

Competition Has Not Lowered US Industrial Electricity Prices

*Jay Apt**

Previous studies have shown that significant price reductions resulted from deregulation in airlines, trucking, railroads, and natural gas. Retail electricity price data from 1990 through 2003 show no such benefit to industrial customers.

*Distinguished Service Professor in Engineering and Public Policy and Executive Director, Carnegie Mellon Electricity Industry Center, Tepper School of Business, 254B Posner Hall, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213 USA. E-mail: apt@cmu.edu. This research was funded in part by the Alfred P. Sloan Foundation and the Electric Power Research Institute under grants to the Carnegie Mellon Electricity Industry Center. I thank Lester Lave and Samir Nandy for helpful discussions.

I. Introduction

Restructuring of the electric power industry followed deregulation of natural gas (1978), airlines (1978), railroads (1980), and the trucking industry (1980). Industrial customers were permitted to select their electricity generation company in the first states during 1998. Nineteen states and the District of Columbia have now implemented competition for industrial customers¹, with rules taking effect through the ensuing six years. Roughly 40% of all electricity in the United States is now sold in restructured states.

Before restructuring got underway, microeconomic studies indicated that efficiency gains of 3-13% were feasible through competitive pressures.^{2,3} The actual record on overall operations costs and thermal efficiencies is mixed.⁴ One study of generators in restructured states⁵ indicates that employment dropped 29% in restructured states and 19% in other states since the peak in 1991; however that 10% difference would have lowered cost by only roughly 0.7%, since labor costs represent about 7% of electricity cost.

The Federal Reserve Bank of New York predicted in 2000 that "... the market forces introduced to the industry by deregulation should cause electricity rates to drop below the levels that would have prevailed under a monopoly system."⁶ This paper examines the effect of restructuring on prices paid by US industrial customers for electricity.

II. Data Source

The United States Energy Information Administration began collecting annual survey data on power sales in 1985 (EIA form 861). The annual data are collected from ~3,300 electric utilities and ~1,600 independent power producers, unregulated generation units of regulated utilities, and power marketers. Operating revenue data include "energy charges, demand charges, consumer service charges, environmental surcharges, fuel adjustments, and other miscellaneous charges. Electric power industry participant operating revenues also include State and Federal income taxes and taxes other than income taxes paid by the utility."⁷ Data are collected on energy (kilowatt-hours) sold.

EIA also performs a monthly survey of 450 large utilities and energy service providers accounting for approximately 70% of sales (form 826). Data have been collected since 1947; the survey instrument was last revised in January 1990 and data are available in a consistent format from that date through the present, with a lag of approximately eight months.⁸

The annual survey data submitted on form 861 by April 30th each year are used by EIA to correct the monthly data, and to scale the monthly data to account for all sales. Schedule A of form 861 is completed by vertically integrated utilities, schedule B by power marketers (without transmission or distribution facilities), and schedule C by distribution companies. No statutory requirement compels power marketers (or some other firms) to return the form, and the sum of schedule B is in some states less than the schedule C reported total. Although schedules B and C match well for most states, there are important errors. For example, one power marketer with large sales in Maine and Texas does not report. Adjustments to the schedule B data are made by EIA specialists, often after additional contacts with the involved parties, using their best judgment and knowledge of the particular state.

Reporting firms segment the data into industrial, commercial, residential, transportation, and “other” sectors.⁹ Although changes implemented during 2003 in the segmentation introduce relatively small shifts, inconsistent definitions of what constitutes industrial and commercial customers exist: some distribution companies report large retailer stores as industrial, while power marketers may report the same load as commercial.

Occasional units errors appear in the EIA data. For example, the Alaska data for January 2003 was contaminated by one firm reporting in kWh and dollars, instead of the requested MWh and \$k. EIA corrected this error when shown a discontinuity in the time series for Alaska.

Despite these sources of inaccuracy, the EIA data is the best national data source for electricity sales and revenue covering the period before and after the inception of restructuring. EIA staff are quick to correct inconsistencies in the data, and have applied corrections for underreporting in a thoughtful manner. The necessity for EIA staff to adjust the raw electricity data would be lessened greatly if all firms were compelled to report, and clear guidance for segmentation of sales were applied.

III. Price History

The benefits of retail competition in the electric power industry are best studied by examining prices for large industrial customers, who have both the incentive and resources to shop for the best price. Because small customers were not expected to switch suppliers readily, 14 of the states that introduced retail competition mandated rate reductions for residential customers,¹ generally of approximately 5%. The commercial sector consists of a mix: large retailers, small shops, universities, hospitals, high-rise office buildings, and small strip malls. The heterogeneity of the commercial sector makes analysis of the effects of restructuring more difficult than for the industrial sector. Data from the industrial sector are used here. See Appendix 1 for a discussion of how the seasonal periodicity was removed from the raw EIA data. See Appendix 2 for the full set of results for all three sectors.

Results for the industrial sector prices for five western states are shown in Figure 1. The strong collateral influence of the market failure in California is seen in Washington, Oregon, and Nevada as well (the latter two are regulated states).

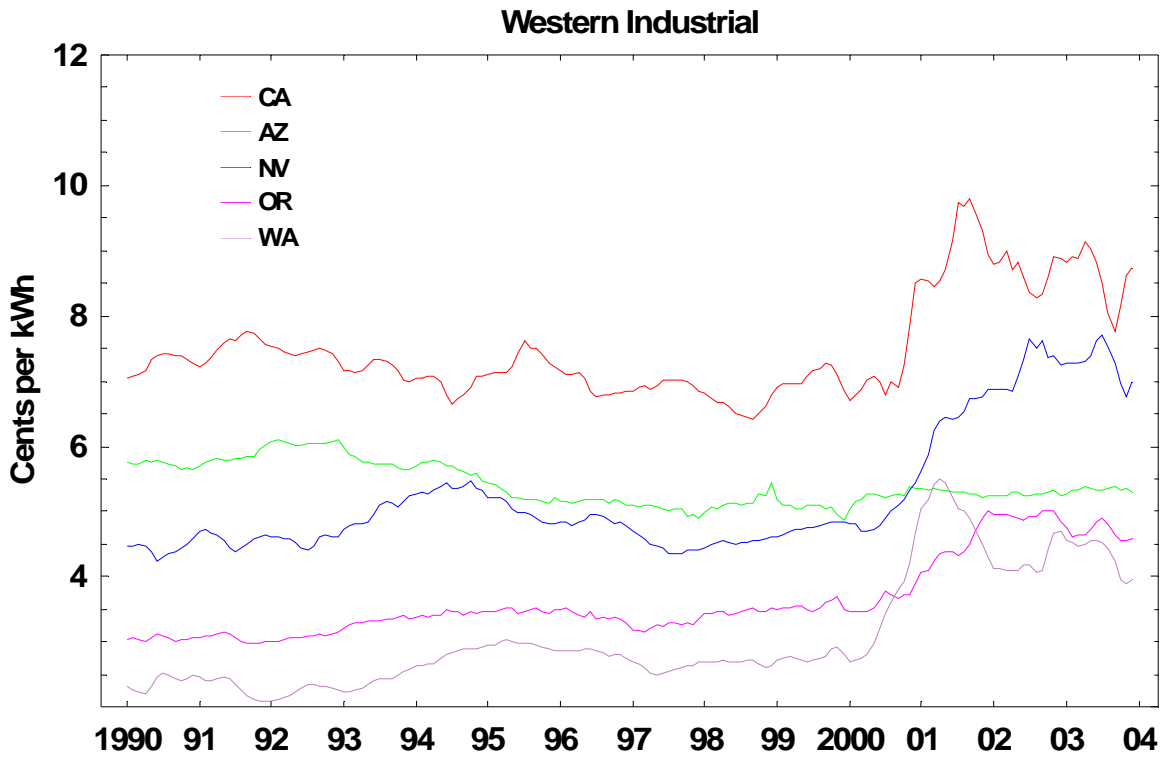


Figure 1: Industrial prices in five western states, 1990-2003

Much less price volatility is seen in the regulated southern states, the price history for five of which are in Figure 2.

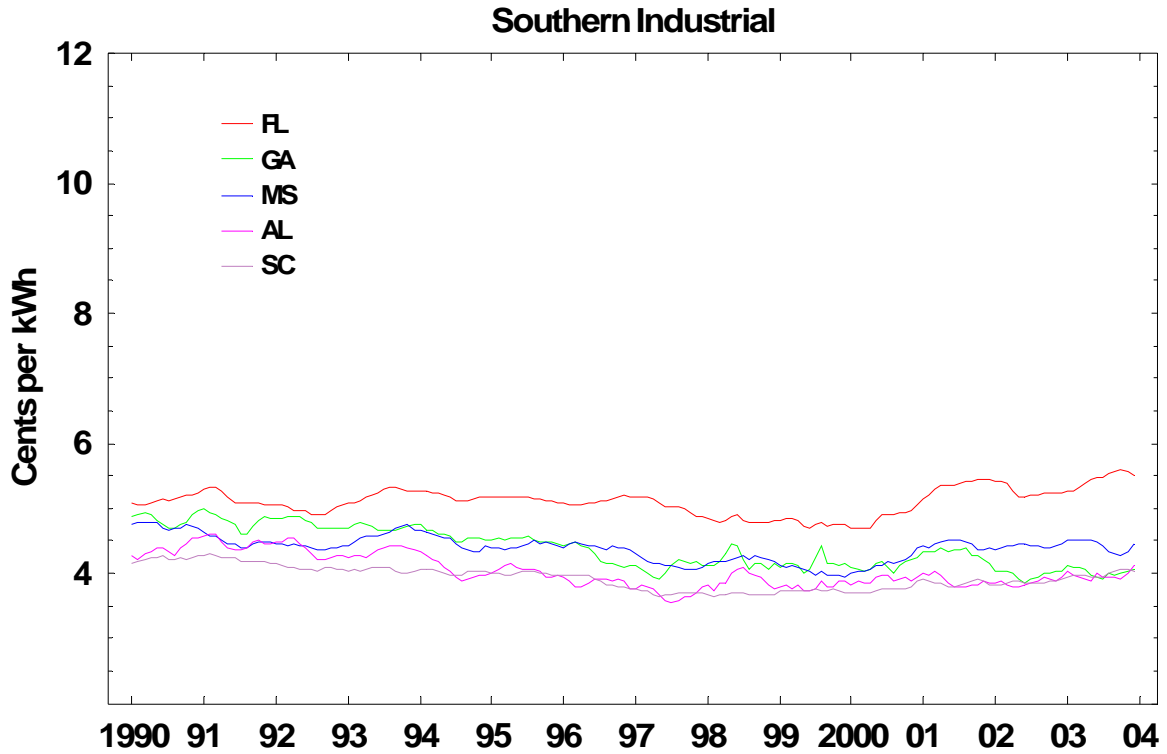


Figure 2: Industrial prices in five regulated southern states, 1990-2003

The New England states quickly followed California and Pennsylvania in implementing electric restructuring. Figure 3 shows the industrial price history for five New England states.

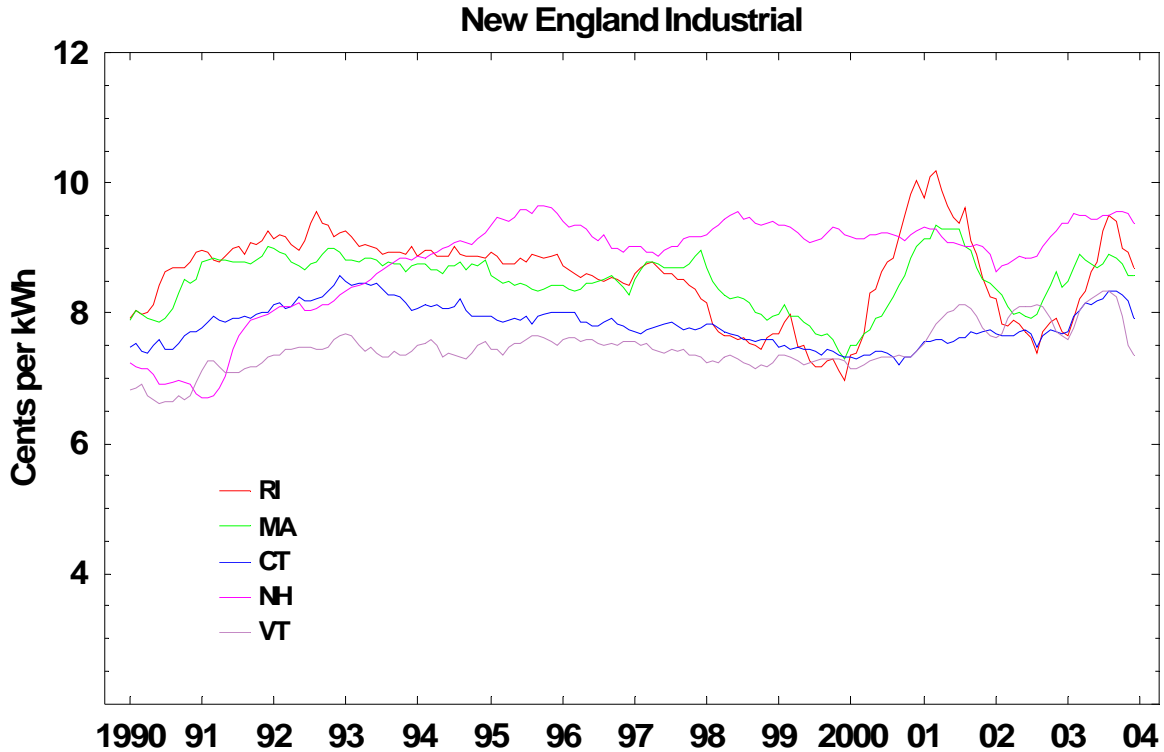


Figure 3: Industrial prices in five New England states, 1990-2003

Two aspects of the price history in New England deserve further comment. The price increases in Rhode Island and Massachusetts in 2000 and again in 2003 are most likely due to natural gas fuel cost increases. This hypothesis is supported by an examination of a number of states which generate large percentages of their electricity from natural gas, shown in Figure 4. The 2000 and 2003 peaks are a good match to natural gas prices.¹⁰

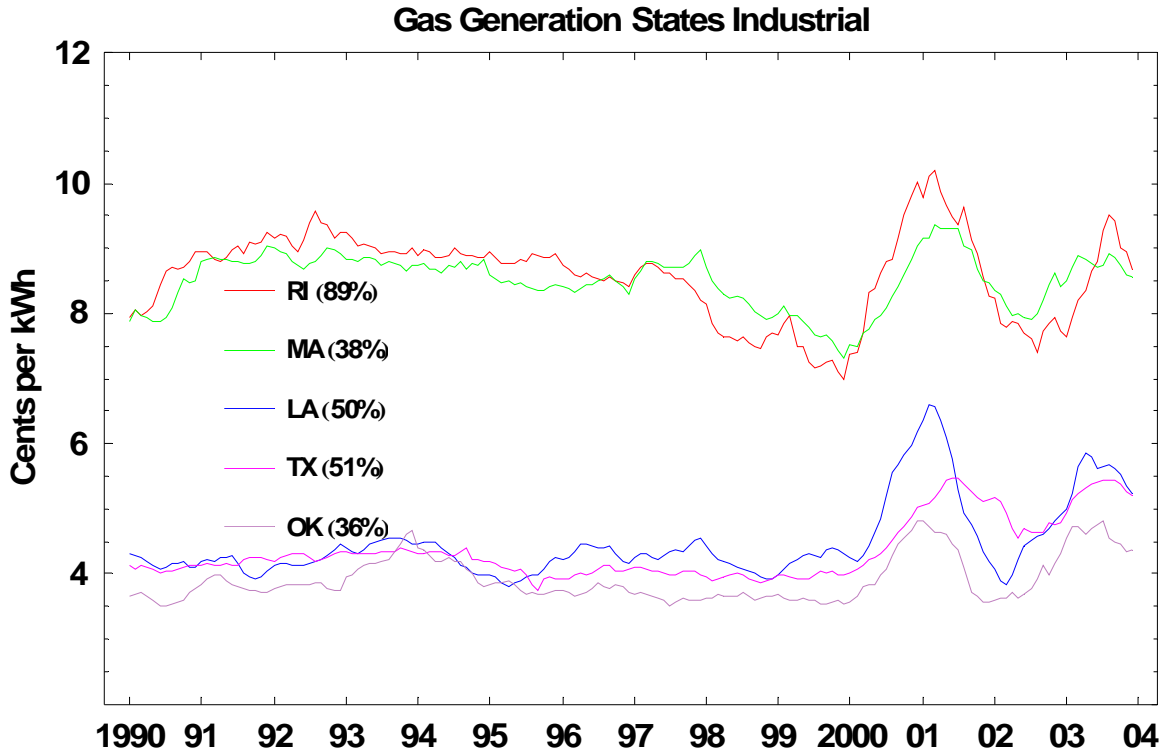


Figure 4: Industrial prices in states with large percentage of net generation from natural gas¹¹ (2002 percentage shown in parentheses), 1990-2003.

Second, the state of Maine is heavily dependent on electric generation fueled by natural gas. Prices in that state began to rise in 2000, but have fallen significantly since (Figure 5). However, the price decrease appears to be correlated with completion of two natural gas pipelines from the Sable Island field off Nova Scotia. Prices subsequently have fallen to levels characteristic of other states close to large natural gas resources.

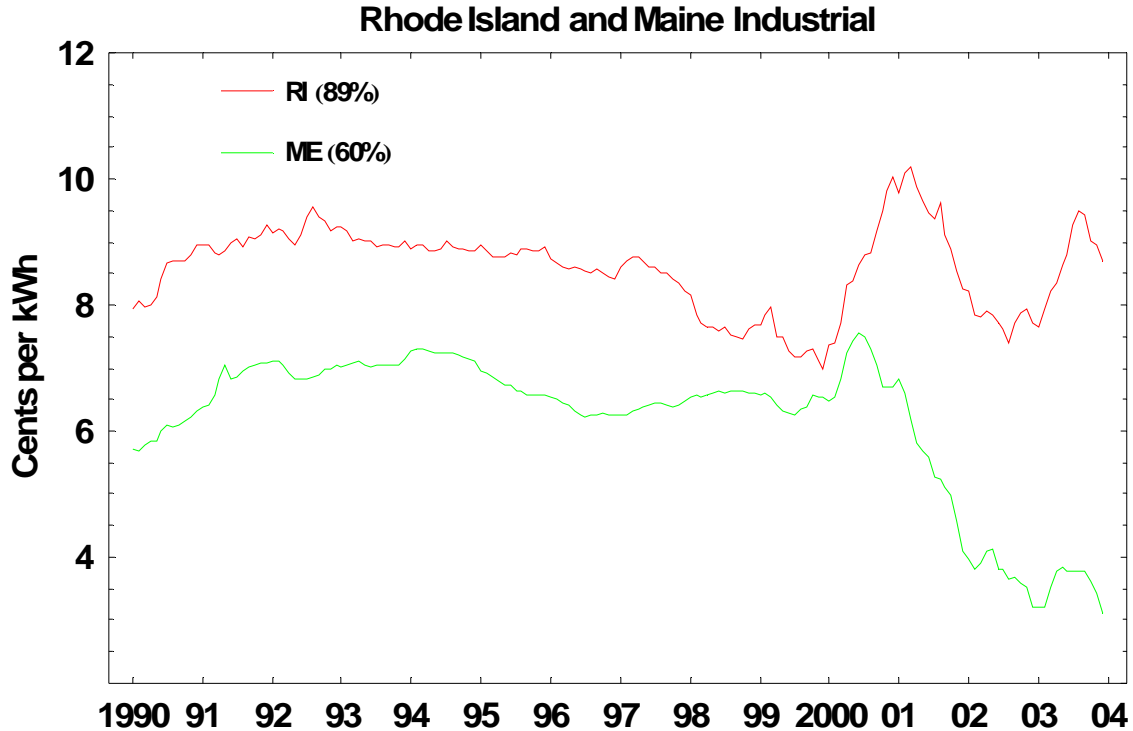


Figure 5: Industrial prices in Rhode Island and Maine (2002 percentage of generation from natural gas shown in parentheses), 1990-2003.

IV. Discussion

New England provides a laboratory for examining the effects of restructuring, since Vermont is the only regulated state in the region. As Figure 3 shows, there is little difference between the price history of Vermont and that of the other four states in the figure, with the exceptions of natural gas price changes.

A broader view can be obtained by using the data to calculate the annual rate of industrial price change in the period before and after the phase-in of restructuring for the restructured states, given in Table 1 and Table 2. We can compare these to the price changes in nearby regulated states, shown in Table 2. The regional data in Table 2 were calculated as the average of the rates of the individual listed states. These data are shown graphically in Figures 6 and 7.

Using New England as an example, the average annual rate of industrial price change for Connecticut, Massachusetts, Maine, New Hampshire, New York, and Rhode Island from January 1990 to one month prior to the beginning of the phase-in period for industrial competition (shown in Table 1) was 0.9% per year increase. The corresponding annual rate after phase-in of competition was -1.7% per year (a decrease). Before proclaiming that restructuring has been a boon for industrial customers in New England we should recall that the 20% decrease in Maine's prices was due to other reasons. When Maine is removed, the "before" rate for the remaining five states was 0.8%, but industrial prices rose 2.0% after restructuring in those states. For comparison, Vermont's regulated prices rose 0.8% annually from 1990 through March 1998, and fell 0.8% from 2001-2003.

(Those time periods are used as comparison periods for all regulated states to encompass the periods before and after phase-in of restructuring in other states).

We can characterize the same data by noting that the annual rate after phase-in of competition minus that before for the New England states (without Maine) was $2.0\% - 0.8\% = 1.2\%$ (the difference between the annual rate of change after and before). The same figure for Vermont was -1.6% . This annual rate difference is the difference between the black bar and cross-hatched bar in Figures 6 and 7. Considering all 50 states and the District of Columbia, industrial prices decreased by an average of 0.4% annually before the beginning of the period of restructuring, and have increased by 0.4% after. The restructured jurisdictions had annual increases of 0.4% prior to restructuring, and increases of 0.5% annually after (removing Maine the corresponding figures are 0.3% prior to and 1.7% after restructuring).

Using this difference between the annual price change after phase-in of industrial sector competition and before it began as the dependent variable, we can perform a regression analysis for all 50 states (with the exception of Virginia, where phase-in is in progress) and the District of Columbia. The analysis shows that the variable of restructuring fails to explain the price changes. Figure 8 is a plot of the annual price change difference for all regulated and all restructured states. The plot includes the District of Columbia but not Virginia, whose phase-in period overlaps the end of the data. The lowest point, showing the greatest difference since restructuring, is Maine.

Inspection of Figure 8 shows there is no correlation between restructuring or regulation and improvement in the annual rate of price change. The formal regression analysis leads to the same conclusion, with an r^2 of 0.01 (r^2 would be close to one if restructuring was correlated closely with the difference in the annual price change after and before restructuring). Restructuring in the electricity industry has not led to lower industrial prices, nor to decreased rates of annual price increases.

V. Conclusion

A review of improvements in consumer welfare in other deregulated industries¹² concluded that substantial price reductions resulted from deregulation in airlines, trucking (both less-than-truckload and full truckload), railroads, and natural gas. The review notes that reductions in real terms ranged from 30 to 75% in these industries.

The industrial sector price data for electricity shows no similar improvement. Lave et al.¹³ discuss a number of factors which tend to increase costs. These include free markets which are not competitive, incomplete markets for essential services, paying market clearing prices for all generation, the cost of new institutions such as RTOs, and the increase in the cost of capital due to increased uncertainty. The first and last of these apply to some industries with successful restructuring records. It may be that appropriate regulatory involvement can lead to conditions which foster lower prices in the electricity industry as well, but issues such as shared transmission infrastructure must be resolved.

Consumer welfare has not been improved by restructuring in the electricity industry, and considerable thought should be given to whether it is wise to extend restructuring to other states before the full range of issues has been resolved and reduced prices or reduced rate of price increase have been demonstrated.

Table 1: State Industrial Price Change Before and After Restructuring

State	Phase-in Period for Industrial Sector Competition ¹⁴	Annual Percentage Change of Industrial Price	
		1990 to One Month Prior to Beginning of Phase-in Period	One Month After End of Phase-in Period through 2003
Arizona	January 1999 - December 2002	-0.6%	0.6%
California	April 1998	-0.6%	5.0%
Connecticut	January - July 2000	-0.2%	2.2%
Delaware	October 1999 - April 2000	0.9%	3.5%
D.C.	January 2001	0.1%	3.3%
Illinois	October 1999 - December 2000	-0.8%	3.0%
Maine	March 2000	1.3%	-20.1%
Maryland	July 2000 - July 2002	-1.9%	1.2%
Massachusetts	March 1998	0.9%	0.6%
Michigan	June 1999 - December 2001	-1.4%	-3.9%
Montana	July 1998	-1.1%	5.9%
New Hampshire	July 1998 - May 2001	3.3%	1.3%
New Jersey	November 1999	0.2%	1.3%
New York	May 1998 - July 2001	-1.0%	4.3%
Ohio	January 2001	1.0%	0.5%
Oregon	March 2002	4.0%	-4.2%
Pennsylvania	January 1999 - December 1999	-0.3%	2.7%
Rhode Island	July 1997 - January 1998	1.1%	1.8%
Texas	January 2002**	1.9%	0.9%
Virginia	January 2002 - January 2004	-0.2%	N/A

* Michigan industrial rates were capped through December 2003

** Except municipals, co-ops, and rural southeast Texas

Table 2: Regional Industrial Price Change Before and After Restructuring

Region	Annual Percentage Change of Industrial Price	
	1990 to One Month Prior to Beginning of Phase-in Period	One Month After End of Phase-in Period through 2003
Western Restructured (AZ, CA, MT, OR)	0.4%	1.8%
Ohio Valley Restructured (IL, OH, PA)	0.0%	2.1%
New England Restructured (CT, MA, ME, NH, NY, RI)	0.9%	-1.7%
New England Restructured without Maine	0.8%	2.0%
All Restructured	0.4%	0.5%
All Restructured without Maine	0.3%	1.7%
<u>Regulated States Comparison</u>	1990 – March 1998	2001 – 2003
Western Regulated (CO, ID, NM, NV, UT, WA, WY)	0.0%	1.0%
Upper Midwest Regulated (IA, MN, ND, NE, SD, WI)	-0.6%	1.3%
Lower Midwest Regulated (KS, MO, OK)	-1.3%	-1.8%
Ohio Valley Regulated (IN, KY, WV)	-0.7%	2.5%
Vermont	0.8%	-0.8%
South Regulated (AL, AR, FL, GA, LA, MS, NC, SC, TN)	-1.3%	-0.8%
All Continental US Regulated	-0.7%	0.3%
All US Regulated	-0.7%	0.1%

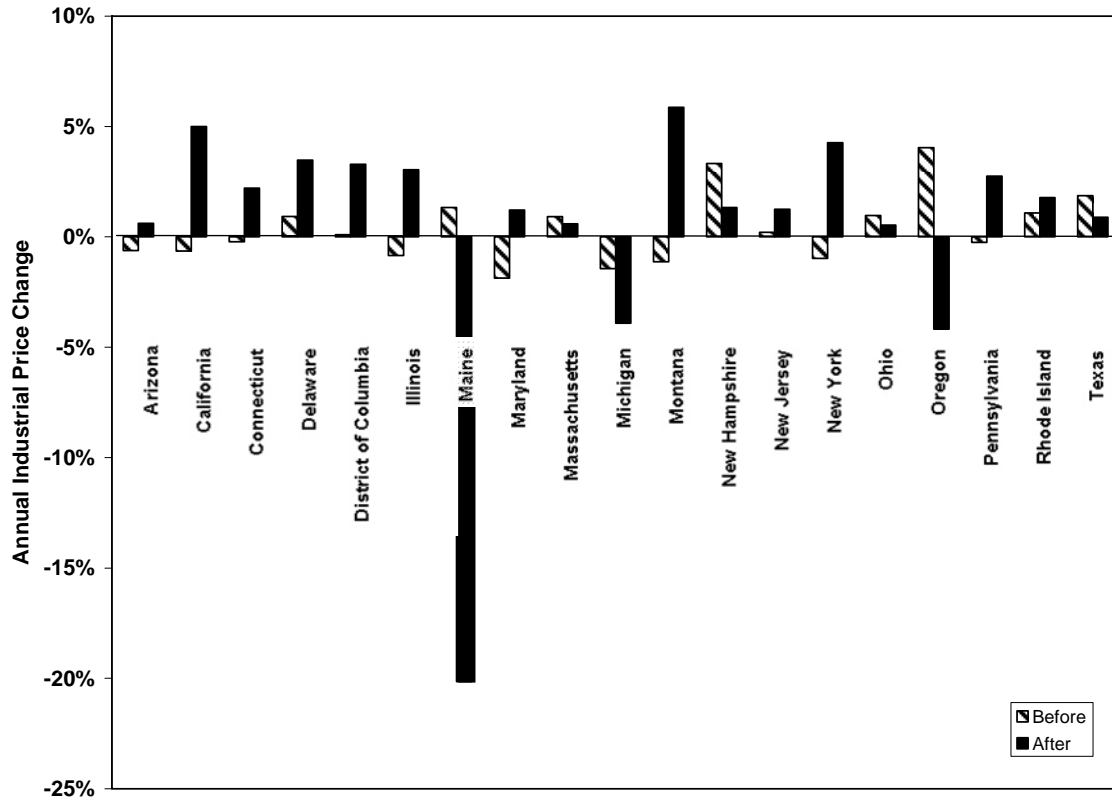


Figure 6: Annual rate of industrial price change in restructured states before and after restructuring phase-in (data from Table 1)

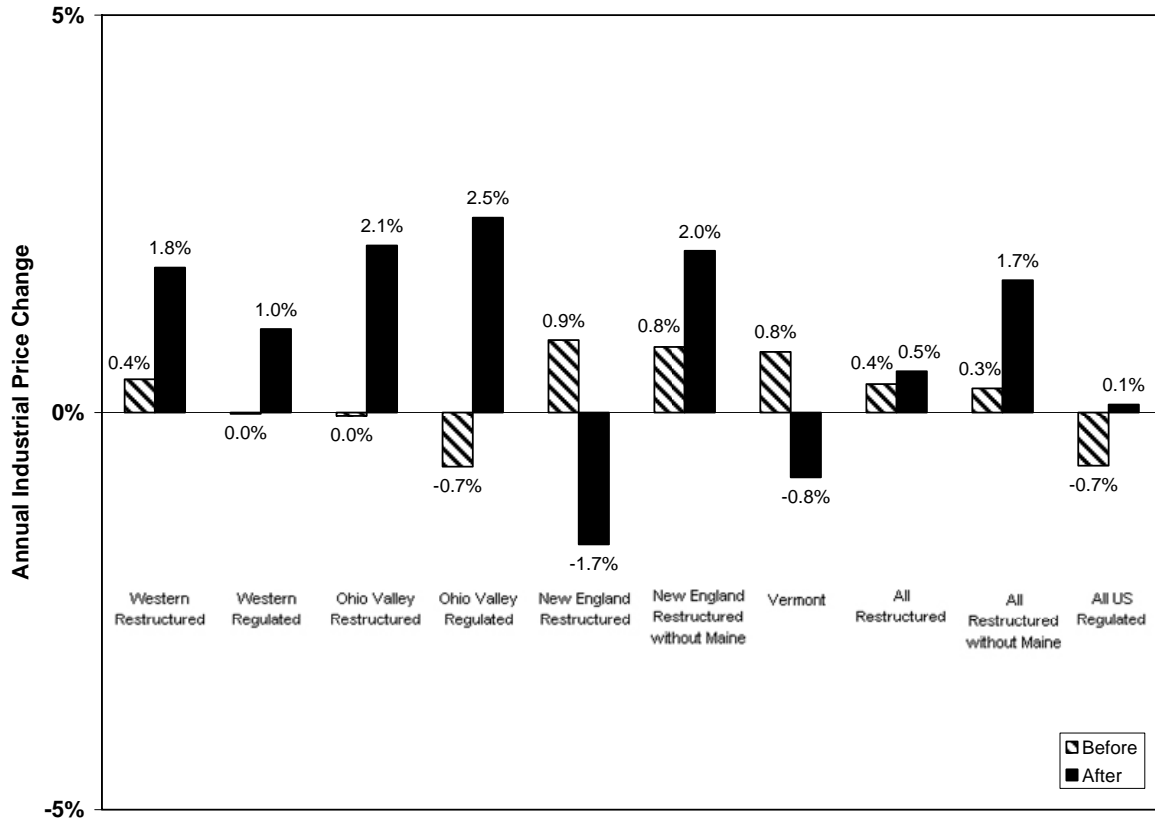


Figure 7: Regional average annual rate of industrial price change before and after restructuring phase in (data from Table 2)

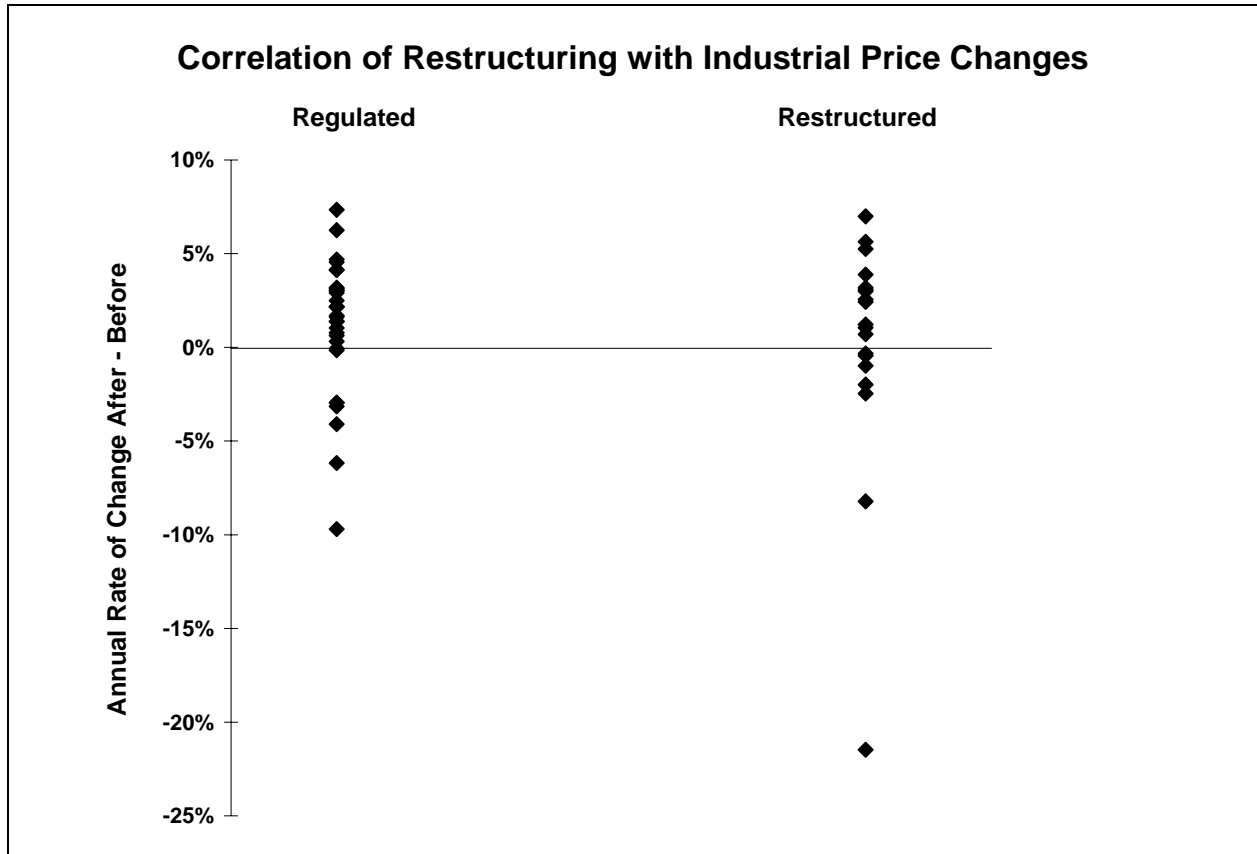


Figure 8: Each point represents the difference between the annual percentage change of industrial price after the phase-in of competition and the annual change before the phase-in for one state. The “before” period for the regulated states is 1990-March 1998; the “after” period is 2001-2003. There is no statistically significant correlation between restructuring and improved industrial prices.

Appendix 1. Data Processing

Data for many states exhibit cyclical trends in revenue, sales, or their quotient. As an example, Figure 9 shows the quotient of the EIA revenue data divided by the EIA sales data for the industrial sector in Maryland from January 1990 through December 2003.

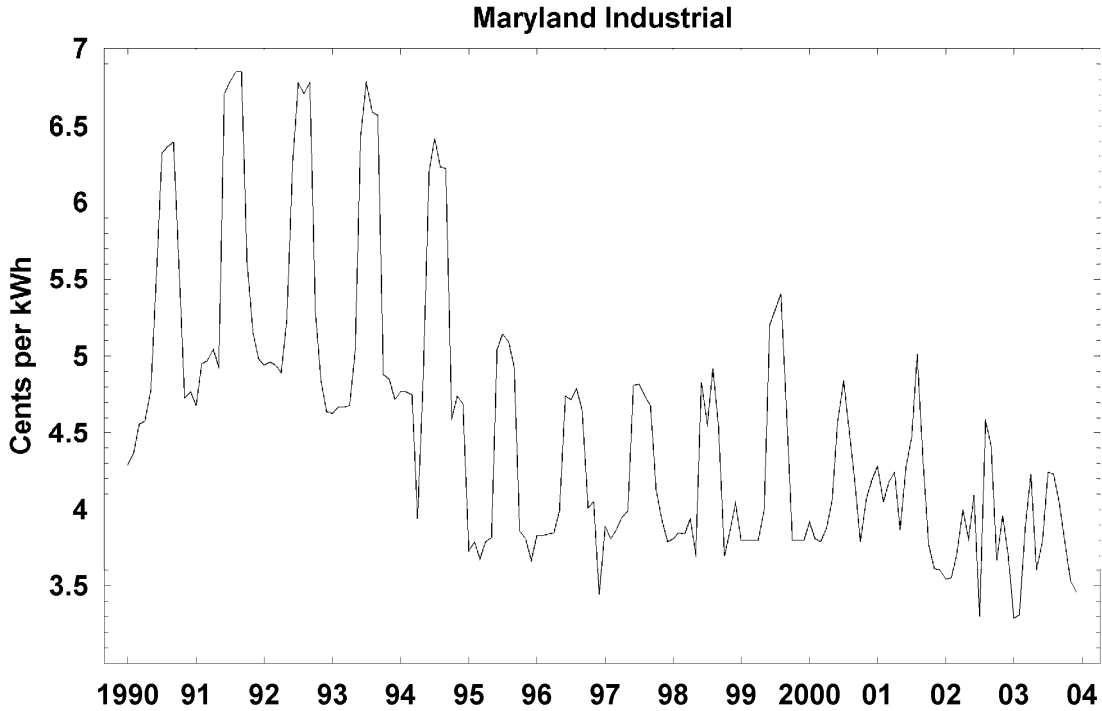


Figure 9: Monthly industrial sector price data (revenue / sales) for Maryland

Various techniques exist for reducing the seasonal periodicity in such data so that underlying trends can be examined quantitatively. Here we discuss three such techniques for data sets of length M months. A 12-month trailing moving average of the form

$$\text{Average}_n = \frac{1}{12} \sum_{k=n-11}^n \text{Data}_k \quad (1)$$

can be constructed for each month n starting with the 12th month of data running through the end of the data at month M . This is the form of the moving average trendline used by Microsoft[®] Excel. The disadvantage of this technique is that it lags actual changes in the data by several months.

A better form of a moving average for examining price data is centered around month n :

$$\text{Average}_n = \frac{1}{12} \sum_{k=n-5}^{n+6} \text{Data}_k \quad (2)$$

This average is constructed from the 6th month of the data set to the M-6th month. As shown in Figure 10, the centered average does an acceptable job of showing annual trends in the data.

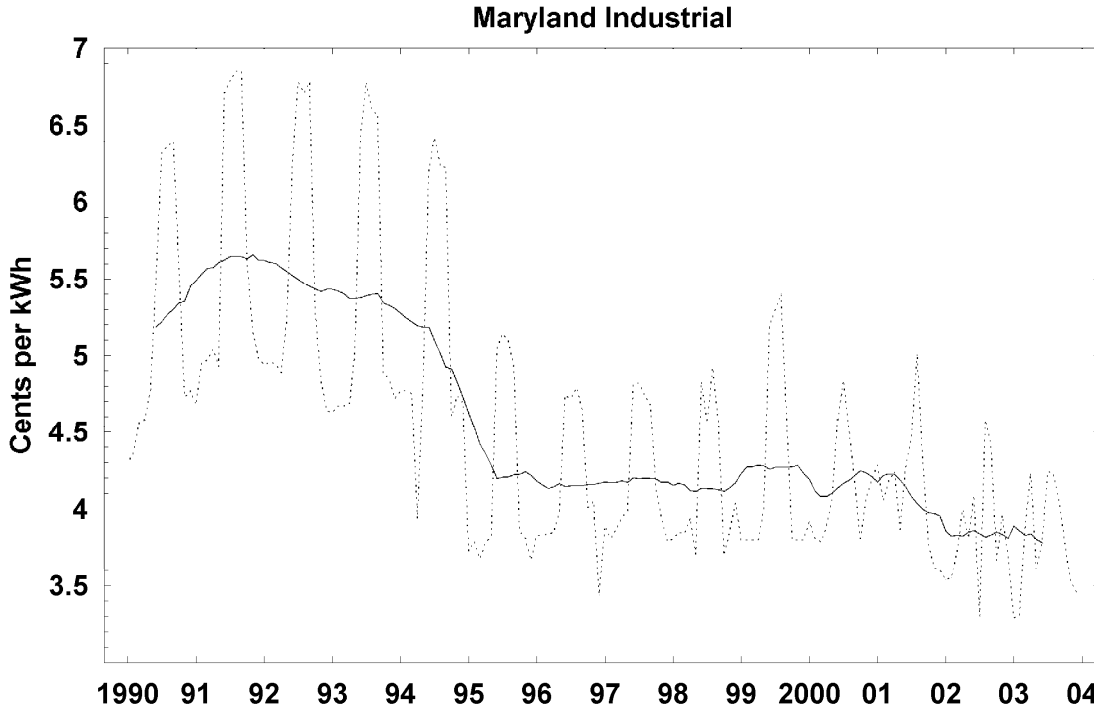


Figure 10: Centered 12-month average applied to Maryland industrial monthly price data

In the electricity data, several states have had price spikes due to market forces which coincide with summer or winter peaks. These are not well represented by the centered average technique. There is a third technique, which allows some of the abrupt changes to be displayed without obscuring the underlying trends. In this approach, the time series of data points is examined for frequencies corresponding to yearly periodicities and their harmonics (6 and 3 months for example). These frequencies are removed, and the resulting data show general trends, while allowing sharp changes to be displayed without the 12-month smoothing inherent in equation 2 above.

This technique is most easily applied by taking the discrete Fourier transform¹⁵ of the 168-month-long data set (after padding each end with the first and last 12 months of data respectively). The discrete Fourier transform F_n is at frequency n is constructed for N data points as

$$F_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} \text{Data}_k e^{-k2\pi\sqrt{-1}/N} \quad (3)$$

For data sampled at 1-month intervals, the maximum frequency in the transformed data is 2 months. This restriction, known as the Nyquist sampling theorem, states that a time series must be sampled at twice the frequency at which accurate data is desired. This restriction is not a serious limitation for the monthly electricity data series, as semi-monthly information is sufficient to

analyze behavior. Figure 11 is the frequency spectrum of the Maryland industrial price data of Figure 9.

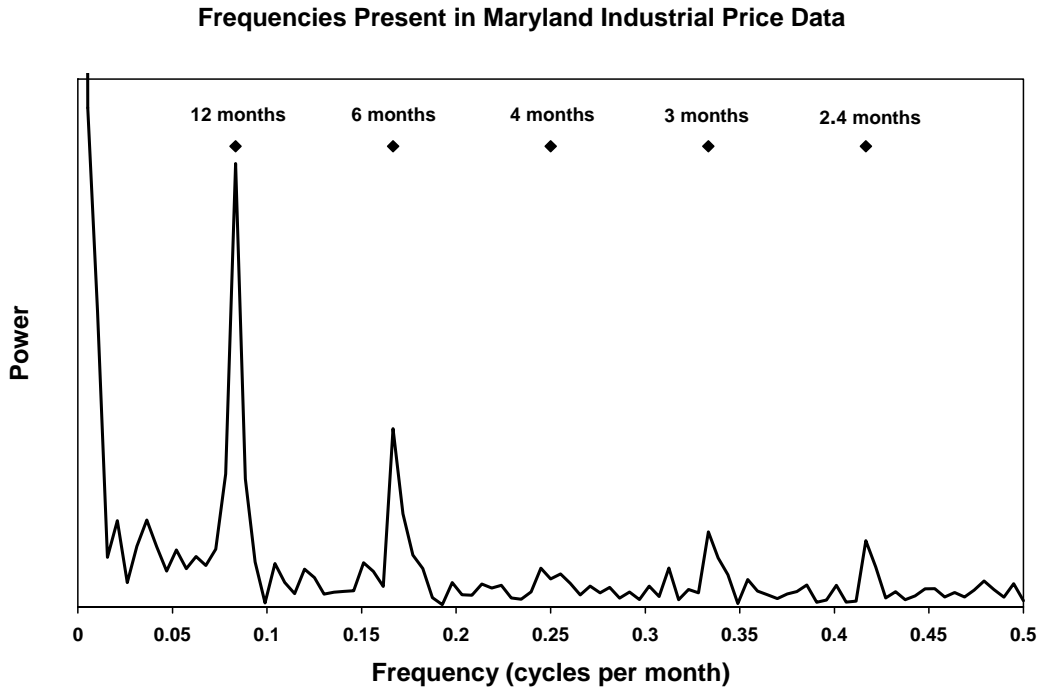


Figure 11: Frequency spectrum of Maryland industrial price data. Diamonds mark the frequencies corresponding to the annual periodicity and its first four harmonics. The power at zero frequency arises from the average price for the 14 years of data.

The spikes arising from the five frequencies corresponding to periods of 12, 6, 4, 3, and 2.4 months (the annual periodicity and its first four harmonics) were removed by first setting the power at that frequency equal to the average of that at the frequency immediately below and above, then smoothed by a 7-point Gaussian filter of the form

$$\frac{e^{-k^2/2\sigma^2}}{\sigma\sqrt{2\pi}} \quad (4)$$

where frequency k runs from 3 points below the center of the spike to 3 points above, and σ is set to 1.2 so that the center frequency of the filter contains $\sim 1/3$ of the area. The data are then re-transformed to the time domain; Figure 12 shows the result.

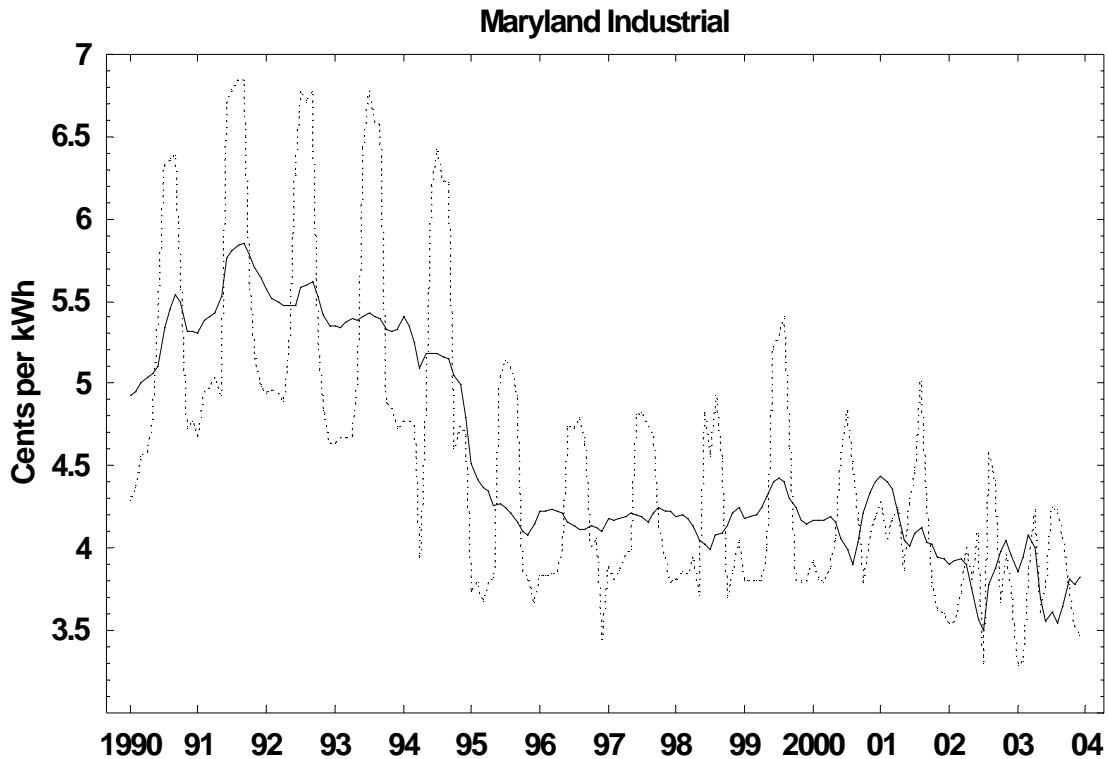


Figure 12: Fourier transform applied to monthly price data

The results of the three techniques are compared in Figure 13. It is apparent that the 12-month trailing moving average displays a lag of several months in responding to the price changes in 1995, 2000, and 2001. The centered average and Fourier transform techniques give similar results. We have used the latter in this work to capture short-term behavior of the data, but our conclusions are identical when we use the centered average technique.

Other techniques are feasible, such as asymmetric averages. However, the essential features of the data are well characterized by either the Fourier or centered average technique.

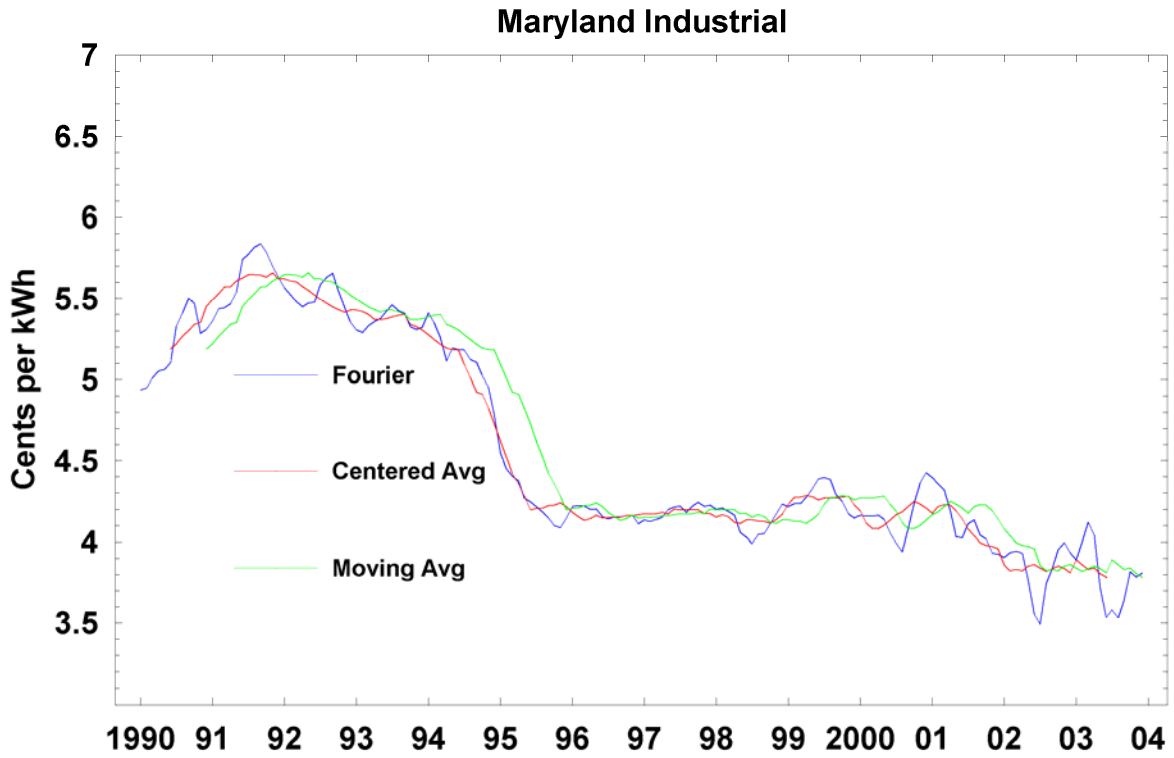


Figure 13: Comparison of three techniques for reducing seasonal periodicities

REFERENCES

- ¹ U.S. Energy Information Administration (EIA) (2003), *Status of State Electric Industry Restructuring*, accessed through http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf.
- ² Laurits R. Chirstensen and William H. Greene, "Economies of Scale in U.S. Electric Power Generation", *Journal of Political Economy*, 84:4 (1976) at 655-676.
- ³ Andrew N. Kleit and Dek Terrell, "Measuring Potential Efficiency Gains from Deregulation of Electricity Generation: A Bayesian Approach", *The Review of Economics and Statistics*, 83:3 (2001) at 523-530.
- ⁴ See section 4 of the review by Catherine Wolfram, "The Efficiency of Electricity Generation in the U.S. after Restructuring," Center for the Study of Energy Markets, University of California Energy Institute Working Paper no. 111, June 2003, available at <http://www.ucei.berkeley.edu/PDF/csemwp111.pdf>.
- ⁵ M. Scott Niederjohn, "Regulatory reform and labor outcomes in the U.S. electricity sector", *Monthly Labor Review*, 26:5 (May, 2003) at 10-19.
- ⁶ Thomas Klitgaard and Rekha Reddy, "Lowering Electricity Prices Through Deregulation", *Current Issues in Economics and Finance*, 16:14 (December 2000) at 1-6, Federal Reserve Bank of New York
- ⁷ See Appendix C, Technical Notes, *Electric Power Monthly*, U.S. Energy Information Administration (October 2004) at 139. <http://tonto.eia.doe.gov/ftproot/electricity/epm/02260410.pdf>.
- ⁸ U.S. Energy Information Administration (EIA) (2004), *Historical 1990 through Current Month Retail Sales, Revenues, and Average Retail Price of Electricity by State and by Sector*, accessed through http://www.eia.doe.gov/cneaf/electricity/page/sales_revenue.xls and *Form EIA-826 Database Monthly Electric Utility Sales and Revenue Data*, accessed through <http://www.eia.doe.gov/cneaf/electricity/page/eia826.html>.
- ⁹ As noted by EIA, "For the 2003 period forward, the Transportation consumer sector replaces the Other sector which included public street lighting, public buildings, electrified rail and transit systems and some agricultural sector data such as irrigation load. The Transportation sector consists entirely of electrified rail and urban transit systems. Data previously reported under the Other consumer sector have been relocated to the Commercial sector for 2003. Agriculture related data (i.e., irrigation load) previously reported in the Other sector have been relocated to the Industrial sector where identified." <http://www.eia.doe.gov/cneaf/electricity/page/eia861.html>.
- ¹⁰ e.g. U.S. Energy Information Administration (EIA) (2004), *Natural Gas City Gate Price 1983-2004*, accessed through <http://tonto.eia.doe.gov/dnav/ng/hist/n3050us3m.htm>.
- ¹¹ U.S. Energy Information Administration (EIA) (2004), *State Electricity Profiles 2002, Table 5*, accessed through http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html.
- ¹² Clifford Winston, "U.S. Industry Adjustment to Economic Deregulation", *Journal of Economic Perspectives*, 12:3 (1998) at 89-110, table 3.
- ¹³ Lester B. Lave, Jay Apt, and Seth Blumsack, "Rethinking Electricity Deregulation", *The Electricity Journal*, 17:8 (2004) at 11-26.
- ¹⁴ U.S. Energy Information Administration (EIA) (2003), *Status of State Electric Industry Restructuring Activities as of February 2003*, accessed through http://www.eia.doe.gov/cneaf/electricity/chg_str/restructure.pdf.
- ¹⁵ Ron Bracewell, *The Fourier Transform and Its Applications*, New York: McGraw-Hill, 1965.

Price Data, 1990 – 2003 (prices in U.S. cents per kilowatt-hour)

Red – Residential
Green – Commercial
Blue – Industrial

Blue vertical lines on graphs for restructured jurisdictions indicate the period over which industrial competition was phased in (a single blue vertical line is shown when all industrial customers were allowed retail choice on the same date).

Yellow highlighted states in the list below designate regulated states, while blue highlights designate restructured jurisdictions.

Click on a state abbreviation to go to that state's graph.

AK AL AR AZ CA CO CT DE DC FL GA HI IA ID IL IN KS KY LA ME MD MA MI MN MO MS
MT NC ND NE NH NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY

Appendix 2. Price History Data for All 50 States and the District of Columbia
with seasonal periodicities removed via the Fourier transform method discussed in Appendix 1.

