2014-01-01

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Ileana M. Resendez
University of Texas at El Paso, ileresendez@gmail.com

Recommended Citation

Resendez, Ileana M., "Residential Electricity Demand in Arkansas" (2014). *Open Access Theses & Dissertations*. 1334.
https://digitalcommons.utep.edu/open_etd/1334

RESIDENTIAL ELECTRICITY DEMAND IN ARKANSAS

ILEANA M. RESENDEZ

Department of Economics and Finance

APPROVED:

Thomas M. Fullerton, Jr., Ph.D., Chair

Timothy P. Roth, Ph.D.

Charles H. Martin, Ph.D.

Charles Ambler, Ph.D.
Dean of the Graduate School

RESIDENTIAL ELECTRICITY DEMAND IN ARKANSAS

by

ILEANA M. RESENDEZ, MPA

THESIS

Presented to the Faculty of the Graduate School of
The University of Texas at El Paso
in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Economics and Finance
THE UNIVERSITY OF TEXAS AT EL PASO
August 2014

Abstract

This study analyzes residential electricity demand in Arkansas. Explanatory variables utilized include real per capita income, residential electricity price, heating degree days, cooling degree days, and residential natural gas price. The results indicate that the income effect dominates the substitution effect given a real personal income increase and a decline in real electricity rates in the state of Arkansas during the period under study.

Table of Contents

List of Tables

Chapter 1: Introduction

Electricity plays a key role on daily activities and its accessibility has become a determinant of society's quality of life. Families and businesses vary their electricity consumption according to some contextual situations such as weather conditions, the price charged for it and the trends of electric appliances. Despite the variations of electricity consumption, utility companies are always interested in meeting customer demands at any given time. Therefore, it is important to understand the determinants of electricity demand so that later they can be used to generate consumption forecasts.

The demand of electricity is highly driven by local conditions and specific customer needs. Weather conditions may impact electricity demand differently in terms of relevance and magnitude over time and across different geographical areas. Additionally, the concentration of different types of customers generates different patterns of electricity demand. Therefore, it is important to analyze electricity demand at a local level and differentiate by consumer sector. Local aggregated demand is impacted by the number of customers in the sector, total quantity consumed at a certain period of time and the prices or rates charged, among other contextual determinants.

The purpose of this study is to analyze residential electricity demand in the state of Arkansas. In order to accomplish the goal, electricity demand analysis will be conducted for short and long-run. The study has the following objectives: (1) to provide clear understanding of residential electricity demand determinants, (2) to analyze the magnitude at which each explanatory variable impacts residential electricity demand in the short and long-run, and (3) to estimate price and income demand elasticities in the state of Arkansas.

In this study, an autoregressive model of order 1 is used to analyze residential electricity demand in the state of Arkansas. The dependent variable used for this analysis is residential electricity consumption by customer in the state of Arkansas expressed in Kilowatt-hour. The explanatory variables include: price of residential electricity, personal income per capita, heating degree days, cooling degree days and residential natural gas price.

The analysis covers data for 42 years, from 1970 to 2011. The main data sources are the U.S. Bureau of Economic Analysis, the National Data Climatic Center and the State energy Data System of the U.S. Energy Information Administration. Prices and income variables are expressed in real terms deflated using the personal consumption expenditure index at 2005 prices level.

The next chapter provides a summary of previous studies analyzing electricity demand. The studies vary in timeframe, the electricity market studied and the geographical location of the research. Chapter 3 provides a description of the theoretical framework and model used to conduct the analysis of the residential electricity market in the state of Arkansas. The subsequent chapter describes the empirical results obtained in the study. The last chapter highlights the conclusions and recommendations for future research.

Chapter 2: Literature Review

In the United States electricity prices vary by type of consumer and geographical area. Given that electricity cannot be stored, the utility companies are always interested in forecasting electricity demand. However, different types of consumers have different consumption patterns, making it more complicated for utility companies to accurately forecast demand but, in general terms, electricity consumption determinants are: number of customers, consumers' behavior, the cost of substitute goods and weather conditions.

Previous studies have conducted electricity demand analysis to provide information to the different stakeholders and facilitate informed decisions making. The first major study of electricity demand in the United States was conducted by Fisher and Kaysen (1962). In the study the authors analyzed short-run and long-run electricity consumption. In the short-run model, electricity consumption was explained by its price, income and the stock of electric appliances. The long-run model introduced changes in utilization rates and changes in equipment stock. The authors found difficulties on the stock of appliances data and described it as "ranged from somewhat below the sublime to a bit above the ridiculous".

Silk and Joutz (1997) used a co-integration technique to develop an error-correction model to analyze the residential electricity demand of the United States using data from 1949 to 1993. Additionally, the authors created indices of seasonal electricity appliances to capture weather and stock appliance effects on residential electricity demand. The results obtained followed the economic theory, short-run income and price elasticities were similar in magnitude with opposite signs. The effects of the weighted cooling degree days have similar effects in the short and in the long run while the weighted heating degree days have greater effects in the short run.

Contreras (2008) conducted regional electricity demand analysis in the United States for the residential, commercial, and nonprofit sector which included public entities. Ordinary least square approach was used to estimate explanatory variables' elasticities of each of the 9 regions defined by the Census Bureau and aggregated for the United States. The explanatory variables used for the analysis were electricity price, customers, income, heating degree days and cooling degree days. The results obtained showed that residential electricity behaves as an inferior good. Commercial, industrial, nonprofit electricity and total aggregated demand showed that electricity markets reacted negative to price increases and positive to an increase in the number of consumers.

Electricity demand analysis is usually tailored to the consumer type. The traditional consumer types are: residential, commercial and industrial. However, much of what is documented regarding electricity consumption is for residential customers due to data availability (Contreras, Smith, and Fullerton, 2011).

Aggregated residential electricity demand determinants were studied by Dergiades and Tsoulfidis (2008). The authors estimated electricity demand in the United States using real per capita income, real average residential price of electricity, cooling and heating degree days' index, the average price of oil for heating purposes and the per capita stock of housing. Their assumption is that electricity using equipment should be intrinsically linked to the stock of occupied units since the use of appliances stock does not consider the use of electricity for lightening purposes per occupied dwelling. Their results supported the expected negative relationship for the income elasticity and positive relationship for the rest of the explanatory variables.

Residential demand for electricity in Taiwan was studied by Holtedahl and Joutz (2004) using data from 1955 to 1996. The authors suggest that electricity demand models for developing countries may require a different framework than those use to analyze electricity in developed countries. For their study, they used a cointegration model and an error correction model in which they incorporated an urbanization variable as a proxy for electricity-using capital stock since cities are electrified sooner than rural areas and adopt modern household appliances faster. The results showed that the urbanization variable provides strong explanatory power in both short and long-run models. Urbanization had both positive long-run and short-run effects on consumption as it captures economic development factors not included in income effects.

Contreras et al. (2009) conducted an empirical analysis for all 50 U.S. states and the District of Columbia using regional economic, demographic and climatic data. The authors included dummy variables to incorporate differences among the nine regions defined by the United States Census Bureau. The results obtained showed that residential electricity demand was statistically significant and price inelastic. Additionally, this study provided significant evidence of the residential electricity as an inferior good for the aggregated U.S. Market; this means that increases in personal income levels will lead to decreases in electricity consumption. An explanation offered by the authors is by having access to higher quality home appliances, households' electricity demand decreases.

The study conducted by Kamerschen and Porter (2004) analyzes residential, industrial and total electricity demand. The authors used aggregated data for the United States from 1973 to 1998. They used a flow adjusted model based on the idea that past behavior affect current decisions. They found that the flow adjusted model yield positive price elasticities, concluding that simultaneous equation models are more appropriate. The results showed that the residential customers are more price sensitive than the industrial customers and total electricity was the least price sensitive. Cold weather had more effect than hot weather on the demand of electricity.

Bernstein and Griffin (2007) conducted a study to determine the existence of geographic differences in the demand for energy in the United States. The authors examine residential electricity demand, residential natural gas demand and commercial electricity demand. The findings show that demand is relatively inelastic to changes in price and seventeen states even showed positive residential price elasticity. The authors argue that this is the result of a decline in real electricity prices over the period over study.

Fullerton, Juarez and Walke (2012) conducted an empirical analysis for residential electricity consumption in Seattle. The authors started the analysis by testing for simultaneity between residential electricity consumption and the average price. The methodology used to conduct this test was to estimate an artificial regression in which the average price is tested for endogenous relationship with Kilowatt-hour consumption. In order to conduct this test, two additional variables were included in the regression: national fixed asset price deflator for electric power structures and the national electricity price index. The results were not sufficient to reject the null hypothesis of no correlation between the average price and the error term. Long-run demand function incorporated fitted values of the average price to correct the estimates. The results showed that an increase in real per capita personal income of 1% leads to a decrease of 0.20% of residential electricity consumption, providing evidence that residential electricity in Seattle behaves as an inferior good. However, in the short run, residential electricity consumption behaves as a normal good. This change in behavior is explained by the fact that house appliance stocks are fixed in the short-run.

Labandeira, Labeaga and Otero (2012) proposed a simple instrument for estimating electricity demand using real data on prices and electricity consumption. The authors' goal was to develop a simple tool that can be used for analysis and policy decision making in Spain that can also be applied in different markets. Their findings show that residential consumers react more than commercial and large consumers to price fluctuations.

Atamturk and Zafar (2012) highlighted the differences in residential price elasticities obtained through different studies. The authors conducted a review of some of the major studies for electricity demand. Overall, a positive relationship between demand and income is found, but there is not enough studies to demonstrate different elasticities at different income brackets. They concluded that the differences in price-demand relationships vary by time, location and specification model and they do not recommend to use specific estimates to inform policy decision making.

Chapter 3: Theoretical Framework

Electricity does not provide direct utility to the consumers. The benefits of consuming electricity are obtained through the use of appliances that require electricity to operate. Heaters and air conditioners increase significantly electricity consumption in areas where extreme weather is observed.

Previous studies assumed aggregated residential electricity demand to be dependent on price, personal income, number of customers, climatic factors, and the price of substitutes. The demand equation for residential electricity consumption can be represented by the general function

$$\mathrm{KWHR}=\mathrm{f}(\mathrm{Price}, \mathrm{Income}, \mathrm{HDD}, \mathrm{CDD}, \mathrm{NGPrice})$$

where the KWHR represent the per customer residential electricity consumption, Price is the real residential electricity price, Income is the real personal income, HDD and CDD are heating and cooling degree days respectively and NGPrice is the real natural gas price.

Annual frequency data from 1970 to 2011 is used for the present analysis. The United States Energy Information Administration is the source for the prices, customers and consumption data. Population, income and deflator data is obtained from the Bureau of Economic Analysis. Cooling and heating degree days are from the National Data Climatic Center.

Total residential electricity consumption in kilowatt hour divided by the number of residential customers is used as the depend variable per customer residential electricity consumption in Arkansas. The per capita personal income as well as the prices are adjusted at 2005 prices by using the personal consumption expenditure index. The customers' serie was available only from 1990, therefore data from 1970 to 1989 is estimated. A regression using employment and population data as explanatory variables is used to estimate residential electricity customers in the state of Arkansas for the entire period under study.

Given the model specification in which the kilowatt hour appears on both sides of the equation, it was necessary to test for potential simultaneity. To examine this possibility, an artificial regression was used (Davidson & MacKinnon, 1989) employing two instrumental variables to test for endogeneity between the average price and the kilowatt hour per customer dependent variable. The specification appears in Equation (1).

$$\mathrm{Ln}(PPCE_t) = c + \alpha_1 \mathrm{LN}(ElecStruct_t) + \alpha_2 \mathrm{LN}(USPPCE_t) + \alpha_3 u_t + \varepsilon_t \qquad (1)$$

The null hypothesis is that the price variable is not correlated with the error term of the long-run equation. The variables used were the USPPCE as the national residential electricity price in cents per kilowatt hour and the ElecStruct as the national fixed asset price deflator for electric power structures. In the presence of endogeneity, fitted prices must be estimated for the long run demand equation.

Given the possibility of serial correlation presence in the long-run, the model must be tested. Serial correlation occurs when the errors in one time period are correlated directly with errors in the ensuing period (Pyndyck & Rubienfeld, 1998). The autoregressive model was used to correct for first-order serial correlation. In the autoregressive process, the current observation is generated by a weighted average of past observations by incorporating the first lagged value of the residual into the long term specification model. The long-run electricity demand per household is specified in Equation 2. The data are logarithmically transformed prior to estimate so that the parameters represent the elasticities of demand.

$$LN(KWHR) = \alpha_0 + \underset{(+)}{\alpha_1 LN(YPCE_t)} + \underset{(-)}{\alpha_2 LN(PPCE_t)} + \underset{(+)}{\alpha_3 LN(HDD_t)} + \underset{(+)}{\alpha_4 LN(CDD_t)} + \underset{(+)}{\alpha_5 LN(GAS_t)} + AR(1) + u_t \tag{2}$$

The numbers in parentheses in Equation 2 reflect the expected signs of the coefficients according to the economic theory. Assuming residential electricity as a normal good, an increase in the real per capita income is expected to increase the consumption of electricity. However, some previous studies have provided evidence of residential electricity as an inferior good (Fullerton, Juarez and Walke, 2012).

According to the economic theory, the own price coefficient is expected to be negative as an increase in price may lead to a reduction in the consumption of the good. The opposite is expected for the natural gas price coefficient. It is expected that as the price of substitute good, in this case natural gas, increases, the demand for electricity increases. Both climatic variables are expected to impact positively the demand for electricity as temperatures fluctuate above or below 65^{o}F, increasing the need for air conditioning or heater, respectively.

An error correction model is used to analyze short-run dynamics of residential electricity consumption. The residuals from the long-run equation are used to represent the deviation from the long run equilibrium. Short-run parameters are obtained by differentiating the variables. The error correction term is u_{t-1} specified in Equation 3.

$$dLn(KWHR)= \delta_0 + \underset{(+)}{\delta_1 dLN(YPCE_t)} + \underset{(-)}{\delta_2 dLN(PPCE_t)} + \underset{(+)}{\delta_3 dLN(HDD_t)} + \underset{(+)}{\delta_4 dLN(CDD_t)} + \underset{(+)}{\delta_5 dLN(GAS_t)} + \underset{(-)}{\delta_6 (u_{t-1})} + \upsilon_t \tag{3}$$

The numbers in parenthesis represent the expected signs of the coefficients. In the short-run, the parameters are expected to behave similar to the long-run. The error correction coefficient is expected to be negative as deviations from previous periods are expected to be corrected in subsequent periods.

Chapter 4: Empirical Results

Annual data from 1970 to 2011 are used for this study. The United States Energy Information Administration is the source for the prices, customers and consumption data. Consumption data used is reported in kilowatt hour by number of customers over the period under study. All the prices and income data are deflated using the price index for personal consumption expenditure. Population, income, employment and deflator data are obtained from the Bureau of Economic Analysis. Cooling and heating degree days are from the National Data Climatic Center. Table 4.1 lists all the variables, descriptions, sources and abbreviations used for the empirical analysis.

Table 4.1 Variables Description

Variable Mnemonic	Description	Units	Source
RKwHr	Arkansas total residential electricity consumption	Kilowatt Hour	U.S. Energy Information Administration
RCUS	Arkansas residential customers	Number of customers	U.S. Energy Information Administration
KWHR	Arkansas per customer residential electricity	Kilowatt Hour per customer	U.S. Energy Information Administration
PRICE	Arkansas residential electricity price	Cents per Kilowatt hour Administration	U.S. Energy Information
PPCE	Arkansas real residential electricity price	Cents per kilowatt hour (Index, 2005=100)	
RNGAS	Arkansas residential natural gas price	Dollars per million BTU	U.S. Energy Information Administration
GAS	Arkansas real residential natural gas price	Dollars per million BTU (Index, 2005=100)	
USP	U.S. residential electricity price	Cents per Kilowatt hour	U.S. Energy Information Administration
USPPCE	U.S. real residential electricity price	Cents per kilowatt hour (Index, 2005=100)	
Y	Personal income	Dollars	Bureau of Economic Analysis
POP	Arkansas population	Number of persons	Bureau of Economic Analysis

Y.POP	Per capita personal income	Dollars	Bureau of Economic Analysis
YPCE	Arkansas real per capita personal income	Dollars (Index, 2005=100)	Bureau of Economic Analysis
PCE	Personal consumption expenditure	Index, 2005=100	Bureau of Economic Analysis
EMP	Wage and salary employment in Arkansas	Number of jobs	Bureau of Economic Analysis
ELECSTRUCT	Price Indexes for Private Fixed Investment in Structures by Type	Index, 2005=100	Bureau of Economic Analysis
HDD	Heating degree days. Difference between 65^o F and average temperature (whenever average temperature is below 65^o F)	Number of degrees	National Data Climatic Center
CDD	Cooling degree days. Difference between average temperature and 65^o F (whenever average temperature is above 65^o F)	Number of degrees	National Data Climatic Center

Per customer residential electricity average in Arkansas is 10,707 kilowatt hour (kWh) annually from 1970 to 2011. Per customer residential electricity consumption has increased over time, the minimum kWh registered is 5,916 in 1970 while the maximum residential electricity consumed was 14,538 kWh in 2010. The average real residential electricity price in Arkansas decreased during the same period. The minimum price observed is \$0.0758 in 2004 while the maximum price observed is \$0.129 in 1983. The average real price over the period of study is \$0.0992. This seems to indicate that a downward sloping demand curve is observed.

The real residential electricity price in the United States (U.S.) is higher and shows less variation than the Arkansas' prices previously described. The average real price from 1970 to 2011 is \$0.105 with a minimum of \$0.091 and a maximum of \$0.128 for 2002 and 1983 respectively. As it can be observed, the minimum price in Arkansas is lower than the minimum price in the U.S.; however, the maximum price registered is higher in Arkansas than in the U.S. Therefore, the standard deviation in Arkansas is higher with 1.56 cents versus 1.05 cents for the U.S.

The population, employment, personal income and real per capita personal income in Arkansas have shown an increase over the same period of time. The average real per capita personal income registered an average of $21,035 with a minimum of $11,990 and a maximum of $30,163 for the years 1970 and 2008 respectively. In Arkansas, the population in 1970 was 1,930,077 and the employment was 637,435. In 2011 the population was 2,937,979 with employment of 1,229,913. Table 4.2 below shows the principal descriptive statistics of the variables used for this study.

Table 4.2 Descriptive Statistics

Variable Mnemonic	RKwHr	RCUS	KWHR	PRICE	PPCE	RNGAS
Mean	1.15E+10	1,045,837	10,707	6.67	9.92	5.91
Median	1.05E+10	998,906	10,721	7.49	9.78	4.97
Maximum	1.92E+10	1,328,286	14,538	9.27	12.93	13.97
Minimum	4.32E+09	730,530	5,916	2.33	7.58	0.75
Std. Dev.	4.02E+09	168,884	2,162	2.15	1.56	4.10
Skewness	1.996E-01	1.289E-01	-0.29	-0.95	0.22	0.61
Kurtosis	2.045E+00	2.028E+00	2.39	2.51	1.87	2.26
Observations	42	42	42	42	42	42

Variable

Mnemonic	GAS	USP	USPPCE	Y	POP	YPOP
Mean	7.46	7.26	10.55	41,965,814,238	2,453,367	16,063
Median	7.17	7.94	10.44	34,966,155,500	2,369,865	14,753
Maximum	13.52	11.72	12.83	99,127,035,000	2,937,979	33,740
Minimum	3.16	2.22	9.10	5,482,180,000	1,930,077	2,840
Std. Dev.	2.97	2.65	1.05	28,713,779,910	277,498	9,582
Skewness	0.40	-0.41	0.50	0.53	0.09	0.34
Kurtosis	2.41	2.42	2.39	2.07	2.04	1.91
Observations	42	42	42	42	42	42

Variable Mnemonic	YPCE	PCE	EMP	ELECSTRUCT	HDD	CDD
Mean	21,035	10	993,923	67	1,877	3,342
Median	20,074	10	991,710	65	1,802	3,374
Maximum	30,163	13	1,263,298	133	3,464	3,960
Minimum	11,991	8	637,435	18	1,397	2,055
Std. Dev.	5,387	2	204,011	31	401	345
Skewness	0.19	0.22	-0.14	0.39	2.67	-1.07
Kurtosis	1.84	1.87	1.56	2.48	11.01	5.93
Observations	42	42	42	42	42	42

4.1 LONG-RUN ESTIMATION RESULTS

Given the model specification in which kilowatt hours appears on both sides of the equation, it was necessary to test for potential simultaneity. To examine this possibility, an artificial regression was used (Davidson & MacKinnon, 1989) employing two instrumental variables to test for endogeneity between the average price and the kilowatt hour per customer dependent variable. The null hypothesis tested is that the average price variable is not correlated with the error term of the long-run equation. The variables used are: the national residential electricity price in cents per kilowatt hour and the national fixed price asset price deflator for electric power structures. The null hypothesis is not rejected, implying the ordinary least squares parameter estimates are unbiased.

Table 4.3 below reports the estimation results obtained for the long-run equation for per customer residential electricity usage. Similar to prior studies of electricity demand, serial correlation is present in the residuals (Fullerton, Juarez, and Walke, 2012). The latter problem is resolved by including a first-order autoregressive term for the residuals (Pagan, 1974). Some of the coefficient estimates differ from the economic theory. All the coefficients, with exception of the natural gas parameter, are statistically significant at the 5-percent level.

The estimated income elasticity is 1.18. This result supports the expected sign indicated by the economic theory for normal goods (Pyndyck & Rubinfeld, 1998). Positive income elasticity supports that residential electricity is a normal good in the long-run. Additionally, this result indicates that residential electricity demand in Arkansas exhibits greater than unitary income elasticity. This outcome aligns well with results reported in other studies. Houthakker (1980) reports a long-run income elasticity of 1.78 for the United States. Espey and Espey (2004) find that residential customers are more sensitive to changes in income over time. Data from 36 separate studies report long-run income elasticities that range from 0.02 to 5.74 with a mean of

0.97 and a median of 0.92. The increasing prevalence of electric appliances due rising incomes is argued to have fostered greater electricity use.

Table 4.3 Long-Run Arkansas per Customer Residential Electricity Demand

Dependent Variable: LNKWHR
Method: Least Squares
Date: 10/16/13 Time: 04:17
Sample (adjusted): 1971 2011
Included observations: 41 after adjustments
Convergence achieved after 18 iterations

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	2.408703	4.239143	0.568205	0.5736
LNYPCE	1.185584	0.251118	4.721216	0.0000
LNPPCE	1.089858	0.453518	2.403119	0.0219
LNHDD	0.233579	0.049003	4.766641	0.0000
LNCDD	0.239051	0.079339	3.013012	0.0049
LNGAS	0.009671	0.088818	0.108885	0.9139
AR(1)	0.621024	0.130831	4.746755	0.0000

R-squared	0.979761	Mean dependent variable	23.12659
Adjusted R-squared	0.976189	S.D. dependent variable	0.352219
S.E. of regression	0.054350	Akaike information criterion	-2.832502
Sum squared residuals	0.100432	Schwarz criterion	-2.539941
Log likelihood	65.06629	Hannan-Quinn criterion	-2.725967
F-statistic	274.3218	Prob. (F-statistic)	0.000000
Durbin-Watson statistic	2.258749		
Inverted AR Roots	.62		

The own-price elasticity for residential electricity is 1.08 and statistically significant. A positive sign for price elasticity runs counter to what is hypothesized for this coefficient. In fact, this result differs substantially from the own-price elasticity estimates documented in all 36 of the studies surveyed in Espey and Espey (2004). It also differs from the 18 negative long-run price elasticities surveyed in Labandeira, Labeaga, and López-Otero (2012). An upward sloping demand curve is surprising, but cannot be ruled out as a theoretical possibility. As pointed out in Vandermeulen (1972), it can occur whenever the income effect exceeds the substitution effect in absolute value, even for cases involving normal goods such as what is indicated for Arkansas residential electricity in Table 4.3. Empirically, that condition is most likely to occur during periods when household incomes are rising.

Recent empirical evidence of upward sloping electricity demand curves is reported in Bernstein and Griffin (2006). In that study, seventeen states, but not Arkansas, in the United States with positive residential price elasticity for the 1977-2004 sample period. Regional incomes, adjusted for inflation and population growth, rose throughout the United States during this period. As noted in the study, real electricity prices declined over much of the sample period utilized, also potentially affecting the own-price elasticity estimates obtained for the seventeen states in question.

Table 4.3 further indicates that both climate variables, heating degree days and cooling degree days, are positively correlated with residential electricity consumption. Both of the parameters estimated for these explanatory variables are statistically significant at the 5-percent level. Although Arkansas tends to be a warm weather state, the estimated coefficients for both weather variables are almost identical in magnitude. The coefficients fall within the inelastic range indicated by prior studies (Silk and Joutz, 1997; Filippini, 1999; Cebula, 2012). The results imply that a one-percent increase in annual heating degree days increases residential electricity consumption by 0.2335 percent while a one-percent increment in cooling degree days raises consumption by 0.2390 percent.

Silk and Joutz (1997) find a positive linkage between cooling degree and greater residential electricity demand in the United States. That study reports a statistically significant cooling degree-days elasticity of 0.26. Cebula (2012) also obtains evidence that electricity consumption in the United Stated is an increasing function of the cooling degree days. Statistically significant cooling degree-days elasticities that range from 0.00016 to 0.18 are documented in that effort.

The natural gas coefficient estimate is 0.0096. The positive cross-price elasticity indicates that it is a substitute product. However, the small magnitude of the coefficient implies that residential natural gas is highly imperfect substitute good for residential electricity in Arkansas. Further underscoring that point, the computed t-statistic does not satisfy the 5-percent significance criterion. The influence of variations in natural gas prices on residential electricity usage may be rather small because of constraints on consumers in terms of fuel switching (Silk & Joutz, 1997). Digital video recorders and other household appliances can only be operated using electrical power sources. This outcome corroborates similar results reported in other recent studies (Bernstein and Griffin, 2006; Contreras et al., 2008).

4.2 SHORT-RUN ESTIMATION RESULTS

Table 4.4 reports the coefficient estimates for the short-run error correction model estimated for per customer residential electricity demand. The error correction term is one-period lag of the long-run equation residuals. As noted in Holtedahl & Joutz (2004), that series represents deviations in electricity consumption from its long-run mean. First differences of the explanatory variables from the long-run equation are used as regressors in the short-run equation.

Table 4.4 Short-Run Arkansas per Customer Residential Electricity Demand

Dependent Variable: DLNKWHR
Method: Least Squares
Date: 10/16/13 Time: 04:26
Sample (adjusted): 1972 2011
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	0.028639	0.010852	2.639104	0.0126
DLNYPCE	0.368525	0.349546	1.054294	0.2994
DLNPPCE	0.516294	0.486761	1.060673	0.2965
DLNHDD	0.214329	0.039992	5.359356	0.0000
DLNCDD	0.209199	0.064182	3.259482	0.0026
DLNGAS	-0.094238	0.082854	-1.137393	0.2636
RESIDLRAR1(-1)	-0.545054	0.162917	-3.345593	0.0021

R-squared	0.569146	Mean dependent variable	0.034443
Adjusted R-squared	0.490809	S.D. dependent variable	0.071531
S.E. of regression	0.051043	Akaike info criterion	-2.954676
Sum squared residuals	0.085977	Schwarz criterion	-2.659122
Log likelihood	66.09352	Hannan-Quinn criterion	-2.847813
F-statistic	7.265355	Prob. (F-statistic)	0.000053
Durbin-Watson statistic	2.005345		

The constant term underscores the almost inexorable growth of per customer residential electricity usage over the course of the four decade sample period. The computed t-statistic for that coefficient exceeds the 5-percent critical value, indicating that the upward trend in per customer demand occurs on a very consistent basis. The presence of statistically significant deterministic component that is greater than zero is similar to what is reported for Seattle (Fullerton, Juarez, and Walke, 2012), but the rate of growth for Arkansas shown in Table 4.4 is much higher.

Not surprisingly, the short-run elasticities are almost always smaller in magnitude than those reported in the long-run. Those outcomes are similar to what has been previously documented for residential electricity (Dergiades & Tsoulfidis, 2008). Although many of the parameters in Table 4.4 exhibit the hypothesized signs, three of the six slope coefficients do not satisfy the 5-percent significance criterion.

The real per capita income coefficient is positive in Table 4.4, indicating that residential electricity in Arkansas is also a normal good in the short-run. This parameter indicates that a one percent increase in real per capita income will lead to an increase of 0.36 percent in per customer consumption. However, the coefficient obtained is not statistically significant at the 5-percent level.

The magnitude of the coefficient obtained corroborates the inelastic estimates listed in other studies. Espey and Espey (2004) report short-run income elasticity estimates that range from 0.04 to 3.48 with a mean of 0.28 and median of 0.15. Silk & Joutz (1997) found similar short-run results for income elasticity. The 0.38 parameter for income elasticity in that effort is estimated using national data and satisfies the 5-percent criterion. Dergiades & Tsoulfidis (2008) report a statistically significant short-run income elasticity of 0.1.

The own-price elasticity remains positive in the short-run but fails to satisfy the 5-percent significance criterion. The parameter obtained for the short-run own-price elasticity is 0.52. This implies that residential demand is also upward sloping in the short-run, but the coefficient is not statistically different from zero. Most regions exhibit negative short-run price elasticities (Espey and Espey, 2004), but some evidence of the opposite has been documented (Bernstein and Griffin, 2006).

Parameters estimated for the climate variables, heating degree days and cooling degree days, are both greater than zero in Table 4.4. Both coefficients are also statistically significant, implying that residential customers also react to temperature extremes in consistent manners in the short-run. The magnitudes of these elasticities further indicate that short-run household electricity consumption is equally sensitive to both cold and hot weather.

The short-run cross-price elasticity of natural gas fails to satisfy the 5-percent significance criterion. However, the estimated coefficient is greater than zero. At 0.094, it is similar in magnitude to that reported in Contreras et al. (2008) using national data for the United States. While short-run changes in the price of natural gas may influence residential electricity consumption in Arkansas, the effect appears fairly muted and not entirely reliable.

The error-correction parameter result shown in Table 4.4 corroborates evidence reported in earlier studies. The estimated coefficient is -0.545 and statistically significant. This result implies that 54 percent of the consumption adjustment to any prior period disequilibrium occurs within twelve months of the shock. Approximately 1.83 years are required for complete adjustment. That is less time than what is reported for Seattle by Fullerton, Juarez, and Walke (2012) and what is estimated for the United States by Dergiades and Tsoulfidis (2008).

4.3 POLICY IMPLICATIONS

The average price for residential electricity in Arkansas has failed to keep pace with inflation from 1983 forward. Similarly, kilowatt hour usage per customer has consistently moved upward over the course of the entire 1971-2011 period for which data are available. Given these conditions, if needed, there is ample room for electric rate increases in most, if not all, of the twenty two service areas regulated by the Arkansas Public Service Commission. This is also likely to be the case for the municipally owned electric utilities that are not regulated by the state agency (APSC, 2013). While fuel charges may not rise very much, that may not be the case for generation, transmission, distribution. Should those costs increase, covering them should be feasible.

Long-run household electricity consumption is elastic with respect to income gains. Per capita income growth in Arkansas is projected to exceed the rate of inflation in the United States (Garg, 2013). Given that, residential electricity usage in fast growing regions such as Little Rock, Fayetteville, and other areas may force loads to increase more rapidly than in other regions of the United States. Pressures to increase generation, transmission, and distribution capacities are likely to be experienced in several service areas throughout the state.

Weather extremes may become more prevalent as a consequence of climate change. For example, data from the last 50 years indicate that prevailing temperatures have increased to record levels, especially from 2000 forward (Arndt, Baringer, and Johnson, 2010). Should these patterns continue, the outcomes in Tables 4.3 and 4.4 imply that additional investment in generating capacities will be required across Arkansas. The latter is because both summer and winter peak energy requirements are likely to increase more rapidly than total usage in the various service areas. If keeping pace with peak demands forces investing in underutilized generation capacity, rates will be forced upwards much more rapidly than has been the case in recent decades.

Chapter 5: Conclusion

This study analyzes residential electricity demand in Arkansas. The analysis is completed within a dynamic framework that employs a long-run cointegrating equation and short-run error correction equation. Explanatory variables utilized include real per capita personal income, a statewide average real residential electricity price, heating degree days, cooling degree days, and a statewide real residential natural gas price.

Several of the log-run estimation results are unexpected. Most surprisingly, the sign of the price coefficient in the long-run equation is positive, indicating that the demand curve for this product is upward sloping. Theoretically, this implies that the income effect dominates the substitution effect. Empirically, this corroborates findings reported in at least one other study and probably reflects the combination of increasing real personal income and declining real electricity rates across Arkansas during the sample period utilized. Demand is found to income elastic in the long-run and households treat electricity as a normal good. Natural gas is found to be a very imperfect substitute. Hot weather and cold weather are found to exercise almost identical long-run usage impacts.

The short-run estimation results also contain several unexpected outcomes. Neither of the price coefficients satisfies the 5-percent significance criterion. The same holds true for the income parameter. Jointly those results indicate that usage habits do not respond to economic stimuli in the short-run. Household consumption does respond to changes in weather conditions during both summer and winter. Those reactions are statistically reliable and almost identical in magnitude. Finally, the error correction parameter is also significantly different from zero. Its magnitude indicates that the effects of any consumption shocks will completely dissipate in less than 24 months, fairly rapid in comparison with what has been documented for other regions.

Weather conditions, as measured by cooling degree days and heating degree days, are positively correlated with residential electricity consumption in Arkansas. Warmer days and cooler days, over the long-run, tend to raise household electricity usage. The error correction equation further indicates that weather variables have similar impact on residential electricity consumption in the short-run. Additional research may help unveil additional information regarding the interplay temperature levels and electricity usage.

The results documented for Arkansas in this study have interesting policy implications associated with them, especially as pertains to generation, transmission, and distribution capacities throughout the state. The results are also intriguing from several microeconomic perspectives. Whether they are unique to this region is unknown at this juncture. In order to rule out the possibility of upward sloping demand curves and symmetrical weather reactions for other regions requires additional research that falls beyond the scope of this effort. It would be useful to eventually attempt to document such conditions, or the absence thereof, for other regional economies.

References

Arkansas Economic Development Commission Energy Office. (2013). Utilities in Arkansas. Retrieved November 2013, from http://arkansasenergy.org/energy-in-arkansas/utilities-in-arkansas.aspx

APSC. (2013). *Electric Section*. Arkansas Public Service Commission. Retrieved November 2013 from http://www.apscservices.info/electric.asp.

Arndt, D.S., Baringer, M.O., & Johnson, M.ER. (2010). State of the climate in 2009. *Bulletin of the American Meteorological Society* 91 (7), S1–S224.

Atamturk, N., & Zafar, M. (2012). *Electricity Use and Income: A Review.* Public Utilities Commission State of California. .

Bernstein, M. A., & Griffin, J. (2006). *Regional Differences in the Price-Elasticity of Demand For Energy.* Golden, Colorado: National Renewable Energy Laboratory.

Bureau of Economic Analysis. (2013). *National Income and Product Accouts Tables*. Retrieved August 2013, from http://www.bea.gov/iTable/

Cebula, R. J. (2012). Recent evidence on residential electricity consumption determinants: a panel two stage least square analysis, 2002-2005. *Journal of Economics and Finance, 36*, 925-936.

Contreras, S. (2008). *Regional Electricity Demand in the United States (Master's thesis).* University of Texas at El Paso.

Contreras, S., Smith, D., Roth, T., & Fullerton, T. M. (2009). Regional Evidence regarding U.S. Residential Electricity Consumption. *Empirical Economics Letters,* 8, 821-232.

Contreras, S., Smith, W. D., & Fullerton, M. T. (2011). U.S. Commercial Electricity Consumption. *Mountain Plains Journal of Business and Economics, 12*, 27-41.

Davidson, R., & MacKinnon, J. G. (1989). Testing for Consistency Using Artificial Regressions. *Econometric Theory, 5*, 363-384.

Dergiades, T., & Tsoulfidis, L. (2008). Estimating residential demand for electricity in theUnited States, 1965-2006. *Energy Economics,* 30, 2722–2730.

Energy Information Administration. (2011). *The Annual Electric Power Industry Report 2010*

Filippini, M. (1999). Swiss residential demand for electricity. *Applied Economics Letters,* 6, 533-538.

Fullerton, T. M., Juarez, D. A., & Walke, A. G. (2012). Residential Electricity Consumption in Seattle. *Energy Economics,* 34, 1693-1699.

Garg, A. (2013). Arkansas. *IHS Global Insight US Markets State Economies South*, Summer, 39-48.

Holtedahl, P., & Joutz, F. L. (2004). Residential electricity demand in Taiwan. *Energy Economics, 26*, 201-224.

Houthakker, H. S. (1980). Residential electricity Revisited. *The Energy Journal, 1*, 29-41.

Labandeira, X., Labeaga, J. M., & Lopez-Otero, X. (2012). Estimation of elasticity price of electricity with incomplete information. *Energy Economics,* 34, 627-33.

National Climatic Data Center. (2013). *NOAA Satellite and Information Service*. Retrieved August 2013, from http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp#

National Grid. (2005, December). Understanding Electric Demand. New York, NY, U.S.

Pagan, A.R. (1974). A generalised approach to the treatment of autocorrelation. *Australian Economic Papers*, 13, 260-280.

Silk, J.I., & Joutz, F.L. (1997). Short and long-run elasticities in US residential demand: a co-integration approach. *Energy Economics*, 493-513.

U.S. Energy Infomrmation Administration. (2013). *State Profile and Energy Estimates*.

U.S. Energy Information Administration. (2010). *Annual Electrict Power Industry Report.*

U.S. Energy Information Administration. (2013). *State Energy Data System (SEDS): 1960-2011*.

U.S. Energy Information Administration. (2011, November). *Monthly Electric Sales and Revenue Report with State Distributions Report*. Retrieved February 14, 2012

Vandermeulen, D.C. (1972). Upward sloping demand curves without the Giffen paradox. *American Economic Review*, 62, 453-458.

Weather in Arkansas. (2014, June 10). Retrieved from Arkansas the Natural State: http://www.arkansas.com/travel-tools/weather-in-arkansas/

Appendix

Table A1. Historical Data U.S. Energy Information Administration

YEAR	Total Residential Electricity Consumption	Residential Customers	Per Customer Residential Electricity	Residential Electricity Price	Real Residential Electricity Price
1970	4,321,454,000	730,530	5,916	2.33	9.83
1971	4,737,254,000	755,651	6,269	2.36	9.56
1972	5,483,279,000	783,358	7,000	2.42	9.46
1973	6,141,583,000	807,762	7,603	2.40	8.91
1974	6,082,450,000	832,932	7,302	2.89	9.71
1975	7,751,196,000	866,878	8,942	3.19	9.91
1976	7,745,974,000	873,507	8,868	3.66	10.77
1977	8,816,121,000	896,864	9,830	4.06	11.24
1978	9,322,000,000	917,423	10,161	4.24	10.95
1979	8,862,000,000	934,216	9,486	4.40	10.44
1980	10,227,000,000	945,794	10,813	5.32	11.39
1981	8,426,339,000	948,353	8,885	5.65	11.11
1982	8,616,814,000	948,638	9,083	6.53	12.18
1983	8,797,506,000	955,726	9,205	7.23	12.93
1984	8,763,581,000	964,538	9,086	7.21	12.41
1985	8,935,852,000	969,072	9,221	7.48	12.47
1986	9,253,757,000	972,209	9,518	7.74	12.60
1987	9,707,593,000	978,737	9,918	7.66	12.05
1988	9,945,727,000	979,382	10,155	7.61	11.51
1989	9,957,250,000	981,903	10,141	7.77	11.26
1990	10,557,866,000	993,402	10,628	8.07	11.18
1991	11,000,632,000	1,004,409	10,952	8.10	10.84
1992	10,440,088,000	1,020,921	10,226	8.28	10.76
1993	11,761,761,000	1,039,655	11,313	8.27	10.51
1994	11,642,130,000	1,061,800	10,965	8.07	10.05
1995	12,416,960,000	1,085,627	11,438	7.98	9.73
1996	12,933,994,000	1,105,851	11,696	7.77	9.27
1997	12,989,655,000	1,120,884	11,589	7.80	9.13
1998	14,339,398,000	1,140,321	12,575	7.51	8.70
1999	14,045,427,000	1,159,684	12,111	7.42	8.47
2000	14,870,777,000	1,177,901	12,625	7.46	8.30
2001	15,103,946,000	1,189,161	12,701	7.71	8.43
2002	15,527,374,000	1,201,823	12,920	7.25	7.82
2003	15,598,301,000	1,221,890	12,766	7.24	7.65
2004	15,619,397,000	1,240,613	12,590	7.36	7.58
2005	17,133,693,000	1,260,764	13,590	8.00	8.00
2006	17,065,081,000	1,283,520	13,296	8.85	8.62
2007	17,414,562,000	1,298,492	13,411	8.73	8.28
2008	17,392,467,000	1,308,810	13,289	9.27	8.51
2009	16,985,526,000	1,315,041	12,916	9.14	8.39
2010	19,230,961,000	1,322,833	14,538	8.85	7.97
2011	18,787,349,000	1,328,286	14,144	9.01	7.92

YEAR	Residential Natural Gas Price	Real Residential Natural Gas Price	US Residential Electricity Price	U.S. Real Residential Electricity Price
1970	0.75	3.17	2.22	9.38
1971	0.78	3.16	2.32	9.40
1972	0.83	3.25	2.42	9.47
1973	0.87	3.23	2.54	9.43
1974	1.06	3.57	3.10	10.44
1975	1.12	3.48	3.51	10.90
1976	1.23	3.62	3.73	10.98
1977	1.94	5.36	4.05	11.20
1978	1.96	5.06	4.31	11.13
1979	1.54	3.65	4.64	11.01
1980	2.49	5.34	5.36	11.49
1981	3.06	6.02	6.20	12.20
1982	3.84	7.16	6.86	12.79
1983	4.32	7.72	7.18	12.83
1984	4.29	7.39	7.15	12.32
1985	4.35	7.25	7.39	12.33
1986	4.77	7.77	7.42	12.08
1987	4.57	7.18	7.45	11.70
1988	4.78	7.23	7.48	11.31
1989	4.83	7.00	7.65	11.08
1990	5.06	7.01	7.83	10.85
1991	4.89	6.54	8.04	10.75
1992	5.06	6.57	8.21	10.66
1993	5.31	6.75	8.33	10.58
1994	5.59	6.96	8.38	10.44
1995	5.05	6.15	8.40	10.24
1996	5.77	6.88	8.36	9.97
1997	6.58	7.70	8.43	9.87
1998	6.68	7.75	8.26	9.58
1999	7.09	8.09	8.17	9.32
2000	7.29	8.12	8.24	9.17
2001	9.90	10.82	8.58	9.38
2002	8.74	9.42	8.45	9.10
2003	10.02	10.59	8.72	9.21
2004	11.62	11.96	8.95	9.21
2005	13.52	13.52	9.44	9.44
2006	13.73	13.37	10.40	10.13
2007	12.96	12.28	10.65	10.10
2008	13.97	12.82	11.26	10.34
2009	13.24	12.15	11.51	10.56
2010	11.45	10.31	11.54	10.39
2011	11.29	9.92	11.72	10.30

Table A2. Historical Data Bureau of Economic Analysis

YEAR	Personal Income	Population	Per capita personal income	Real per capita personal income	Personal Consumption Expenditure Index
1970	5,482,180,000	1,930,077	2,840	11,991	23.685
1971	6,089,663,000	1,972,028	3,088	12,506	24.692
1972	6,880,585,000	2,018,116	3,409	13,350	25.536
1973	8,188,566,000	2,058,491	3,978	14,781	26.913
1974	9,174,337,000	2,100,385	4,368	14,699	29.716
1975	10,075,261,000	2,158,291	4,668	14,498	32.198
1976	11,184,577,000	2,168,688	5,157	15,183	33.966
1977	12,486,268,000	2,207,228	5,657	15,640	36.171
1978	14,496,074,000	2,241,019	6,469	16,714	38.705
1979	15,929,916,000	2,269,115	7,020	16,660	42.137
1980	17,213,787,000	2,288,738	7,521	16,118	46.663
1981	19,509,866,000	2,293,204	8,508	16,737	50.833
1982	20,525,912,000	2,294,254	8,947	16,680	53.640
1983	21,818,603,000	2,305,766	9,463	16,914	55.948
1984	24,325,474,000	2,319,767	10,486	18,059	58.065
1985	25,895,775,000	2,327,046	11,128	18,557	59.965
1986	27,108,232,000	2,331,988	11,625	18,925	61.427
1987	28,161,393,000	2,342,357	12,023	18,899	63.618
1988	30,113,776,000	2,342,655	12,855	19,433	66.151
1989	32,207,901,000	2,346,354	13,727	19,887	69.025
1990	33,938,706,000	2,356,586	14,402	19,953	72.180
1991	35,993,605,000	2,383,144	15,103	20,194	74.789
1992	39,148,520,000	2,415,984	16,204	21,047	76.989
1993	41,001,582,000	2,456,303	16,692	21,215	78.679
1994	43,634,403,000	2,494,019	17,496	21,788	80.302
1995	46,297,028,000	2,535,399	18,260	22,247	82.078
1996	49,308,500,000	2,572,109	19,170	22,858	83.864
1997	51,620,980,000	2,601,090	19,846	23,230	85.433
1998	54,622,677,000	2,626,289	20,798	24,115	86.246
1999	57,163,803,000	2,651,860	21,556	24,597	87.636
2000	60,467,596,000	2,678,588	22,574	25,133	89.818
2001	64,232,708,000	2,691,571	23,864	26,072	91.530
2002	65,646,579,000	2,705,927	24,260	26,148	92.778
2003	69,230,717,000	2,724,816	25,407	26,841	94.658
2004	73,719,848,000	2,749,686	26,810	27,605	97.121
2005	77,475,378,000	2,781,097	27,858	27,858	100.000
2006	82,918,067,000	2,821,761	29,385	28,606	102.723
2007	89,312,492,000	2,848,650	31,353	29,719	105.499
2008	94,460,843,000	2,874,554	32,861	30,163	108.943
2009	91,793,885,000	2,896,843	31,688	29,070	109.004
2010	94,581,100,000	2,921,588	32,373	29,142	111.087
2011	99,127,035,000	2,937,979	33,740	29,651	113.790

YEAR	Employment	National Fixed Asset Price Deflator
1970	637,435	18.05
1971	656,335	19.80
1972	684,235	20.99
1973	717,319	22.73
1974	741,607	26.74
1975	719,725	31.14
1976	750,953	33.23
1977	786,654	35.75
1978	823,141	37.62
1979	833,787	41.67
1980	831,250	45.71
1981	825,689	49.52
1982	803,534	52.08
1983	821,515	53.73
1984	855,958	55.04
1985	870,748	55.67
1986	884,686	56.29
1987	910,314	56.92
1988	941,111	60.73
1989	962,936	62.95
1990	987,409	65.06
1991	996,011	65.40
1992	1,022,390	66.54
1993	1,052,725	68.70
1994	1,087,678	71.41
1995	1,123,528	73.80
1996	1,140,685	75.17
1997	1,159,687	76.65
1998	1,175,697	78.19
1999	1,194,966	78.99
2000	1,210,817	82.19
2001	1,207,826	84.71
2002	1,202,909	87.13
2003	1,202,986	88.86
2004	1,217,065	93.93
2005	1,234,501	100.00
2006	1,259,810	106.89
2007	1,262,522	115.12
2008	1,263,298	124.10
2009	1,227,077	123.76
2010	1,226,354	127.75
2011	1,229,913	132.89

Table A3. Historical Data National Data Climatic Center.

YEAR	Heating Degree Days	Cooling Degree Days
1970	1869	3510
1971	1800	3174
1972	1829	3386
1973	1775	3147
1974	1568	3067
1975	1645	3299
1976	1397	3495
1977	3464	3464
1978	1939	3960
1979	1559	3909
1980	2230	3637
1981	1760	3344
1982	1731	3383
1983	1792	3870
1984	1660	3308
1985	1844	3557
1986	1991	3097
1987	1959	3236
1988	1803	3561
1989	1508	3568
1990	1862	2883
1991	1934	3151
1992	1437	3223
1993	1774	3814
1994	1608	3247
1995	1748	3364
1996	1681	3625
1997	1630	3519
1998	2311	2982
1999	1879	2932
2000	1988	3490
2001	1867	3271
2002	1831	3507
2003	1692	3461
2004	1721	3053
2005	2027	2986
2006	2039	2805
2007	1927	3178
2008	1630	3615
2009	1535	3537
2010	2214	3697
2011	3356	2055

Vita

Ileana M. Resendez was born and raised in Monterrey, Mexico. In 2002 she graduated from the Instituto Tecnologico y de Estudios Superiores de Monterrey with a bachelor degree in Economics. After graduation she hold different positions in the private and public sectors. In 2006 she entered graduate school at the University of Texas at El Paso. While conducting studies, she worked for a non-profit organization as a Manager for Performance Analysis and Reporting. In 2008, Ileana received a degree of Master in Public Administration.

Currently, Ileana holds a position at an international non-profit organization. She provides support as a monitoring and evaluation professional. Ileana is responsible for effective design and implementation of the planning, monitoring and evaluation system of the organization world-wide.

She holds a certificate in Regional Integration and Economic Processes by the University of Barcelona and a certificate in Public Policy by the Escuela de Graduados en Administracion Publica (EGADE). Ileana is also a certified Project Manager in Development professional.

Permanent address: 1629 Rockwater Blvd.
North Little Rock, AR, 72114

This thesis was typed by Ileana Resendez.