An Analysis of Residential Demand for Electricity in South Region of the United States

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Route…….

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Introduction

- U.S. households - three sources of energy: natural gas, electricity, and fuel oil
- Electricity consumption continues to grow more rapidly than the consumption of natural gas and fuel oil (Regional Energy Profile, 2005; EIA, 2011)
- Residential sector uses 22% of total energy consumption US (EIA, 2005)
- Of this total consumption, heating, ventilation, and cooling used 31%
- Kitchen and laundry appliances, refrigerators, freezers, dish washers, and lighting and home electronics are the main electricity users in a household.

- Over the past three decades, the share of residential electricity used by appliances and electronics in U.S. homes has nearly doubled from 17% - 31%, increasing from 1.77 quadrillion Btu (quads) to 3.25 quads (EIA, 2011)

- From 2000 to 2009 the demand for electricity increased by 0.5% per year (Annual Energy Outlook, 2011)

- Part of the demand for electricity was off-set by efficiency gains from new appliance standards and investments in energy-efficient equipments

- The overall energy consumption remains virtually the same with the enacted federal energy efficiency standards (EIA, 2011)

Background information

- The South region- DC and 16 States (U.S. Census Bureau, 2008)
- The largest and fastest growing region in US, 36% of the nation's population lives
- The south consumes 44% of the nation's total energy consumption and 43% of the nation's electric power (Brown et al. 2010)
- Low electricity rates, relatively weak energy conservation ethics, low market penetration of energy-efficient products, lower than average expenditures on energy-efficiency programs, and the significant heating and cooling loads - the main reasons of this energy-intensive lifestyle (Brown et al. 2010)

- EIA (2011) projects energy consumption in RCI sectors of the South to increase over the next 20 years, expanding from 30,000 TBtu in 2010 to > 35,000 TBtu in 2030

- Energy efficiency is highly considered factor in south region with its high consumption of electricity (South Atlantic Household Electricity Report, 2006)

Objective of the study

- To examine the demand for residential electricity consumption to understand the pattern of growth in electricity consumption in the south region of the United States

Literature review

- Residential energy demand estimates have been used by many researchers to investigate demand behavior and to understand, forecast, and management of energy demand (Halicioglu, 2007)

- Aggregate data - normally based on price and income variables along with some other additional factors like climate or urbanization (Zachariadis and Pashourtidou, 2007; Narayan and Smyth, 2005; Holtedahl and Joutz, 2004)

- Microeconomic data - with a number of specific variables (Labenderia et al., 2006; Boonekamp, 2007; Filippini and Pachauri, 2004; Larsen and Nesbakken, 2004; Poyer et al., 1997)

- Most of the residential electricity demand relied on log-linear functional forms, which provide a convenient framework for the calculation of elasticities (Madlener, 1996)

- Within the last two decades, many econometric estimation procedures were employed to investigate the energy demand functions

- Univariate/multivariate cointegration procedures, fully modified OLS procedures, and full information maximum likelihood techniques (Engle and Granger, 1987; Phillipsand Hansen, 1990; Johansen, 1988; Johansen and Juselius, 1990; Johansen, 1996; De Vita et al. 2006)

- The availability of electricity demand data is often limited and restricted. Thus in practice, the studies fall well short of the ideal empirical specifications (Narayn and Smyth, 2005)

- Electricity consumption is presented as a function of own price, substitute price, real income, population, and temperature (Al-Zayer and Al-Ibrahim, 1996; Dincer and Dost,1997; Al-Faris, 2002)

Methodology

Empirical model

A modified 2SLS model is adopted based on Holtedahl and Joutz (2004);

$$\ln C_t = a_0 + a_1 \ln Y_t + a_2 \mathbf{\ln P_t} + a_3 \ln P_g + a_4 \ln P_{lpg} + a_5 \ln P_w + a_6 X_t + a_7 D_1 + a_8 D_2 + \mu_t$$

$$\mathbf{\ln P_t} = b_0 + b_1 \ln P_o + b_2 \ln P_k + b_3 \ln P_g + b_4 \ln P_c + b_5 X_t + v_t$$

Where,

$\ln C_t$ is =residential electricity consumption (mkWh)

$\ln Y_t$ = monthly household income

$\ln P_t$ = retail price of residential electricity (cents/kWh)

$\ln P_g$ = natural gas price (cents/kWh)

$\ln P_{lpg}$ = LPG price(cents/kWh)

$\ln P_w$ = wood and wood waste price (cents/kWh)

$\ln P_o$ = price of distillate oil (cents/kWh)

$\ln P_k$ = price of kerosene (cents/kWh)

$\ln P_c$ = price of coal (cents/kWh)

X_t = state level annual median population

D_1 = 1 for SAD; D_2 = 1 for WSCD; D1, D2 = 0 for ECD.

Types and Sources of Data

- A panel state-level data for 24 years (1984-2008) - U.S. DOE and U.S. DOC

- ✓ SAD - West Virginia, Virginia, North Carolina, South Carolina, Delaware, Maryland, Florida, Georgia, and DC
- ✓ WSCD -Arkansas, Louisiana, Oklahoma, and Texas
- ✓ ESCD – Kentucky, Tennessee, Mississippi, and Alabama

- Statistical package of STATA 9.1

Empirical Results and Analysis

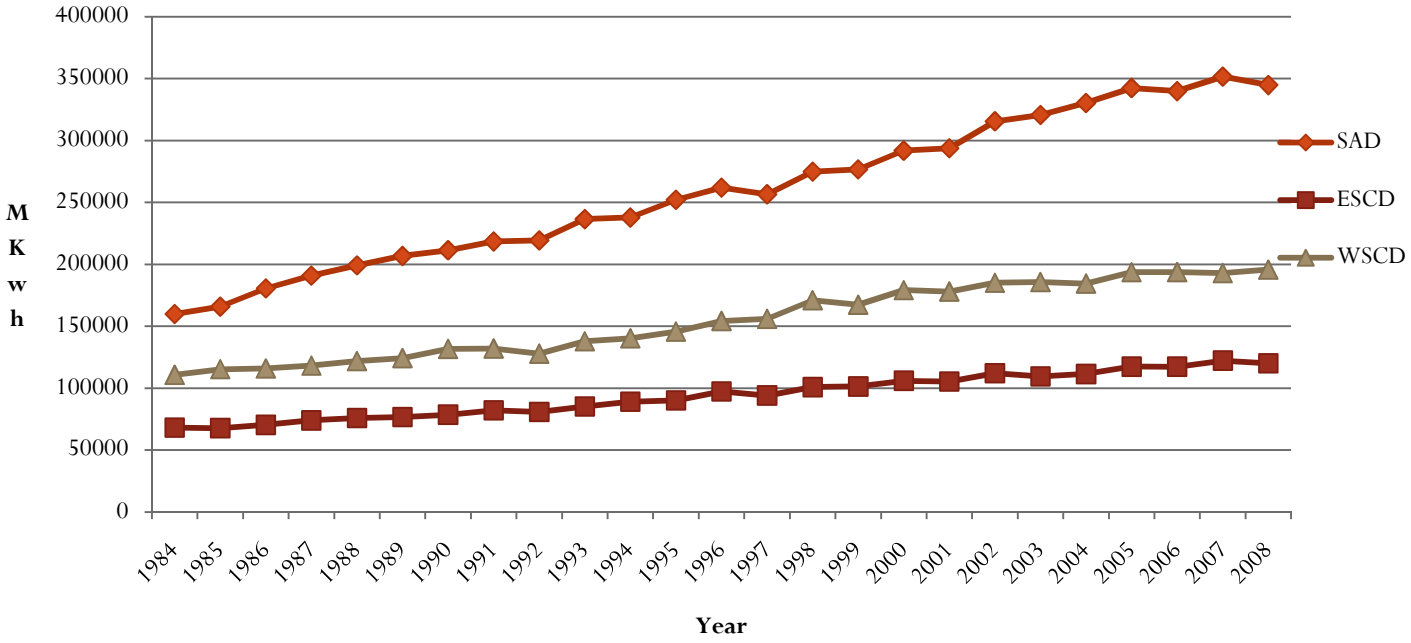

Figure 1. Residential electricity consumption 1984-2008

Table 1.Desriptve Statistics of Variables used in Analysis

Variable	Mean	Std. Deviation	Min Value	Max Value
C_t(mkWh)	29859.63	27105.84	1227	127712
Y_t (US$)	41141.95	10981.87	15674	67926
X_t (‘000)	5912.99	4886.03	565	24304
P_t(cents/kWh)	7.1554	2.1633	0.3413	13.9385
P_g(cents/kWh)	2.7192	1.3007	0.3413	7.1263
P_c (cents/kWh)	0.9856	0.3610	0.3412	2.8259
P_k (cents/kWh)	2.7853	1.6842	0.3413	9.0171
P_{lpg}(cents/kWh)	4.7898	2.3556	0.3413	13.2628
P_w (cents/kWh)	1.4313	0.7113	0.3412	3.6587

Table 2. Regression analysis (2SLS) for residential electricity consumption (lnC_t)

Indep. Variable	coefficient	Std.Error	T value	P value
Intercept	4.1962	0.0768	54.63	0.000
lnP_t	-0.3125**	0.1046	-2.99	0.003
lnY_t	1.94e-07	1.70e-06	0.11	0.909
X_t	0.00007**	2.55e-06	27.77	0.001
lnP_{lpg}	-0.3375*	0.2052	-1.64	0.101
lnP_g	0.6249**	0.2014	3.10	0.002
lnP_w	0.0021	0.1380	0.01	0.988
d1-SAD	-0.1556**	0.0376	-4.13	0.000
d2- WSCD	-0.0366	0.0374	-0.98	0.329

R^2 =0.6980 Adj. R^2 = 0.6922 N = 425 F(8, 416) =120.17

** significant @ 1% level and *significant at 10% level

- Price elasticity of demand for electricity is negatively elastic
- The positive cross-price elasticity of demand indicates that natural gas (P_g) is a substitute energy for residential electricity
- The cross price elasticity of LPG indicates that LPG works as a complimentary energy for electricity
- Income elasticity is relatively low as expected
- Population growth tends to perpetuate the strong rate of growth in the residential demand for electricity
- D_1 and D_2 indicate such differences compared to ESCD.

Conclusions

- First, retail price of electricity, natural gas price, and population - main determinants

✓ Price elasticity of demand is negatively elastic

✓ Natural gas is a substitute energy for electricity

✓ Electricity could be viewed as a normal good

✓ Understand and plan the potential future energy supplies based on the demand pattern of the region

- Secondly, the demand for electricity was different from division to division, and ESCD demands more residential electricity

Thank You

Comments/suggestions?