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Communication

Short- and long-run elasticities of electricity demand in the Korean service sector

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HIGHLIGHTS

- We examine the electricity demand function in the Korean service sector.
- We use the annual data covering the period 1970–2011.
- The demand function is estimated using a co-integration and error-correction model.
- The short- and long-run price elasticities are −0.421 and −1.002, respectively.
- The short- and long-run income elasticities are 0.855 and 1.090, respectively.

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ABSTRACT

This paper attempts to examine the electricity demand function in the Korean service sector using the annual data covering the period 1970–2011. The short- and long-run elasticities of electricity demand with respect to price and income are empirically estimated using a co-integration and error-correction model. The short- and long-run price elasticities are estimated to be −0.421 and −1.002, respectively. The short- and long-run income elasticities are computed to be 0.855 and 1.090, respectively. Electricity demand in the service sector is inelastic to changes in both price and income in the short-run, but elastic in the long-run. Therefore, it appears that a pricing policy is more effective than the direct regulation of reducing electricity demand in the long-run in order to stabilize the electricity demand in the service sector. Moreover, it is necessary to encourage a more efficient use of electricity to cope with increasing demand for electricity following economic growth because the electricity demand in the service sector is income-elastic in the long-run.

1. Introduction

Over the past 3 decades, Korea has undergone dramatic economic development. Real gross domestic product (GDP) has grown at an average annual rate of 6.7% during the period 1980–2011 (Bank of Korea, 2013). The demand for electricity had a higher growth rate of 8.9% during the same period (Korea Electric Power Corporation, 2012). Thus, the amounts of electricity consumption per GDP and per capita in Korea are greater than those of the developed countries. For example, according to World Bank (2013), the electricity consumption per GDP in Korea, Austria, Japan, France, Germany, and the U.K. were 9.74, 8.36, 8.39, 7.73, 7.22, and 5.73 kWh/USD in 2010, respectively. The electricity consumption per capita in these countries were 0.60, 0.31, 0.21, 0.34, 0.28, and 0.20 kWh in 2010, respectively. This is because the price of electricity in Korea is lower than that in the developed countries. For instance, the electricity prices for households in the countries were 116.5, 230.8, 182.8, 143.0, 297.2, and 179.8 in USD per MWh using purchasing power parities in 2010 (International Energy Agency, 2012).

High electricity intensity in Korea reflects inefficient usage. The low electricity rates, which were less than 87.4% of production costs in 2011, has incurred a financial disaster with debts amounting to 1.48 trillion Korean won (approximately USD 1.33 billion) in 2010. As a result, this not only makes it difficult to cope with the rapidly increasing demand of electricity, but also encourages people to waste electricity. Moreover, in 2011, Korea underwent an electricity crisis that led to national rolling blackouts due to the sudden increase in the demand for electricity causing an overload in the electricity supply. Accidents caused by shortage of electricity have caused enormous damage to the entire Korean national economy.

Such situations require researchers to provide policy-makers with accessible and responsible information on the price and income elasticities of electricity demand, which have had important

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implications for policies related to pricing, optimal taxation, demand forecasting, and the demand-side management of electricity. This study attempts to pay closer attention to the use of electricity in the Korean service sector (mainly commercial buildings and stores), as it is the second largest consumer of electricity after the manufacturing industry, accounting for 21.9% of the national consumption of electricity (Korea Ministry of Trade, Industry & Energy, 2012). The purpose of this paper is, therefore, to estimate the price and income elasticities of the electricity demand in the Korean service sector, to add some empirical findings from Korea to existing literature, and to obtain the policy implications for Korea.

2. Material and methods

2.1. The model

The Cobb–Douglas demand function that is the most widely used in the literature takes the following form:

$$E_t = A(P_t)^{\alpha_1}(Y_t)^{\alpha_2} \quad (1)$$

where the subscript t indicates time; E_t is the demand for electricity; P_t is the real price of electricity; and Y_t is the real income.

Taking the logarithm of Eq. (1), we obtain:

$$\ln E_t = \ln A + \alpha_1 \ln P_t + \alpha_2 \ln Y_t \quad (2)$$

Replacing $\ln A$ with α_0 and adding a stochastic error term u_t to Eq. (2) yields the econometric specification:

$$\ln E_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 \ln Y_t + u_t \quad (3)$$

An estimation of Eq. (3) requires the time series of variables to be stationary (Stock and Watson, 1989). Therefore, we can first test the unit roots of $\ln E_t$, $\ln P_t$, and $\ln Y_t$ in order to confirm the stationarity of each variable by employing the Phillips–Perron (PP) tests (Phillips and Perron, 1988) among several alternative tests because the PP test is known to be robust for a variety of serial correlations and time-dependent heteroscedasticities. If any variables are found to be non-stationary, we need to compute the difference and then estimate the demand function with the differenced data.

However, if the series are non-stationary and co-integrated, then an estimation of Eq. (3) of the differenced data will be invalid, and a more comprehensive model, an error-correction model (ECM) is needed (Engle and Granger, 1987). Thus, testing the co-integration property of the series is required before estimating Eq. (3). For this, we employ the Johansen co-integration test (Johansen and Juselius, 1990). If the variables have the property that a particular combination of them $Z_t = \ln E_t - \alpha_0 - \alpha_1 \ln P_t - \alpha_2 \ln Y_t$ is stationary, then we can say that the variables are co-integrated. The coefficients α_1 and α_2 from a particular combination that is stationary are long-run price and income elasticities, respectively.

If the variables are non-stationary, but they become stationary after the first-differencing and co-integrated, the ECM is constructed to estimate the short-run behavior as follows:

$$\Delta \ln E_t = \beta_{10} + \sum_{i=0}^{L_{11}} \beta_{11i} \Delta \ln P_{t-i} + \sum_{j=0}^{L_{12}} \beta_{12j} \Delta \ln Y_{t-j} + \sum_{k=1}^{L_{13}} \beta_{13k} \Delta \ln E_{t-k} + \beta_{14} \hat{u}_{t-1} + \varepsilon_t \quad (4)$$

where Δ is the difference operator, L_s' are the numbers of lags, β_s' are parameters to be estimated, $\hat{u}_{t-1}$ is the error-correction term (ECT) which is derived from the long-run co-integration relationship, and ε_t is the serially uncorrelated error term. Coefficients β_{110} and β_{120} indicate the short-run income and price elasticities, respectively.

Table 1
Descriptive statistics of the variables.

	Mean	Standard deviation	Minimum	Maximum
Electricity demand	29,980	31,505	1583	99,504
Electricity price	205	119	86	473
Real GDP	4527	3252	617	1081

Notes: The data set consist of annual data from 1970 to 2011 in Korea. The electricity demand, electricity price, and real GDP are measured in GWh, Korean won, and trillion Korean won.

Table 2
Results of Phillips–Perron (PP) unit root tests.

Variables	Levels		First-differences	
	PP values	*p*-Values	PP values	*p*-Values
$\ln E_t$	−8.698 [2]	0.529	−40.235 [2][a]	0.001
$\ln P_t$	−4.806 [7]	0.835	−25.069 [9][a]	0.025
$\ln Y_t$	0.037 [2]	0.997	−36.879 [2][a]	0.002

Notes: The numbers inside the brackets are the optimum lag lengths determined using Akaike's information criterion described in Pantula et al. (1994).
[a] indicates statistical significance at the 5% level.

2.2. Data

In order to estimate the demand function for electricity in the service sector, data covering the period 1970–2011 are used. The choice of the starting period was constrained by the availability of data on electricity demand. The electricity demand in service sector is expressed in terms of megawatt-hour (MWh). The prices of electricity in the service sector are real prices. They came from Bank of Korea (2013). The real GDP series are measured in billions of Korean won in constant 2005 and were obtained from Korea Electric Power Corporation (2012). Descriptive statistics of the variables are reported in Table 1.

3. Results and discussion

3.1. Results of unit roots and co-integration tests

The results of the unit roots test are summarized in Table 2. The PP tests indicate that the series of all the variables are non-stationary and thus estimating Eq. (3) with the series in levels is invalid. However, overall, non-stationarity can be rejected for first-differences of these series at the 5% level. Hence, the demand function should be estimated with first-differenced data. The results of the Johansen co-integration test are reported in Table 3. The likelihood ratio tests show that the null hypothesis of absence of co-integrating relation $(R=0)$ can be rejected at the 5% level, the null hypotheses of existence of at most one and two co-integrating relation cannot be rejected. This implies that there is only one co-integrating equation.

The co-integration vector equation is estimated to be $Z_t = \ln E_t - 5.346 + 1.002 \ln P_t - 1.090 \ln Y_t$ by the use of a canonical co-integrating regression method suggested by Park (1992). Thus, the long-run price and income elasticities of demand for electricity in the service sector are computed to be −1.002 and 1.090, respectively and are all statistically significant at the 5% level. The demand for the electricity in service sector is elastic with respect to both price and income in the long-run.