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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 5 (3): 401-404, 2006
ISSN 1812-5638

Electricity Demand Function for the Industries of Iran

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Abstract: The aim of this study is to estimate electricity demand functions for the industries in Iran. The demand functions estimate electricity demand for 17 groups of industries. Value added in the manufacturing sector over a specified period, electricity price for industrial users and the number of industrial users are utilized as variables in the demand function in this survey. The results show that for industrial electricity demand, the coefficient of electricity price and value added are statistically significant in the most of industries such as food, furniture, basic metallic.

Key words: Electricity consumption, estimate, demand function, industrial sector

INTRODUCTION

Energy demand in general and in Iran electricity demand in particular has been growing at a very rapid rate over the last decade. Given, current trends in population growth, industrialization, urbanization, modernization and income growth, electricity consumption is expected to increase substantially in the coming decades as well. Tariff reforms could play a potentially important role as a demand side management tool in Iran. However, the effects of any price revisions on consumption will depend on the price elasticity of demand for electricity. In this survey, we obtain electricity demand function for the industries in Iran (in 17 groups of industries). These functions are used to calculate price elasticity.

For estimating electricity demand in residential industrial, agriculture and service sectors in recent decades, expanded studies in different countries have been done. The domain of these studies included different sectors. For example, some of the studies have shifted their attention toward electricity demand in residential sector and others are limited to investigate electricity demand in industrial sector. Other consumption sectors such as agriculture and services have been studied. David *et al.* (2004) have formulated the demand for residential, industrial and total electricity, by a partial adjustment approach. Beenstock *et al.* (1999) have estimated electricity for electricity in Israel. Quarterly data for Israel have used to compare and contrast three dynamic econometric methodologies for estimating the demand for electricity by households and industrial companies. Arima (1992) has investigated electricity consumption in residential, commercial and industrial sectors in Nigeria and for this, he has used poling inputs. Eltony and Hajeeh (1998) have investigated electricity demand in residential, commercial and industrial sectors in Kuwait; they have used Error-Correction Model and Co integration Model. In addition, in electricity demand study, we can mention Silk and Joutz (1997) have investigated short and long run effects of economic variable on energy consumption with using Co integration Model and Error-Correction Model.

For estimating energy demand, especially electricity, in Iran, we can point to the introductory report of establishing energy model in Iran that plan and budget organization (Anonymous, 1978) has investigated energy carrier's demand. In addition, plan and budget organization (Anonymous, 1988) has formulated econometrics model for forecasting energy supply and demand. The oil product, electricity and natural gas demand models has estimated for various sectors and total economy. In addition, Zamani (1998) has investigated and have estimated electricity demand in residential and industry sectors in Lorestan province. Sadeghi (1999) has investigated the stability of demand for energy and effective factors on it and Sadeghi (2003) has forecasted electricity consumption by econometric methods.

In this research, effective factors on electricity demand for industries have been investigated and then annual time series data from 1980 to 2002 has been used to estimate electricity demand functions.

DEMAND FUNCTION

To determine the electricity demand function, econometric models are used. An econometric model determines the relationships between economic

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variables. These relationships are determined by one or more equations, which contain some exogenous or endogenous variables that affect the dependent variable (or variables). The first step to define the relationship between these variables is to determine the functional form of the model. In the second step, because used variables are time series, it is necessary to avoid false regression; model co integration should be verified. Third step is to test classical fundamental assumptions (Lack of autocorrelation, variance heterogeneity and co linearity) in order to assure the validity of model calculation. The fourth step is to investigate the test related to variables being significant and goodness of fit criterion. All mentioned processes lead to determine the relationship between dependent variable and independent variables affecting it.

There is an array of methods that are available today for modeling demand. An appropriate method is chosen based on the nature of the data available and the desired nature and level of detail of the models. An approach often used is to employ more than one method. In this study, we use Econometric methods to model demand functions. This approach combines economic theory with statistical methods to produce a system of equations for estimating energy demand. Taking time-series (detailed data over the last, some 25 to 30 years) or cross-sectional/pooled data, causal relationships could be established between electricity demand and other economic variables. Causal relationships are functional forms where a cause-and-effect relationship is established between variables. For example, changes in Income cause a change in consumption and/or vice versa. The dependant variable, in our case, demand for electricity, is expressed as a function of various economic factors. To model electricity demand, economic investigation and theories propose various variables to explain electricity demand. These variables are also different according to the type of consumer such as residential, industrial, etc. In most of the studies and investigations, industrial electricity demand is considered as function of average price of industrial electricity, industrial value added, the number of industrial consumers and some times electricity consumption in the previous period (t-1). Functional form of this function is a Log-Linear Auto-Regression Model like following:

$$Ln(EC_i) = \alpha_0 + \alpha_1 Ln(VA_{i(t-1)}) + \alpha_2 Ln(PR_i) + \alpha_3 Ln(NC_i) \quad (1)$$

Where:

EC: Industrial electricity consumption in proportion to 1000 KW per hour.

$VA_{(t-1)}$: Industrial value added in proportion to 1000 RLS and stable prices in 1997.

PR: The average price of industrial electricity in proportion to RLS.

NC: The number of industrial consumers.

α: Coefficient of variables and model intercept.

Several functional forms and combinations of these and other variables may have to be tried till the basic assumptions of the model are met and the relationship is found statistically significant.

AN EXPLANATION ON STATISTICAL DATA

Statistical sources and the data related to the model variables is obtained from a statistical leaflet from industrial workshops of the country (compiled annually by the statistic center of Iran) (Anonymous, 1980-2001). In this list if new divisions of industries are put in the form of the third edition of the international classification of the economical activities, the data will be just limited to the years from 1994 to 2001 and this amount of information is less and can make large errors in the results. If we use the data before the year of 1994, the problem of the comparison of new statistics and the data with old ones can be presented. The modification and transformation of data and compatibility with many new international definitions is difficult or even unlikely. Hence, the classification of industries based on the second edition is considered, the international classification with three digit is used as a criterion to change the third edition into the second one. The essential data (on the basis of international classification and the second edition) from 1980 to 2001 are available and 21 series of statistical data are suitable for estimations. Of course the above mentioned data is related to the great industrial workshops of the country (which has 10 or more employees). The data related to the small workshops have not yet been compiled and is unavailable.

ESTIMATE ELECTRICITY DEMAND FUNCTION FOR THE INDUSTRIES OF IRAN

The aim of this study is to obtain the electricity demand function in 17 groups of industries in Iran. Doing so required statistic data was collected separately according to each industry. Then annual time series data from 1980 to 2002 has been used to estimate electricity demand functions. The functions estimate by Ordinary Least Square (OLS) method. The results of best fitness are briefly presented in Table 1. Equation 2 and 3 show food and textile demand functions.

Table1: The results of electricity demand estimation in different industries

Industries	Intercept	$VA_{(t-1)}$	PR	NC	Dummy	R^2	D-W**	F
Food products	8.54	0.11	-0.21	0.46	-0.07	0.69	1.7	21.3
	(4.14)*	(1.03)	(-1.17)	(1.91)	(-0.19)			
Beverage	6.2	NA***	NA	1.39	1.68	0.77	1.3	32
	(8.08)			(6.3)	(6.19)			
Textile	13.01	NA	-.83	0.48	2.21	0.91	2.1	32.05
	(12.92)		(-5.76)	(3.9)	(12.39)			
Clothes	15.55	NA	-1.58	NA	-1.07	0.62	1.63	5.25
	(9.36)		(-3.13)		(-5.96)			
Wood products	13.34	NA	-0.46	NA	1.17	0.75	1.9	12.20
	(27.52)		(-3.66)		(14.98)			
Furniture	12.88	-0.21	-0.13	0.31	1.68	0.90	2.06	16.19
	(7.6)	(-2.34)	(-1.2)	(4.05)	(10.3)			
Papers products	NA	0.62	NA	NA	2.07	0.83	1.81	20.48
		(58.44)			(17.68)			
Printing	NA	2177	NA	NA	4908	0.62	1.6	1.26
		(14.23)			(4.5)			
Chemical	NA	0.43	NA	0.64	NA	0.65	1.73	37.4
		(8.88)		(3.34)				
Petroleum	4.33	0.13	NA	0.84	0.96	0.92	1.12	73.39
	(4.92)	(2.62)		(11.12)	(2.59)			
Rubbers products	10.48	NA	-0.38	0.50	1.35	0.77	1.3	14.74
	(10.42)		(-2.3)	(3.6)	(6.1)			
Leathers products	12.38	NA	-0.35	NA	-0.66	0.76	2.1	19.75
	(83.37)		(-9.10)		(-5.62)			
Fabric metal	4.85	0.32	-0.05	0.08	NA	0.88	1.99	58.40
	(0.69)	(0.75)	(0.14)	(0.15)				
Basic metal	-8.19	0.94	NA	0.9	NA	0.86	2.1	60.37
	(-3.6)	(7.92)		(3.01)				
Electricity equip	NA	0.30	-0.24	0.91	-4.79	0.94	1.98	74.77
		(5.46)	(4.56)	(4.68)	(-13.72)			
Transportation	9.17	NA	NA	0.55	1.10	0.81	1.47	27.31
	(19.29)			(5.76)	(3.68)			
Other machinery	11.27	NA	-0.79	0.20	1.48	0.97	1.65	110.18
	(17.37)		(-4.3)	(7.03)	(9.83)			

*The t-statistics appear in parentheses, **Durbin-Watson stat, ***Null variables

$$\mathrm{Ln}(EC_{food}) = 8.54 + 0.11\mathrm{Ln}(VA_{i(t-1)}) - 0.21\mathrm{Ln}(PR_i) + 0.46\mathrm{Ln}(NC_i) - 0.07DUM \quad (2)$$

$$\mathrm{Ln}(EC_{textile}) = 13.01 - 0.83\mathrm{Ln}(PR_i) + 0.48\mathrm{Ln}(NC_i) + 2.21DUM \quad (3)$$

- Results obtained from standard tests for correcting the estimation of electricity demand model (test of homoscedasticity, normality test,) is a good verification for the fitness of these models.
- In order to remove the shock of imposed war (Iran-Iraq, 1981-1989) and economic fluctuations, dummy variables are used.

ACKNOWLEDGMENT

The author grate fully acknowledges the supports provided kindly by the ministry of energy in Iran.

CONCLUSIONS

The resent energy deliberations made many countries to be more concerned on their limited resources of energy. Electric energy is a clean source of energy and its supply and demand is among policy makers challenges. The productivity of the industries from demand side and the price mechanism from supply side could be considered as powerful tools for decision making, managing and controlling the demand of the electricity consumption in industries.

In the aftermath of Iran-Iraq war in 1987, the government of Iran has tried to perform an energy market reform and increase energy prices gradually to their appropriate cost levels. Since the energy market in Iran is totally regulated and administered by the government. The question is that how the energy demand growth is influenced by energy prices and other related variables. For this reason, developing appropriate tools for analyzing and forecasting energy demand is an important issue in Iran. The above model may serve this purpose. The estimation results of this model indicates the weak sensitivity of industrial energy consumption to price changes although industrial energy demand is considerably affected by the level of economic activity and number of users(or factories).

Some subjects that are suggested for further research are:

- Estimating price and income elasticity of electricity demand in Iran: sectored approach.
- Obtaining electricity demand function in residential and commercial sectors of Iran.
- Obtaining electricity demand function in transportation sector of Iran.
- Calculating elasticity of electricity demand in Iran.
- Development of Energy Control Strategies for Iran
- Studying on relationship between electricity consumption and economic growth in Iran.
- Designing system for optimization and control of electricity consumption.
- Optimization for the operation of electric power generation.

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