Mountain Plains Journal of Business and Economics

Volume 12 | Issue 1 Article 3

Date Published: 10-1-2011

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U.S. COMMERCIAL ELECTRICITY CONSUMPTION

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ABSTRACT

Commercial electricity usage exceeds that of industrial usage and is almost as large as residential electricity consumption in the United States. In this study, regional economic, demographic, and climatic data are used to analyze commercial electricity demand in the United States. Results indicate that total commercial demand for electricity is negatively related to price. In addition, the number of businesses and service income positively affect electricity demand for commercial use. The results are similar for equations estimated for kilowatt-hours demanded per business. The regional dummy variables exhibit different signs, which may occur due to climate factors because warm weather regions experience greater volumes of cooling degree-days, while cool weather regions observe larger amounts of heating degree-days. Although coefficients for the price of natural gas are positive, they do not satisfy the 5-percent significance criterion. The latter suggests that natural gas may not be a substitute good for electricity within the commercial sector of the U.S. economy.

I. INTRODUCTION

In planning for future electric grid development and generation capacity, it is important to understand how customer classes respond to pricing policies. Public utility planners and electricity producers will be faced with increased demand for electricity as time passes. Uncertainties regarding future power supplies and prices indicate that better insights to the various aspects of electricity demand are warranted. The latter includes understanding how consumption behaves among the different sectors and regions that comprise the economy of the United States. As noted in Brown and Koomey (2003), one of the most important lessons from energy policy efforts in the United States is that energy usage analysis, and how energy usage changes over time, can yield important policy design insights.

[1] Acknowledgments: Funding support for this research was provided by El Paso Electric Company, Hunt Communities, Hunt Companies, Inc., JPMorgan Chase Bank of El Paso, a UTEP College of Business Administration Faculty Research Grant, and the James A. Baker III Institute for Public Policy at Rice University. Helpful suggestions and comments were provided by Tim Roth, Gaspare Genna, David Tufte, and two anonymous referees. Econometric research assistance was provided by Karen Fierro, Carlos Morales, Francisco Pallares, and Emmanuel Villalobos.

Electricity users include household, commercial, industrial, and non-profit categories. Because much of the research in this area examines residential consumption patterns (Contreras, Smith, Roth, and Fullerton, 2009), this study employs least squares regression analysis to examine commercial electricity demand across the different census regions in the United States. In addition to determining the own price elasticity of demand, regional differences in the commercial demand for electricity are examined. Historically, commercial electricity consumption has not received very much attention in the applied economics literature. Because commercial electricity usage in the United States exceeds industrial usage and is nearly as large as residential consumption, more empirical analysis of commercial consumption appears warranted.

Prior studies have shown that regional differences in consumption patterns may be substantial (Badri, 1992). Although regional differences are controlled for in other studies cited within the paper, in general, those efforts do not directly test or report the specific regional differences. The differences reported in this paper are determined from the inclusion of regional dummy variables.

Explanatory variables for commercial electricity consumption include price per gigawatt-hour (GWH), numbers of businesses in each state, state service sector incomes, heating degree days, and cooling degree days. Dummy variables are defined for each of the nine geographic regions designated by the Census Bureau. Aggregate data for 2002 are collected for state populations, numbers of businesses, service sector earnings in dollars, heating degree days, and cooling degree days. Natural gas is considered as a potential substitute good. Data sources include the Regional Economic Information System of the Bureau of Economic Analysis, the Census Bureau, the Energy Information Administration, and the National Climatic Data Center.

Estimated elasticities for each of the explanatory variables are compared with results obtained in prior research efforts. The next section summarizes previous studies and models of commercial demand for electricity in the United States. The subsequent section discusses data and methodology. Empirical results and concluding remarks follow.

II. LITERATURE REVIEW

Academic, public, and private researchers have analyzed and modeled the demand for electricity in a variety of contexts. Businesses rely on the accuracy of these models to help improve planning efforts while public institutions use results from these models to help design more effective policies (Fullerton, 1983; Brown and

Koomey, 2003). Empirical parameter estimates from demand equations and model simulation results are frequently presented before public utility regulatory commissions and company boards of directors. Much of what is documented regarding electricity consumption is, however, for residential customers. That is, in large part, due to data availability.

Private and public institutions have an interest in determining the demand for electricity. The Electric Power Research Institute uses detailed residential end use energy policy system models to study future demand for electricity on a worldwide scale (McMenamin, Rohmond, Pritchard, and Fabsiszak, 1991). The Lawrence Berkeley Laboratories employ a random effects model to study future energy demand for the United States (McMahon, 1987). Typical of corporate utilities, El Paso Electric Company relies upon time series and econometric modeling strategies to forecast short- term loads in a regional economy that encompasses Far West Texas, Southern New Mexico, and Northern Mexico (Fullerton, 1983).

For econometric studies, total energy demand in the United States is usually broken down into residential, commercial and industrial uses. Mount, Chapman, and Tyrell (1973) use time series and cross-sectional data for 1947-1970 in order to estimate electricity demand. Independent variables in that study include population, per capita income, average price of electricity, average price of natural gas, and the price of appliances. Those variables are lagged one year, and a dummy variable is used for regions in the final specification. The estimated coefficients exhibit the expected signs. Commercial and residential demands are found to be more price elastic than industrial uses. That result is potentially a consequence of the pre-energy crisis sample period. Industrial users generally have a greater number of alternative electricity sources than residential or commercial customers, and, thus, exhibit greater elasticity with respect to price (Horowitz, 2007).

Denton, Mountain, and Spencer (2003) employ an econometric model for the demand for electricity in commercial buildings by region in the United States using cross sectional data for 1986 and 1992. The model uses simultaneous equations to identify and estimate energy price elasticities based on endogenous marginal and exogenous average energy prices. Independent variables include marginal and average prices of electricity and natural gas, a large number of building characteristics such as total floor area, number of stories, etc., and annual number of heating and cooling days. The own price elasticity coefficients for electricity are negative, as expected, and are statistically significant when using either marginal or average prices. The equations that utilize average prices rather than marginal prices report higher elasticity values.

Houthakker (1962) argues that consumers will equal marginal benefits with marginal costs and concludes that marginal costs of electricity should be employed instead of average costs. However, Taylor (1975) observes that marginal costs cover only part of the required information because of block pricing in the electricity sector. In addition, because consumers adjust the stock of their appliances as prices change over time, it makes it difficult to measure short-run and long-run demand responses to the price of electricity. Halvorsen (1975) estimates supply and demand equations using two-stage least squares and instrumental variables estimation to account for simultaneity. Empirical results using average price measures are found to be more accurate than those relying on other price measures.

Roth (1981) incorporates both marginal and average prices of electricity to estimate electricity demand under block pricing. Results indicate that electricity is an inferior good, with responses to changes in average price equal in magnitude to those for changes in real income. Strong multicollinearity between average and marginal price exists because both tend to move together over the course of the data sample. The latter reduces the reliability of the individual price elasticity estimates but does not affect the accuracy of simulation exercises generated with the fully specified version of the model.

III. DATA AND METHODOLOGY

Data utilized in this study are for 2002. That is the most recent year for which complete data could be assembled for all of the electric user categories and the various explanatory variables for all 50 states and the District of Columbia (Contreras, Smith, Roth, and Fullerton, 2009). Nearly complete data sets are also available for 1993 and 1997, but 2002 is the only year for which observations for all of the variables were successfully assembled. Population estimates are from the United States Census Bureau, while the income data are from the Regional Economic Information System of the Bureau of Economic Analysis. The Energy Information Administration is the source for the electricity usage and pricing data. Cooling and heating degree-days are from the National Weather Service and substitute for the intensities and the mixture of appliances that are used throughout the year. Table 1 lists variable names, definitions, and units of measure. All dollar amounts are indexed to 2002.

TABLE 1
VARIABLE NAMES AND UNITS OF MEASURE

Variable	Unit of Measure
GWHC	Commercial Electricity Usage in Gigawatt Hours
PC	Price for Commercial Electricity in Cents per Kilowatt Hour
PCNG	Price for Commercial Natural Gas in Dollars per Thousand cubic Feet
BUSN	Number of Businesses
SVC	State Service Sector Earnings
HDD	Heating Degree Days
CDD	Cooling Degree Days
NE	New England
MIDATL	Mid-Atlantic Region
ENC	East North Central Region
WNC	West North Central Region
SA	South Atlantic Region
ES	East South Central Region
WSC	West South Central Region
MOU	Mountain Region
PAC	Pacific Coast Region

Electricity demand for commercial users can differ from that for residential users in several key manners. A different rate per kilowatt-hour is assessed for businesses than for households. Electricity provided to a business is used to power devices that might not be found in a typical house (Horowitz, 2004). The product mix of goods and services that are provided by individual businesses differs between locations. State service sector income is used to indicate the scale of commercial activities throughout each region. Service income should have a positive effect on usage if electricity is an input to production.

The demand function for commercial users is in the form GWHC=f (PC, BUSN, SVC, HDD, CDD) and is specified in a linear equation similar to those reported in Horowitz (2004). Commercial electricity consumption in each state is measured in gigawatt-hours (GWHC). Other variables include average price per kilowatt hour (PC), the number of businesses in each state (BUSN), state service income (SVC), heating degree days (HDD), and cooling degree days (CDD). Heating degree-days are calculated as differences between average temperatures and 650F during cool weather days. Cooling degree-days are calculated in the same manner except they measure days when energy will be used to cool a residence (NCDC, 2002). Average price measures have previously been shown to perform reliably in several public utility contexts, including electricity (Shin, 1985; Fullerton, Tinajero, and Mendoza Cota, 2007).

Dummy variables are included for each of the nine regions defined by the Census Bureau. A value of one is assigned if a state belongs to a region and a zero is assigned if it does not. Because the dependent variable is logarithmically transformed and regional indicator variables are not, the latter coefficients are first transformed using exponential functions. To avoid perfect multicollinearity, the Pacific Region is excluded from estimation and is assigned a value of zero, so its exponential transformation will equal one. Regional indicator coefficients with negative signs reflect less commercial electricity usage than the Pacific Region. Alternatively, a positive sign indicates greater usage than the Pacific region.

As noted above, the data are logarithmically transformed prior to estimation. Given that, resulting coefficients are elasticities of demand. The basic specification for total commercial usage, GWHC, is shown in Equation (1). The specification for usage per business, GWHC/BUSN, appears in Equation (2). In both equations, the value of the subscript ranges from 1 to 51, while u and v are random disturbance terms.

$$\begin{aligned} \log(GWHC_i) = {} & \alpha_0 + \alpha_1\log(PC_i) + \alpha_2\log(BUSN_i) + \alpha_3\log(SVC_i) + \alpha_4\log(HDD_i) \\ & + \alpha_5\log(CDD_i) + \alpha_6 NE_i + \alpha_7 MIDATL_i + \alpha_8 ENC_i + \alpha_9 WNC_i + \alpha_{10} SA_i \\ & + \alpha_{11} ESC_i + \alpha_{12} WSC_i + \alpha_{13} MOU_i + u_i \end{aligned} \tag{1}$$

$$\begin{aligned} & \log(GWHC_i/BUSN_i) \\ & = \alpha_0 + \alpha_1\log(PC_i) + \alpha_2\log(SVC_i/BUSN_i) + \alpha_3\log(HDD_i) \\ & + \alpha_4\log(CDD_i) + \alpha_5 NE_i + \alpha_6 MIDATL_i + \alpha_7 ENC_i + \alpha_8 WNC_i + \alpha_9 SA_i \\ & + \alpha_{10} ESC_i + \alpha_{11} WSC_i + \alpha_{12} MOU_i + v_i \end{aligned} \tag{2}$$

As specified, these equations may suffer from omitted variable bias in one key aspect. Namely, cross-price measures for substitute energy sources such as natural gas or co-generation electricity from on-site equipment are not included in either specification. Similarly, marginal block pricing structures in place for some utilities may cause upward price bias to result for the own-price measure utilized. The reason for these omissions is simply because it was not feasible to collect aggregate data for cogeneration electricity prices and utility block pricing structures for commercial electricity users across the entire sample for 2002. Consequently, interpretation of the results discussed below is subject to the dual risk of omitted variable bias and upward price bias. Results of specifications using the price of natural gas as a substitute price are discussed below.

IV. EMPIRICAL RESULTS

As specified, Equations (1) and (2) may be affected by simultaneity. That is due to the manner in which the price variable is calculated as cents per kilowatt hour.

That calculation causes GWHC to appear on both sides of the equations and may result in estimation bias. To examine this possibility, an artificial regression test for endogeneity is employed (Davidson and MacKinnon, 1989). In both cases, total GWHC consumed and gigawatt hours per business, the null hypotheses of parameter consistency fail to be rejected. Given those outcomes, endogeneity does not appear to be a severe risk, in spite of utilizing average cents per kilowatt hour as the price measure for all 51 observations.

To determine whether logarithmic data transformations prior to estimation are appropriate, the Deviance Information Criterion (DIC) developed by Spiegelhalter, Best, Carlin, and van der Linde (2002) is employed. This approach has been previously utilized to select among competing specifications in a study of residential electricity consumption (Xiao, Zarnikau, and Damien, 2007). The two forms tested are specifications of Equations (1) and (2) in linear and logarithmic versions.

The selection criterion favors specifications with the smallest DIC (Spiegelhalter, Best, Carlin, and Linde, 2002). The results are mixed. For aggregate consumption, GWHC, the DIC favors the linear specification under which the data are not transformed. For consumption per customer, GWHC / BUSN, the DIC points to the logarithmic specification as best suited to modeling the data. For consistency, Tables 2 and 3 report the logarithmic results. The linear specification results are included in the appendix. Results are broadly similar in each case.

Results for Equation (1) are shown in Table 2. Because heteroscedasticity is present in the sample, a consistent version of the covariance matrix is employed (White, 1980). Business will tend to purchase electricity only if the marginal cost is less than the marginal income the electricity helps generate. The own price elasticity estimates of - 0.21 is statistically insignificant and is relatively small in absolute magnitude. All other variables held constant, a one percent increase in the price of electricity for commercial use leads to a 0.21 percent decrease in gigawatt-hours consumption. The own price elasticity estimate is similar in magnitude to the inelastic value reported by Mount, Chapman, and Tyrell (1973), but lower than that reported by Denton, Mountain, and Spencer (2003).

If all other variables are held constant, increasing the number of commercial sector enterprises by one percent increases the total demand for commercial gigawatthours by 0.64 percent. The elasticity of service sector income is 0.29, substantially higher than what is reported by Mount, Chapman, and Tyrell (1973). The temperature effects of cool weather are similar to those found in Denton, Mountain, and Spencer (2003). For warm weather, the result in Table 2 is approximately one-third of that documented in the latter study.

Regional dummy coefficients that point to statistically significant different power consumption patterns from that observed along the Pacific Coast include: the Northeast, Middle Atlantic, East North Central, and Mountain regions. The coefficient for the West North Central does not quite satisfy the 5-percent criterion but exhibits a plausible magnitude and algebraic sign (Ziliak, 2008). In all five cases, less commercial sector electricity is consumed relative to the Pacific Coast region after controlling for the explanatory variables included in the specification. The dummy variable parameters estimated for the three remaining regions (South Atlantic, East South Central, and West South Central) fail to satisfy the 5-percent significance criterion by wide margins, indicating no significantly different power consumption patterns from that observed along the Pacific Coast.

TABLE 2
EQUATION (1) LOGARITHMIC ESTIMATION RESULTS

Dependent Variable: LOG(GWHC)
Method: Least Squares
Number of Observations: 51
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-1.9397	0.6724	-2.8847	0.0065
LOG(PC)	-0.2141	0.1214	-1.7639	0.0860
LOG(BUSN)	0.6449	0.2426	2.6588	0.0115
LOG(SVC)	0.2996	0.1950	1.5362	0.1330
LOG(HDD)	0.0718	0.0215	3.3441	0.0019
LOG(CDD)	0.1068	0.0285	3.7546	0.0006
NE	-0.3605	0.0972	-3.7089	0.0007
MIDATL	-0.1388	0.0602	-2.3078	0.0267
ENC	-0.1227	0.0441	-2.7830	0.0084
WNC	-0.1790	0.0921	-1.9434	0.0596
SA	0.0415	0.0657	0.6313	0.5317
ESC	0.0693	0.0711	0.9752	0.3358
WSC	-0.0448	0.0883	-0.5068	0.6153
MOU	-0.1446	0.0682	-2.1203	0.0407

R-squared	0.9814	Dependent Variable Mean	9.5266
Adjusted R-squared	0.9748	Dep. Variable Standard Deviation	1.0167
Std. Err. Regression	0.1613	Sum of Squared Residuals	0.9624
F-Statistic	149.9980	F-Statistic Probability	0.0000
Log Likelihood	28.8733	Deviance Information Criterion	976.2509

Regarding the Pacific Coast region, Brown and Koomey (2003) examine the growth in electricity demand in California between 1980 and 2000 and conclude that electricity use in California in the 1990s did not grow explosively, nor was the amount of growth unanticipated. Increases in economic growth and population appear to be the main factors correlated with electricity growth. Most of the growth in electricity use has been in the buildings sector, particularly commercial buildings, with the building sector accounted for 2/3 of annual electricity consumption and 3/4 of the summer peak load in 2000. Within the building sector, two of the largest ends uses in terms of annual consumption are commercial lighting and commercial air conditioning. Perhaps not surprisingly, peak load is strongly dominated by air conditioning, followed by commercial lighting, and miscellaneous uses.

The dummy variable parameters estimated for the South Atlantic, East South Central, and West South-Central regions in Table 2 indicate no significantly different power consumption patterns from that observed along the Pacific Coast. That suggests that certain regions that share similar summer weather patterns and cooling degree days (those with greater cooling needs), tend to have relatively higher and similar electricity demands. Broadly similar regional economic performances within the United States probably contribute to that pattern of usage similarity.

Equation (2) examines commercial sector electricity demand in gigawatt-hours per business and its results are shown in Table 3. Interestingly, heteroscedasticity is not uncovered in these results. The own price elasticity estimate is statistically insignificant and is relatively small in absolute magnitude. Holding all other variables constant, as the price of electricity for commercial use increases by one percent, a 0.23 percent decrease in demand for kilowatt-hours per business will result.

The estimated coefficient for income per business in Table 3 satisfies the significance criterion and indicates that a one percent increase in service income per business will increase electricity consumption per business by 0.28 percent. Both weather variables have positive signs but do not quite achieve the 5-percent significance threshold. A one percent increase in heating degree-days leads to a 0.05 percent increase in GWH demand, while a similar increase in the number of cooling degree-days increases demand for commercial electricity per business by 0.07 percent.

The only dummy variable coefficient in Table 3 that satisfies the 5-percent significance criterion is that for the Northeast Region and it carries a negative sign. A likelihood ratio test, not reported, indicates that the other regional qualitative variables should be retained (Pindyck and Rubinfeld, 1998). The West South-Central regional dummy coefficient is, for all practical purposes, indistinguishable from zero. Although they have relatively large standard deviations associated with them, the estimated parameters for the other regions have the same signs as in the aggregate usage equation. In that regard, the results for per business usage relative to the Pacific Coast region point to the same patterns as those for aggregate consumption.

As noted below, Equations (1) and (2) are specified without substitute electricity co-generation prices or marginal block pricing structures due to data constraints. Average natural gas prices for commercial customers in 2002 were successfully collected for each of the 51 jurisdictions in the sample and utilized in several alternative specifications. As expected for the price of a substitute product, the estimated natural gas price coefficients are positive in all of those equations. In no case, however, do the computed t-statistics satisfy the 5-percent significance criterion. Table 6 in the appendix below summarizes the output for one of those estimates. Although the magnitude of the substitute price elasticity is similar to that reported by Mount, Chapman, and Tyrrell (1973), the diagnostics shown in Table 6 suggest that the inclusion of the natural gas price does not improve overall model characteristics in a meaningful manner. Natural gas may not, therefore, serve as an effective substitute for electricity in the commercial sectors of the national economy.

TABLE 3
EQUATION (2) LOGARITHMIC ESTIMATION RESULTS

Dependent Variable:	LOG(GWHC/BUSN)
Method:	Ordinary Least Squares
Number of Observations:	51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-2.2269	0.7502	-2.9685	0.0052
LOG(PC)	-0.2316	0.1884	-1.2294	0.2265
LOG(SVC/BUSN)	0.2867	0.1039	2.7593	0.0089
LOG(HDD)	0.0546	0.0319	1.7112	0.0952
LOG(CDD)	0.0748	0.0457	1.6364	0.1100
NE	-0.2906	0.1161	-2.5033	0.0167
MIDATL	-0.1545	0.1378	-1.1210	0.2693
ENC	-0.1213	0.1219	-0.9955	0.3258
WNC	-0.1087	0.1275	-0.8530	0.3990
SA	0.0927	0.1205	0.7699	0.4461
ESC	0.1269	0.1421	0.8928	0.3776
WSC	-0.0036	0.1459	-0.0250	0.9802
MOU	-0.0676	0.1188	-0.5695	0.5723

R-squared	0.6561	Dependent Variable Mean	-1.8839
Adjusted R-squared	0.5475	Dep. Variable Standard Deviation	0.2457
Std. Err. Regression	0.1653	Sum of Squared Residuals	1.0384
F-Statistic	6.0411	F-Statistic Probability	0.0000
Log Likelihood	26.9342	Deviance Information Criterion	-186.7093
White Heteroskedasticity Test:			
F-Statistic	0.9349	Probability F(12,38)	0.5238
Obs*R-squared	11.6245	Probability Chi-Square(12)	0.4763
Scaled Explained SS	18.8625	Probability Chi-Square(12)	0.0919

V. CONCLUSION

In this study, elasticities for commercial electricity demand in the United States are estimated for total and per business consumption using least squares regression techniques. In the United States, commercial electricity usage exceeds industrial usage and is nearly as large as residential consumption. Heteroscedasticity is present in the aggregate usage equation residuals, but not in the per business equation residuals. Differences in regional consumption patterns are controlled for using qualitative variables defined using Census Bureau geographic designations. Average commercial electricity price, numbers of businesses, service sector income, and weather variables for each state are used as right hand variables to estimate commercial demand elasticities.

As expected, results indicate that commercial demand for electricity is negatively related to the own price of electricity for both total and per business consumption. In addition, the number of businesses and state service sector incomes positively affect electricity demand, as also suggested by prior empirical studies. The results are similar for the equation with gigawatt-hours per business as the dependent variable. Specification form selection is carried out using an empirical criterion. Because results are not conclusive, additional results beyond those shown above are included in the appendix. Separately, natural gas is considered as a potential substitute for electricity, but estimation results do not support that hypothesis. Representative empirical output for the latter is also reported in the appendix below.

Among the regional dummy variables, for four regions (Northeast, Middle Atlantic, East North Central, and Mountain) where less commercial sector electricity is consumed relative to the Pacific Coast, the coefficients are shown to be negative and statistically significant. That is potentially due to substantially fewer cooling degree days in many regions reducing the volume of electricity required for on-site commercial comfort levels to be maintained. The negative coefficient for the West North Central does not quite satisfy the 5-percent criterion but indicates a plausible magnitude and algebraic sign.

The dummy variable parameters estimated for the three remaining regions (South Atlantic, East South Central, and West South Central) fail to satisfy the 5-percent significance criterion by a wide margin, indicating no significantly different power consumption patterns from that observed along the Pacific Coast. Because the dummy variable parameters estimated for these three regions indicate no significant difference from that observed in the Pacific Coast region, the results can be interpreted to suggest that certain regions that share similar summer weather patterns and cooling degree day totals tend to have relatively higher levels of electricity demand.

In planning for future electric grid development, it is important to understand how customers respond to pricing policies. Public planners and electricity producers will be faced with increased demand for electricity as time passes. Uncertainties regarding future power supplies and prices reveal a need to examine different categories of electricity demand and understand how consumption varies between different regions across the United States. Additional research regarding industrial and nonprofit consumption patterns will likely prove helpful in this regard.

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APPENDIX

TABLE 4
EQUATION (1) LINEAR ESTIMATION RESULTS

Dependent Variable: GWHC
Method: Ordinary Least Squares
Number of Observations: 51
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-2805.588	5588.306	-0.5020	0.6186
PC	-585.924	527.0751	-1.1117	0.2735
BUSN	0.2162	0.0267	8.0910	0.0000
SVC	-0.0791	0.0311	-2.5440	0.0153
HDD	0.6821	0.5368	1.2707	0.2118
CDD	3.6015	1.6329	2.2056	0.0337
NE	217.5137	727.0591	0.2992	0.7665
MIDATL	-968.0257	2256.401	-0.4290	0.6704
ENC	-2546.267	2315.976	-1.0994	0.2787
WNC	-3276.436	2871.663	-1.1410	0.2612
SA	1693.599	2652.117	0.6386	0.5270
ESC	-210.7857	2957.791	-0.0713	0.9436
WSC	-1195.380	3200.134	-0.3735	0.7109
MOU	-2371.627	2637.595	-0.8992	0.3744

R-squared	0.9866	Dependent Variable Mean	21886.98
Adjusted R-squared	0.9819	Dep. Variable Standard Deviation	22392.52
Std. Err. Regression	3015.721	Sum of Squared Residuals	3.36E+08
F-Statistic	209.2098	F-Statistic Probability	0.0000
Log Likelihood	-472.774	Deviance Information Criterion	438.9359

TABLE 5
EQUATION (2) LINEAR ESTIMATION RESULTS

Dependent Variable: GWHC / BUSN
Method: Ordinary Least Squares
Number of Observations: 51
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.1014	0.0606	1.6728	0.1026
PC	-0.0076	0.0044	-1.7128	0.0949
SVC/BUSN	0.1137	0.0242	4.6946	0.0001
HDD	1.09E-06	5.48E-06	0.1995	0.8429
CDD	6.39E-06	1.54E-05	0.4150	0.6805
NE	-0.0010	0.0083	-0.1238	0.9021
MIDATL	0.0016	0.0226	0.0696	0.9449
ENC	0.0060	0.0244	0.2463	0.8068
WNC	0.0142	0.0285	0.4979	0.6214
SA	0.0369	0.0276	1.3390	0.1885
ESC	0.0518	0.0303	1.7071	0.0960
WSC	0.0275	0.0328	0.8380	0.4072
MOU	0.0177	0.0258	0.6860	0.4969

R-squared	0.6128	Dependent Variable Mean	0.1571
Adjusted R-squared	0.4905	Dep. Variable Standard Deviation	0.0476
Std. Err. Regression	0.0340	Sum of Squared Residuals	0.0438
F-Statistic	5.0112	F-Statistic Probability	0.0001
Log Likelihood	107.6349	Deviance Information Criterion	-65.2009

TABLE 6
EQUATION (1) PLUS NATURAL GAS PRICE LOGARITHMIC ESTIMATION RESULTS

Dependent Variable: LOG(GWHC)
Method: Ordinary Least Squares
Number of Observations: 51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-2.0633	0.9583	-2.1531	0.0381
LOG(PC)	-0.2022	0.1947	-1.0386	0.3059
LOG(PCNG)	0.0380	0.1790	0.2121	0.8332
LOG(BUSN)	0.6526	0.1161	5.6183	0.0000
LOG(SVC)	0.2942	0.1061	2.7737	0.0087
LOG(HDD)	0.0749	0.0363	2.0614	0.0465
LOG(CDD)	0.1020	0.0539	1.8915	0.0666
NE	-0.3705	0.1308	-2.8325	0.0075
MIDATL	-0.1386	0.1365	-1.0148	0.3170
ENC	-0.1182	0.1223	-0.9671	0.3399
WNC	-0.1652	0.1478	-1.1181	0.2709
SA	0.04699	0.1256	0.3740	0.7106
ESC	0.0770	0.1491	0.5167	0.6085
WSC	-0.0315	0.1591	-0.1980	0.8442
MOU	-0.1321	0.1392	-0.9490	0.3489

R-squared	0.9814	Dependent Variable Mean	9.5266
Adjusted R-squared	0.9742	Dep. Variable Standard Deviation	1.0167
Std. Err. Regression	0.1634	Sum of Squared Residuals	0.9612
F-Statistic	135.6921	F-Statistic Probability	0.0000
Log likelihood	28.9051	Deviance Information Criterion	980.1438