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Demand Function for Industrial Electricity: Evidence from South Korean Manufacturing Sector

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Abstract: Electricity is a crucial input to the industrial production of South Korea. Estimating the demand function for electricity in the manufacturing sector is an important task because electricity consumption in the manufacturing sector accounts for 56.3% of total electricity consumption in South Korea. Thus, this article tries to estimate the demand function for industrial electricity in the manufacturing sector of South Korea using cross-sectional data for analyzing the influence of manufacturing firms' characteristics. To this end, 946 observations collected from a nationwide survey of manufacturing firms in 2018 are used and analyzed. As a robust approach, the least absolute deviations estimation method is applied to obtaining the demand function. The results show that the price elasticity and the sales amount elasticity of the industrial electricity demand are estimated to be −0.9206 and 0.2568, respectively, which are statistically significant at the 1% level. Furthermore, the economic benefits of industrial electricity consumption are computed to be 1.46 times as great as the price of electricity. The results of this study can be utilized in policy planning, making, and evaluation.

Keywords: industrial electricity; demand function; price elasticity; least absolute deviations; economic benefits

1. Introduction

Electricity is an essential input to industrial production, such as labor and capital [1]. The activity of producing goods or services through the input of electricity results in an increase in sales or added value [2]. In particular, South Korea's industrial demand for power accounts for 56.3% of its total electricity demand, the second-largest figure among OECD countries after Iceland [3]. Increased added value by the industrial sector through the stable supply of industrial electricity has played an important role in South Korea's promotion from developing countries to advanced countries. In other words, industrial power consumption has driven economic growth [4,5]. Thus, if electricity is not properly supplied to the manufacturing sector, the country will suffer from a severe negative impact on growth, beyond just inconvenience [6].

For example, South Korea experienced a nationwide rolling blackout in 2011 due to an unexpected surge in demand for electricity in the manufacturing sector, and the manufacturing sector suffered massive damage [7]. Since then, although the supply of electricity has been stabilized thanks to the large-scale expansion of power supply facilities, there has been a concern that a rapid increase in demand for electricity in the manufacturing sector may occur again. The most basic information in analyzing the power demand pattern of manufacturing will be the industrial power demand function.

Therefore, it is necessary to estimate the industrial power demand function by identifying the determinants affecting the power demand for industrial use. The power demand function has various uses. First, it is possible to induce information about the price elasticity of power demand from the power demand function [8]. This can be useful for ex-ante evaluation of the impact of pricing policy on the demand-side management of electricity [9–11]. Second, the sales elasticity of power demand can be derived from the power demand function. This can be used to develop power generation, transmission, and distribution facilities plans, taking into account the impact of expected future changes in sales or industrial size on power demand. Third, using the price elasticity of demand derived from the power demand function, the economic value or benefits of power consumption can be estimated [8,12]. Information on the economic value or economic benefits of power consumption is essential in the economic feasibility analysis of new power supply projects. Fourth, the power demand function can be used to identify various factors affecting power demand and the extent of their impact, which are then utilized to predict future power demand.

In short, it is necessary to estimate the price elasticity of demand and the sales elasticity of demand after estimating the power demand function for industrial use. This article seeks to estimate the power demand function for industrial use in the manufacturing sector. To this end, 946 available observations were gathered from a power consumption survey, which was conducted on manufacturing firms nationwide in 2018. The authors expect the implications of this paper to be useful, as it is the first attempt to estimate the power demand function for industrial use using micro data obtained through a survey of manufacturers.

The subsequent composition of this paper is as follows. Section 2 provides a literature review. Section 3 looks at models and methodologies related to estimating the industrial demand function for industrial use and the data used. In particular, the least absolute deviations (LAD) estimation method given in Koenker and Bassett [13] is used as a robust approach rather than the ordinary least squares estimation method for estimating the demand function. Section 4 presents and discusses the analysis results. It will elicit some elasticity information and explore the factors that affect industrial power demand. The last section outlines the conclusions.

2. A Brief Literature Review

We reviewed the literature concerning the estimation of the demand function of electricity and found some previous related studies, which are summarized in Table 1. There have been many studies about the demand for energy, which will be explained below in detail [8,12,14–22]. However, there are few studies on the estimation of the industrial electricity demand function. Although most of the studies are based on panel data [15–17,21,22] and time-series data [8,18,20], some used cross-sectional data [12,14,19]. Cross-sectional data are often unable to include data on confounding factors, other variables that affect the relationship between the putative cause and effect. For example, data only on present industrial electricity price and industrial electricity demand would not allow the role of past industrial electricity use, or of other causes, to be explored. On the other hand, panel data enable analysis of many important economic questions that cannot be addressed using cross-sectional or time-series data sets. However, obtaining panel data needs considerable time and cost compared to cross-sectional data. Therefore, this study aims to estimate the demand for industrial electricity using cross-sectional data to analyze the influence of manufacturing firms' characteristics.

Table 1. Summary of previous studies on electricity demand function.

Sources	The Goods to Be Valued	Country	Period	Main Results	
				Price Elasticity	Income Elasticity
Filippini and Pachauri [14]	Residential electricity	India	1993	Short run: −0.42	Short run: 0.60
				Long run: −0.29	Long run: 0.64
Dimitropoulos et al. [15]	Underlying energy	United Kingdom	1967 to 1999	Long run: −0.13	Long run: 0.58
Adeyemi and Hunt [16]	Industrial energy	15 OECD countries	1962 to 2003	-	-
Yoo et al. [12]	Residential electricity	South Korea	2005	−0.25	0.059
Adeyemi and Hunt [17]	Industrial energy	15 OECD countries	1962 to 2010	Long run: −0.06 to −1.22	Long run: 0.34 to 0.96

Chang et al. [18]	Residential, commercial, and industrial electricity	South Korea	1995 to 2012	Residential: −0.42	Residential: 0.90
				Commercial: −0.15	Commercial: 1.97
				Industrial: −0.48	Industrial: 0.89
Lim et al. [8]	Commercial electricity	South Korea	1970 to 2011	Short run: −0.42	Short run: 0.86
				Long run: −1.00	Long run: 1.09
Krishnamurthy and Kriström [19]	Residential electricity	11 OECD Countries	2011	−0.27 to −1.40	0.07 to 0.16
Wang and Mogi [20]	Industrial and residential electricity	Japan	1989 to 2014	Residential electricity	Residential electricity
				−0.720 to −0.311	1.206 to 1.219
				Industrial electricity	Industrial electricity
				−0.797 to −0.160	1.024
Cialani and Mortazavi [21]	Residential and industrial electricity	29 European countries	1995 to 2015	Residential electricity	-
				Short run: −0.044	
				Long run: −0.302	
				Industrial electricity	
				Short run: −0.052	
				Long run: −0.198	
Sharimakin et al. [22]	Industrial energy	29 European countries	1995 to 2009	Short run: −0.91	Short run: 1.41
				Long run: −0.68	Long run: 0.81

3. Model and Data

3.1. Model

In order to estimate the demand function, both dependent and independent variables of the demand function must first be defined. The dependent variable, of course, is the annual industrial power demand. According to microeconomic theory, price and income should be included as independent variables of the demand function. The law of demand implies that the coefficient for the price variable must be negative. In other words, a higher price of a good or service induces less demand for the good or service, and a lower price of a good or service causes more demand for the good or service. If the good or service of concern is a normal good or service, the coefficient for the income variable in the demand function is positive, and if the good or service of concern is an inferior good or service, the coefficient for the income variable in the demand function is negative. Several other factors that may affect demand will be identified and considered as additional independent variables.

The next step in estimating the demand function is to determine the form of the demand function. Economic theory provides no clues as to the form of a demand function. However, the usual practice in the literature concerning estimating demand functions indicates that the natural logarithms of all continuous variables are used. This makes it easy to estimate the elasticity of demand, since the coefficient for each variable is interpreted as elasticity. In addition, the natural logarithm of an economic time-series that is defined only on the positive range of real numbers is defined on the whole range of real numbers, making it easier to deal with the demand function. The natural logarithm is not used for dummy variables.

Let r denote the rth firm for $r = 1, \ldots, R$, Q_r be the annual industrial power demand (kWh) of the rth firm, k be the number of independent variables, Z_r be the $k \times 1$ column vector of factors affecting the power demand of the rth firm, δ the $k \times 1$ column vector of coefficients corresponding to Z_r, and μ_r be the disturbance term. The industrial electricity demand function estimated in this study has the following form:

$$Q_r = Z_r'\delta + \mu_r. \quad (1)$$

Usually, the least squares (LS) estimation method is applied to obtaining the estimate for δ in Equation (1). However, the LS estimation method has a critical problem in that the LS estimator is not robust to the possible existence of outliers. In such a case, the LAD estimation method, which is known to be a robust approach, can be used as an alternative to the LS estimation method. Whereas the LS estimation method has the characteristic of obtaining mean values that are vulnerable to the influence of an outlier, the LAD estimation method has the characteristic of obtaining median values that are not affected by the outlier. If we apply the LS estimation method, it is easy to obtain estimates using differentiation. On the other hand, applying the LAD estimation method cannot use differentiation because the objective function has absolute values, and somewhat complex simplex algorithms should be employed. This is not a problem since it is not difficult to employ the simplex algorithm due to the development of the personal computer that researchers use.

Let δ_{LAD} be the LAD estimator. From Bassett and Koenker's [23] paper, δ_{LAD} can be obtained as:

$$\delta_{LAD} = \underbrace{\operatorname{argmin}}_{\delta} \textstyle\sum_{r=1}^{R} |Q_r - Z_r'\delta|.$$

$$\delta_{LAD} = \underbrace{\operatorname{argmin}}_{\delta} \sum_{r=1}^{R} |Q_r - Z_r'\delta|. \quad (2)$$

3.2. Data

To collect data for estimating the power demand function for industrial use, a survey of manufacturing firms was conducted by a professional survey company. Regarding the survey method, it was stipulated that an interviewer should directly visit each firm and make the firm fill out the questionnaire. Some firms met with interviewers and responded effectively to the questionnaire through face-to-face surveys. However, other firms refused the interviewer's visit, but wanted to respond to a web-based online survey via e-mail. These firms successfully completed the web-based questionnaire they then received by e-mail.

The survey period was about two months from the beginning of September to the end of October 2018, and the survey was conducted on about 2000 manufacturing firms in the country. Some firms failed to respond to some important items, which eventually caused some observations to be excluded from the dataset to be analyzed. Finally, 946 available observations were obtained. The variables used for estimating the demand function are described in Table 2.

Table 2. Description of variables in the model.

Variables	Definitions	Mean	Standard Deviation	Median	1st Quartile	3rd Quartile	Skewness	Kurtosis
Q	Annual demand for industrial electricity during 2017 (unit: MWh)	7336	84,647	1381	733.53	2654	20.76	453.34
P	Average price of industrial electricity during 2017 (unit: Korean won per kWh)	134.74	26.96	133.33	117.00	154.00	−0.20	−0.03
S	Sales amount during 2017 (unit: million Korean won)	58,640	626,447	10,551	5011	25,993	25.54	705.63
L	Average price of labor during 2017 (unit: million Korean won)	1.38	1.80	0.84	0.44	1.64	4.46	31.28
K	Average price of capital during 2017 (unit: billion Korean won)	37.86	1137	0.50	0.26	0.89	30.76	945.99
M	Average price of intermediate goods during 2017 (unit: billion Korean won)	0.74	0.14	0.77	0.68	0.83	−1.54	4.19
UPS	Dummy for firms equipped with uninterruptible power supply (1 = yes; 0 = no)	0.11	0.31	0	0	0	2.53	4.43
$T1$	Dummy for firms belonging to the metal manufacturing industry (1 = yes; 0 = no)	0.06	0.24	0	0	0	3.74	12.03

$T2$	Dummy for firms belonging to the electronic devices manufacturing industry (1 = yes; 0 = no)	0.06	0.24	0	0	0	3.59	10.90
$U1$	Working hours of the day (1 = 24-h operation; 0 = operation only during day or night)	0.33	0.47	0	0	1	0.72	−1.48
$U2$	Working days of the week (1 = 7-day operation; 0 = operation only during weekday or weekend)	0.39	0.49	0	0	1	0.43	−1.82
$U3$	Time of the day when electricity is consumed (1 = 24-h consumption; 0 = consumption only during day or night)	0.33	0.47	0	0	1	0.71	−1.49
$U4$	Season for consuming electricity (1 = evenly consume electricity regardless of the season; 0 = consume lots of electricity in a particular season)	0.52	0.50	1	0	1	−0.08	−2.00

One of the most important factors in estimating demand functions is the correct definition of price variable. To this end, we need to look at the electric power rate system for industrial use. In South Korea, a different voltage-specific rate system is applied to industrial electric power use. In addition, the electric power charges for industrial use differ according to both season of use and time of use. For example, in the summer when electricity demand for cooling is high or in winter when electricity demand for heating is concentrated, electricity rates are high. On the other hand, in spring or fall when demand for electricity is relatively small electricity rates are low. Electricity charges become cheaper as power usage goes into peak, intermediate, and light load times. The basic fee, which is not related to the amount of electricity used, plus the usage fee proportional to the amount of electricity used, is being charged to industrial consumers. In short, it is difficult to define a price variable because different rate structures are applied to each industrial consumer.

The only way to define a commonly applicable price variable for all industrial consumers is to use the average price, which is defined as the total electricity charge divided by total amount of electricity use. For this reason, the average price was used as a price variable in most studies dealing with the electricity demand function for South Korea e.g., in [8,12,18]. Meanwhile, the average price was also used as a price variable in Chang et al. [18], which estimated the electricity demand function through panel analysis using the data from 89 countries. Therefore, the average price is used as a price variable in this study.

The dependent variable, Q, is defined as the annual demand for industrial electricity during 2017 (unit: MWh). A total of 12 independent variables are used, apart from a constant term. The two essential independent variables in estimating the demand function are price and income. As a price variable, the average price, defined as the total electricity charge divided by the amount of electricity used, is adopted in this study. The sales amount is used as a proxy for the income variable. As industrial electricity is used as an intermediate goods for producing final goods rather than as a final goods, the demand for industrial electricity is a derived demand. That is, according to the neoclassical theory of production, the electricity demand function for industrial use is derived through the first-order condition under the objective function of a firm's profit maximization or cost minimization. In other words, solving the problem of profit maximization and the problem of cost polarization results in inverse demand function and demand function for industrial electricity, respectively. That is, the industrial electricity demand will depend on the electricity price, prices of the other inputs, and the scale of production. Therefore, this study basically reflects the electricity price, capital price, labor price, intermediate goods price, and sales as independent variables of the demand function, and includes several additional characteristic variables of the firm that may affect electricity demand. In theory, the scale of production should be used as an independent variable, but the amount of sales that can be expressed in a uniform monetary unit is utilized since the types and units of products vary from firm to firm.

In this regard, labor price which is defined as the annual average wage divided by average number of employees, capital price which is explained as value of fixed assets at the end of the year divided by sales amount during 2017, and intermediate goods price which is value of intermediate goods divided by sales amount during 2017 are also considered as independent variables. Capital means one of the production factors in the production function. Usually, measuring capital is quite a difficult task [24]. In the production function, capital is originally defined as capital stock. However, estimating the capital stock of an individual company is even more difficult and is not the main concern of this study. Therefore, rather than estimating the capital stock of each consumer, this study intends to use the fixed capital formation as a proxy variable for the capital. This approach would not be restrictive because capital stock would be proportional to the fixed capital formation. For this reason, fixed capital formation was used as a proxy variable for capital stock in several studies of estimating the production function e.g., in [2,25–28].

As whether a firm is equipped with an uninterruptible power supply (UPS) or not affects the demand for electricity, we considered a dummy variable for firms equipped with UPS. The dummy variables associated with the two industrial groups are reflected in the estimation of the demand function for electricity, as the overall power demand may vary depending on the industrial group to which a firm belongs. $T1$ and $T2$ indicate dummy variables for firms belonging to the metal manufacturing industry and the electronic devices manufacturing industry, respectively. Finally, four dummy variables in relation to operating and power usage patterns were considered. $U1$, $U2$, $U3$, and $U4$ imply working hours of the day (1 = 24-h operation; 0 = operation only during the day or night), working days of the week (1 = 7-day operation; 0 = operation only during weekdays or weekends), time of the day when electricity is consumed (1 = 24-h consumption; 0 = consumption only during the day or night), and season for consuming electricity (1 = evenly consumes electricity regardless of the season; 0 = consumes lots of electricity in a particular season), respectively.

4. Estimation Results of the Demand Function

4.1. Estimation Results of the Demand Function

Omitting r for brevity, the estimable econometric form of the demand function for industrial electricity can be expressed as:

$$\ln Q = \delta_0 + \delta_1 \ln P + \delta_2 \ln S + \delta_3 \ln L + \delta_4 \ln K + \delta_5 \ln M + \delta_6 UPS + \delta_7 T1 + \delta_8 T2 + \delta_9 U1 + \delta_{10} U2 + \delta_{11} U3 + \delta_{12} U4 + \mu. \quad (3)$$

The method for estimating the demand function given in Equation (3) should be determined. The most widely applied estimation method is the least squares (LS) estimation, which finds the mean. For this reason, the LS estimation method is called mean regression. The median and the mean values of the annual demand for industrial electricity during 2017 given in Table 2 are 7336 and 1381, respectively. The difference between the two is quite large. In particular, the 1st quartile and the 3rd quartile are 734 and 2655, respectively. The mean value is about three times larger than the 3rd quartile. This implies that outliers exist in our data for the demand. The skewness is 20.76, which is much greater than zero. There exists the long-tail in the positive direction. The kurtosis is 453.34, which is much bigger than three, showing the long-tail of the distribution is quite thick. Thus, the application of the LS method in estimating the demand function may result in poor robustness. In this study, the LAD estimation method, known as robust estimation method, is applied. The LAD estimation method is called median regression which indicates it finds the median, a robust location value, unlike the LS estimation that seeks the mean.

The results of applying the LS and LAD estimation methods are presented in Table 3. Interestingly, the results from the LAD estimation show that the estimated coefficients for 12 variables, excluding the estimated coefficient for UPS variable, are statistically significant at the 5% level. On the other hand, when looking at the LS estimation results only the estimated coefficients for seven variables are statistically significant at the 5% level. Of course, it is unclear whether the existence of outliers and/or long-tail is the cause of these estimation results or not. However, from the viewpoint of the statistical significance of the estimated coefficients, it seems clear that the LAD estimation outperforms the LS estimation. Therefore, in this study, we will accept the LAD estimates rather than the LS estimates and make further explanations based on LAD estimates.

Table 3. Estimation results of the demand function for industrial electricity.

Variables [a]	Least Squares Estimation		Least Absolute Deviations Estimation	
	Coefficient Estimates	t-Values	Coefficient Estimates	t-Values
Constant	8.1079	11.21 #	8.9739	17.05 #
$\ln P$	−0.8805	−6.35 #	−0.9206	−9.13 #
$\ln S$	0.3297	10.31 #	0.2568	11.03 #
$\ln L$	−0.2230	−5.74 #	−0.2418	−8.56 #
$\ln K$	0.0921	3.66 #	0.0670	3.66 #
$\ln M$	−0.1678	−1.81 *	−0.1422	−2.11 #
UPS	0.0179	0.17	−0.0418	−0.60
$T1$	0.5005	4.04 #	0.3665	4.07 #
$T2$	−0.2560	−2.12 #	−0.2097	−2.39 #
$U1$	0.3420	1.70 *	0.3004	2.05 #
$U2$	0.1274	1.74 *	0.1852	3.49 #
$U3$	0.3187	1.61	0.3208	2.23 #
$U4$	0.0741	1.25	0.1147	2.67 #
Sample size	946		946	
R^2	0.453		0.449	
Wald statistic (p-value) [b]	63,598 (0.000)		120,609 (0.000)	

Notes: [a] The variables are described in Table 2. [b] The null hypothesis is that all the parameters are jointly zero. The dependent variable is the natural logarithm of electricity demand. # and * denote that the estimated coefficient is statistically meaningful at the 5% and 10% level, respectively.

We applied the Wald test to conduct a specification test of the model. The Wald statistic is distributed as chi-squared with 12 degrees of freedom under the null hypothesis that all the estimated coefficients are zero. The Wald statistic is computed as 120,609, which is large enough to reject the null hypothesis at the 1% level since the critical value at the 1% level is about 26.2. The coefficient of determination (R^2) is calculated to be 0.449, which means that the model explains 44.9% of the variation of the dependent variable. Considering that the data used in this study is cross-sectional, the value is not low.

South Korea's electricity price is regulated by government policy. Therefore, in this study, price elasticity of electricity demand was estimated under circumstances of controlled electricity price. The coefficient for the price term is estimated to be −0.9206, which is the price elasticity of electricity demand. Its sign and value imply that the law of demand applies well to the industrial demand for electricity and the demand is inelastic to a change in price for electricity. In other words, a 1% increase (decrease) in electricity price reduces (increases) electricity demand by 0.9206%. The sales amount elasticity of electricity demand is computed to be 0.2568. The input of electricity positively contributes to increased sales by manufacturing firms. If the sales amount increases (decreases) by 1%, electricity demand increases (decreases) by 0.2568%. The coefficient for the capital price is positive whereas the coefficients for the labor price and the intermediate goods price are negative, which means that as capital price rise or labor price and intermediate goods price decrease, electricity demand will increase.

Contrary to prior expectations, the estimated coefficient for the UPS term is not statistically significant at a significance level of 5%. If other conditions are the same, firms that belong to the metal manufacturing industry consume more industrial electricity than those that do not. On the other hand, firms in the electronics industry use less electricity than firms in other industries. The signs of the estimated coefficients for $U1$, $U2$, $U3$, and $U4$ are consistent with our prior expectations. The longer the manufacturing firms run the factory or the longer they use electricity, the more electricity they consume.

4.2. Implications of the Results

Regarding the implications of the results, there are two points to be addressed. The first concerns the magnitude of the price elasticity. As explained above, the price elasticity was estimated as −0.9206. Korea Ministry of Trade, Industry, and Energy [29] announced 'The 8th Basic Plan for Long-term Electricity Supply and Demand (2017–2031)' in late 2017. The national plan contains predictions of electricity demand by 2031. It is well known that one of the key factors in forecasting power demand is its price elasticity. In the plan, the price elasticity of demand was assumed as −0.2. This value is significantly smaller in terms of absolute value than the price elasticity derived from this study. Of course, while the plan covered the entire national power demand, this paper targeted only the power demand of manufacturing firms. However, it is possible that the function of price was underestimated in the plan, given that the demand for electricity in the manufacturing sector exceeds half of the total demand. Therefore, it is cautiously suggested that the results of this study be reflected in the plan.

Second, the estimated price elasticity can be used for estimating the economic value or benefit of consuming electricity. It is necessary to seek a stable supply of electricity, an essential input factor, in line with the growth of the manufacturing sector. However, since investment in power supply infrastructure is costly, the economic feasibility of the investment project should be considered. An economic feasibility analysis requires information about costs and benefits. Whereas cost information is relatively readily available, it is difficult to obtain information about benefits because it requires an academic approach. From the economic point of view, power consumption benefits are defined as the upper area of the demand function for power. The computation of the area requires numerical integration and requires a constrained assumption of the price at which demand is zero. On the other hand, Alexander et al. [30] suggested a relatively easy-to-use formula for computing the area as follows.

$$\text{Economic benefits of consuming } Q_0 \text{ at price } P_0 = P_0 Q_0 - \frac{P_0 Q_0}{2\epsilon} = P_0 Q_0 \left(1 - \frac{1}{2\epsilon}\right), \quad (4)$$

where ϵ is price elasticity. $P_0 Q_0$ means the consumer expenditure.

Since $\epsilon = -0.9206$, $(1 - 1/2\epsilon)$ in Equation (4) can be computed as 1.46. Therefore, it can be seen that the economic benefits of electricity consumption in the South Korean manufacturing sector are 1.46 times higher than the electricity price. This is quite interesting and useful information.

5. Conclusions

Estimating the power demand function in the manufacturing sector is an important task, as power consumption in the South Korean manufacturing sector accounts for 56.3% of total electricity consumption. However, to the best of the authors' knowledge, this work has not been carried out so far. To do so, we need to collect micro data from manufacturing firms, which is not easy in terms of time and cost. Thus, this article attempted to estimate the power demand function by collecting and analyzing cross-sectional data on 946 manufacturing firms. This analysis was successful in terms of the goodness-of-fit and statistical significance of the estimated demand function. In addition, this paper has some significance in research as well as policy aspects.

In terms of policy, this research derived quantitative information about the price elasticity and sales amount elasticity of industrial power demand. These two elasticities are essential information in forecasting power demand, evaluating the economic value or benefits of the power supply, and so on. More specifically, the price elasticity and the sales amount elasticity of demand were estimated to be −0.9206 and 0.2568, respectively. The benefits of power consumption were computed to be 1.46 times the price of electricity. As there is currently no reliable quantitative information on power supply benefits, the government evaluates the economic benefits of power supply on the basis of cost information, such as the system's marginal price, when analyzing the economic feasibility of new power supply public investment projects. However, since this study estimated the benefits of consuming electricity for industrial use, it is necessary to utilize them.

From a research perspective, this study is significant in estimating the power demand function for industrial use using cross-sectional data rather than time-series data. The number of observations was 946. Although there have often been analyses using time-series data, there has been a lack of relevant research because conducting a wide-ranging national survey of firms to obtain cross-sectional data needs considerable time and cost. In addition, instead of the LS estimation method, which is commonly applied in demand function estimation, the study used the LAD estimation method, which is known to be robust to the existence of outliers.

This paper seeks to contribute to the current literature by estimating the power demand function for industrial use in the South Korean manufacturing sector. There are quite a few studies dealing with energy demand function. Thus, our finding can be compared with former findings [14–22] that present a price elasticity of demand. However, the price elasticity of demand in each previous study ranges from −0.06 to −1.22. The reason why the findings vary is that the goods to be valued, country, and the study period are all different. The price elasticity of the demand of our study, −0.9206, is included in the price elasticity range of previous studies.

The framework of this study needs to be expanded in two respects. First, if the panel data of manufacturing firms is constructed through years of survey and the demand function is estimated using that panel data, new insights can be obtained. In particular, since dynamic analysis is possible using panel data, the application of models whose elasticity varies over time will be possible. This requires a multi-year follow-up survey of the same firms. Second, it is necessary to obtain a larger number of observations, divide the firms into several groups of sub-industries, and then estimate the demand function separately for each sub-industry. As price elasticity and sales amount elasticity may vary from one sub-industry to another, a separate demand function will be required for each sub-industry. This would enable the establishment of policies differentiated by sub-industry.

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