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A Research Note on:

IMPACTS OF TEMPERATURE ON GAS AND ELECTRICITY USAGE AND EXPENDITURES FOR 1981-1982

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ABSTRACT

The purpose of this paper is to analyze the impact of outside temperatures on gas and electricity usage and expenditures for 1981 and 1982 for a sample of households in central Iowa. A sample of 93 households, who lived continuously in the same dwelling and had given full information on utilities for the entire two years, is used in the analysis. The unit of analysis is a monthly segment, which this study uses in a form of time-series analysis. Plot procedures are used to examine the general trends of utility usage and expenditures. Linear regression analyses are used to estimate the effects of monthly average temperature or monthly average heating and cooling degree days on utility usage and expenditures. Monthly average temperature and/or cooling degree days explain most of the variances in monthly average gas and electricity usage and expenditures. Attitude toward the energy problem has no significant effect on gas usage or electricity usage.

INTRODUCTION

This paper analyzes the impacts of outside temperature on gas and electricity usage and expenditures for 1981 and 1982. Some methodological techniques utilizing a form of time-series analysis are presented as a way to test utility data. This is a preliminary study to a more detailed analysis of the relationships between attitudes toward the energy problem and actual changes in usage and expenditures for gas and electricity.

The data were collected from December 1981 to March 1982. A sample of 194 families in Boone, Fort Dodge, Webster City, and Carroll, Iowa, were interviewed with a lengthy questionnaire on various attitudes and behaviors related to energy usage and conservation.

The monthly data on the amount of gas and electricity usage and expenditures from January 1981 to December 1982 were obtained from the utility companies. There are 114 cases in Fort Dodge, Webster

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city, and Carroll, Iowa, with complete information on utility usage and expenditures. Only 93 cases lived continuously in the same dwelling and had full information on utilities for the entire two years. All households except two had used both gas and electricity.

Monthly averages of gas usage, electricity usage, gas expenditure, electricity expenditure, and total utility expenditure are obtained by summing the monthly amount for each household and dividing by the number of households. Monthly average temperature, monthly heating degree day totals, and monthly cooling degree day totals are obtained from Climatological Data of Iowa (NOAA, 1981, 1982). To calculate monthly average temperature, monthly heating degree days, and cooling degree days of the three areas, the number of cases in each city is used to weight the temperature, heating degree day totals, and cooling degree day totals of each area. The discrepancies of electricity usage, gas usage, expenditure, temperature, heating degree days, and cooling degree days are calculated by substracting the monthly amount of each item in 1982 from the one in 1981.

The unit of analysis for this study is a monthly segment, which this study uses in a form of time-series analysis. The year of 1981 has 12 monthly segments as does 1982. Plot procedures are used to examine general tendencies of gas and electricity usage and expenditures for the 24 monthly segments. Linear regression analysis is used to estimate the effects of monthly average temperature, heating degree days, and cooling degree days on gas and electricity usage and expenditures.

General trends of gas and electricity usage and expenditure

Monthly usage of gas decreased insignificantly over the 24-month period, while the monthly average usage of electricity and monthly average expenditures rose. To compare monthly average expenditure for the year of 1981 with that for 1982, Figure 1 shows monthly average expenditures for the two years. Each month in 1982 has higher expenditures than does each one in 1981. The discrepancy of expenditures between 1981 and 1982 is shown in the shaded area of Figure 1.

Usage of gas and electricity

The higher utility expenditures in 1982 may be caused by the higher utility usage due to temperature differences and the higher unit price of the utility. Figure 2 shows monthly electricity usage for 1981 and 1982. During the months of July and October in 1982, less electricity is actually used than is used in those months in 1981. Figure 3 shows monthly gas usage for 1981 and 1982. During the months of October and December in 1982, less gas is used than is used in those months in 1981.

Even though less electricity is used during the months of July and October of 1982 than during the same period in 1981, there are higher electrical expenditures for those months in 1982. Also, less

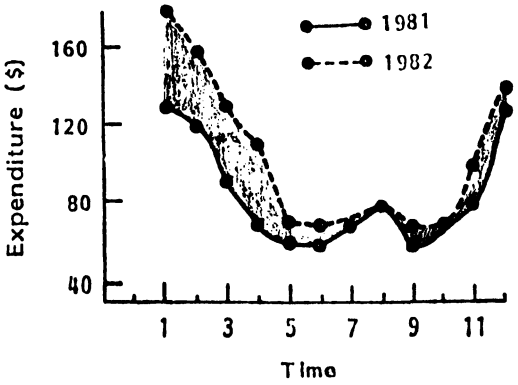

Figure 1. Utility expenditure of each month in 1981 and 1982

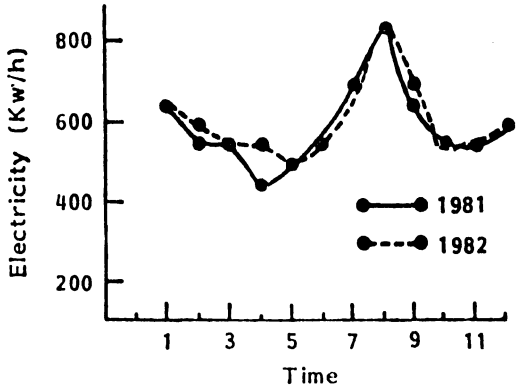

Figure 2. Monthly usage of electricity in 1981 and 1982

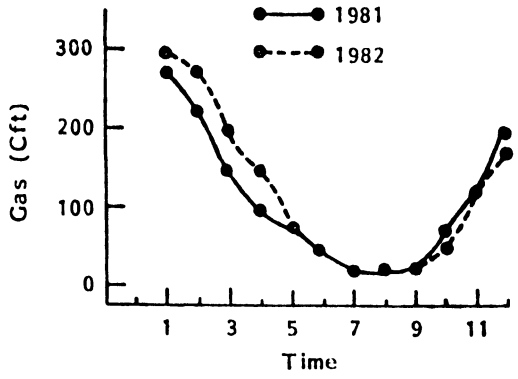

Figure 3. Monthly usage of gas in 1981 and 1982

gas is used during the months of October and December of 1982 than during those same months in 1981, but there are higher gas expenditures for those months in 1982 than in 1981. It is obvious that the increase in monthly expenditures in 1982 is caused in part by rising prices. However, most of the increase in monthly expenditures in 1982 is affected by the increase in usage, which may be influenced by outside temperature.

Table 1 shows how much the monthly usage of gas and electricity is influenced by the monthly average temperature. Monthly average temperature is not a significant indicator of electricity usage, but it is a significant indicator of gas usage. In other words, electrical usage is much less affected by outside temperature than is gas usage. Eighty-eight percent of the variance in monthly gas usage in 1981 and 91 percent of that in 1982 can be explained by monthly average temperature. The monthly time variable is significant in estimation of the usage of gas only when monthly average temperature is controlled. Given the month to be estimated, 97 percent of the variance in gas usage is explained by the monthly average temperature.

Monthly heating degree days and cooling degree days, instead of monthly average temperatures, are used to estimate gas and electricity usage. The monthly time variable is significant only to estimate gas usage when monthly average heating degree and/or cooling degree days are controlled. Given the month to be estimated, 99 percent of the variance in gas usage in 1981 and 97 percent of the gas usage variance in 1982 are explained by monthly heating and cooling degree days. Almost half of the variance in electricity usage is also explained.

Monthly cooling degree days is a significant indicator of electricity usage, whereas monthly heating degree days has a significant effect on gas usage. Monthly heating degree days and the month to be estimated can predict 99 percent of the variance in gas usage.

Utility expenditure

Monthly average temperature or monthly heating and cooling degree days is assumed to have a direct effect on monthly expenditure. Table 3 shows that the monthly time variable insignificantly increases the R^2 when monthly average temperature or monthly heating and cooling degree days are controlled.

The monthly average temperature explains 79 percent of the variance in utility expenditure in 1981 and 89 percent of that in 1982. Monthly heating and cooling degree days are significant indicators of utility expenditures. They explain 94 percent of the variance in utility expenditure in 1981 and 1982. Given the month to be estimated, 95 percent of the variance in utility expenditure is explained by them.

Table 1. Regression Analyses of Monthly Utility Usage on Time and Temperature

	Usage of electricity in 1981			Usage of gas in 1981		
	b	t-ratio		b	t-ratio	
Average temperature	2.01	1.17	$R^2 = 0.12$	-4.27	8.63*	$R^2 = 0.88$
Time (month)	4.15	0.46		-6.74	-4.75*	
Average temperature	1.87	1.03	$R^2 = 0.14$	-4.04	-14.31*	$R^2 = 0.97$
	Usage of electricity in 1982			**Usage of gas in 1982**		
	b	t-ratio		b	t-ratio	
Average temperature	1.21	0.88	$R^2 = 0.07$	-4.10	-9.83*	$R^2 = 0.91$
Time (month)	0.59	0.06		-6.92	-4.08*	
Average temperature	1.17	0.75	$R^2 = 0.07$	-3.69	-13.19*	$R^2 = 0.97$

Table 2. Regression Analyses of Monthly Utility Usage on Time, Average Heating Degree Days, and Average Cooling Degree Days

	Usage of electricity in 1981			Usage of gas in 1981		
	b	t-ratio		b	t-ratio	
Time (month)	4.79	0.63		-6.92	-9.88*	
Heating degree days	0.07	0.95		0.16	22.38*	
Cooling degree days	0.81	2.36*	$R^2 = 0.47$	0.05	1.50	$R^2 = 0.99$
Time (month)	3.92	0.52				
Cooling degree days	0.59	2.36*	$R^2 = 0.41$			
Time (month)				-6.93	-9.27*	
Heating degree days				0.15	27.57*	$R^2 = 0.99$
	Usage of electricity in 1982			**Usage of gas in 1982**		
	b	t-ratio		b	t-ratio	
Time (month)	3.90	0.53		-7.06	-3.89*	
Heating degree days	0.07	0.53		0.14	9.64*	
Cooling degree days	0.83	2.74*	$R^2 = 0.50$	-0.02	-0.24	$R^2 = 0.97$
Time (month)	0.75	0.10				
Cooling degree days	0.60	2.46*	$R^2 = 0.41$			
Time (month)				-7.02	-4.11*	
Heating degree days				0.14	13.08*	$R^2 = 0.97$

* Significant at the .05 level

Table 3. Regression Analyses of Monthly Utility Expenditure on Time, Temperature, Heating Degree Days, and Cooling Degree Days

	Utility expenditure in 1981			Utility expenditure in 1982		
	b	t-ratio		b	t-ratio	
Average temperature	-1.31	-6.14*	$R^2 = 0.79$	-1.68	-8.84*	$R^2 = 0.89$
Time (month)	-0.81	-0.73		-1.31	-1.06	
Average temperature	-1.29	-5.78*	$R^2 = 0.80$	-1.60	-7.90*	$R^2 = 0.90$
Heating degree days	0.06	10.07*		0.07	10.20*	
Cooling degree days	0.09	3.13*	$R^2 = 0.94$	0.07	1.67	$R^2 = 0.94$
Time (month)	-0.82	-1.34		-1.10	-1.17	
Heating degree days	0.06	10.27*		0.07	9.33*	
Cooling degree days	0.09	3.26*	$R^2 = 0.95$	.06	1.56	$R^2 = 0.95$

Table 4. Regression Analyses of the Discrepancies of Monthly Utility usage and Expenditure on the Discrepancies of Temperature, Heating Degree Days, and Cooling Degree Days Between 1981 and 1982

	Discrepancy of electricity usage		Discrepancy of gas usage		Discrepancy of expenditure	
	b	t-ratio	b	t-ratio	b	t-ratio
Time (month)	-0.82	-0.21	-2.99	-2.12*	-0.96	-0.84
Discrepancy of temperature	-1.27	-0.61	-1.40	-1.90	-1.45	-2.42*
	$R^2 = 0.12$		$R^2 = 0.76$		$R^2 = 0.68$	
Time (month)	-0.28	-0.07	-2.95	-2.07*	-1.29	-1.07
Discrepancy of heating degree days	0.07	0.28	0.05	1.98*		
Discrepancy of cooling degree days	0.06	0.84	0.03	0.36	0.07	0.95
	$R^2 = 0.17$		$R^2 = 0.78$		$R^2 = 0.68$	
Time (month)					-0.21	-0.17
Discrepancy of temperature					-0.98	-1.56
Discrepancy of gas usage					0.21	0.76
Discrepancy of electricity usage					0.13	1.28
					$R^2 = 0.81$	

* Significant at the .05 level

Discrepancies in temperature, utility usage and expenditure

The discrepancy in monthly usage between 1981 and 1982 is estimated by the discrepancy of the monthly average temperature. Table 4 shows that the 1981-1982 discrepancy of monthly average temperature explains 12 percent of the variance in the 1981-1982 discrepancy of monthly electricity usage. It also explains 76 percent of the variance in the 1981-1982 discrepancy of monthly gas usage. The much smaller impact of temperature discrepancy on the difference in electricity usage shows that the larger amount of discrepancy of electricity usage is influenced by factors other than the difference in outside temperature.

The discrepancy of average temperature explains 68 percent of the variance in the discrepancy of utility expenditure when the monthly time is controlled. Seventy-four percent of the variance is explained by the discrepancy of utility usage in the same condition as the temperature. When the differences in temperature are combined with the differences in gas usage and electricity usage, 81 percent of the variance is explained.

Attitude toward the energy problem

Through the findings of impacts of monthly average temperature or monthly heating/cooling degree days on utility usage and expenditure, a small portion of the variance in utility usage and/or in utility expenditure is unexplained. This may be caused by such factors as attitudes toward the energy problem. Two items on attitude to the energy problem are analyzed to find the effect of energy attitude on utility usage. Attitude toward the energy problem has a significant effect on neither gas usage nor electricity usage.

SUMMARY

The purpose of this paper is to analyze the impacts of outside temperature on gas and electricity usage and expenditures for 1981 and 1982. Some methodological techniques utilizing a form of time-series analysis are presented as a way to test utility data. The trend of monthly average gas usage was insignificantly decreased over 24 monthly periods, whereas the trends of monthly average usage of electricity and utility expenditures rose insignificantly.

The time variable has an insignificant effect on usage and expenditures by itself. However, it is significant when monthly average heating degree days are controlled. Monthly average temperature is a significant indicator of gas usage. To estimate utility usage, monthly average heating degree days and monthly average cooling degree days are better indicators of utility usage than is monthly average temperature. Monthly average cooling degree days are significantly related to monthly average usage of electricity. Monthly average heating degree days are related to monthly average gas usage. Monthly average temperature or monthly average heating/cooling degree days explains much more of the variance in monthly average of electricity usage than that in monthly average gas usage.

Monthly average temperature or monthly average heating and cooling degree days explains most of the variance in monthly average utility expenditures in 1981 and 1982. The discrepancies of monthly average temperature, gas usage, and electricity usage explain 81 percent of the variance in the discrepancy of monthly utility expenditures between 1981 and 1982. Thus, a small portion of the variance in utility usage and in utility expenditure is actually left out. Attitude toward the anergy problem has no significant effect on monthly average gas usage and electricity usage.

This research presents some methodological techniques that could be used to analyze data with a form of time series. This methodology could be extended to study trends or changes in individual household consumptions over time.

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