research is the theory of monopoly versus competitive markets. The theory involved states that markets operating in a pure monopoly will charge a higher price for a widget to consumers. As competition is increased in a market, the



price will be pushed down by innovation and efficiency gains and create saving for the consumer. This theory is displayed graphically in graph 1 in the appendix.

## Model Specification & Results

Elaborating on the theoretical model of a supply function, the model specification can be developed by using key indicators located on the U.S. Energy Information Administration website. A cheap and as well as an expensive variable for resource price should be used in the model. In this particular model the price of coal and the price of natural gas will be used. Also a relatively cheaper and also a relatively more expensive source of electricity generation should be used taking into account the percentage of this generation technique. A state with available hydropower, which is cheaper than almost all alternatives, will be more likely to have a cheaper price for electricity and a lower coefficient than the coefficient representing a relatively more expensive generating technique such as nuclear power (Kury). In this particular model the percentage of hydroelectric generation and the percentage of nuclear generation will be used. Past research, and key indicators from the EIA suggest a model using panel data for state over time of:

$$\mathbf{Price}_{it} = \mathbf{a}_0 + \mathbf{\beta}_0 \mathbf{Sales}_{it} + \mathbf{\beta}_1 \mathbf{PCoal}_{it} + \mathbf{\beta}_2 \mathbf{PNatGas}_{it} + \mathbf{\beta}_3 \mathbf{PCTHydro}_{it} + \mathbf{\beta}_4 \mathbf{PCTNuclear}_{it} + \mathbf{\beta}_5 \mathbf{RTO}_{it} + \mu_{it}$$

**i:** State (Continuous 48 states)

**t:** Time (1990-2014)

**Price:** The average price of electricity

**$\alpha$ :** Fixed effects of the model

**Sales:** The total sales of electricity in megawatt hours

**PCoal:** The average price of coal for all end-use sectors in dollars per million BTU

**PNatGas:** The average price of natural gas for all end-use sectors in dollars per million BTU

**PCTHydro:** Percentage of electricity generation from hydroelectric sources

**PCTNuclear:** percentage of electricity generation from nuclear sources

**RTO:** Participation in a regional transmission organization

For this estimate, panel data was used, involving the 48 continuous states over the period of time 1990-2013. Full data descriptions and sources are depicted in Table 1 located in the appendix. The variable  $\alpha$  represents the fixed effects of this above model. These are effects such as the geographical location of the state, each states availability of low cost or high cost fuel, and the type of generation used for electricity. These are choices that the state must make for generating techniques which might affect price. While generating techniques are used in the model, the variable doesn't take into account a state's availability of these techniques, only the percentage of their use. A state's generation techniques are long lived assets and changes little over time. These heterogeneous characteristics such as geographical location and generating technique change very little over time by a given state. An example of this would be New England states which have little access to lower priced coal, and must use higher priced natural gas as fuel. This can lead to higher prices but their prices will change little over time given that they continue to use natural gas. Heterogeneous effects of  $\alpha$  can be removed by measuring this model using a two way fixed effect estimator.

The time of creation of each RTO and each state participant was used to create a dummy variable for participation and year of inclusion in an RTO. RTO is measured by the majority of a state participating in a regional transmission organization, not by full participation by the entire

state. This variable has limitations by not including portions of certain states that have partially participated in an RTO. There is a chance that a state participating in a regional transmission organization will have a lagged effect on the price of electricity, as the effect won't show up in the same year which a state joins a RTO. In order to account for this effect, the variable RTO must be lagged by one year in order to observe any effect which is lagged on price. In order to check for further lagged effects of RTO, I will lag RTO for one, two, and three years in various estimators of electricity price. The RTO variable may be limited also by when the RTO creates a whole sale market for electricity. The lagged variable RTO cannot account for when the wholesale market was created since it is different for each state and could take longer than 3 years for the wholesale market of electricity to begin, creating competition in the market. This will be remedied by estimating the model with the year the state began its wholesale market under a regional transmission organization. This variable will be denoted by **RTOW**.

In order to account for change over time, the variables price, sales, price of coal, and the price of natural gas will be logged in order to have each variable represent a percentage. After logging each of these variables, accounting for heterogeneous factors, and lagging RTO the new model will look like:

$$\begin{aligned}
 \ln Price_{it} = & a_i + \beta_0 \ln Sales + \beta_1 \ln PCoal_{it} + \beta_2 \ln NatGas_{it} \\
 & + \beta_3 PCTHydro_{it} + \beta_4 PCTNuclear_{it} + \beta_5 RTO_{it} + \beta_6 RTO_{it-1} \\
 & + \beta_7 RTO_{it-2} + \beta_8 RTO_{it-3} + \mu_{it}
 \end{aligned}$$

The very first estimation of the model began with using an OLS estimator without lagging the variable RTO. The results of this OLS can be found in table 2 in the appendix. The OLS results in table 2 show a large positive coefficient for RTO of 0.18484 significant at the

0.01% level. This estimate is troubling since it concludes that a state joining a RTO will result in an increase of 18.5% in the price of electricity for end use customers in that state. A small r-squared of 0.3920 shows that the model seems to be missing important variables or not taking into account certain aspects such as the geographical location or the long lived generating assets used in the state. These are heterogeneous characteristics which can be removed using a fixed effects model instead of an OLS model.

In order to better estimate the effect of a RTO on the price of electricity in a given state over time, a fixed effect model involving lags of the variable RTO was used and shown in Table 3, Panel A. The fixed effect model computed the RTO variable at -0.02499 which was significant at the 0.1% level. Lag1RTO, Lag2RTO, and Lag3RTO all were insignificant but it is important to note that the coefficients for these variables were negative or indistinguishable from zero. This model, shown in Table 3, Panel A, estimates that a state's participation in an RTO will have a -2.5% decrease on the price of electricity in that state. This fixed effect model's R-squared raised to 0.9510 and has a much smaller error than the results using OLS.

In order to see not only the effect of the creation of an RTO but the creation of the competitive wholesale market for electricity, a fixed effect model was estimated in Table 3, Panel B. The wholesale of electricity in a state is important to move the market from a monopoly to a more competitive one. As seen in Table 3, Panel B, RTOW was estimated at -0.04406% and is significant at the 0.01% level, proving to have a stronger correlation with the price of electricity than just the creation of a RTO variable. Lag1RTO, Lag2RTO, and Lag3RTO are all insignificant as they were in the previous model. The model for RTOW raised very small in R-squared up to 0.9512 and the error decreased very little comparing to the model for the creation of a RTO. Using this fixed effect model, one can state that the creation of an

RTO whole sale market for electricity in a given state will have a -4.4% decrease on the price of electricity in a given state.

In order to understand what type of customer is being effected the most by the creation of a RTO, a fixed effect model for residential, commercial, and industrial customers were all ran separately and shown in Table 2 in the appendix. Variables for price and sales were changed for each of these models in order to reflect only data for each specific customer class being estimated. Residential customers saw a decrease of -3.3% on the price of their electricity after their state joined a RTO. Commercial customers have a slightly smaller decrease in the price of electricity with a decrease of -3.1%. Industrial customers of electricity saw an insignificant effect of an RTO on the price of electricity. Lag3RTO is the only variable for RTO which had any type of significance, at the 0.1% level and found an increase in the price of electricity of 3.7%.

## Interpretation of Results

Using a fixed effects model for the estimation of the effect of regional transmission organizations on the price of electricity in a given state over time, the creation of an RTO will result in a decrease in the price of electricity by 2.5%. When a state creates a wholesale electricity market, in order to increase competition, the price of electricity will decrease 4.4%. The creation of an RTO might save customers 2.5% overall on their electric bill, certain customer classes see more of the advantages gained by efficiencies from the creation of an RTO. Residential customers such as a family of four living in a house, will save 3.3% on their electric bill if they live in a state who joined an RTO. Commercial businesses such as a tanning salon

will see a decrease of 3.1% on their electric bill after their state joins a RTO. A company which makes the magnetic strips for credit cards will actually see an increase of 3.7% on the electric bill for their company buildings after the state they do business in joins a regional transmission organization. Overall, end use customers gained more, in the form of lower prices, after competition was increased in the market for electricity production, transmission, and distribution. The creation of the wholesale market for electricity saved customers more money than just the creation of the RTO.

## Conclusions and Suggestions for Future Study

The Federal Electric Regulatory Commission created Regional Transmission Organizations under the belief that they will benefit customers as well as utilities making utilities more efficient and allow the customers to reap benefits in the form of lower electricity rates. The goal of this research was to find out if customers were benefiting in the form of lower prices after RTOs were created. After conducting this research, one can draw the conclusion that the creation of a RTO in a state will result in a drop of the price of electricity in that state. However, this research wasn't without its flaws. One would believe the econometric model estimated should have positive coefficients since the model is a supply curve which should be upward facing. In all the models run, the coefficient for sales was negative. The sign is troubling and leads me to believe that there are other problems in the model. Previous research mentions an endogeneity problem between Price and Sales which perhaps is hindering the fixed effect models from being a valid estimator. A 2SLS will need to be run in order to properly estimate an RTO's effect on the price of electricity. Possible instrumental variables can be heating and cooling days, per capita income, and population all variables by state and year. Even if price has

endogeneity problems with the sales of electricity, heating and cooling days, income, and population would not, allowing for a better estimation of the model. These instrumental variables will need to be used in two-staged least squared analysis.



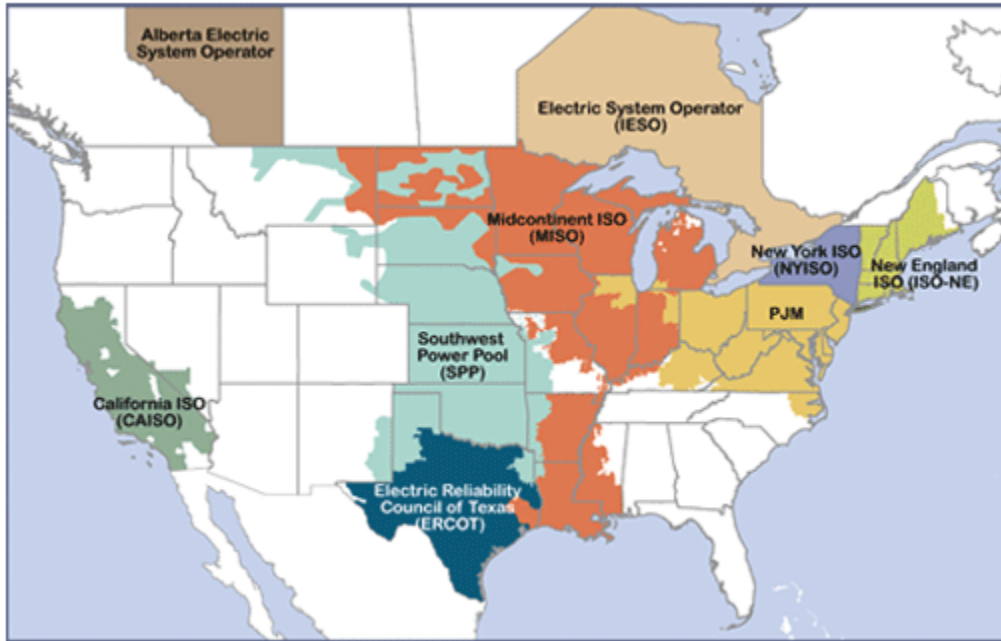


## Bibliography

- Fabrizio, K. R., Rose, N. L., & Wolfram, C. D. (2007). "Do markets reduce costs? Assessing the impact of regulatory restructuring on U.S. electric generation efficiency." *American Economic Review*, 97(4), 1250–1277.
- Greenfield, Daniel, and John Kwoka. "The Cost Structure of Regional Transmission Organizations." *Energy Journal* 32.4 (2011): 159-81.
- Haymes, A., Gish, B., & Apperson, J. (1999). *United States of America, Federal Energy Regulatory Commission, 18 CFR Part 35: , Regional transmission organization (issued December 20, 1999)* (United States, FERC). Washington, DC: United States Federal Energy Regulatory Commission.
- Kury, Theodore J. "Price effects of independent transmission system operators in the United States electricity market." *Journal of Regulatory Economics* 43.2 (2013): 147-167.
- Kwoka, John, Michael Pollitt, and Sanem Sergici. "Divestiture Policy and Operating Efficiency in U.S. Electric Power Distribution." *Journal of Regulatory Economics* 38.1 (2010): 86-109.
- Taber, John T., Duane Chapman, and Timothy D. Mount. *Examining the Effects of Deregulation on Retail Electricity Prices*. Cornell University, Department of Applied Economics and Management, Working Papers: 127082, 2005.

# Appendix

Figure 1: Regional Transmission Organizations and Independent System Operators in the United States



Source 1: <http://www.ferc.gov/industries/electric/indus-act/rto.asp>

Graph 1: Competitive Markets versus Pure Monopolies

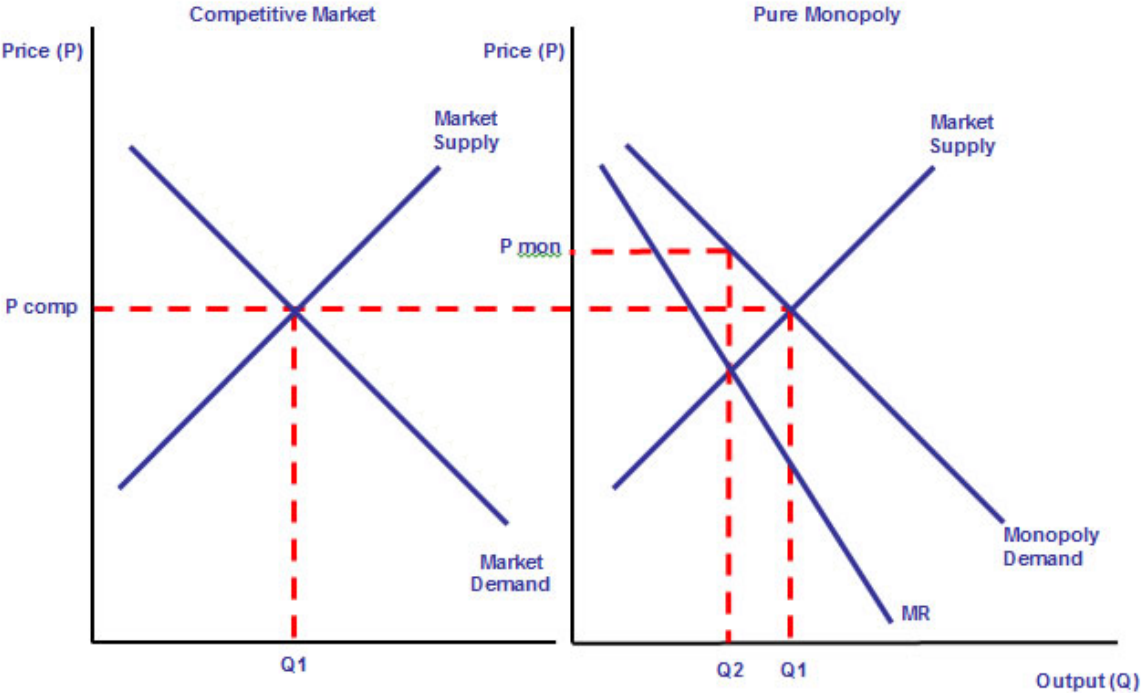


Table 1: Data descriptions and sources

<b>Variable description. Years Included. (Dataset) Location Found. Manipulation</b>
<b>lnPrice:</b> Average Retail Price of Electricity. 1990-2014. (EIA-861) U.S. Department of Energy – U.S. Energy Information Administration. The log is taken in order to show a percentage.
<b>lnSales:</b> Total Sales to All Customers. 1990-2014. (EIA-861) U.S. Department of Energy – U.S. Energy Information Administration. The log is taken in order to show a percentage.
<b>lnPCoal:</b> Average price of coal for all end-use sectors, in dollars per million BTU. 1990-2014. (SEDS) U.S. Department of Energy – U.S. Energy Information Administration – State Energy Data System (SEDS). The log is taken in order to show a percentage.
<b>lnPNatGas:</b> Average price of natural gas for all end-use sectors, in dollars per million BTU. 1990-2014. (SEDS) U.S. Department of Energy – U.S. Energy Information Administration – State Energy Data System (SEDS). The log is taken in order to show a percentage.
<b>PCTHydro:</b> Percentage of Electricity Generation from Hydroelectric Sources. 1990-2013. (EIA-906) U.S. Department of Energy – U.S. Energy Information Administration.
<b>PCTNuclear:</b> Percentage of Electricity Generation from Nuclear Sources. 1990-2013. (EIA-906) U.S. Department of Energy – U.S. Energy Information Administration.
<b>RTO:</b> Whether the majority of the electric customers in the state are served by a utility that belongs to a RTO. Collected by The Federal Electric Regulatory Commission website, and each separate RTO/ISO companion websites for state participation and year of induction. Dummy Variable
<b>Lag1RTO:</b> This is a lagged dummy variable which is stated as 1 if an RTO was created one year previous.
<b>Lag2RTO:</b> This is a lagged dummy variable which is stated as 1 if an RTO was created two years previous.
<b>Lag3RTO:</b> This is a lagged dummy variable which is stated as 1 if an RTO was created three years previous.

Table 2. OLS estimation of LnPrice

Variable	Parameter	Error	Pr >  t	Significance
<b>Intercept</b>	1.9473	0.1486	<.0001	***
<b>lnSales</b>	-0.0282	0.0082	0.0006	***
<b>lnPCoal</b>	0.0187	0.0069	0.0068	**
<b>lnPNatGas</b>	0.22523	0.0241	<.0001	***
<b>%Hydro</b>	-0.1699	0.0389	<.0001	***
<b>%Nuclear</b>	0.4428	0.0428	<.0001	***
<b>RTO</b>	0.1848	0.0179	<.0001	***
<b>R-sq: 0.3956</b> <b>Adj R-Sq: 0.3920</b> <b>SSE: 56.78748</b> <b>F-Value: 109.20 Pr &gt; F: &lt;0.0001</b> <b>N: 1008</b> * - Significant at the 0.1% level ** - Significant at the 0.05% level *** - Significant at the 0.01% level				

Table 3: Fixed Effect estimates for RTO and RTOW

Variable	Panel A (RTO)		Panel B (RTOW)	
	Parameter (Error)	Pr >  t	Parameter (Error)	Pr >  t
Intercept	<b>8.0051</b> (0.6439)	<.0001***	<b>7.6536</b> (0.6472)	<.0001***
lnSales	<b>-0.37853</b> (0.0386)	<.0001***	<b>-0.3578</b> (0.0388)	<.0001***
lnPCoal	<b>0.0104</b> (0.0023)	<.0001***	<b>0.0105</b> (0.0023)	<.0001***
lnPNatGas	<b>0.0860</b> (0.0238)	.0003***	<b>0.0873</b> (0.0236)	.0002***
%Hydro	<b>-0.0437</b> (0.0395)	0.2691	<b>-0.0568</b> (0.0393)	0.1481
%Nuclear	<b>-0.0580</b> (0.0413)	0.1611	<b>0.0643</b> (0.0411)	0.1188
RTO(w)	<b>-0.0250</b> (0.0134)	0.0634*	<b>-0.0441</b> (0.0138)	0.0014***
Lag1RTO(w)	<b>-0.0067</b> (0.0175)	0.7008	<b>0.0003</b> (0.0185)	0.9851
Lag2RTO(w)	<b>-0.0021</b> (0.0178)	0.9056	<b>0.0208</b> (0.0190)	0.2727
Lag3RTO(w)	<b>0.0007</b> (0.0139)	0.9572	<b>0.0144</b> (0.0147)	0.3261
<b>Model 1</b>	<b>R-Sq: 0.9510 SSE: 4.6013 DF: 67</b>			
	<b>F-Value: 148.93 Pr &gt; F: &lt;0.0001</b>			
<b>Model 2</b>	<b>R-Sq: 0.9512 SSE: 4.5834 DF: 67</b>			
	<b>F-Value: 135.69 Pr &gt; F: &lt;0.0001</b>			
* - Significant at the 0.1% level				
** - Significant at the 0.05% level				
*** - Significant at the 0.01% level				

Table 4: Fixed Effect Models for Residential, Commercial, and Industrial customer classes

Variable	Model 1 (Residential)		Model 2 (Commercial)		Model 3 (Industrial)	
	Parameter (Error)	Pr >  t	Parameter (Error)	Pr >  t	Parameter (Error)	Pr >  t
Intercept	<b>8.4761</b> (0.6723)	<.0001***	<b>3.1443</b> (0.3223)	<.0001***	<b>3.3732</b> (0.0357)	<.0001***
lnSales	<b>-0.4299</b> (0.0451)	<.0001***	<b>-0.0831</b> (0.0208)	<.0001***	<b>-0.1226</b> (0.0187)	<.0001***
lnPCoal	<b>0.0088</b> (0.0022)	<.0001***	<b>0.0068</b> (0.0025)	0.0070***	<b>0.0127</b> (0.0031)	<.0001***
lnPNatGas	<b>0.0832</b> (0.0222)	.0002***	<b>0.0872</b> (0.0257)	0.0007***	<b>0.1260</b> (0.0321)	<.0001***
%Hydro	<b>-0.0225</b> (0.0370)	0.5429	<b>-0.0339</b> (0.0427)	0.4275	<b>-0.0835</b> (0.0534)	0.01182
%Nuclear	<b>0.0712</b> (0.0387)	0.0659*	<b>0.0793</b> (0.0449)	0.0778*	<b>-0.0156</b> (0.0562)	0.7811
RTO	<b>-0.0334</b> (0.0126)	0.0085***	<b>-0.0313</b> (0.0146)	0.0320**	<b>-0.0112</b> (0.0182)	0.5406
Lag1RTO	<b>-0.0064</b> (0.0164)	0.7008	<b>0.0021</b> (0.0190)	0.9124	<b>-0.0153</b> (0.0237)	0.5197
Lag2RTO	<b>-0.00191</b> (0.0167)	0.9056	<b>-0.0010</b> (0.0193)	0.9585	<b>-0.0022</b> (0.0242)	0.9273
Lag3RTO	<b>-0.0120</b> (0.0131)	0.9572	<b>0.0083</b> (0.0151)	0.5835	<b>0.0365</b> (0.0189)	0.0540*
<b>Model 1</b>	<b>R-Sq: 0.9479 SSE: 4.0346 DF: 67 F-Value: 139.17 Pr &gt; F: &lt;0.0001</b>					
<b>Model 2</b>	<b>R-Sq: 0.9278 SSE: 5.4205 DF: 67 F-Value: 105.23 Pr &gt; F: &lt;0.0001</b>					
<b>Model 3</b>	<b>R-Sq: 0.9246 SSE: 8.4648 DF: 67 F-Value: 79.39 Pr &gt; F: &lt;0.0001</b>					
* - Significant at the 0.1% level						
** - Significant at the 0.05% level						
*** - Significant at the 0.01% level						

## SAS Data

```
%let dir=C:\Users\myers\Dropbox\Sam; /* change this line to match your drive
like e:\ */
libname sam 'C:\Users\myers\Dropbox\Sam';
```

```
/****** PART ONE *****/
```

```
PROC IMPORT OUT= WORK.energyprices
            DATAFILE= "&dir\EnergyPrices.xls"
            DBMS=xls REPLACE;
            SHEET='sasdata';
            RUN;
```

```
Data work.energyp;
    set work.energyprices;
    select=0;
    if MSN= 'CLTCD' OR MSN= 'ESTCD' OR MSN= 'NGTCD' Then select=1; /* to
add another variable add another msn=varname */
    if state= 'DC' or state= 'US' then select = 0;
    if select=0 then delete;
    drop select;
    run;
```

```
proc freq data=work.energyp;
    tables msn;
    run;
```

```
proc sort data=energyp;
    by msn state;
    run;
```

```
proc transpose data=energyp out=energypt;
    var Y1990-Y2013;
```

```
    by msn state;
    run;
```

```
Data work.energypt2 work.cltcd work.estcd work.ngtcd;
    set work.energypt;
    drop _label_ _name_;
    length year 8.;
    _name_=substr(_name_,2,4); /* strip out the y on the year date */
    year=_name_;
```

```
    if MSN= 'CLTCD' then output work.cltcd;
    if MSN= 'ESTCD' then output work.estcd;
    if MSN= 'NGTCD' then output work.ngtcd;
    output work.energypt2;
    run;
```

```
data work.cltcd;
    set work.cltcd;
    drop COL1;
    cltcd=COL1;
    run;
```

```
data work.estcd;
```



```

        set work.estcd;
        drop COL1;
        estcd=COL1;
        run;

data work.ngtcd;
    set work.ngtcd;
    drop COL1;
    ngtcd=COL1;
    run;
proc sort data=work.cltcd; by year state; run;
proc sort data=work.estcd; by year state; run;
proc sort data=work.ngtcd; by year state; run;

Data sam.energypt3; /* writing permanent sas dataset */
    merge work.cltcd work.estcd work.ngtcd;
    by year state;
    drop MSN;
    run;

/***** PART TWO *****/

PROC IMPORT OUT= work.rto
    DATAFILE= "&dir\rto.xlsx"
    DBMS=xlsx REPLACE;
    sheet=sasdata;
    run;

PROC IMPORT OUT= work.generation
    DATAFILE= "&dir\annual_generation_state.xls"
    DBMS=xls REPLACE;
    sheet=sasdata;
    run;

PROC IMPORT OUT= work.salesrevenue
    DATAFILE= "&dir\sales_revenue.xls"
    DBMS=xls REPLACE;
    sheet=sasdata;
    run;

data work.rto;                set work.rto;                if year<1990 then
delete; run;
data work.generation;        set work.generation;        if year<1990 then delete;
run;
data work.salesrevenue;      set work.salesrevenue;      if year<1990 then delete;
run;

proc sort data=work.rto;                by year state; run;
proc sort data=work.generation;        by year state; run;
proc sort data=work.salesrevenue;      by year state; run;

Data sam.energyfinal; /* writing permanent sas dataset */
    merge work.rto work.generation work.salesrevenue sam.energypt3;
    by year state;
    if year >2013 then delete;
    if state="AK" or state="HI" or state="US" or state="DC" then delete;

```

```

run;

proc sort data=sam.energyfinal;
  by state year;
run;

Data sam.energylags;
  set sam.energyfinal;

  lntot_price_cents_kwh=log(tot_price_cents_kwh);
  lnres_price_cents_kwh=log(res_price_cents_kwh);
  lncom_price_cents_kwh=log(com_price_cents_kwh);
  lnind_price_cents_kwh=log(ind_price_cents_kwh);
  lntot_sales_megawatthours=log(tot_sales_megawatthours);
  lnres_sales_megawatthours=log(res_sales_megawatthours);
  lncom_sales_megawatthours=log(com_sales_megawatthours);
  lnind_sales_megawatthours=log(ind_sales_megawatthours);

  if cltcd <=0 then cltcd=.0001; /* missing or 0 values in RI and
VT */
  lncltcd=log(cltcd);

  lnngtcd=log(ngtcd);

  pcthydro      =hydro/total_mwh;
  pctnuclear    =nuclear_mwh/total_mwh;

  dlncprice      =dif(lntot_price_cents_kwh);
  dlncsales      =dif(lntot_sales_megawatthours);
  dlncpcoal      =dif(lncltcd);
  dlncpnatgas    =dif(lnngtcd);

  dpcthydro      = dif(pcthydro);
  dpctnuclear    = dif(pctnuclear);

/* rto */
LAG1RTO=Lag(RTO);
LAG2RTO=lag2(RTO);
LAG3RTO=lag3(RTO);
if year=1990 then do;
  lag1rto      =.;
  lag2rto      =.;
  lag3rto      =.;
  dlncprice    =.;
  dlncpcoal    =.;
  dlncsales    =.;
  dlncpnatgas  =.;
  dpcthydro    =.;
  dpctnuclear  =.;
end;

if year=1991 then do;
  lag2rto      =.;
  lag3rto      =.;
end;

```

```

        if year=1992 then do;
            lag3rto          =.;
            end;

drto          =dif(rto);
dlag1rto      =dif(lag1rto);
dlag2rto      =dif(lag2rto);
dlag3rto      =dif(lag3rto);
/* rtow */
LAG1RTOW=Lag (RTOW);
LAG2RTOW=lag2 (RTOW);
LAG3RTOW=lag3 (RTOW);
if year=1990 then do;
    lag1rtow          =.;
    lag2rtow          =.;
    lag3rtow          =.;
    end;

if year=1991 then do;
    lag2rtow          =.;
    lag3rtow          =.;
    end;

if year=1992 then do;
    lag3rtow          =.;
    end;

drtow         =dif(rtow);
dlag1rtow     =dif(lag1rtow);
dlag2rtow     =dif(lag2rtow);
dlag3rtow     =dif(lag3rtow);

run;

proc print data=sam.energylags;
    var state year lntot_price_cents_kwh lnprice rto lag1rto lag2rto
lag3rto;
run;

Proc contents data=sam.energyfinal;
run;
proc means data=sam.energylags;
run;

ods pdf file='C:\Users\myers\Dropbox\Sam\RTOnew.pdf';
options orientation=portrait;
Proc reg data=sam.energylags s;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto ;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto ;

```

```

        model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto lag3rto;
run;
/*
proc reg data=sam.energylags s;
    model dlnprice = dlnsales dlnpcoal dlnpntgas dpcthydro dpctnuclear
drto /noint;
    model dlnprice = dlnsales dlnpcoal dlnpntgas dpcthydro dpctnuclear
drto dlag1rto /noint;
    model dlnprice = dlnsales dlnpcoal dlnpntgas dpcthydro dpctnuclear
drto dlag1rto dlag2rto /noint ;
    model dlnprice = dlnsales dlnpcoal dlnpntgas dpcthydro dpctnuclear
drto dlag1rto dlag2rto dlag3rto /noint;
run;
*/
data work.sam;                                /* writes out a work.sam dataset */
    set sam.energylags;
    if year < 1993 then delete; /* eliminates missing data for lags */
run;
proc sort data=work.sam; by state year; run;
proc panel data=work.sam;
id state year;

model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixtwo;
run;

/*
proc panel data=work.sam ;
id state year ;

model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixone;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixone;
model lntot_price_cents_kwh =lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixone;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixone;
run;
*/
ods pdf close;

ods pdf file='C:\Users\myers\Dropbox\Sam\rtownew.pdf';
options orientation=portrait;
Proc reg data=sam.energylags s;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rtow;

```

```

    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rtow lag1rtow;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rtow lag1rtow lag2rtow ;
    model lntot_price_cents_kwh = lntot_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rtow lag1rtow lag2rtow lag3rtow;
run;
/*
proc reg data=sam.energylags s;
    model dlnprice = dlnsales dlnpcoal dlnpnatgas dpcthydro dpctnuclear
drtow /noint;
    model dlnprice = dlnsales dlnpcoal dlnpnatgas dpcthydro dpctnuclear
drtow dlag1rtow /noint;
    model dlnprice = dlnsales dlnpcoal dlnpnatgas dpcthydro dpctnuclear
drtow dlag1rtow dlag2rtow /noint ;
    model dlnprice = dlnsales dlnpcoal dlnpnatgas dpcthydro dpctnuclear
drtow dlag1rtow dlag2rtow dlag3rtow /noint;
run;
*/
data work.sam;                                /* writes out a work.sam dataset */
    set sam.energylags;
    if year < 1993 then delete; /* eliminates missing data for lags */
run;
proc sort data=work.sam; by state year; run;
proc panel data=work.sam;
id state year;

model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow lag2rtow /fixtwo;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow lag2rtow lag3rtow /fixtwo;
run;

/*
proc panel data=work.sam printfixed;
id state year ;

model lntot_price_cents_kwh =lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow /fixone;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow /fixone;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow lag2rtow /fixone;
model lntot_price_cents_kwh = lntot_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rtow lag1rtow lag2rtow lag3rtow /fixone;
run;
*/
ods pdf close;

ods pdf file='C:\Users\myers\Dropbox\Sam\RTO_RES.pdf';
options orientation=portrait;
Proc reg data=sam.energylags s;

```

```

    model lnres_price_cents_kwh = lnres_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto ;
    model lnres_price_cents_kwh = lnres_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto;
    model lnres_price_cents_kwh = lnres_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto ;
    model lnres_price_cents_kwh = lnres_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto lag3rto;
run;

data work.sam;                                /* writes out a work.sam dataset */
    set sam.energylags;
    if year < 1993 then delete; /* eliminates missing data for lags */
run;
proc sort data=work.sam; by state year; run;
proc panel data=work.sam;
id state year;

model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixtwo;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixtwo;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixtwo;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixtwo;
run;

/*
proc panel data=work.sam ;
id state year ;

model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixone;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixone;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixone;
model lnres_price_cents_kwh = lnres_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixone;
run;
*/
ods pdf close;

ods pdf file='C:\Users\myers\Dropbox\Sam\RTO_COM.pdf';
options orientation=portrait;
Proc reg data=sam.energylags s;
    model lncom_price_cents_kwh = lncom_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto ;
    model lncom_price_cents_kwh = lncom_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto;
    model lncom_price_cents_kwh = lncom_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto ;
    model lncom_price_cents_kwh = lncom_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto lag3rto;

```

```

run;

data work.sam;                                /* writes out a work.sam dataset */
    set sam.energylags;
    if year < 1993 then delete; /* eliminates missing data for lags */
run;

proc sort data=work.sam; by state year; run;
proc panel data=work.sam ;
id state year;

model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixtwo;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixtwo;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixtwo;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixtwo;
run;

/*
proc panel data=work.sam ;
id state year ;

model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixone;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixone;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixone;
model lncom_price_cents_kwh = lncom_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixone;
run;
*/
ods pdf close;

ods pdf file='C:\Users\myers\Dropbox\Sam\RTO_IND.pdf';
options orientation=portrait;
Proc reg data=sam.energylags s;
    model lnind_price_cents_kwh = lnind_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto ;
    model lnind_price_cents_kwh = lnind_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto;
    model lnind_price_cents_kwh = lnind_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto ;
    model lnind_price_cents_kwh = lnind_sales_megawatthours LNCLTCD LNNGTCD
pcthydro pctnuclear rto lag1rto lag2rto lag3rto;
run;

data work.sam;                                /* writes out a work.sam dataset */
    set sam.energylags;
    if year < 1993 then delete; /* eliminates missing data for lags */
run;

```

```

proc sort data=work.sam; by state year; run;
proc panel data=work.sam ;
id state year;

model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixtwo;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixtwo;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixtwo;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixtwo;
run;

/*
proc panel data=work.sam ;
id state year ;

model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto /fixone;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto /fixone;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto /fixone;
model lnind_price_cents_kwh = lnind_sales_megawatthours lncltcd lnngtcd
pcthydro pctnuclear rto lag1rto lag2rto lag3rto /fixone;
run;
*/
ods pdf close;

```