An evaluation of electricity market restructuring: analysis based in the U.S. and Canada

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Abstract

What factors affect electricity rates in the electricity market? This is a simple question with a complicated answer. The use of electricity is very universal. Electricity is one of the sources for of progress for human civilization. Wherever there is a market, there is some competition. However, some industrial fields are resistant to competition. The electricity market is one of them. In electricity markets, deregulation has been undertaken for more than two decades. The purpose of this paper is to examine how the deregulation of the electricity markets in the U.S. and Canada affects electricity rates. In the statistical tests, I set four different rates as dependent variables： total rates, residential rates, commercial rates and industrial rates. The estimation results reveals that electricity deregulation in the U.S. and Canada is a failed experiment and the costs are borne by the residential consumers. Unexpectedly, commercial and industrial consumers are not affected by deregulation based on the test results[1].

[1] In the models which commercial and industrial rates are dependent variables, the deregulation variable is not statistical significant.

1 Introduction

What factors affect electricity rates in the electricity market? In order to answer this simple question, a lot of background factors need to be considered. The use of electricity is universal. As the major source of energy, Electricity powers the progress of civilization. When there is a market, competition always exists. However, not every industrial field is completely open to competition. The electricity market is one of them. In electricity market, deregulation of electricity has been undertaken for more than two decades. The deregulated industries, especially the deregulated electricity industry, has received attention from both governments and the public constantly. However, in the electricity industry, deregulation is much more complicated than it is in other industries. Joskow (2006) mentions that even though deregulation programs had a great success in many market sectors, such as airlines, trucking, telecommunications and natural gas, in the electricity sector, deregulation generates a lot of negative effects. Electricity industry has many special characteristics. One of them is the fact that its supply and demand must be matched with each other at all moment. In other words, there is little capacity for electricity storage. This unique characteristic attracts economists and analysts to study this industry. Electricity deregulation is one of the most frequent discussed topics in the field of economy.

The purpose of deregulation is to allow every actor in the market to compete more freely with each other and to make rates more affordable for customers in this process. Meanwhile, less oversight results in cost reduction by government as well. After implementing deregulation for such a long period of time, what changes does it bring to electricity rates? In this paper, the effects of deregulation on electricity rates are examined while taking into account other explanatory variables. The aim of this paper is to investigate the impacts of deregulation, cooling degree days, energy efficiency programs, share of residential sales, share of industrial sales, share of electricity generated by coal, share of electricity generated by nuclear, share of electricity generated by coal, share of electricity generated by hydro and income per capita on electricity rates.

In this paper, the study is solely based on U.S. and Canada. Data from forty-eight states from U.S. and nine provinces of Canada are built into the dataset. Binary variables are used to distinguish the deregulation area and non-deregulation area. The source of deregulation status for U.S. is from U.S. Energy Information Administration and the evidence of deregulation status in Canada is based on observational reports. There are four categories of electricity rates analyzed in this paper. Total electricity rates, residential electricity rates, commercial electricity rates and industrial electricity rates are treated as dependent variables in four regression models.

The OLS estimation method is used to measure the relationship between a dependent variable and several explanatory variables. In my results, deregulation shows significance only in the residential rates model (U.S. Data only). Residents who live in the areas with deregulated electricity sectors will bear 10.4% higher rates than residents who live in the area without deregulation. The result does not turn out my expectation which deregulation in electricity market should lower the electricity rates properly. On the contrary, the data present us the electricity deregulation in the U.S. and Canada is a failed experiment and the costs are borne by the residential consumers. What’s more, in the cases of commercial and industrial rates, deregulation does not have statistical significant impact on them. In conclusion, electricity deregulation does not turn out the results as expected. For the other determinants, high share of coal-fired power generation and hydro power generation are result in low electricity rates. As a matter of fact, spending on Energy Efficiency Programs increases the electricity rates.

The major research paper is structured as following: Section 1 is the Introduction. Section 2 presents a literature review including definitions, empirical findings and basic information on the electricity market.

In Section 3 is an overview of the model specification. Section 4 states data and method description. The last two sections present the results and brief conclusions.

2 Literature Review

2.1 Why Do We Need Deregulation

Electricity deregulation has been discussed and developed for quite a long time. In order to understand why it has been discussed so much, it is helpful to know the basic elements of this industry. Joskow (2006) makes an overview of electricity sector liberalization over the previous 20 years. After UK implemented privatization and restructuring program in the early ninety's, several countries followed UK's lead and implemented comprehensive electricity sector reform programs. Joskow (2006) argues that there is no mandatory comprehensive federal restructuring law that applies to the U.S.. Most states in the U.S. have limited liberalization reforms in the wholesale markets. According to the latest recording from EIA, there are 14 states whose deregulation status are active. However, deregulation programs had a great success in many different market sectors, such as airlines, trucking, telecommunications, and natural gas.

Joskow (2006) analyses several reasons to explain the motivations of implementing deregulation. The most essential point is to give consumers the rights to choose the retail power supplier they prefer. "Retail power supplier offering the price and service quality combination that best meet their needs", (Joskow, 2006, p. 11). He also proposes various approaches to measure the effects of liberalization reforms, for instance, using time series data to analysis the effects and making comparisons between different countries and states. In Joskow's lessons learned, he regards the electricity sector reform in England and Wales as the gold standard, because the reform followed the basic architecture of the textbook model[2] and had significant performance effects on many dimensions. On the generation side, competitive wholesale electricity networks carry out enormous incentives which can reduce generator operating costs and improve generation availability. Meanwhile, deregulation can create a well-functioning transmission investment framework. However, in many countries or states where electricity liberalization has been implemented, transmission investment do not keep pace with the development.

In Joskow (1997)'s earlier paper, he states an overview of regulatory reform in the U.S. electricity sector and how essential the role electricity market is in the whole economy. It has been considered as a long and sophisticated process for a sector which has been thought as a natural monopoly to implement reform in numerous states. The core concept is letting consumers to choose their own generation service suppliers from a large number of competing groups. "While the basic model for structural and regulatory reform in electricity is fairly straightforward, the details of the institutional reforms that are necessary to improve on the performance of the present U.S system are complex" (Joskow, 1997, p. 120).

Joskow (2006) reaches the conclusion that it is important to make a strong political commitment. This commitment includes technical, institutional and political challenges. There are also significant performance problems when reforms are introduced. However, challenges and problems do not imply restructuring, regulatory reform and development of the competitive wholesale market are ill-considered. There are always many solutions and several approaches at hand. One of the primary questions is how to make people know reforms in electricity markets will lead to a more efficient markets and better performance. (Joskow, 2006)

2.2 Successful Examples and Objections

[2] Textbook model includes privatization of state-owned enterprises, vertical and horizontal restructuring to facilitate competition, PBR regulation, etc.

Zarnikau and Adib (2007) study the success of the Electric Reliability Council of Texas (ERCOT)[3] market. In this market, high customer switching rates exist and competition is enforced in many segments. Consumers have been provided with new choices of suppliers and services. Compared to the California market, many issues are avoided. In reality, the market still faces a few elusive policy problems and challenges. One of them is the electricity prices. “Electricity consumers in the competitive areas of Texas face much higher electricity prices than their neighbors in areas not opened to retail competition” (Zarnikau and Adib, 2007, p. 1). According to the 2011’s electricity rates, New Mexico and Louisiana residential, commercial and industrial electricity rates are relatively lower than Texas’.

“Texas law permits traditional utility providers to remain involved in both regulated and competitive activities” (Zarnikau and Adib, 2007, p. 3). There is still regulatory oversight on both transmission and distribution. The commission also sets rules and places a few limitations on the information exchange between regulated activities and competitive markets. Meanwhile, there are some concerns behind the successful performance. Restructuring can reduce the price pressure and increase the price of an area where restructuring took place. According to the residential price data in Texas from 1998 to 2006, there is an obvious upward trend, especially for the last ten years.

Zarnikau and Adib (2007) conclude that there are also challenges that need to be addressed by the policy makers, such as retail competition, demand response, market power restriction, long-term resource adequacy and implementing a nodal wholesale market structure.

[3] The Electric Reliability Council of Texas (ERCOT) manages the flow of electric power to 23 million Texas customers- representing 85 percent of the state’s electric load. As the independent system operator for the region, ERCOT schedules power on an electric grid that connects 40,500 miles of transmission lines and more than 550 generation units. ERCOT also performs financial settlement for the competitive wholesale bulk-power market and administers retail switching for 6.7 million premises in competitive choice areas. ERCOT’s members include consumers, cooperatives, generators, power marketers, retail electric providers, investor-owned electric utilities and municipal owned electric utilities. Source from ERCOT.

Banks (2002) declares that deregulation is a failure in an OPEC review paper. Deregulation does not bring lower and affordable prices for customers. Some serious failures occur, like the cases in California, Alberta and Brazil.

Banks (2002) mentions that the price risk is increased with deregulation. Deregulation itself is an uncertain process. Electricity prices may increase during the transition toward competition and uncertainty can bring investment to decline. According to Woo, Lyoyd and Tishler (2003), "electricity reform is highly risky and irreversible. The California experience surely suggests that a reversible regulatory reform is a safe alternative to an irreversible market reform". They provide an assessment for some areas where reforms have already happened, such as UK, Norway, Alberta and California, "the introduction of a competitive generation market, of itself, has failed to deliver reliable service at low and stable prices" (Woo, Lloyd and Tishler, 2003, p. 1).

2.3 Difficulties and Challenges

Pressure and criticism from stakeholders impose restrictions on the process of regulatory reform. In order to study why electricity sector reforms took place, Joskow (1997) did some analysis on the industry performance. Generally, in Joskow's thinking, the whole United States' electric power sector performed rather well. High level of reliability, additional build of new capacity to keep up with demand on time and rates are fairly acceptable compared with many other countries in the world. However, through the outlook of medium-run and long-run, there are opportunities for cost savings, especially associated with long-run investments in generating capacity. Joskow (1997) mentions, there was a gap between regulated bundled electricity prices and the unbundled electricity prices. That would be the primary stimulus to reform. Regulated electricity prices always included the implicit price of generation services. On the other hand, in the wholesale deregulated electricity market, consumers could see this price directly and further pay for transmission and distribution costs.

Another challenge comes from the transmission price. “Transmission pricing is a particularly challenging problem because of the existence of transmission constraints from time to time, complementarities between generation and transmission, and potential network externalities arising from the interrelationships between generators and demand at different locations on the network” (Hunt and Shuttleworth, 1996). What’s more, “vertical control issues” may exist. Transmission-owning utilities have rights to choose the generators they prefer, not only competitive assets (generation) they own, but also regulated monopoly assets (transmission) they operate. The problem is that they have the incentive and rights to favor its own generators and exclude the other generators (Joskow, 1997).

Joskow (2006) states that not only in the U.S., but also in some other countries’, electrical power wholesale markets may not provide enough incentives to stimulate adequate generating capacity during the deregulation period. He analyzed two reasons. First, policymakers studied the excess generating capacity in many countries in Europe and observed that new generating capacity cannot meet rapidly growing demand. At the beginning of reform, large opportunities like replacing old generators, greatly increase the generating capacity. In recent years, the speed of generating capacity addition has not increased as much as expected. Second, trading and generating companies are affected dramatically by financial problems in the last few years. Potential investors will not invest unless the policymakers change traditional project financing arrangements.

2.4 Inspiration From Empirical Study

Stigler and Friedland (1962) carry out an investigation about how the regulation in electricity affect rates and returns. “There are two basic purposes of the public regulation of prices: the curtailment fo the exercise of monopoly power and the elimination of certain forms of price discrimination" (Stigler and Friedland, 1962). The authors state regulation has connection with economic characteristics. For instance, size and urbanization of the population, the extent of industrialization, cost of fuel, per capita income. They fit the equation,

$$\log P = a + b \log U + c \log Pf + dH + e \log Y + fR$$

Where p is average revenue per KWH, in cents, U is population in cities over 25,000 (in thousands), pf is price of fuel, H is proportion of power from hydroelectric sources, Y is per capita state income and R is dummy variable (regulation). This model becomes the fundamental one in my paper. The distinction is I test the effect of deregulation on electricity rates. What's more, more economic characteristics are added into the model, for instance, cooling degree days, energy efficiency programs, etc.

3 Specification of Model

3.1 Description of Model

In my paper, I want to measure the impact of electricity market deregulation on electricity rates in the U.S. and Canada. Four types of rates are considered: total rates, residential rates, commercial rates and industrial rates. I set them as dependent variables into four different regression models.

With respect to explanatory variables, I treat the non-quantitative variable "deregulation" as a dummy variable. When label value equals to 1, the state or province is operating a deregulated electricity market, otherwise, the state or province is not in electricity deregulation. Many other factors which may affect electricity rates are taken into consideration: cooling degree day[4], energy efficiency programs[5], income

[4] Degree day is a quantitative index demonstrated to reflect demand for energy to heat or cool houses and businesses. This index is derived from daily temperature observations at nearly 200 major weather stations in the contiguous United States. The "heating year" during which heating degree days are accumulated extends from July 1st to June 30th and the "cooling year" during which cooling degree data are

per capita, share of residential sales, share of industrial sales, share of electricity generated by coal, share of electricity generated by nuclear, share of electricity generated by hydro and share of electricity generated by others[6].

3.2 Regression Model

The four types of regression models are listed below:

(1) $TOP_i = \beta_0 + \beta_1 CDD_i + \beta_2 EEPM_i + \beta_3 INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(2) $REP_i = \beta_0 + \beta_1 CDD_i + \beta_2 EEPM_i + \beta_3 INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(3) $COP_i = \beta_0 + \beta_1 CDD_i + \beta_2 EEPM_i + \beta_3 INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(4) $INP_i = \beta_0 + \beta_1 CDD_i + \beta_2 EEPM_i + \beta_3 INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

Where,

TOP= total rates (cents per kilowatt hour)

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accumulated extends from January 1st to December 31th. A mean daily temperature of 65 ℉ is the base for both heating and cooling degree day computations. Cooling degree days are summations of positive differences from the same base. Sources from Climate Prediction Center of National Weather Service, 2005.

[5] Utility energy efficiency programs have expanded fairly steadily over the years, despite a temporary period of decline during the utility deregulation in the 1990s. In the 21st century, energy efficiency is regarded as an important utility system resource that can also reduce greenhouse gases, save money for customers, and generate jobs. Source from "Energy Efficiency Programs for Utility Customers", ACEEE.

[6] Generation methods except coal, nuclear and hydro, for instance, solid-state, wind, biomass, geothermal power, etc.

REP=residential rates (cents per kilowatt hour)
COP=commercial rates (cents per kilowatt hour)
INP=industrial rates (cents per kilowatt hour)
CDD=cooling degree days
EEPM=energy efficiency program
INCOME=2011 income per capita
SRES=share of residential sales
SINS=share of industrial sales
SHARECOAL=share of electricity generated by coal
SHARENU=share of electricity generated by nuclear
SHAREHYDRO=share of electricity generated by hydro
SHAREOTHER=share of electricity generated by others
DEREGU=deregulation status

The distinction from one another is the dependent variable. In electricity markets, electricity sectors provide distinguish electricity prices for specific clients: residential consumers, commercial consumers and industrial consumers. Based on these four models, we will see how deregulation in electricity market impacts on these four types of electricity rates with keep the other independent variables unchanged.

3.3 Omitted Variables

At the very beginning of my research, there were a few other variables which should be considered, however, they were dropped due to look at statistical significance in the estimation stage. This is the case of population density and share of urban population, both of them are expected to decrease electricity rates. Note that the share of commercial sales on the demand side and the share of electricity generated by natural gas are excluded to void the dummy variable trap.

3.4 Motivation and Expectation

Wholesale prices are affected by many factors that relate to the supply and demand for electricity. The structure of this model is based on two sides-demand and supply. As Jahangir (2011) states the relationship between costs and price, “a first step in identifying the main determinants of the electricity price, it is convenient to focus on the main components included in the cost of service approach”. What’s more, the electricity price level depends in part on structural characteristics of demand, supply and some policy initiatives. The explanatory variables in this regression model can reflect these three categories.

● Demand : share of residential sales
share of industrial sales
cooling degree days
income per capital

● Supply : share of electricity generated by coal
share of electricity generated by nuclear
share of electricity generated by hydro
share of electricity generated by others

● Policy Initiatives: energy efficiency programs
deregulation status

Here are my priori expectations for the estimation results, share of residential sales, cooling degree days, income per capita, share of electricity generated by others and energy efficiency programs will present positive sign in the estimation results. The share of industrial sales, share of electricity generated by coal and share of electricity generated by hydro will present negative sign in the estimation results. For the share of electricity generated by nuclear, the expectation is indeterminate.

4 Data and Methods

4.1 Data Description

In this paper, the data used to estimate the model come from a variety of sources in the U.S. and Canada. In this section, I will present a detailed description of the variables and data sources. The sample is cross section for the year 2011.

Furthermore, the observations are all the states in U.S. except Alaska[7], Hawaii and Federal District of Columbia, as well as including all the provinces except Prince Edward Island, Northwest Territories, Yukon and Nunavut. The total number of observations is 57.

4.1.1 Cooling Degree Days

The source of cooling degree days in U.S. is from NWS (national weather service)[8], which is a component of the National Oceanic and Atmospheric Administration (NOAA). The year of cooling degree days data is 2011. The annual data by state are aggregated from the monthly data and the unit of cooling degree days is in Fahrenheit.

The source of cooling degree days in Canada is obtained in a report from Canadian Council of Ministers of the Environment (CCME)[9]. The data in this report are based on the information from Environment

[7] Since in the CDD record of Alaska is quite small value, consider this would be significant different from the other cooling degree data, I drop this observation to make sure there is less bias in the estimate results.

[8] The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.

[9] CCME aims to assist its members to meet their mandate of protecting Canada's environment. CCME serves as a principal forum for members to develop national strategies, norms, and guidelines that each environment ministry across the country can use. CCME is not another level of government regulator, but a council of government ministers holding similar responsibilities.

Canada and they are used to calculate the average annual totals from 1971 to 2000 for selected Canadian Cities.

Since the unit of Canadian cooling degree days data is in Celsius, conversion is necessary. The following formula is applied:

$$℃\text{ HDD to } ℉\text{ HDD: } ℉\text{ HDD} = (9/5) \times (℃\text{ HDD})$$

Means, lowest and highest of the related variables are displayed in Table 1. From the table, it is obvious to observe the significant difference between U.S. and Canada. In Canada, heating is always a more important concern than cooling. Basically, the higher this index is, the more cooling the area needs. According to the lowest and highest cooling degree days location list below, this index also reflects some information on geological location.

Table 1: Means, lowest and highest of cooling degree days

	Mean	**Low**	**High**
U.S.	1264.25	223 (Washington)	3739 (Florida)
Canada	212.8889	50 (Alberta)	454 (Ontario)

Source from NOAA and CCME

4.1.2 Electricity Rates

U.S. electricity rates data: residential prices, commercial prices, industrial prices and total prices are from U.S. Energy Information Administration (EIA)[10]. EIA provides an extraordinary detailed industry

[10] The U.S Energy Information Administration (EIA) collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment.

sector category[11], in this paper, all the rates data are chosen from the total electric industry category. The unit for each variable is cents per kilowatt-hour.

Since there are no direct electricity rates data available for Canada, other approaches to obtain the rates data are required. According to CANSIM[12] database in Statistics Canada, Table 127-0008 presents the data table below,

Table 2: Supply and disposition of electric power, electric utilities and industry

Total sales of electricity to ultimate customers	Electricity quantity (megawatt hours)
	Electricity value (dollars x 1,000)
Residential sales of electricity	Electricity quantity (megawatt hours)
	Electricity value (dollars x 1,000)
Agriculture sales of electricity	Electricity quantity (megawatt hours)
	Electricity value (dollars x 1,000)
Mining and manufacturing sales of electricity	Electricity quantity (megawatt hours)
	Electricity value (dollars x 1,000)
Other industries sales of electricity	Electricity quantity (megawatt hours)
	Electricity value (dollars x 1,000)

Source from CANSM, Statistics Canada.

Residential sales were calculated by (Residential sales of electricity) + (Agriculture sales of electricity). Industrial sales were calculated by Mining and manufacturing sales of electricity. Commercial sales are

[11] The industry Sector Category includes total electric industry, full-service providers, restructured retail service providers, energy-only providers and delivery-only service.

[12] CANSIM is Statistics Canada's key socioeconomic database. Updated daily, CANSIM provides fast and easy access to a large range of the latest statistics available in Canada. Source from Statistics Canada.

taken to be other industrial sales. The rates are calculated by the formula: Rates = Electricity value * 1000/Electricity quantity * 1000[13].

Means, lowest and highest values of the key variables are displayed in Table 3 and Table 4.

Table 3: Means, lowest and highest of electricity rates in U.S.

U.S. (cents/KWH)	Mean	Low	High
Total Rates	9.74	6.44 (Idaho)	16.35 (Connecticut)
Residential Rates	11.60	7.87 (Idaho)	18.26 (New York)
Commercial Rates	9.80	6.41 (Idaho)	15.81 (New York)
Industrial Rates	7.21	4.09 (Washington)	13.38 (Massachusetts)

Table 4: Means, lowest and highest of electricity rates in Canada

Canada (cents/KWH)	Mean	Low	High
Total Rates	8.35	5.97 (Manitoba)	11.18 (Nova Scotia)
Residential Rates	10.43	6.91 (Manitoba)	13.63 (Nova Scotia)
Commercial Rates	9.11	6.18 (Manitoba)	11.99 (New Brunswick)
Industrial Rates	5.34	1.92 (Newfoundland)	7.55 (Nova Scotia)

In the U.S., Idaho offers the most affordable electricity rates across the nation in residential and commercial sector in 2011. It is straightforward to explain the reason, since nearly 80 percent of its electricity is provided by hydroelectricity. A greater percentage of electricity is generated from

[13] Since for U.S. data from EIA, the unit is cents per KWH. So we convert MWH to KWH. 1 megawatt=1000 kilowatts.

hydroelectricity in Idaho than in any other U.S. states. Low operating cost of the hydro facilities reflects relatively low electricity rates the consumers need to pay. With respect to highest rates part, New York State occupied the highest rates position in both residential and commercial sectors. High peak demand, low average demand, limited use of hydropower and taxes are considered to be the main factors which increase the electricity rates in New York.

In Canada's electricity market, people who live in Manitoba enjoy the most affordable electricity bills in Canada compared with other province residents. Due to the 98.4 percent of hydroelectricity generation, it can explain why low electricity rates occur in Manitoba. On the contrary, people who live in Nova Scotia have to pay the highest electricity rates in the country.

What's more, consumers in the electricity deregulated area paid an average of 19.56% more for residential electricity rates in 2011 than consumers who live in regulated states. The number in commercial, industrial and total electricity rates are 16.99%, 27.10% and 22.49% respectively. These data verify the electricity deregulation in North America is a failure experiment.

4.1.3 Electricity Generation[14]

In this paper, all the data relate to electricity generation instead of electricity capacity. EIA provides the generation quantity data of the U.S. in 2011. It affords a variety of categories in electricity generation. I treat Biomass, Wind, Solar Thermal and Photovoltaic, Gases and Petroleum as "other generation". For the interpretation of in the results section, share of electricity generated by natural gas was excluded to avoid the dummy variable trap.

[14] Capacity is the maximum electric output a generator can produce under specific conditions. Generation is the amount of electricity a generator produces over a specific period of time. Sources from EIA.

Canadian electricity generation data are obtained from the Canadian Electricity Association (CEA)[15]. A report called "Key Canadian Electricity Statistics" was released on March 21, 2012. It provides the total electricity generation type in Canada by province.

Table 5 and Table 6 summarized mean, lowest and highest generation share value in the U.S. and Canada.

Table 5: Means, lowest and highest of electricity generation share in the U.S.

Type	Mean	Low	High
Coal	0.41	0[16]	0.96 (West Virginia)
Nuclear	0.18	0[17]	0.72 (Vermont)
Hydro	0.11	0[18]	0.81 (Idaho)
Other	0.07	0 (Kentucky)	0.32 (Maine)

[15] Founded in 1891, the Canadian Electricity Association (CEA) is the national forum and voice of the evolving electricity business in Canada. The Association contributes to the regional, national and international success of its members through the delivery of quality value-added services. Sources from CEA.

[16] Since there is more than one observation has 0 value generation by coal type, I list them here, they are: Rhode Island and Vermont.

[17] Since there is more than one observation has 0 value generation by nuclear type, I list them here, they are: Colorado, Delaware, Idaho, Indiana, Kentucky, Maine, Montana, North Dakota, New Mexico, Nevada, Oklahoma, Oregon, Rohde Island, South Dakota, Utah, West Virginia and Wyoming.

[18] Since there is more than one observation has 0 value generation by hydro type, I list them here, they are: Delaware, Kansas, Mississippi and New Jersey.

Table 6: Means, lowest and highest of electricity generation share in Canada

Type	Mean	Low	High
Coal	0.32	0.004 (Manitoba)	0.83 (Nova Scotia)
Nuclear	0.071	0[19]	0.618 (Ontario)
Hydro	0.529	0.028 (Alberta)	0.984 (Manitoba)
Other	0.021	0.001 (British Columbia)	0.052 (New Brunswick)

In the U.S., thermal power (coal-fired) generation dominates in the whole electricity generation. Nearly 41% electricity are generated by coal. West Virginia has the highest share of generation: 96%. In Canada, share of hydro power is 52.9% in average. Manitoba's hydro generation share is as high as 98.4%.

4.1.4 Share of Sales by End User

The share of sales is based on three categories, share of residential sales, share of commercial sales and share of industrial sales. Based on the datasheet from EIA, it is quite straightforward to calculate the share of sales for each category by using 2011 sales data by state.

The sales data of provinces in Canada can be obtained from the CANSIM database in Statistics Canada. For the calculation approach for residential part, I treat the sum of agriculture sales and residential sales as the total residential sales. The other industrial sales of electricity are treated as commercial sales.

[19] Since there is more than one observation has 0 value generation by nuclear type, I list them here, they are: Newfoundland and Labrador, Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta and British Columbia.

Share of commercial sales was dropped to avoid the dummy variable trap. Table 7 and Table 8 present the mean, lowest and highest value of key variables.

Table 7: Means, lowest and highest of electricity generation share in U.S.

	Mean	Low	High
Share of residential sales	0.371	0.161 (Wyoming)	0.517 (Florida)
Share of industrial sales	0.282	0.075 (Florida)	0.589 (Wyoming)

Table 8: Means, lowest and highest of electricity generation share in Canada

	Mean	Low	High
Share of residential sales	0.364	0.245 (Saskatchewan)	0.449 (Newfoundland)
Share of industrial sales	0.324	0.182 (Ontario)	0.438 (Saskatchewan)

The share of residential sales reflects the population in some way. For example, the United States Census Bureau estimates the population of Wyoming was 576,412 in 2012. Low population corresponds to low share of residential sales.

4.1.5 Energy Efficiency Program

The data on energy efficiency program spending per capita in U.S. are obtained from American Council for an Energy-Efficiency Economy (ACEEE)[20]. In a report named "The 2010 State Energy Efficiency

[20] The American council for an Energy-Efficient Economy (ACEEE), a non-profit, 501 (C)(3) organization, acts as a catalyst to advance energy efficiency policies, programs, technologies, investments, and behaviors.

Scorecard", it provided the 2009[21] State Electricity Efficiency Program budgets per Capita, as well as the ranking for each state.

Canadian energy efficiency program data is obtained from INDECO[22]. In the report of Canadian Energy Efficiency Program Study, it records energy efficiency programs spending per capita for each province in 2009. The following two tables present the mean, lowest and highest value of energy efficiency program in U.S. and Canada. One thing should be noted is that the unit in this report is in Canadian dollar, according to the exchange rate in 2009 from Bank of Canada, the exchange rate is 1 USD=1.142 CAD, by using this rate I generated the EEPM data of Canada in USD.

Table 9: Means, lowest and highest of energy efficiency program spending per capita in U.S.

	Mean	Low	High
EEPM spending per capita	10.396	0 (West Virginia)	49.83 (Vermont)

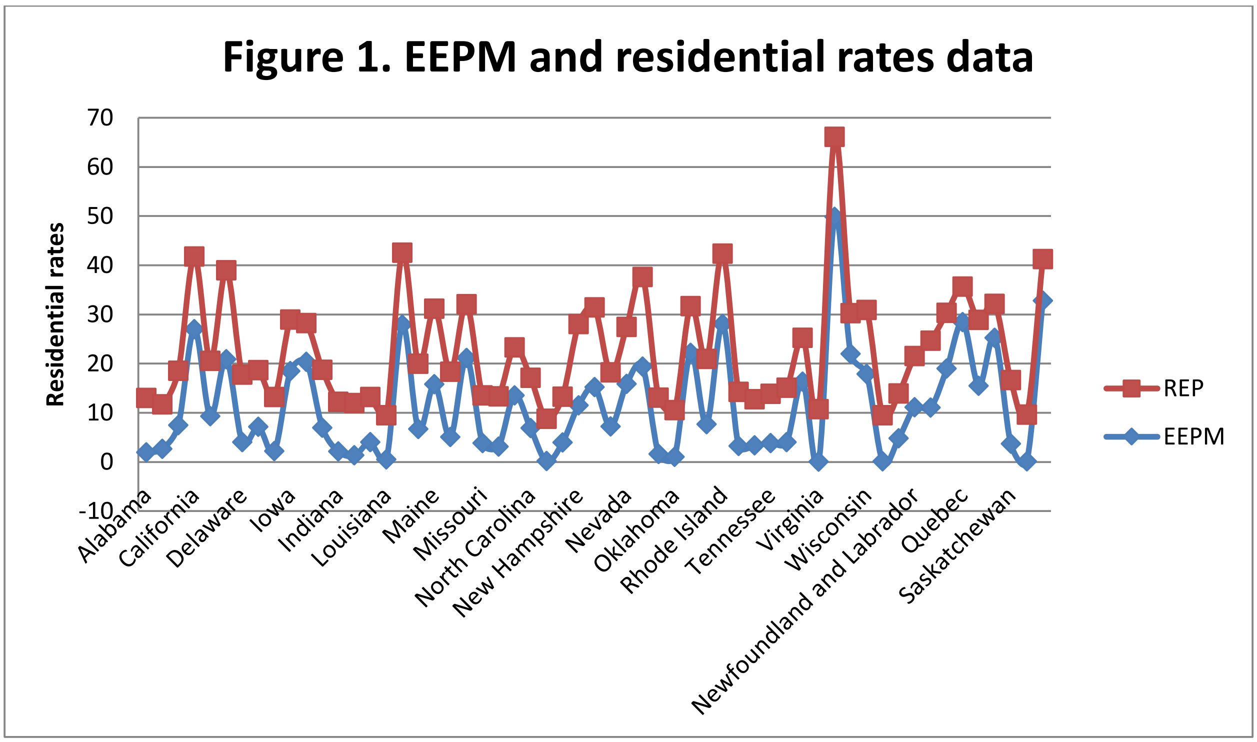
Table 10: Means, lowest and highest of energy efficiency program spending per capita in Canada.

	Mean	Low	High
EEPM spending per capita	16.311	0.09 (Alberta)	32.78 (British Colombia)

[21] The reason I use 2009 data is that need to be match with the year of Canadian data. Since in the available data of energy efficiency program, only the year of 2009 is complete and acceptable.

[22] IndEco Strategic Consulting inc is a team of dedicated professionals who help your organization facilitate, manage and adapt to the major changes society will be going through in the next couple of decades. Source from INDECO.

For some reasons, there is no energy efficiency program spending in some states, for instance, West Virginia. Tracking back to last 5 years, West Virginia has no record showing expense on EEPM. In order to keep the integrity, I put a fairly small number (0.09) into West Virginia's EEPM expense. Energy efficiency has received more and more interests in the recent years. The purposes of this program are to direct the public to a clean energy using society, help customers to save money and make a better environment to live.



However, as shown in Figure 1, the value of residential rates and EEPM spending per capita almost keep the same pace in each state. Comparing any two of state's data, higher EEPM spending per capita means higher residential rates[23].

4.1.6 Income Per Capita

[23] The reality is that high electricity rates area usually has high EEPM spending. When people face expensive electricity bills, they will increase the EEPM expense in order to avoid expensive cost. This programs cannot offer more affordable electricity prices in some way.

The U.S. Department of Commerce, Bureau of Economic Analysis released the personal income per capita by state from 1990 to 2012 on March 2013. The data used in this paper are from this report. The data of Canadian personal income per capita are from Statistics Canada. The currency unit is USD. The average personal income per capita in the U.S. and Canada are fairly close. Table 11 presents the means, lowest and highest of income per capita in the U.S. and Canada.

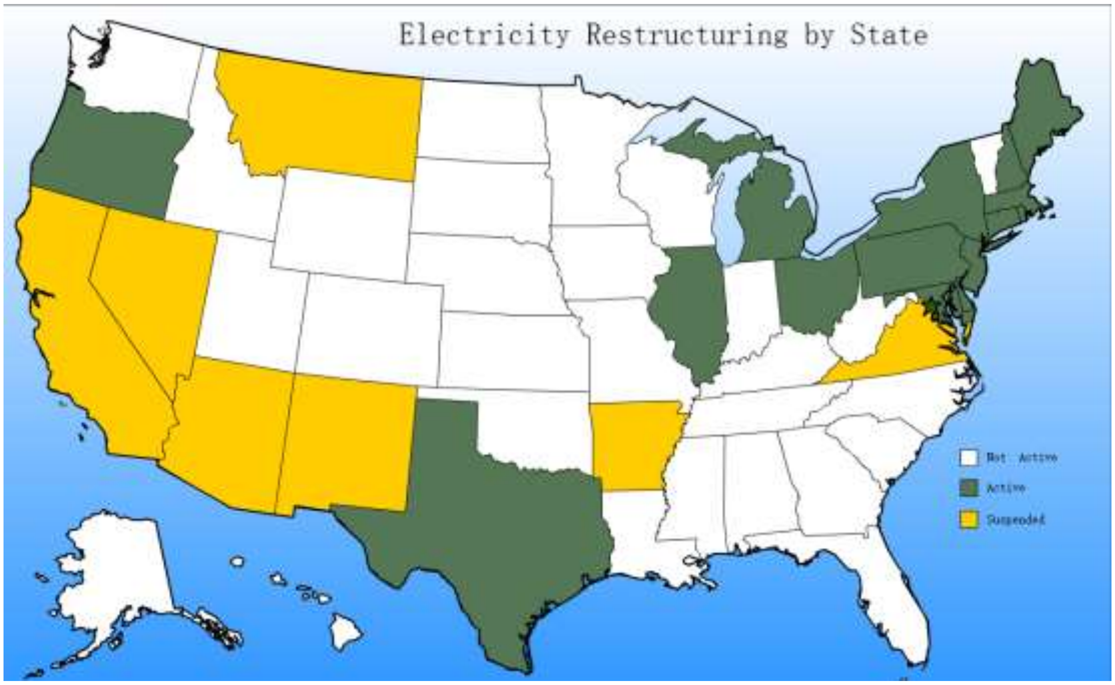
Table 11: Means, lowest and highest of income per capita in the U.S. and Canada

	Mean	Low	High
U.S.	40586.83	32000 (Mississippi)	57902 (Connecticut)
Canada	41262.22	34275 (Newfoundland)	55709 (Alberta)

4.1.7 Deregulation Status

The electricity restructuring map by state from EIA (Figure 2) shows the restructuring status for each states. The data were released in 2010.

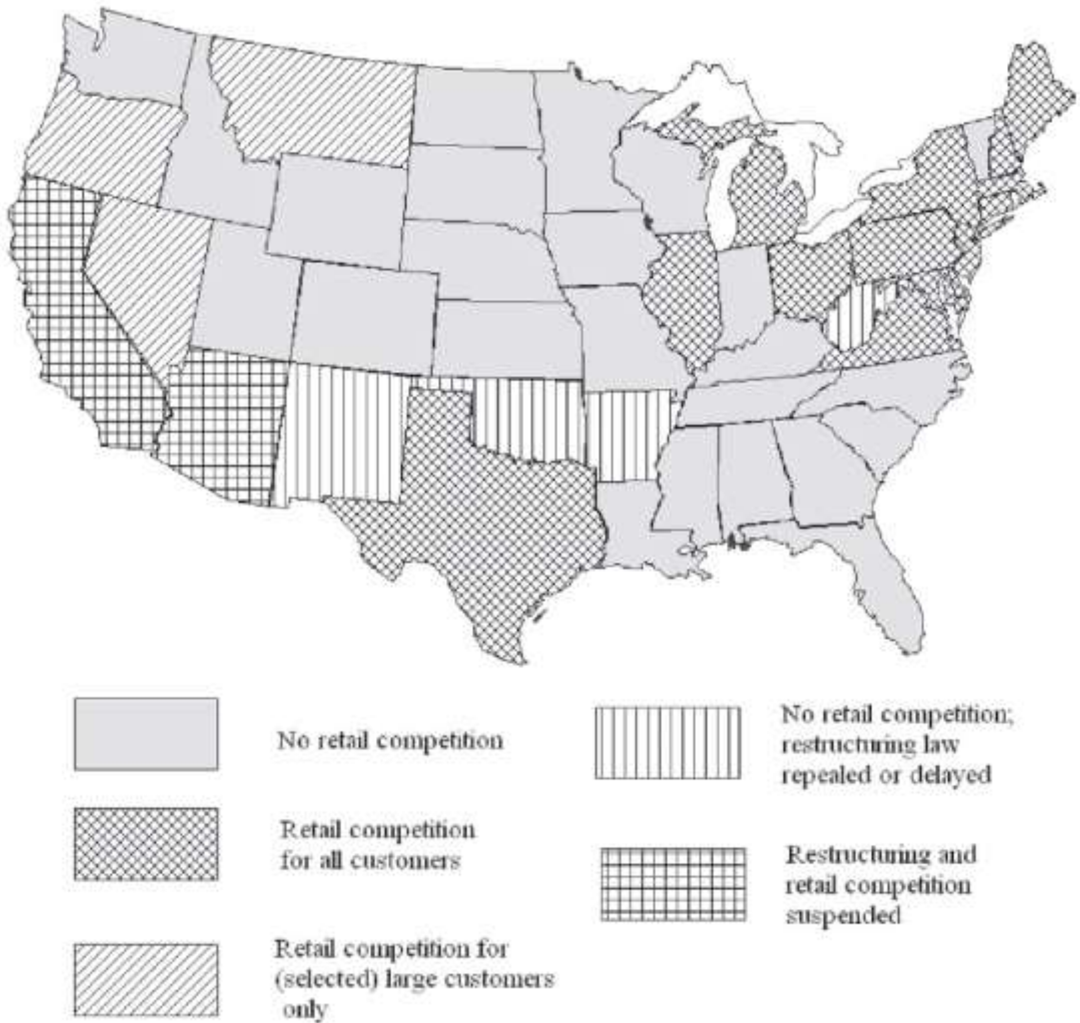
Figure 2: Status of Electricity Restructuring by State



Source: Energy Information Administration, 2010

There are three types of status: active (green), not active (white) and suspended (yellow). In this paper, ‘active’ is regarded as indicating deregulation, while ‘not active’ and ‘suspended’ mean no-deregulation. Joskow (2006) mentiones this restructuring status in his paper as well, “All of the states, except for Texas, that have implemented and sustained comprehensive retail competition programs are in the Northeast and Upper Midwest”. His personal assessments provide specific detail about the status. This assessment of the retail competition status is displayed in Figure 3.

Figure 3: Status of retail competition and restructuring reforms 2005



Source: Markets for Power in the United States, P.L. Joskow (2006)

Comparing these two figures, two states have changed their status in these four years. Oregon transfer from retail competition for selected large customers only to retail competition for all customers. However, one state is moving backward: Virginia's status became suspended from active.

Daniel, Doucet and Plourde (2001) who wrote a paper specialized in the electricity deregulation in Alberta, say Alberta started implementing its restructuring of the electricity industry at a very early era, even in North America, i.e., in the early 1990's. Daniel, Doucet and Plourde (2001) state that "the Alberta market has most of the essential elements, and problems, of electrical systems elsewhere but it is modest in size and somewhat isolated from many complicating factors which tend to confound analysis of larger more interconnected systems." The authors conclude that "A nascent electricity forward market does exist in Alberta, but it is still immature and very thin." (Daniel, Doucet and Plourde, 2001，p.24). Alberta has completed a five-year program since January, 1996, that is the year when it started implementing wholesale access. In 1995, the government of Alberta passed the Alberta Electric Utilities Act, the aim of this act is to separate the vertically integrated utilities, which include generation, transmission and distribution. To be more specific, buyers and sellers can make trade in a power pool. The price of power is strictly set by the market force. Open access to the transmission grid is also an important key for this plan.

In Trebilcock and Hrab (2005)'s paper, a short-lived electricity deregulation example in Ontario was discussed since Ontario opened its wholesale market for electricity market competition in 2002. Back to 1998, Ontario passed the Energy Competition Act to open access to retail and wholesale electricity market. Due to some problems the government faced, a decision was made by the government to push back the date of deregulation until May 2002. The problem it brought with is the increased electricity price. People criticised that it is very similar to the situation when California experienced the electricity crisis in 2001.

Based on those observations, there are no other records showing electricity deregulation in other Canadian provinces.

4.2 Method

Before applying OLS estimation, structure break test is necessary. In this paper, there are two sets of observations. One is from the U.S. and the other is from Canada. Since the number of observations for the U.S. is 48, it is not problematic to apply the OLS estimation method. However, there are only 9 Canadian provinces in the sample; the number of observations is less than the number of explanatory variables. That causes OLS estimation to be inappropriate. The solution is to combine U.S. data and Canada data to perform the estimation. Therefore, structure break test is indicated.

4.2.1 Chow Test

In order to test whether the same relationship holds over the whole sample, we apply a structure break test. Two equations are listed below:

$Y_i=\beta_0+X_i\beta_{us}+e_i$ $\quad i \in$ *(U.S.)*

$Y_i=\beta_0+X_i\beta_{ca}+e_i$ $\quad i \in$ *(Canada)*

The null hypothesis is

$H_0 : \beta_{us}=\beta_{ca}$

The total number of observations is n=n_{us}+n_{ca} and the number of parameters is k. let $\hat{\beta}_{us}$ and $\hat{\beta}_{ca}$ be the parameter estimates from these regressions, with residuals $\hat{\varepsilon}_{us}$ and $\hat{\varepsilon}_{ca}$ and sum of squares $RSS_{us}=\hat{\varepsilon}'_{us}\hat{\varepsilon}_{us}$ and $RSS_{ca}=\hat{\varepsilon}'_{ca}\hat{\varepsilon}_{ca}$. The unrestricted sum of squares for the whole data set is URSS=$RSS_{us}+RSS_{ca}$, which has (n_1-k) + (n_2-k) = n-2k degrees of freedom. Since there are insufficient observations for the Canada subsample, the data series are not long enough to estimate one or the other of the separate regressions for a test of structural change. Therefore the Chow predictive test is used indeed by following the steps below,

1. Estimate the regression by using the full data set and obtain the restricted sum of squared residuals, RRSS.
2. Then use the adequate subsample set (n_1 $observations$) to estimate the regression, and compute the unrestricted sum of squares, RSS_{us}.
3. The F statistic is then computed by

$$F\,[n_2, n_1 - k] = \frac{(RRSS - RSS_{us})/n_2}{RSS_{us}/(n_1 - k)} \text{ under } H_0$$

4.2.2 Logs Transformation in a Regression Equation

At the estimation stage, some variables are transformed by taking the natural logarithm, including independent and dependent variables. After transforming, the models are:

(5) $\text{Log}TOP_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(6) $\text{Log}REP_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(7) $\text{Log}COP_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

(8) $\text{Log}INP_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$

One problem needed to be solved: in the U.S. dataset, two states have 0 value in their energy efficiency program, i.e., Delaware and West Virginia. There is no way to take natural logarithm for a zero value. According to 2011 State Energy Efficiency Scorecard, we can find Delaware spend $4.02 per capita on energy efficiency program; therefore, Delaware's data problem has been solved by using data in 2011. Unfortunately, we do not find any record showing that West Virginia had any energy efficiency program spending in the last few years. The solution is to assign a small number instead of zero for West Virginia, eventually, we use 0.09 for West Virginia's energy efficiency program data.

4.2.3 Heteroscedasticity test

In this regression model, the Breusch-Pagan test is used to test for heteroscedasticity, by applying the following procedures,

(1) Estimate the following model

$$\text{Log}RATES^{24}{}_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$$

(2) Obtained the residuals from this model and then regress the squared residuals on all the independent variables.

$$\hat{u}^2 = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$$

(3) Compare the result by using the Chi-Square table.

[24] LogRATES includes four types of rates: residential rates, commercial rates, industrial rates and total rates.

4.2.4 Durbin-Wu-Hausman test

Durbin-Wu-Hausman test is designed to test for the endogeneity problem in the regression model. In our model, the suspicious independent variable is 'share of industrial sales', because industrial users tend to locate where electricity prices are low. Here is the test procedure,

(1) Regress SINS on all the other independent variables.

$$SINS_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$$

(2) Obtain the residuals SINS_res, then perform the regression below:

$$\text{SINS\_res}_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$$

(3) According to the estimation results, checking the t-value of variable SINS_res. The model may be considered to have endogeneity problem if the variable is significant, otherwise, it is not.

5 Results

5.1 Results based on U.S. data

There are 48 observations composing the U.S. subsample[25]. Table 12 displays the OLS estimation results for the model

$$\text{Log}\,RATES_i = \beta_0 + \beta_1 \text{Log}CDD_i + \beta_2 \text{Log}EEPM_i + \beta_3 \text{Log}INCOME_i + \beta_4 SRES_i + \beta_5 SINS_i + \beta_6 SHARECOAL_i + \beta_7 SHARENU_i + \beta_8 SHAREHYDRO_i + \beta_9 SHAREOTHER_i + \beta_{10} DEREGU_i + e_i$$

[25] Hawaii, Alaska and District of Columbia are dropped. Due to its unique geographic feature, cooling degree days records are significantly different from other states.

5.1.1 Impact on total rates

Based on the first column of Table 12, which displays the results of deregulation impacts on total electricity rates in U.S., cooling degree days, share of industrial sales, share of electricity generated by coal and share of electricity generated by hydro have statistically significant effects at a 1% significance level. Energy efficiency program spending per capita has statistically significant effect at a 10% significance level.

My expectation was that the need for cooling will increase the electricity rates. However, the result shows a negative sign, which means one percentage increase in cooling degree days will cause 0.12% decrease in the total electricity rates. The estimated coefficient of industrial sales share is -0.848; the result verifies my expectation. An increase of one point in the share of industrial sales relative to the share of commercial sales would result in 0.00848 decreases in total electricity rates while keeping other variables constant. The estimate of coefficients of coal generation share is -0.347, the result verifies my negative sign expectation. An increase of one point in the coal generation share relative to natural gas generation share would result in 0.00347 decreases in total electricity rates. The same expectation is verified for the share of hydro generation. An increase of one point in the share of hydro relative to share of natural gas would result in 0.00735 decreases in total electricity rates. What’s more, energy efficiency programs is expected to increase the electricity rates and the results reflect that. One percentage increase in energy efficiency program will cause 0.023% increase in total electricity rates.

5.1.2 Impact on residential rates

According to the estimation results for residential rates, ‘cooling degree days’, ‘share of industrial sales’, ‘share of electricity generated by coal’ and ‘share of electricity generated by hydro’ have statistically significant effects at the 1% significance level. ‘Deregulation’, ‘energy efficiency program’ and ‘share of electricity generated by nuclear’ have statistically significant effects at the 5% significance level.

In the model of residential rates as the dependent variable, the result of cooling degree days is contrary to my expectation as well. One percentage increase in cooling degree days will cause 0.103% decrease in the residential electricity rates. The estimated coefficient of the industrial sales share is -0.709, the result verifies my expectation. An increase of one point in the share of industrial sales relative to the share of commercial sales would result in 0.00709 decreases in total residential rates while keeping other variables constant. The estimate of coefficients of share of coal is -0.285, the result verifies my negative sign expectation. An increase of one point in the share of coal relative to the share of natural gas would result in 0.00285 decrease in residential rates. The same expectation is verified for share of hydro. An increase of one point in the share of hydro relative to share of natural gas would result in 0.0069 decrease in residential electricity rates. One percentage increase in energy efficiency program will cause 0.027% increase in residential electricity rates.

In this specific model, two new significant variables appear, i.e., deregulation and share of nuclear. An increase of one point in the share of nuclear relative to the share of natural gas would result in 0.00202 increase in residential electricity rates while keeping other variables constant.

The test of deregulation impact on residential electricity rates shows there is a significant impact on residential rates at 5% significance level. This means a market with deregulation status is predicted to increase the residential rates by 10.4%. This is contrary to my expectation, deregulation is supposed to decrease rates, especially for the residential sector. However, the statistically significant difference between the deregulation place and no-deregulation place explained the deregulation experiment in U.S. is failure.

5.1.3 Impact on commercial rates

According to the estimation on commercial rates, cooling degree days, share of electricity generated by coal and share of electricity generated by hydro have statistically significant effects at a 1% significance level.

In this specific model, there are only three significant variables. One percentage increase in cooling degree days will cause 0.120% decrease in the commercial electricity rates. The estimate of coefficients of share of coal is -0.365, the result verifies my negative sign expectation. An increase of one point in the share of coal relative to share of natural gas would result in a 0.00365 decrease in total commercial rates with keeping other variables constant. The same expectation is verified for share of hydro. An increase of one point in the share of hydro relative to share of natural gas would result in 0.00684 decrease in commercial electricity rates.

5.1.4 Impact on industrial rates

According to the estimation on industrial rates, cooling degree days, share of electricity generated by coal and share of electricity generated by hydro have statistically significant effects at a 1% significance level.

In model (4), one percentage increase in cooling degree days will cause 0.164% decrease in the industrial electricity rates. The estimate of coefficients of share of coal is -0.458, the result verifies my negative sign expectation. An increase of one point in the share of coal relative to share of natural gas would result in 0.00365 decrease in total industrial rates with keep other variables constant. The same expectation is verified for share of hydro. An increase of one point in the share of hydro relative to share of natural gas would result in 0.00684 decrease in industrial electricity with keep other variables constant.

TABLE 12 OLS Estimates of the Effect of Deregulation on Electricity Rates (U.S. data only)

Variables	(1)	(2)	(3)	(4)
Cooling degree days	**-.120*** (.035)**	**-.103*** (.031)**	**-.120*** (.042)**	**-.164*** (.046)**
Deregulation	.072 (.043)	.104** (.039)	.039 (.053)	.044 (.057)
Energy efficiency program	.023* (.013)	.027** (.011)	.026 (.015)	.020 (.017)
Income	.001 (.159)	-.137 (.142)	.021 (.193)	.342 (.210)
Share of residential sales	.055 (.548)	-.497 (.491)	-.129 (.667)	1.170 (.724)
Shale of industrial sales	**-.848*** (.272)**	**-.709*** (.244)**	-.493 (.332)	-.198 (.360)
Share of coal	**-.347*** (.086)**	**-.285*** (.077)**	**-.365*** (.105)**	**-.458*** (.114)**
Share of nuclear	.114 (.105)	.202** (.094)	.093 (.128)	-.078 (.139)
Share of hydro	**-0.735*** (.119)**	**-.690*** (.107)**	**-.684*** (.145)**	**-.1.035*** (.158)**
Share of other	.044 (.333)	.376 (.298)	-.308 (.406)	-.146 (.440)
Constant	3.419* (1.866)	**5.029*** (1.673)**	3.220 (2.273)	-.655 (2.468)
Adj R-squared	0.823	0.819	0.747	0.751
NO. of observations	48	48	48	48

Notes: 1. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.
2. Numbers in brackets are standard deviations.
3. (1), (2), (3), and (4) stands for dependent variable total rates, residential rates, commercial rates and industrial rates respectively.
4. Energy efficiency program and income data are per capita. The unit of cooling degree days is ℉.
5. Share of coal=share of electricity generated by coal, share of nuclear=share of electricity generated by nuclear, share of hydro=share of electricity generated by hydro and share of other=share of electricity generated by other.

5.2 Chow test for structure break

Here is the formula of the Chow test for structure break,

$$F\,[n_2, n_1 - K] = \frac{(RRSS - RSS_{us})/n_2}{RSS_{us}/(n_1 - K)} \text{ under } H_0$$

The models in the test are both including general model form and log-transformed form. The critical value is based on F $[n_2, n_1 - K]$ = F [10, 38] = 2.08.

5.2.1 Test for log form

Table 13. Chow test results for structure break

Sector	F-statistical value
Total Rates	0.0226
Residential Rates	0.0226
Commercial Rates	0.0197
Industrial Rates	0.0212

When compared with the critical value 2.08, all the statistical values are far smaller. Therefore we do not reject the null hypothesis.

5.3 Conclusion

All the test results suggest that we do not reject null hypothesis; hence it is appropriate to consider U.S. and Canada data as one dataset.

5.4 Results based on the U.S. and Canada data

There are 57 observations in total. At the estimation stage, all the rates variables, cooling degree days and energy efficiency program are transformed by taking the natural logarithm. Table 14 displays the OLS estimation results for the model

$$\text{Log}RATES_i=\beta_0+\beta_1\text{Log}CDD_i+\beta_2\text{Log}EEPM_i+\beta_3\text{Log}INCOME_i+\beta_4 SRES_i+\beta_5 SINS_i+\beta_6 SHARECOAL_i+\beta_7 SHARENU_i+\beta_8 SHAREHYDRO_i+\beta_9 SHAREOTHER_i+\beta_{10} DEREGU_i+e_i$$

5.4.1 Impact on total rates

The first column of Table 14, which is estimated the effect of deregulation on total electricity rates in the U.S. and Canada.

Cooling degree days, share of industrial sales, energy efficiency program, share of electricity generated by coal and share of electricity generated by hydro have statistically significant negative effects at a 1% significance level. Share of industrial sales has a statistically significant negative effect at a 5% significance level.

The most essential difference between data with and without Canada is that the variable energy efficiency program became significant and verifies my expectation. One percentage increase in energy efficiency program will cause 0.043% increase in total electricity rates. Furthermore, cooling degree days is still significant. One percentage increase in cooling degree days will cause 0.096% decrease in total electricity rates. What’s more, one point increase in share of industrial sales relative to share of commercial sales will result in 0.00701 decrease in total rates while keeping other variables constant. One point increase in share of coal relative to share of natural gas will cause 0.00299 decrease in total rates. One point increase in share of hydro relative to share of natural gas will cause 0.00744 decreases in total rates as well.

5.4.2 Impact on residential rates

According to the estimation on residential rates, cooling degree days, energy efficiency program, share of coal and share of hydro have statistically significant negative effects at the 1% significance level. Share of industrial sales has a statistically significant negative effect at the 5% significance level.

This specific model has the same significant variables as model (1). One percentage increase in energy efficiency program will cause 0.041% increase in residential electricity rates. One percentage increase in cooling degree days will cause a 0.104% decrease in residential electricity rates. What’s more, one point increase in share of industrial sales relative to share of commercial sales will result in a 0.00646 decrease in residential rates. One point increase in share of coal relative to share of natural gas will cause 0.00265 decreases in residential rates with keep other variables constant. One point increase in share of hydro relative to share of natural gas will cause 0.00709 decreases in residential rates.

5.4.3 Impact on commercial rates

According to the estimation on commercial rates, cooling degree days, energy efficiency program, share of electricity generated by coal and share of electricity generated by hydro have statistically significant negative effects at the 1% significance level.

This specific model has the same significant variables as model (1), except the variable ‘share of industrial sales’. One percentage increase in energy efficiency program will cause a 0.051% increase in commercial electricity rates. One percentage increase in cooling degree days will cause a 0.101% decrease in commercial electricity rates. What’s more, one point increase in share of coal relative to the share of natural gas will cause 0.00314 decreases in residential rates with keep other variables constant. One point increase in share of hydro relative to share of natural gas will cause 0.00689 decreases in commercial rates.

5.4.4 Impact on industrial rates

According to the estimation on industrial rates, share of electricity generated by hydro has statistically negative significant effects at a 1% significance level. Energy efficiency programs, income per capita, share of electricity generated by coal have statistically significant effects at a 5% significance level. Share of residential sales has statistically significant effects at a 10% significance level.

In the model (4), the cooling degree days is not significant. For the other independent variables, one percentage increase in energy efficiency program will result in a 0.051% increase in industrial rates. The income would have positive impact on electricity rates. This result verifies my expectation. One point increase in income will cause a 0.00633 increase in industrial rates while keeping other variables constant. Furthermore, one point increase in share of residential sales relative to share of commercial sales will increase industrial electricity rates by 0.00136. One point increase in share of coal relative to the share of natural gas will decrease industrial rates by 0.0032. One point increase the share of hydro relative to the share of natural gas will result in a 0.00992 decrease in industrial rates.

TABLE 14 OLS Estimates of the Effect of Deregulation on Electricity Rates (U.S. and Canada)

Variables	(1)	(2)	(3)	(4)
Cooling degree days	**-.096*** (.022)**	**-.104*** (.022)**	**-.101*** (.027)**	-.045 (.038)
Deregulation	.040 (.043)	.053 (.042)	.002 (.053)	.076 (.073)
Energy efficiency program	**.043*** (.012)**	**.041*** (.012)**	**.051*** (.015)**	.051** (.020)
Income	.041 (.166)	-.105 (.163)	.019 (.206)	.633** (.283)
Share of residential sales	.407 (.472)	-.306 (.465)	-.608 (.586)	1.355* (.806)
Shale of industrial sales	-.701** (.270)	-.646** (.266)	-.236 (.335)	-.165 (.461)
Share of coal	**-.299*** (.090)**	**-.265*** (.089)**	**-.314*** (.111)**	-.320** (.153)
Share of nuclear	.092 (.108)	.165 (.106)	.085 (.133)	-.134 (.184)
Share of hydro	**-0.744*** (.098)**	**-.709*** (.096)**	**-.689*** (.121)**	**-.992*** (.167)**
Share of other	.117 (.302)	.225 (.298)	-.206 (.375)	-.407 (.516)
Constant	2.610* (1.940)	**4.608*** (1.910)**	2.703 (2.404)	-4.896 (3.308)
Adj R-squared	0.785	0.754	0.601	0.638
NO. of observations	57	57	57	57

Notes: 1. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

2. Numbers in brackets are standard deviations.

3. (1), (2), (3), and (4) stands for dependent variable total rates, residential rates, commercial rates and industrial rates respectively.

4. Energy efficiency program and income data are per capita. The unit of cooling degree days is ℉.

5. Share of coal=share of electricity generated by coal, share of nuclear=share of electricity generated by nuclear, share of hydro=share of electricity generated by hydro and share of other=share of electricity generated by other.

5.5 Heteroscedasticity test

5.5.1 BP test

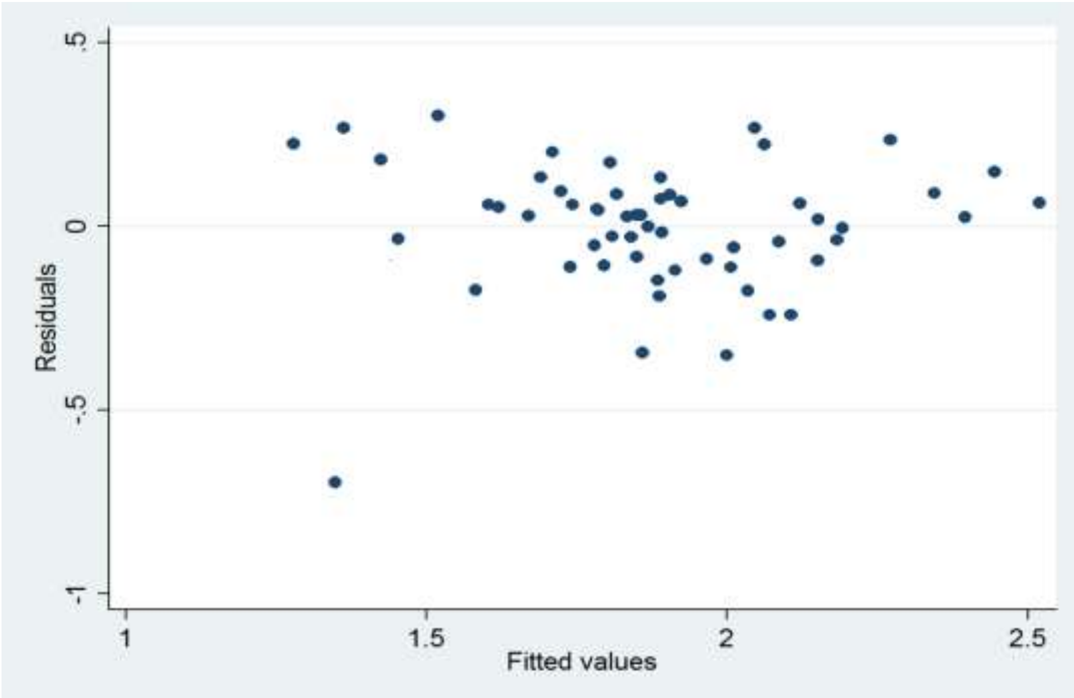
In my model, the degree of freedom is 10 and alpha value is 0.95. According to the Chi-Square table, the critical value is 3.94. The Breusch-Pagan test result is list below.

Table 15. Breusch-Pagan test results

Dependent variable	CHI2 (US data)	CHI2 (US+CA data)
Total rates	0.07	0.01
Residential rates	0.12	0.06
Commercial rates	0.07	0.11
Industrial rates	1.47	**13.17**

Based on this result, the large chi-square value in the model where industrial rates are the dependent variable means the heteroskedasticity. The chi-square value is 13.17, which is far above the critical value 3.94.

Figure 3. Residuals versus fitted values for industrial rates (us+ca data)



Furthermore, in Figure 3, the plot of residuals shows some uneven envelope of residuals, the width of the envelope is considerably larger for some values of X than for others, therefore, heteroscedasticity might be a problem in this specific model.

5.5.2 Solution

5.5.2.1 Use robust standard error

Running the regression model on industrial rates with robust standard error seems not to be an appropriate way to solve this problem. The plot of residuals still shows an uneven envelope of residuals.

5.5.2.2 Use weighted least squares

In weighted least squares, we need to use Generalized Least Squares to do the estimation. Specifically, coefficients are selected which minimize

$$\sum_{j=1}^{N} \frac{(Y_j - \hat{Y}_j)^2}{VAR\ (\mathcal{E}_j)}$$

Where Y = lnrep[26]

Comparing with the Table 14 and Table 16, I found that share of industrial sales became significant before Canadian data is added in to the dataset. Therefore, I regard share of residential sales as the suspicious variable which causes the heteroscedasticity. In other words, the standard deviation of the error term is related to the share of residential sales. The significant variables do not change after applying GLS.

[26] Lrep = Log (residential price)

TABLE 16 GLS Estimates of the Effect of Deregulation on Electricity Rates (U.S. and Canada)

Variables	(4)[27]
Cooling degree days	-.051 (.037)
Deregulation	.060 (.072)
Energy efficiency program	.047** (.019)
Income	.581** (.267)
Share of residential sales	1.466* (.753)
Shale of industrial sales	-.058 (.422)
Share of coal	-.344** (.155)
Share of nuclear	-.233 (.184)
Share of hydro	**-.980*** (.175)**
Share of other	-.147 (.501)
Constant	-4.264 (3.135)
Adj R-squared	0.5939
NO. of observations	57

Notes: 1. ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

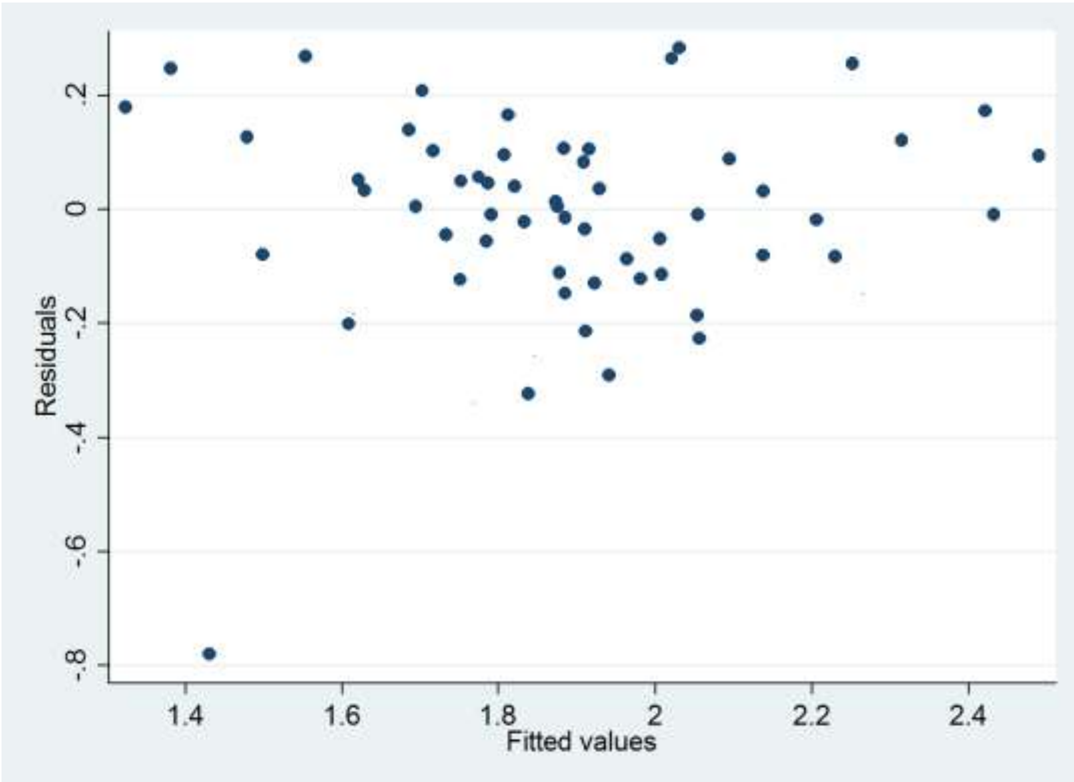
2. Numbers in brackets are standard deviations.

3. Energy efficiency program and income data are per capita. The unit of cooling degree days is ℉.

4. Share of coal=share of electricity generated by coal, share of nuclear=share of electricity generated by nuclear, share of hydro=share of electricity generated by hydro and share of other=share of electricity generated by other.

[27] Industrial electricity rates as dependent variable.

Figure 4. Residuals versus fitted values for industrial rates (U.S. and Canada data, GLS)



What's more, by plotting the residuals versus fitted values, Figure 4 shows that the situation is much better than the Figure 3 shows above. The plot of residuals displays a less uneven envelope of residuals.

5.6 Durbin-Wu-Hausman test

The Durbin-Wu-Hausman test is displayed in the tables below.

Table 17. Durbin-Wu-Hausman test result (U.S. data)

Dependent Variable	**SINS_res (t value)**
TOP	0.10
REP	1.01
COP	0.19
INP	**1.62**

Table 18. Durbin-Wu-Hausman test result (U.S. and Canada data)

Dependent Variable	SINS_res (t value)
TOP	0.86
REP	0.66
COP	1.04
INP	**1.68**

From the results of Table 17 and Table 18, the SINS_res is not statistical significant, which means endogeneity is not a big issue in this model. What's more, due to some limits, I have not found any good instrument variable to replace it; however, a good guess instrument variable could be the share of coal.

6 Conclusion

In the 80s and the 90s', there was a whole wave of deregulation in some industrial sectors, airline, telecommunication, railroad, banking, oil and natural gas pricing etc. There is no doubt that the objectives of deregulation were to give consumers more choices, and lower prices through market competition. Deregulation of these industries in different countries have had significant success. One example of such success is the telecommunication industry in the U.S. Electricity sector was one of the last to be exposed to this policy. Electricity sector is a special area. Firstly, it has complicated industrial structure. From generators to end-users, each part is essential to building the whole system. Secondly, what the end-users consume has to be generated by the electricity generator at the same time. Thirdly, technological challenges and firms holding too much power made maintaining more than one firm difficult. Combining these factors, implementing deregulation in electricity industry became quite a challenge.

The purpose of deregulation in electricity market is to deliver lower electricity prices. In our analysis, the results do not turn out as expected. In fact, in the model where deregulation shows statistically significant impact, a market with deregulation status is predicted to increase the residential rates by 10.4%. Consumers in the areas where electricity market is deregulated paid an average of 19.56% more for residential electricity rates in 2011, than consumers who live in regulated states. The number in commercial, industrial and total electricity rates are 16.99%, 27.10% and 22.49% respectively. From Appendix 9 to Appendix 11., it is obvious that deregulated electricity market are offering much higher rates (including residential, commercial and industrial rates) to its consumers than the markets which do not implement deregulation. The costs are born by the residential consumers, who should have gained benefits from this deregulation revolution. Joskow (2006) states that “creating well-functioning competitive wholesale and retail markets for electricity is very challenging both technically and politically.” Each failed experiment makes policy-makers approach deregulation in electricity industry with more caution.

According to the test results, there might be some alternatives to deregulation that can address high electricity rates problem. One observation is that higher industrial sale will cause lower electricity rates. For those regions where industries are more developed, improving the investment on those industries may lead to electricity rates become lower. On the generation side, using coal and hydro to generate power may also lower electricity rates. Especially for hydro power, with low maintaining cost and efficient operation, it may increase affordability of electricity.

Nevertheless, failures and challenges will not halt the process of regulatory reform. The development of competitive wholesale and retail electricity markets will not stop. Solutions for reaching affordability are being proposed and tested. The determination of government to build a better electricity operation system will lead such reforms to reach a higher level. The government has much to do to ensure that the electricity market will grow favorably in the future. This industrial deregulation still have a long way to go. The mechanism and structure must become more and more efficient and mature. In the future, everyone benefits from the electricity deregulation.

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Figure 2. Status of retail competition and restructuring reforms 2005. Reprinted from "Markets for Power in the United States," by P.L. Joskow, 2006, *The Energy Joural,* Vol. 27, No. 1. Copyright © 2006 by the IAEE.

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Appendix

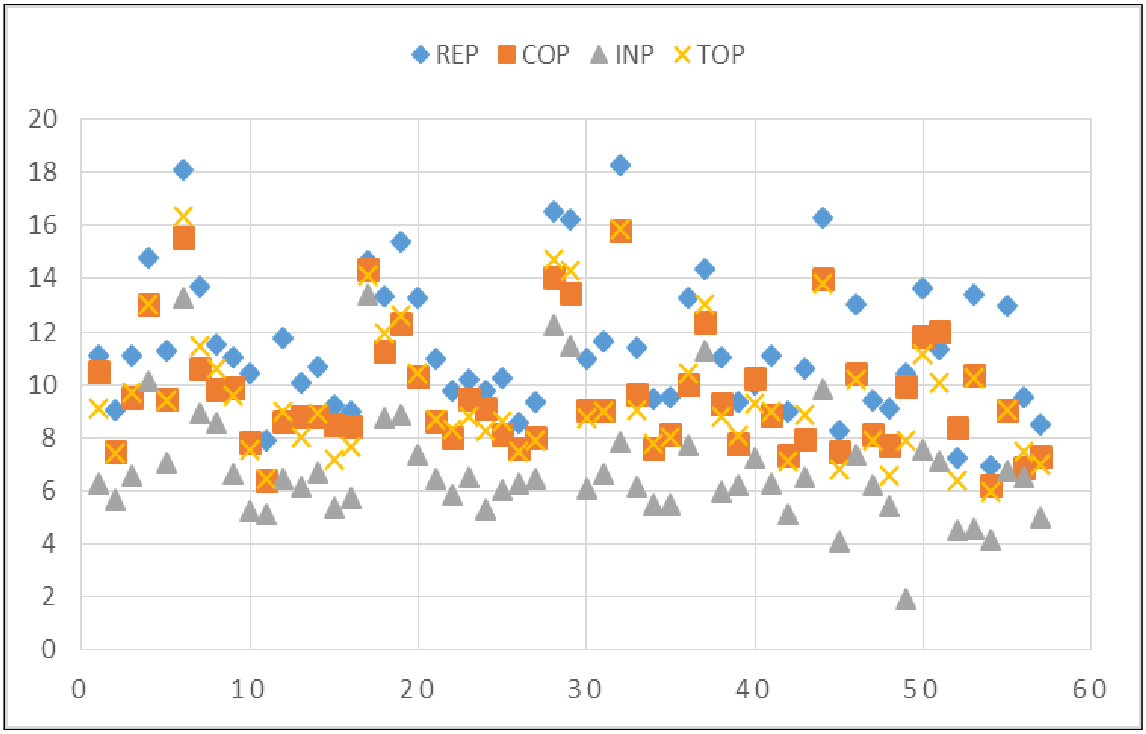
Appendix 1. Electricity rates for U.S. and Canada.

State	REP	COP	INP	TOP
Alabama	11.09	10.47	6.25	9.1
Arkansas	9.02	7.5	5.63	7.43
Arizona	11.08	9.5	6.55	9.71
California	14.78	13.05	10.11	13.05
Colorado	11.27	9.44	7.06	9.39
Connecticut	18.11	15.57	13.24	16.35
Delaware	13.7	10.64	8.91	11.48
Florida	11.51	9.85	8.55	10.61
Georgia	11.05	9.87	6.6	9.61
Iowa	10.46	7.85	5.21	7.56
Idaho	7.87	6.41	5.1	6.44
Illinois	11.78	8.64	6.42	8.97
Indiana	10.06	8.77	6.17	8.01
Kansas	10.65	8.78	6.71	8.89
Kentucky	9.2	8.49	5.33	7.17
Louisiana	8.96	8.44	5.69	7.68
Massachusetts	14.67	14.33	13.38	14.11
Maryland	13.31	11.28	8.76	11.93
Maine	15.38	12.29	8.88	12.58
Michigan	13.27	10.33	7.32	10.4
Minnesota	10.96	8.63	6.47	8.65
Missouri	9.75	8.04	5.85	8.32
Mississippi	10.17	9.48	6.53	8.78
Montana	9.75	9.12	5.27	8.23
North Carolina	10.26	8.13	6.01	8.64
North Dakota	8.58	7.61	6.24	7.5
Nebraska	9.32	7.99	6.43	7.88
New Hampshire	16.52	14.04	12.27	14.74
New Jersey	16.23	13.47	11.43	14.3
New Mexico	11	9.07	6.06	8.74
Nevada	11.61	9.05	6.65	8.97
New York	18.26	15.81	7.83	15.89
Ohio	11.42	9.63	6.12	9.03
Oklahoma	9.47	7.6	5.46	7.8
Oregon	9.54	8.15	5.47	8.04
Pennsylvania	13.26	10.03	7.73	10.45
Rhode Island	14.33	12.37	11.27	13.04
Soouth Carolina	11.05	9.3	5.94	8.8
South Dakota	9.35	7.76	6.2	8.05
Tennessee	9.98	10.27	7.23	9.28

Texas	11.08	8.83	6.24	9
Utah	8.96	7.35	5.1	7.13
Virginia	10.64	7.95	6.49	8.84
Vermont	16.26	14	9.83	13.8
Washington	8.28	7.49	4.09	6.78
Wisconsin	13.02	10.42	7.33	10.21
West Virginia	9.39	8.14	6.18	7.88
Wyoming	9.11	7.72	5.41	6.58
Newfoundland and Labrador	10.42	9.97	1.92	7.86
Nova Scotia	13.63	11.84	7.55	11.18
New Brunswick	11.33	11.99	7.13	10.05
Quebec	7.23	8.38	4.50	6.38
Ontario	13.39	10.37	4.55	10.25
Manitoba	6.91	6.18	4.14	5.97
Saskatchewan	12.99	9.06	6.76	9.02
Alberta	9.50	6.88	6.53	7.45
British Columbia	8.50	7.32	4.98	6.98

Notes: 1. Data source from EIA and Statistic Canada.
2. All data use Red-Yellow-Green Scale to indicate the range.
3. There are 48 U.S. states and 9 Canadian provinces.

Appendix 2 Distribution of Electricity Rates



Notes: The horizontal axis labels are each states and provinces. REP=residential electricity rates, COP=commercial rates, INP=industrial rates and TOP=total rates.

Appendix 3. Cooling Degree Days Statistics

State	CDD
Alabama	2150
Arkansas	2190
Arizona	2871
California	847
Colorado	515
Connecticut	792
Delaware	1525
Florida	3739
Georgia	2027
Iowa	974
Idaho	485
Illinois	1064
Indiana	1084
Kansas	1754
Kentucky	1393
Louisiana	3020
Massachusetts	626
Maryland	1416
Maine	267
Michigan	677
Minnesota	590
Missouri	1484
Mississippi	2389
Montana	326
North Carolina	1788
North Dakota	507
Nebraska	1053
New Hampshire	395
New Jersey	1053
New Mexico	1131
Nevada	1623
New York	779
Ohio	955
Oklahoma	2513
Oregon	284
Pennsylvania	937
Rhode Island	732
Soouth Carolina	2154
South Dakota	802
Tennessee	1574
Texas	3440

Utah	814
Virginia	1408
Vermont	303
Washington	223
Wisconsin	582
West Virginia	1023
Wyoming	406
Newfoundland and Labrador	58
Nova Scotia	187
New Brunswick	67
Quebec	423
Ontario	454
Manitoba	335
Saskatchewan	263
Alberta	50
British Columbia	79

Notes: 1. Source from national weather service and Canadian council of Ministers of the Environment. 2. All data use Red-Yellow-Green Scale to indicate the range. 3. Unit is in ℉.

Appendix 4. Energy Efficiency Program (per capita in USD)

State	EEPM
Alabama	1.93
Arkansas	2.66
Arizona	7.46
California	27.01
Colorado	9.29
Connecticut	20.88
Delaware	0
Florida	7.15
Georgia	2.16
Iowa	18.48
Idaho	20.38
Illinois	6.96
Indiana	2.12
Kansas	1.31
Kentucky	3.99
Louisiana	0.51
Massachusetts	27.88
Maryland	6.67
Maine	15.78
Michigan	5.03
Minnesota	21.11
Missouri	3.79
Mississippi	3.12
Montana	13.54
North Carolina	6.85
North Dakota	0.15
Nebraska	3.95
New Hampshire	11.49
New Jersey	15.19
New Mexico	7.17
Nevada	15.85
New York	19.36
Ohio	1.61
Oklahoma	1.03
Oregon	22.14
Pennsylvania	7.68
Rhode Island	28.01
Soouth Carolina	3.2
South Dakota	3.36
Tennessee	3.84

Texas	3.98
Utah	16.3
Virginia	0.05
Vermont	49.83
Washington	21.98
Wisconsin	17.88
West Virginia	0
Wyoming	4.78
Newfoundland and Labrador	11.10
Nova Scotia	11.05
New Brunswick	18.96
Quebec	28.44
Ontario	15.47
Manitoba	25.25
Saskatchewan	3.66
Alberta	0.09
British Columbia	32.78

Notes: West Virginia and Delaware are not zero value when estimation. All data use Red-Yellow-Green Scale to indicate the range.

Appendix 5. Income per capita

State	income
Alabama	34880
Arkansas	33740
Arizona	35062
California	43647
Colorado	44053
Connecticut	57902
Delaware	41449
Florida	39636
Georgia	35979
Iowa	41156
Idaho	32881
Illinois	43721
Indiana	35689
Kansas	40883
Kentucky	33989
Louisiana	38549
Massachusetts	53471
Maryland	50656
Maine	38299
Michigan	36264
Minnesota	44560
Missouri	37969
Mississippi	32000
Montana	36016
North Carolina	36028
North Dakota	47236
Nebraska	42450
New Hampshire	45881
New Jersey	52430
New Mexico	34133
Nevada	36964
New York	51126
Ohio	37836
Oklahoma	37679
Oregon	37527
Pennsylvania	42291
Rhode Island	43875
Soouth Carolina	33388

South Dakota	44217
Tennessee	36567
Texas	40147
Utah	33509
Virginia	46107
Vermont	41572
Washington	43878
Wisconsin	39575
West Virginia	33403
Wyoming	47898
Newfoundland and Labrador	34275
Nova Scotia	37510
New Brunswick	36196
Quebec	36701
Ontario	44486
Manitoba	40341
Saskatchewan	45902
Alberta	55709
British Columbia	40240

Notes: The unit for income are in USD.

Appendix 6. Share of residential sales and industrial sales

State	SRES	SINS
Alabama	0.371	0.379
Arkansas	0.392	0.355
Arizona	0.441	0.165
California	0.337	0.191
Colorado	0.342	0.285
Connecticut	0.433	0.123
Delaware	0.403	0.226
Florida	0.517	0.075
Georgia	0.423	0.231
Iowa	0.314	0.421
Idaho	0.361	0.383
Illinois	0.329	0.314
Indiana	0.320	0.451
Kansas	0.352	0.265
Kentucky	0.304	0.487
Louisiana	0.371	0.348
Massachusetts	0.368	0.305
Maryland	0.429	0.079
Maine	0.384	0.264
Michigan	0.331	0.301
Minnesota	0.329	0.345
Missouri	0.427	0.206
Mississippi	0.392	0.330
Montana	0.356	0.289
North Carolina	0.443	0.203
North Dakota	0.331	0.314
Nebraska	0.335	0.357
New Hampshire	0.410	0.178
New Jersey	0.383	0.105
New Mexico	0.298	0.300
Nevada	0.339	0.396
New York	0.356	0.093
Ohio	0.347	0.348
Oklahoma	0.408	0.264
Oregon	0.412	0.254
Pennsylvania	0.368	0.333
Rhode Island	0.405	0.118
Soouth Carolina	0.383	0.349
South Dakota	0.398	0.221

Tennessee	0.428	0.284
Texas	0.387	0.272
Utah	0.310	0.323
Virginia	0.415	0.156
Vermont	0.383	0.255
Washington	0.388	0.298
Wisconsin	0.323	0.341
West Virginia	0.376	0.375
Wyoming	0.161	0.589
Newfoundland and Labrador	0.449	0.287
Nova Scotia	0.389	0.315
New Brunswick	0.427	0.341
Quebec	0.385	0.402
Ontario	0.312	0.182
Manitoba	0.432	0.258
Saskatchewan	0.245	0.438
Alberta	0.268	0.365
British Columbia	0.371	0.332

Notes: sources are from EIA and Statistic Canada. SRES = share of residential sales. SINS = share of industrial sales.

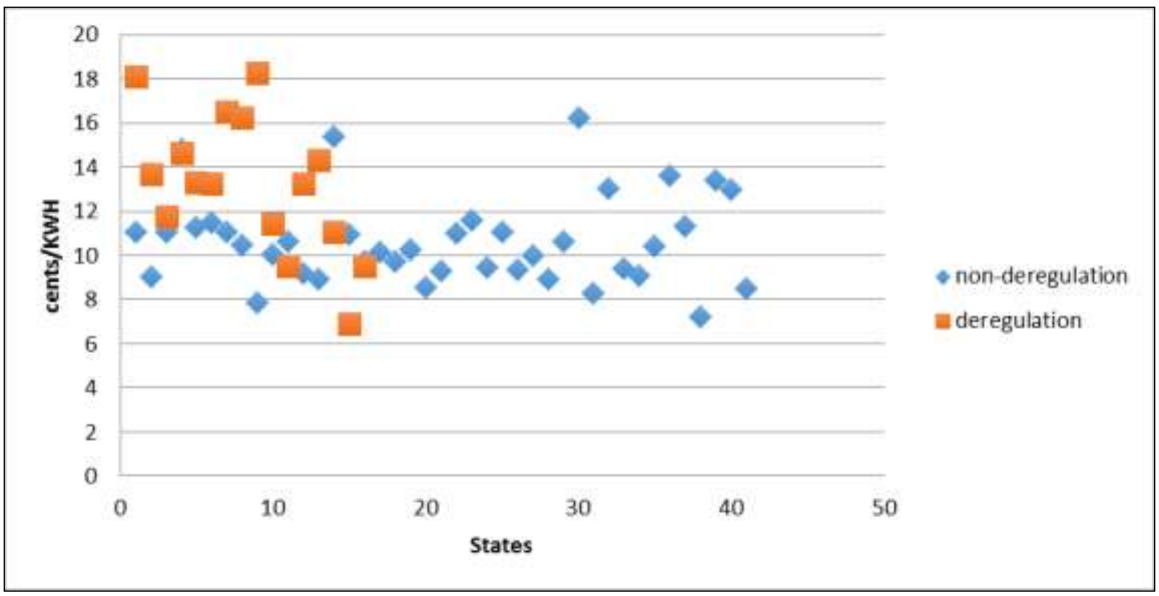
Appendix 7. Share of Electricity Generation

State	sharecoal	sharenu	sharehydro	shareother
Alabama	0.363	0.252	0.057	0.023
Arkansas	0.480	0.232	0.048	0.029
Arizona	0.404	0.289	0.085	0.006
California	0.010	0.183	0.212	0.153
Colorado	0.660	0.000	0.040	0.106
Connecticut	0.016	0.472	0.017	0.045
Delaware	0.221	0.000	0.000	0.061
Florida	0.234	0.099	0.001	0.051
Georgia	0.482	0.259	0.022	0.030
Iowa	0.678	0.093	0.016	0.195
Idaho	0.005	0.000	0.809	0.119
Illinois	0.451	0.480	0.001	0.038
Indiana	0.853	0.000	0.003	0.061
Kansas	0.698	0.161	0.000	0.085
Kentucky	0.932	0.000	0.030	0.000
Louisiana	0.233	0.158	0.010	0.084
Massachusetts	0.107	0.134	0.030	0.059
Maryland	0.504	0.344	0.061	0.036
Maine	0.003	0.000	0.249	0.317
Michigan	0.540	0.301	0.012	0.036
Minnesota	0.532	0.225	0.014	0.166
Missouri	0.825	0.099	0.012	0.014
Mississippi	0.189	0.200	0.000	0.030
Montana	0.500	0.000	0.418	0.068
North Carolina	0.505	0.342	0.033	0.026
North Dakota	0.773	0.000	0.074	0.153
Nebraska	0.719	0.192	0.045	0.032
New Hampshire	0.110	0.417	0.080	0.061
New Jersey	0.064	0.519	0.000	0.029
New Mexico	0.711	0.000	0.005	0.060
Nevada	0.169	0.000	0.069	0.078
New York	0.069	0.310	0.203	0.051
Ohio	0.777	0.110	0.003	0.019
Oklahoma	0.462	0.000	0.020	0.080
Oregon	0.056	0.000	0.709	0.093
Pennsylvania	0.442	0.335	0.014	0.027
Rhode Island	0.000	0.000	0.001	0.017
Soouth Carolina	0.332	0.514	0.015	0.022
South Dakota	0.215	0.000	0.551	0.223

Tennessee	0.503	0.332	0.118	0.015
Texas	0.363	0.091	0.001	0.085
Utah	0.811	0.000	0.030	0.030
Virginia	0.298	0.383	0.018	0.048
Vermont	0.000	0.724	0.210	0.065
Washington	0.045	0.042	0.797	0.074
Wisconsin	0.631	0.183	0.034	0.054
West Virginia	0.962	0.000	0.018	0.017
Wyoming	0.860	0.000	0.026	0.105
Newfoundland and Labrador	0.022	0.000	0.967	0.004
Nova Scotia	0.830	0.000	0.099	0.033
New Brunswick	0.443	0.000	0.340	0.052
Quebec	0.005	0.017	0.972	0.005
Ontario	0.057	0.618	0.247	0.016
Manitoba	0.004	0.000	0.984	0.011
Saskatchewan	0.705	0.000	0.201	0.031
Alberta	0.771	0.000	0.028	0.034
British Columbia	0.061	0.000	0.921	0.001

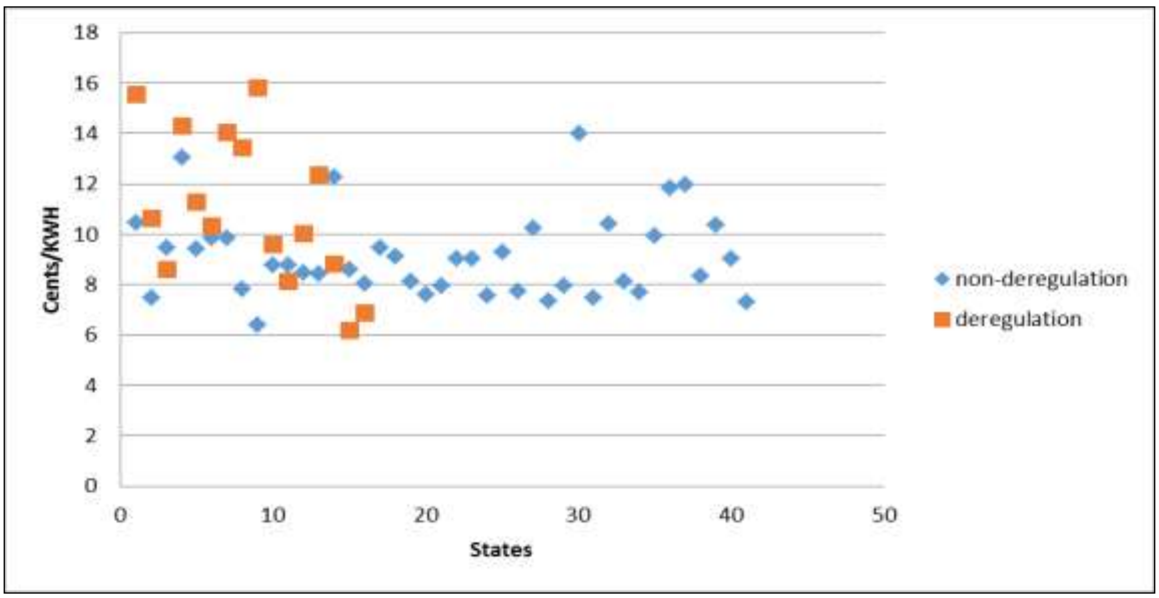
Notes: sources are from EIA and Statistics Canada. Sharecoal = share of electricity generated by coal. Sharenu = share of electricity generated by nuclear. Sharehydro = share of electricity generated by hydro. Shareother = share of electricity generated by other.

Appendix 8. Comparison: Deregulation V.S. Non-deregulation (residential rates)



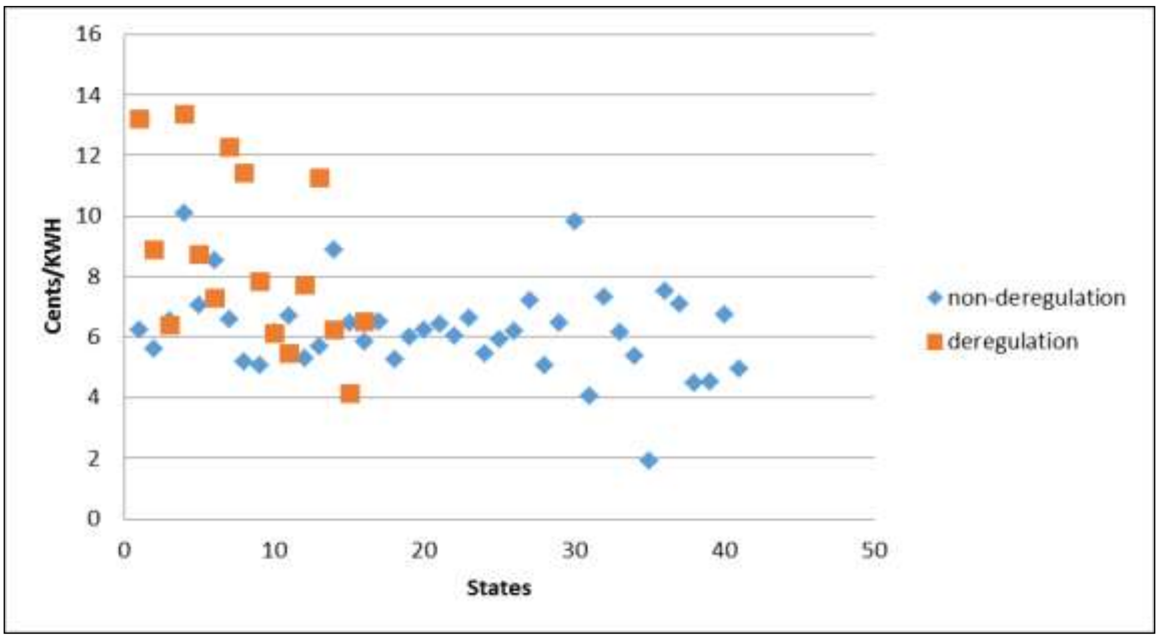
Note: According to Appendix 8, we can observe obvisuly that most of states which has deregulated electricity sectors have higher electricity rates than the states which has non-deregulated electricity sectors.

Appendix 9. Comparison: Deregulation V.S. Non-deregulation (commercial rates)

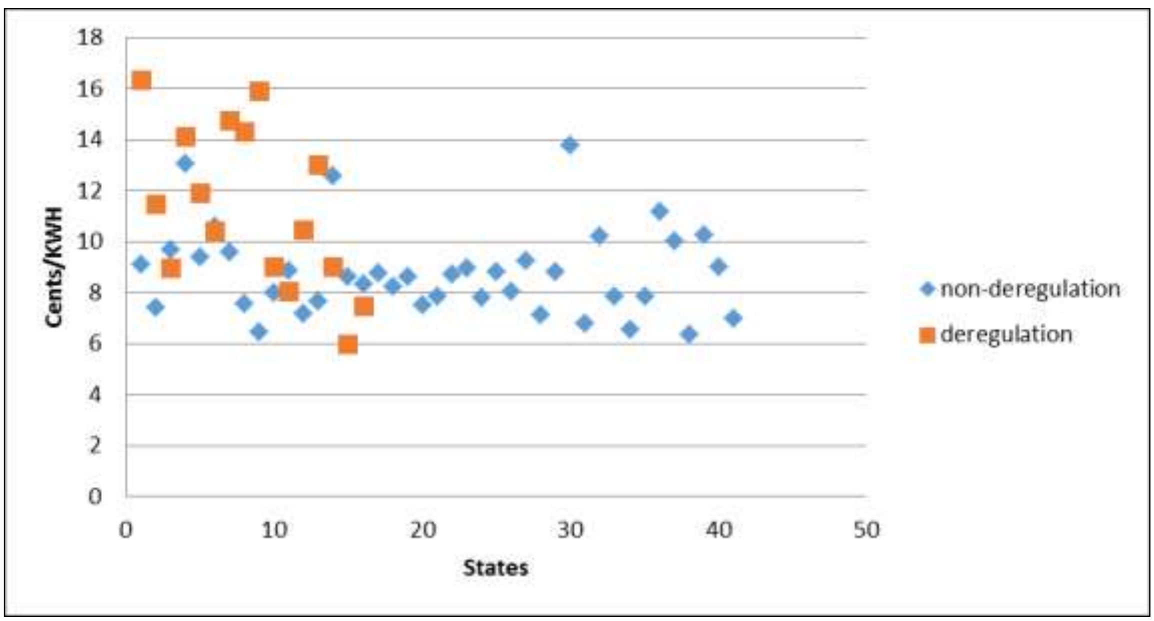


Notes: Commercial electricity rates reflect as the same results as residentail electricity rates does.

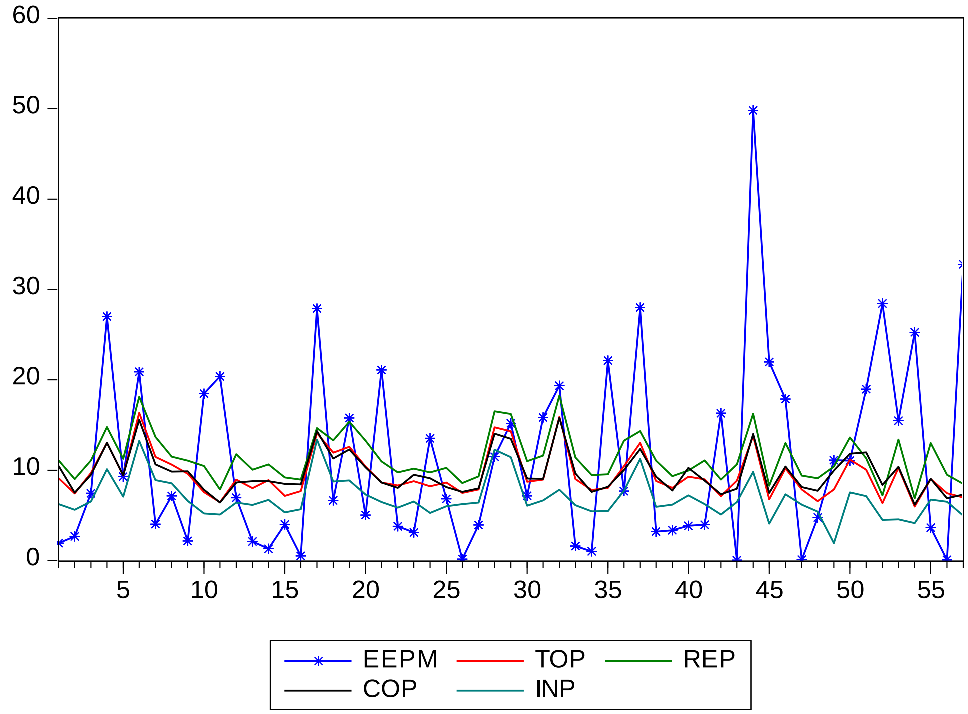
Appendix 10. Comparison: Deregulation V.S. Non-deregulation (industrial rates)



Appendix 11. Comparison: Deregulation V.S. Non-deregulation (total rates)



Appendix 12. EEPM and rates (4 categories)



Notes: I would like to point out one thing is that higher energy efficiency programs spending indicates higher electricity rates, including residential, commercial, and industrial rates. In reality, an area would increase the expense on energy efficiency programs when the electricity rates there are increasing.

Appendix 13. Oreginal datasheet

State	CDD	REP	COP	INP	TOP	EEPM	SRES	SINS	sharecoal	sharenu	sharehydrc	shareother	income	DEREGU
Alabama	2150	11.09	10.47	6.25	9.1	1.93	0.371	0.379	0.363	0.252	0.057	0.023	34880	0
Arkansas	2190	9.02	7.5	5.63	7.43	2.66	0.392	0.355	0.480	0.232	0.048	0.029	33740	0
Arizona	2871	11.08	9.5	6.55	9.71	7.46	0.441	0.165	0.404	0.289	0.085	0.006	35062	0
California	847	14.78	13.05	10.11	13.05	27.01	0.337	0.191	0.010	0.183	0.212	0.153	43647	0
Colorado	515	11.27	9.44	7.06	9.39	9.29	0.342	0.285	0.660	0.000	0.040	0.106	44053	0
Connecticut	792	18.11	15.57	13.24	16.35	20.88	0.433	0.123	0.016	0.472	0.017	0.045	57902	1
Delaware	1525	13.7	10.64	8.91	11.48	4.02	0.403	0.226	0.221	0.000	0.000	0.061	41449	1
Florida	3739	11.51	9.85	8.55	10.61	7.15	0.517	0.075	0.234	0.099	0.001	0.051	39636	0
Georgia	2027	11.05	9.87	6.6	9.61	2.16	0.423	0.231	0.482	0.259	0.022	0.030	35979	0
Iowa	974	10.46	7.85	5.21	7.56	18.48	0.314	0.421	0.678	0.093	0.016	0.195	41156	0
Idaho	485	7.87	6.41	5.1	6.44	20.38	0.361	0.383	0.005	0.000	0.809	0.119	32881	0
Illinois	1064	11.78	8.64	6.42	8.97	6.96	0.329	0.314	0.451	0.480	0.001	0.038	43721	1
Indiana	1084	10.06	8.77	6.17	8.01	2.12	0.320	0.451	0.853	0.000	0.003	0.061	35689	0
Kansas	1754	10.65	8.78	6.71	8.89	1.31	0.352	0.265	0.698	0.161	0.000	0.085	40883	0
Kentucky	1393	9.2	8.49	5.33	7.17	3.99	0.304	0.487	0.932	0.000	0.030	0.000	33989	0
Louisiana	3020	8.96	8.44	5.69	7.68	0.51	0.371	0.348	0.233	0.158	0.010	0.084	38549	0
Massachusetts	626	14.67	14.33	13.38	14.11	27.88	0.368	0.305	0.107	0.134	0.030	0.059	53471	1
Maryland	1416	13.31	11.28	8.76	11.93	6.67	0.429	0.079	0.504	0.344	0.061	0.036	50656	1
Maine	267	15.38	12.29	8.88	12.58	15.78	0.384	0.264	0.003	0.000	0.249	0.317	38299	0
Michigan	677	13.27	10.33	7.32	10.4	5.03	0.331	0.301	0.540	0.301	0.012	0.036	36264	1
Minnesota	590	10.96	8.63	6.47	8.65	21.11	0.329	0.345	0.532	0.225	0.014	0.166	44560	0
Missouri	1484	9.75	8.04	5.85	8.32	3.79	0.427	0.206	0.825	0.099	0.012	0.014	37969	0
Mississippi	2389	10.17	9.48	6.53	8.78	3.12	0.392	0.330	0.189	0.200	0.000	0.030	32000	0
Montana	326	9.75	9.12	5.27	8.23	13.54	0.356	0.289	0.500	0.000	0.418	0.068	36016	0
North Carolina	1788	10.26	8.13	6.01	8.64	6.85	0.443	0.203	0.505	0.342	0.033	0.026	36028	0
North Dakota	507	8.58	7.61	6.24	7.5	0.15	0.331	0.314	0.773	0.000	0.074	0.153	47236	0
Nebraska	1053	9.32	7.99	6.43	7.88	3.95	0.335	0.357	0.719	0.192	0.045	0.032	42450	0
New Hampshire	395	16.52	14.04	12.27	14.74	11.49	0.410	0.178	0.110	0.417	0.080	0.061	45881	1
New Jersey	1053	16.23	13.47	11.43	14.3	15.19	0.383	0.105	0.064	0.519	0.000	0.029	52430	1
New Mexico	1131	11	9.07	6.06	8.74	7.17	0.298	0.300	0.711	0.000	0.005	0.060	34133	0
Nevada	1623	11.61	9.05	6.65	8.97	15.85	0.339	0.396	0.169	0.000	0.069	0.078	36964	0
New York	779	18.26	15.81	7.83	15.89	19.36	0.356	0.093	0.069	0.310	0.203	0.051	51126	1
Ohio	955	11.42	9.63	6.12	9.03	1.61	0.347	0.348	0.777	0.110	0.003	0.019	37836	1
Oklahoma	2513	9.47	7.6	5.46	7.8	1.03	0.408	0.264	0.462	0.000	0.020	0.080	37679	0
Oregon	284	9.54	8.15	5.47	8.04	22.14	0.412	0.254	0.056	0.000	0.709	0.093	37527	1
Pennsylvania	937	13.26	10.03	7.73	10.45	7.68	0.368	0.333	0.442	0.335	0.014	0.027	42291	1
Rhode Island	732	14.33	12.37	11.27	13.04	28.01	0.405	0.118	0.000	0.000	0.001	0.017	43875	1
Soouth Carolina	2154	11.05	9.3	5.94	8.8	3.2	0.383	0.349	0.332	0.514	0.015	0.022	33388	0
South Dakota	802	9.35	7.76	6.2	8.05	3.36	0.398	0.221	0.215	0.000	0.551	0.223	44217	0
Tennessee	1574	9.98	10.27	7.23	9.28	3.84	0.428	0.284	0.503	0.332	0.118	0.015	36567	0
Texas	3440	11.08	8.83	6.24	9	3.98	0.387	0.272	0.363	0.091	0.001	0.085	40147	1
Utah	814	8.96	7.35	5.1	7.13	16.3	0.310	0.323	0.811	0.000	0.030	0.030	33509	0
Virginia	1408	10.64	7.95	6.49	8.84	0.05	0.415	0.156	0.298	0.383	0.018	0.048	46107	0
Vermont	303	16.26	14	9.83	13.8	49.83	0.383	0.255	0.000	0.724	0.210	0.065	41572	0
Washington	223	8.28	7.49	4.09	6.78	21.98	0.388	0.298	0.045	0.042	0.797	0.074	43878	0
Wisconsin	582	13.02	10.42	7.33	10.21	17.88	0.323	0.341	0.631	0.183	0.034	0.054	39575	0
West Virginia	1023	9.39	8.14	6.18	7.88	0.09	0.376	0.375	0.962	0.000	0.018	0.017	33403	0
Wyoming	406	9.11	7.72	5.41	6.58	4.78	0.161	0.589	0.860	0.000	0.026	0.105	47898	0
Newfoundland a	58	10.42	9.97	1.92	7.86	11.10	0.449	0.287	0.022	0.000	0.967	0.004	34275	0
Nova Scotia	187	13.63	11.84	7.55	11.18	11.05	0.389	0.315	0.830	0.000	0.099	0.033	37510	0
New Brunswick	67	11.33	11.99	7.13	10.05	18.96	0.427	0.341	0.443	0.000	0.340	0.052	36196	0
Quebec	423	7.23	8.38	4.50	6.38	28.44	0.385	0.402	0.005	0.017	0.972	0.005	36701	0
Ontario	454	13.39	10.37	4.55	10.25	15.47	0.312	0.182	0.057	0.618	0.247	0.016	44486	0
Manitoba	335	6.91	6.18	4.14	5.97	25.25	0.432	0.258	0.004	0.000	0.984	0.011	40341	1
Saskatchewan	263	12.99	9.06	6.76	9.02	3.66	0.245	0.438	0.705	0.000	0.201	0.031	45902	0
Alberta	50	9.50	6.88	6.53	7.45	0.09	0.268	0.365	0.771	0.000	0.028	0.034	55709	1
British Columbi	79	8.50	7.32	4.98	6.98	32.78	0.371	0.332	0.061	0.000	0.921	0.001	40240	0