Price Elasticity of Demand

DRAFT Working Paper

Kentucky Energy and Environment Cabinet

Department for Energy Development & Independence
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Overview

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Purpose

This study modeled the responsiveness between electricity prices and consumption in three economic sectors, industrial, commercial, and residential, using state-level electric utility data from across the United States for the years 1990 to 2010.

Definition 1 of PED

- This responsiveness is formally called the *price elasticity of demand*, denoted E_d. It measures the percentage change in quantity demanded of a good, given a one percent increase in the price of that good.
- $E_d = \frac{\%\text{ change in quantity}}{\%\text{ change in price}} = \frac{\Delta Q/Q}{\Delta P/P}$
- Since economic's "Law of Demand" implies an inverse relation between P and Q, $E_d \leq 0$ (data don't always agree)

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Results

- The residential sector, on average, decreases their electricity consumption by 0.7% for every 1% increase in price, ceteris paribus.
- The commercial sector, on average, decreases their electricity consumption by 0.3% for every 1% increase in price, ceteris paribus.
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Variables

Primary	
esrcp/rateres	Residential Consumption (gWh / ¢/kWh)
esccp/ratecom	Commercial Consumption (gWh / ¢/kWh)
esicp/rateind	Industrial Consumption (gWh / ¢/kWh)
Secondary	
area	Land Area (Square Miles)
pcpi	Per Capita Personal Income by State
h/cdd	Heating / Cooling Degree Days
pop	Population by State
sp500	S&P 500 Stock Price
unemployment	Unemployment Rate per State

Variable Summary

- Annual data were used. Monthly data was also considered.
- Data over years 1990 to 2010 for the contiguous US states were used.
- All dollars converted to real prices.
- All variables transformed with natural logarithm, denoted *ln*.
- Data come from a combination of sources, listed here.

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Skip assumptions section if statistical / mathematical language will deter you.

Simplifying Assumptions

- Linearity. $Q = \beta_0 + \beta_1 P + \mathbf{X}\beta + \epsilon$
- Constant Variance. $Var(\epsilon_i) = \sigma^2$, for $i = 1, \ldots, N$
- Normality. $\epsilon_i \sim_{iid} N(0, \sigma^2)$, for $i = 1, \ldots, N$
- No misspecification. All relevant predictors of Q included in the model, and linearity and additivity of predictors.
- Price Exogenous. P implies Q, but not vice-versa
- E_d constant over time.

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Definition 2 PED

- Recall: "Law of Demand" implies $E_d \leq 0$
- $E_d = \frac{\partial \log(Q)}{\partial \log(P)}$
- By definition, E_d is estimated with the coefficient term of $\log(P)$, where $\log(Q)$ is regressed on $\log(P)$.

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Model Selection

- Best subset procedure, with *BIC* metric, was used to select final models.
- All possible combinations of the predictor variables were evaluated. A mix of low *BIC*, economic theory, and diagnostic plots were used in picking the models.

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Estimates / Comparison

DEDI's Estimates

- $\hat{E}_{d,r} = -0.73^*$
- $\hat{E}_{d,c} = -0.35^*$
- $\hat{E}_{d,i} = -1.23^*$

Gatton's Estimates

- -0.56^*
- -0.51^*
- -0.83^*

* indicates $p - value < 0.01$.

Diagnostics

- Most assumptions violated: diagnostic plots.
- There exist some outliers, but only significant to the industrial sector. Residential and commercial sectors stable with respect to the inclusion/exclusion of outliers.
- Serial correlation in all sectors may imply missing predictor variable(s).
- Still need to check E_d constant over time.

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Take Away

- Linear model seems forced on the data, however estimates appear to match theory: decent first step.
- Differences between two studies suggest all estimates only approximate.
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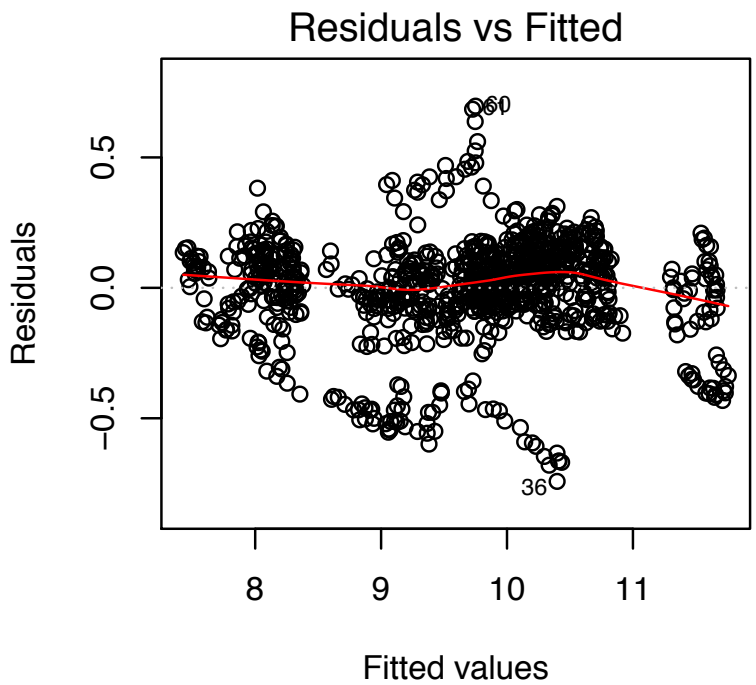
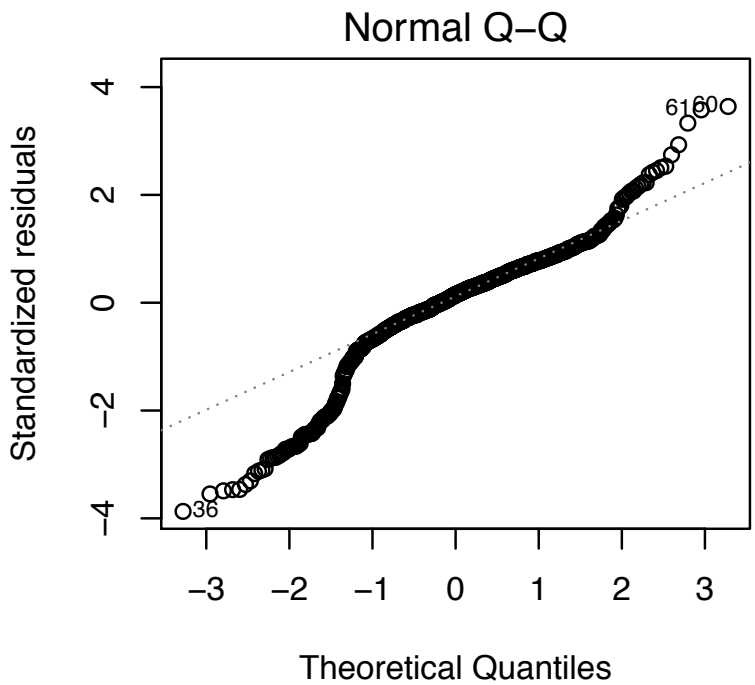
Thank you

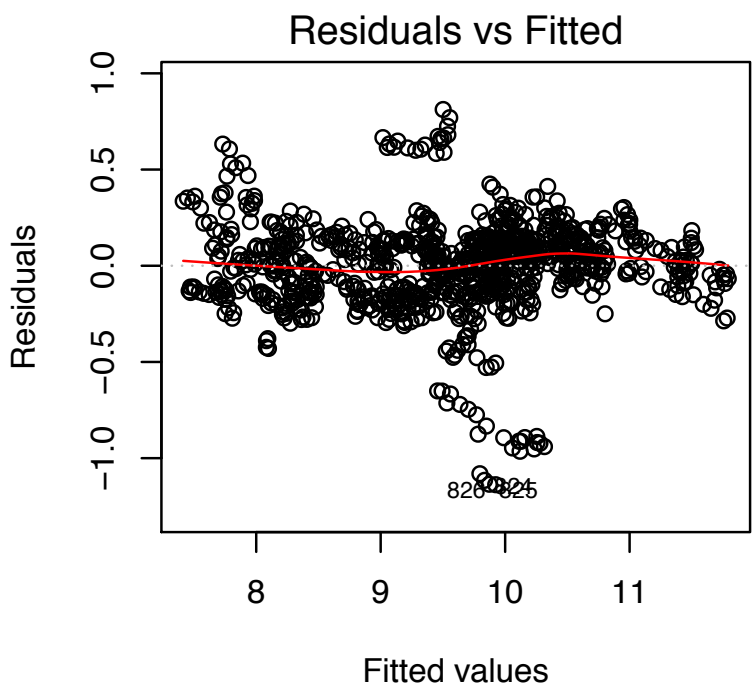
Residential

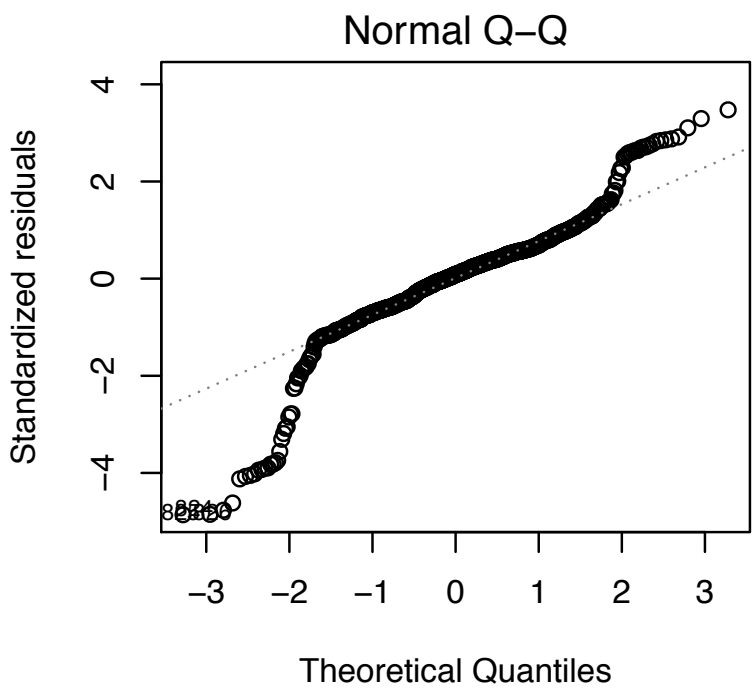




- Stable estimates with or without outliers.

Commercial





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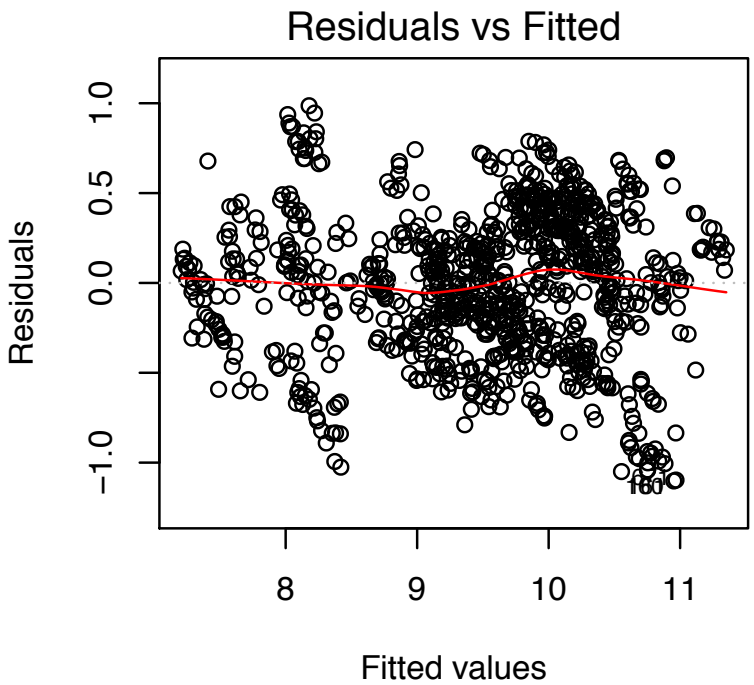
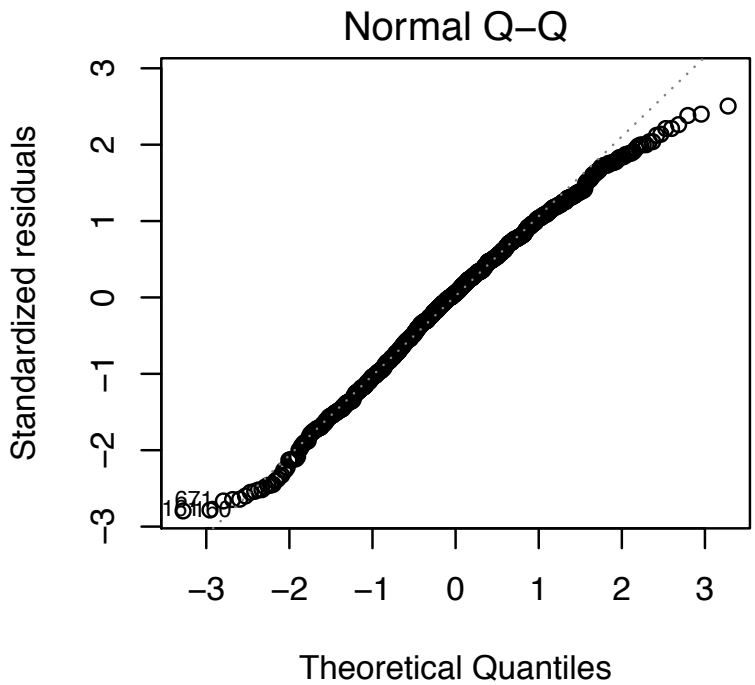
Industrial





- Estimate goes to -0.7 with outliers removed.

Residential Model

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-1.3554	0.2986	-4.54	0.0001
lesrcd	-0.7298	0.0255	-28.58	0.0001
lwacdd	0.0725	0.0139	5.20	0.0001
lwahdd	-0.2183	0.0207	-10.52	0.0001
lpop	0.9332	0.0071	130.81	0.0001

Commercial Model

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-4.1050	0.2804	-14.64	0.0001
lesccd	-0.3464	0.0319	-10.87	0.0001
lsp500	0.1845	0.0222	8.32	0.0001
lwahdd	-0.1487	0.0163	-9.14	0.0001
lpop	0.9538	0.0087	109.38	0.0001

Industrial Model

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.0066	0.3919	0.02	0.9865
lesicd	-1.2339	0.0534	-23.08	0.0001
lsp500	-0.2918	0.0373	-7.83	0.0001
larea	0.0325	0.0148	2.19	0.0288
lwacdd	0.0738	0.0184	4.00	0.0001
lpop	0.8628	0.0147	58.73	0.0001

Data Sources

Variable	Source
Price Consumption	(EIA, 2009)(EIA, 2011)(EIA-SEDS, 2009)
area pop	(Census, 2011)
pcpi unemployment	(BLS, 2011)
hdd cdd	(NOAA, 2011)
sp500	(Shiller, 2001)

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