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Estimating the Elasticity of Electricity Demand in Iran: A Sectoral-Province Approach

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Abstract

Energy is one of the main and essential factors in economic growth. Electricity as one of the most important resources of energy supply for economic sectors on one hand, and as an index of welfare, on the other hand, is one of the economic development benchmarks. The growth of GDP will increase the demand for energy resources, including electricity. Hence, policymakers should pay attention to secure electricity supply in their economic planning process. In this study, due to the different structure of each economic sector and the impact of geographical and climate conditions, the electricity demand function in different economic sectors (industry, agriculture, and services) between 31 Iranian provinces during the period of 2010-2014 is estimated in which different panel data method was employed. The results of this study show that the value-added (income) elasticity of electricity demand in all economic sectors is significant, positive and smaller than unity. The elasticities estimated for the industry, agriculture, and service sectors are 0.39, 0.6 and 0.53, respectively. Also, the own price elasticity of electricity demand for industry and service sectors is significant and smaller than unity and is not significant for the agricultural sector. Additionally, the results indicate that the value-added of the Iranian economic sectors has a positive and significant effect on the electricity demand of each sector.

Keywords: Value-Added, Electricity Demand, Economic Sectors, Elasticity, Panel Data.

JEL Classification: C33, D22, O12, Q12, Q32, Q41.

1. Introduction

The necessity of economic growth in developing countries on one hand, and the vital role of energy, on the other hand, indicates the importance

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of energy consumption in different economic sectors. Recognizing the variables affecting energy consumption and the impact of these variables (more precisely, short-run and long-run price or income elasticities) allow policymakers to plan and make more precise economic predictions about energy consumption in the coming years. Meanwhile, electricity is one of the most important energy carriers in energy mix consumption due to the effective role in the production and consumption of all economic sectors. Electricity is one of the energy carriers, which cannot be stored; therefore, electricity is a form of just-in-time production with no delay between generation and consumption. Therefore, electricity demand side is particularly important (Jalaei et al., 2013). Electricity demand studies in line with the development of sub-sectors of the economy and social changes are important and necessary in the planning for optimal energy system development.

Due to the development of advanced technologies and a large amount of electrical equipment, its abundant applications and low relative prices, population and economic growth, environmental issues, etc., electricity has the fastest growth in the energy consumption basket.

Additionally, increasing the growth of electricity demand more than electricity supply (which is generally due to the growing number of consumers and the development of agriculture, industry and services, and insufficient attention to electricity demand management), as well as the need for a large amount of investment for developing the generation, transmission and distribution capacities is one of the main issues that causes the lack of electricity supply (Verharami & Movahedian, 2017). Therefore, planning for the development of power plants and planning for required capacities and secure electricity supply in different sectors, requires understanding the demand functional model and its main effective factors especially based on economic sectors. In this paper, we examine the factors affecting the demand for electricity in manufacturing sectors, including industrial and agricultural sectors, as well as services. Since electricity is used as one of the most important production factors in many industries and services or agriculture sectors, we seek to investigate by changing the value-added of each sector (as one of the most influential factors) how much does their electricity consumption change. In other words, the main objective of this study is to estimate the value-added elasticity of the Iranian economic sectors in order to measure the potential electricity consumption of these sectors according to the development plan. Therefore, the demand function model of electricity is estimated based on theoretical principles of microeconomics and database of 31 Iranian provinces for the period of 2010-2014 to analyze the value-added elasticity as well as the price elasticity. For this purpose, the main part of this article is organized as follows: in section 2, we present the literature review and in section 3, explore the theoretical approach of energy demand function form. Section 4, Database and economic variables are introduced based on energy demand function in the sector level of Iranian provinces. In section 5, we present the empirical results and finally, section 6 ends with the summary and conclusions.

2. Literature Review

According to a literature review of electricity demand, a vast review of the article has been formed in which studying estimation of electricity demand function in the economic sectors. The most important articles will be reviewed as follows. Asgari (2002) estimated electricity demand and short-run and long-run income and price of industry, agriculture and services sectors during periods 1974-1999 with ordinary least squares (OLS) and error correction model (ECM). In this study, the results of estimation of electricity demand showed that the income and price elasticity in the short employing run is less than the unit and in the long-run is more than the unit. Price elasticity of agriculture sector in short-run and long-run estimated less than units, while income elasticity in short-run and long-run is more than a unit. In the service sector is also the income and price elasticity in the short-run is less than the unit and in the long-run is more than the unit. Cross-price elasticity of demand in these sectors also showed that the supply of electricity and alternative fuels in the sectors of industry and services are complementary, and in the agricultural sector are substitutable.

Azarbayejani et al. (2006), with using time series data for the period of 1984-2007 and employing Autoregressive distributed lag model (ARDL) and error correction model (ECM), the industrial electricity demand of Iran estimated in long-run and short-run. The results showed that due to the lack of significant changes in the price variable of electricity in the long-run and its low price elasticity in the short-run, pricing policies such as government subsidy policies would not have much effect on demand management. Also, the elasticity of demand in the long-run and short-run is 0.71 and 0.16 respectively.Samadi et al. (2008) analyzed the Iranian electricity demand and estimated price and income elasticities in short-run and long-run by using the co-integration concept and time series data analysis for the period of 1984-2004. The results show that the reaction of electricity consumers in Iran after changing price and income is quite limited.

Salavati-Nezhad and Ismaili-Bani (2014) estimated the demand for electricity by using Panel Data econometric analysis for household, industrial, commercial and public sectors of Iran, among 16 provinces over the years 1995-2009. The results showed that the long-run price elasticity of household, commercial and public sectors is more than short-run price elasticity, and in the long-run, electricity demand is more sensitive than short-run. But the long-run price elasticity in the industrial sector has been smaller than the short-run. In the long-run, natural gas can be used as a substitute fuel in the industrial sector, while in households, commercial and public sectors, due to the existence of consumption habits and the lack of changeability in the pattern of consumption and production, there is no good alternative for electricity. Also, Income elasticity, for all sectors, in the long-run, is larger than the short-run. In the household sector (0.309) and the commercial sector (0.321), electricity is an essential energy commodity. Income elasticity for industrial and public sectors was estimated at about 1.196 and 1.321, respectively, indicating the luxury of electricity being used in the long-run.

Amadeh et al. (2014) estimated demand for electricity of Iranian agricultural sector by using annual data during the period 1973-2010. Based on Kalman filter algorithm, the estimation of the electricity demand by using the variables of electricity price, the value-added of a sector and the price of gas oil as a substitution in the agricultural sector. The results of their estimation showed that price and income electricity demand in the short-run of -0.1422 and 0.441. Long-run elasticities were equal to -0.355 and 0.07773 respectively. Cross-price elasticity of electricity demand in the short-run and long-run were estimated to be 0.1139 and 0.19 respectively. Mohammadi et al. (2014), Nazari and Sadeghi (2015) and Salimifar et al. (2017) have done similar studies for different economic sectors at different time periods in Iran.

In other countries also a lot of studies have also been carried out on the estimation of the electricity demand function and the price and income elasticity which we review some of them. For example, Bose and Shukla (1999) divided electricity consumers into five groups: household, commercial, agriculture, small, medium and large industries. Then, the income and price elasticities were estimated by integrating the data from nineteen states in India over the period 1985-2014 for these consumer groups. The results show that the income elasticity in the commercial and large industries is more than unit and in households, agriculture and small and medium industries are less than a unit. Also, the short-run price elasticity of electricity demand is -1.35 in the agricultural sector, -0.65 in the household sector, -0.45 in the large industries, -0.26 in the commercial sector and very small in the small and medium industries.

Kamerschen and Porter (2004) Estimate of the demand function of electricity in the United States for residential, industrial and public sectors during the years 1973-1998 by using a partial adjustment model and simultaneous equations. The research findings indicate that the price elasticity of electricity in the residential sector is more than the price elasticity of the industrial sector.

Bianco et al. (2009) estimated the electricity demand function of Italy during the period of 1970-2007. The price elasticity of consumption has been estimated in short-run and long-run and in general, the elasticity of income has been more than the elasticity of the price. The results show that the elasticity of electricity demand is about 0.8 and constant, and the elasticity of energy prices and effective variables are all negative and less than a unit.

Chang et al. (2014) estimated the long-term electricity demand function for residential, industrial and commercial sectors using a co-integrate vector model in South Korea. For this purpose, data in the period 1995-2012 for the residential sector and data in the period 1985-2012 for the industrial and commercial sector were employed. The authors concluded that the rapid development of South Korea provides conditions for the possibility of changing the coefficients of the demand function over time.

Latif (2015) Investigated factors affecting Canadian electricity consumption using panel data during the period 1983-2015. The results of estimation indicated a positive and significant relationship between GDP per capita and electricity consumption. Despite the negative effects of electricity price, it does not have a significant impact on electricity consumption.

Campbell (2018) used the bounds testing approach to cointegration to obtain long-run price elasticity of demand estimates for the period 1970–2014. The analysis focuses on aggregate electricity demand and three categories of consumers: residential, commercial, and industrial. The findings suggest that residential and industrial consumers are most responsive to price changes, with long-run price elasticities of demand of −0.82 and −0.25, respectively.

Saha and Bhattacharya (2018) estimated price and income elasticities of electricity demand for four consumer categories, Agriculture, Commerce, Industry, and Domestic, for two major utilities (one public and the other private) that supply electricity in West Bengal, India. They used panel data analysis covering 15 years for the four consumer categories.

Feehan (2018) used the natural experiment allows for a simple differences-in-differences calculation of the long-run price elasticity of residential demand for electricity in the similar adjacent regions in a Canadian province. He showed that the price elasticity of demand is -1.2.

3. Theoretical Backgrounds of Energy Demand

According to the microeconomic theory, production is a function of capital, labor, energy, and other inputs of economic factors, and a profit-maximizing firm combines the necessary inputs subject to the minimum possible cost of the firm to produce a certain amount of product. By minimizing the cost function of the firm and assuming a certain amount of production based on a certain price of the production factors the demand function for the production factors, including electricity will be estimated.

An economic firm combines electricity and other production factors in the industrial, agriculture or service sector to produce. Therefore, the production function of an economic firm can be defined as follows.

$$Q = f(L.K.E_i) \tag{1}$$

In which (L) labor force, (K) capital and (E_i) types of energy carriers, which means the *i*th type of energy, including electricity. We also assume that the firm's cost function defines as equation (2):

$$C = P_L L + P_K K + \sum_{i=1}^{n} P_{E_i} E_i \tag{2}$$

The production cost equation (C) depends on the cost of inputs such as labor cost (P_L),
the price of capital (P_K), or the interest rate, the price of energy carriers, including electricity (P_{E_i}) and the other prices.

Optimization producer problem requires minimizing the cost function at a certain level of production. Hence, we use the Lagrangian function method.

$$\ell = P_L L + P_K K + \sum_{i=1}^{n} P_{E_i} E_i + \lambda[\bar{Q} - f(L.K.E_i)] \tag{3}$$

By deriving Lagrange's function and solving equations, the demand function for each of the production factors is obtained. The electricity demand function is obtained as a production factor as equation (4).

$$E_i^{\,*} = f(P_L.P_K.\sum_{i=1}^{n} P_{E_i}.Q) \tag{4}$$

The demand function for the production factors is estimated, which is a function of the production and the price of production factors. These categories of functions are called conditional or indirect demand functions because the demand for inputs is conditional on a certain level of production (Mehrara, 2005). Also, by deriving the firm's cost function from the price of each input based on the Shephard's Lemma, the conditional demand function is generated. In this method, first of all, a dual cost function based on a production function is determined; then, by deriving the cost function relative to the electricity price, the electricity demand function is produced.

Now we can categorize the energy input into a variety of energy carriers. Energy carriers are generally divided into four main groups of natural gas, petroleum products, electricity, and coal. According to our purpose, which is to estimate the electricity demand in the manufacturing sectors, the energy input divides into two groups of electricity and the other energy carriers.

$$Q = f(X_E.X_{OE}) \tag{5}$$

Where X_E represents the electricity input, and X_{OE} is the other energy carriers. By minimizing production costs at a certain level of Q, the electricity demand function is extracted as follows:

$$X_E = f(W.Q) \tag{6}$$

Where $W(w_{X_E}.w_{X_{OE}})$ represents the relative price vector of electricity and the other energy carriers. Also, Q is the value-added of the economic sector.

According to the derived demand function and the theoretical foundations mentioned above, in this research, the demand function of electricity in the economic sectors (industry, agriculture, and services) in logarithmic form proposed. According to the following equation, the electricity demand function is:

$$\ln E = \beta_0 + \beta_1 \ln RPE + \beta_2 \ln RPOE + \beta_3 \ln RVA + \varepsilon \tag{7}$$

Based on the logarithmic equation that is often used for presenting energy demand in empirical studies, in this paper, we use the logarithmic form of sectoral energy consumption ($\ln E$) as a dependent variable, and the logarithm of real price of electricity for sector ($\ln RPE$), the logarithm of the real price of the other energy carriers (as a substitute or complement) ($\ln RPOE$), and the logarithm of the sectoral value-added based on fixed price of 2004 as independent variables and ε is residual of the regression. Constant elasticities are resulted from the regression which is estimated directly. The estimation of the equation (7) can result in electricity price elasticity (β_1), electricity cross-price elasticity (β_2), and electricity income elasticity (β_3). According to the above model, the electricity demand function of the economic sectors can be defined as the real price of electricity, the real price of alternative fuels and the real value-added of that economic sector. Non-economic factors such as rainfall in the agricultural sector can also be included in the model because rainfall as an environmental parameter can be effective in the amount of electricity consumed by the agriculture sector.

4. Database and Model Specification

The main purpose of this study is to determine the effective factors on the electricity consumption in the economic sectors of 31 Iranian provinces. In order to estimate these factors, the database of 31 Iranian provinces has been used based on the time series data available during the period of 2010-2014. Hence the model is based on the panel data analysis as follows.

$$\ln E_{it} = \beta_0 + \beta_1 \ln RPE_{it} + \beta_2 \ln RPOE_{it} + \beta_3 \ln RVA_{it} + \beta_4 \ln X_{it} + \varepsilon_{it} \quad (8)$$

The variables are defined in the province i and time t, according to the equation (7). The variable X_{it} includes other factors affecting the electricity consumption of economic sector. The data used in the regression equation (8) are presented in Table (1).

Since the objective of this study is an estimating of elasticities, we use the logarithmic equations as mentioned before. Per capita consumption of electricity and value-added of each sector is calculated by the number of subscribers in that sector. Also, for determining the real value of each sector, the producer price index in Iran was used in the groups of agriculture, industry and services (for producer sectors) based on the base year of 2004.

Table 1: Introduction of Variables of Electricity Demand Model during the period of 2010-2014

Variable	Definition	Description

$\ln CE$	Logarithm of electricity per capita	The amount of electricity supplied by the Ministry of Energy based on the economic sector and province (GWh) per subscriber
$\ln RVA$	Logarithm of real value-added	Provincial added value of each sector divided by the average of producer price index of that sector in Iran based on the base year of 2004 for each subscriber
$\ln RPE$	Logarithm of real electricity price	Electricity sold to the subscribers based on Rial divided by kilowatt-hours of electricity consumption (Rials/kWh) according to the constant prices of 2004
$\ln RPNG$	Logarithm of real natural gas price	Weighted average price of natural gas for two periods (seven and five months) in each sector at constant prices in 2004 (Rials per cubic meter)
$\ln RPGO$	Logarithm of real gas oil price	Based on dividing the total Rial value of the gas oil in the Iranian provinces by the gas consumption (billion Rials per million liters) at constant prices in 2004
$\ln NR$	Logarithm of rainfall	Annual rainfall in the center of the province (millimeter) since2011

Source: Research Results

5. Empirical Results

5.1 Electricity Demand Model Estimation in Industrial Sector

In 2014, the industrial sector, with a share of 33.7 percent of the total electricity Demand had the largest share compared to the other sectors. Iron and steel industry, copper, petrochemicals, cement, sugar, aluminum manufacturing industries, casting and textile industries are among the industries with high energy-intensive consumption. The high energy consumption of some of the Iranian big industries has led them to build dedicated power plants to provide part of their energy. The average electricity consumption of each industrial subscriber in 2014 was 360.5 MWh and decreased by 1.3% toward 2013. Considering the fact that the consumption of the industrial sector is calculated taking into account the consumption of the transport sector (Energy Balance of Iran, 2014). Due to the factors affecting the process of electricity consumption in the industrial sector, the electricity demand model in this sector is presented as follows.

$$\ln CE_{it} = \beta_0 + \beta_1 \ln RPE_{it} + \beta_2 \ln RVA_{it} + \beta_3 \ln RPGO_{it} +$$

$$\beta_4 lnRPNG_{it} + \varepsilon_{it} \tag{9}$$

Additionally, to the price of electricity and value-added as independent variables, natural gas, and gas oil take to the account as alternative fuels of electricity consumption of industrial sector.

Now we are going to estimate the electricity demand of industrial sector between 31 Iranian provinces in the period of 2010-2014. For the first step, we determine whether the data can be panel or pool. For this purpose, Chow test is employed. Chow Test examines whether parameters of one group of the data are equal to those of other groups. If only intercepts are different across groups, this is a fixed effect model. The results of the Chow test are presented in the table (2).

Table 2: Chow Test for Industrial Sector

Redundant Fixed Effects Tests
Test cross-section fixed effects

Statistic Test	Statistic Value	Probability
F	125.340*	0.000
Chi-square	532.105*	0.000

Source: Authors' Calculation based on Eviews 10.0
*The coefficient is significant at the confidence level of 5 %

Therefore, the null hypothesis, which means the absence of fixed effect model is rejected. Parameters in the consumption and demand of industrial electricity of one province are different to those of other provinces.

Another hypothesis that needs to be tested is the test of model estimation as a random effect, which is known the Hausman test. This test determines the use of the random-effects model (null hypothesis) versus the fixed effect model (the alternative hypothesis). To perform the Hausman test, you must first estimate a model with your random-effects specification. The results of this test present as the table (3).

Table 3: Hausman Test for Industrial Sector

Correlated Random-Effects - Hausman Test
Test cross-section random-effects

Statistic Test	Statistic Value	Probability

Chi-square	2.372	0.6676

Source: Authors' Calculation based on Eviews 10.0
*The coefficient is significant at the confidence level of 5%.

Therefore, the null hypothesis as a random-effects model is not rejected. The results of estimating the random-effects model in the industrial sector are presented in Table (4).

Table 4: Random Effect Specification Model for Industrial Sector

Dependent Variable: ln CE

Variables	Coefficient	t-Value	Probability	
ln RPE	-0.1416*	-2.04	0.0426	R^2=0.3143
ln RVA	0.3937*	7.65	0.0000	$\bar{R}^2$=0.2957
ln $RPGO$	-0.1573**	-1.68	0.0941	F-statistic=16.85
ln $RPNG$	-0.0175	-0.19	0.8426	Prob(F-statistic)=0.000
C	1.1570**	1.63	0.1045	

Source: Authors' Calculation based on Eviews 10.0
*The coefficient is significant at the confidence level of 5 %
**The coefficient is significant at the confidence level of 10 %

According to the results of table (4), the price elasticity of demand in the industrial sector is -0.14, which means with one percent increase in the real price of electricity, the demand for electricity in the industrial sector decreases 0.14 percent Because the price elasticity is less than unity, the demand for electricity is inelastic related to the price. Also, the income elasticity of electricity consumption in the industrial sector is inelastic. Hence, with a one percent increase in production (value-added of the industry), the demand for electricity will increase by 0.39%. Obviously, the higher level of production, the greater the use of production factors, including electricity. Due to the lack of level of production of industrial firms' variable, we use actual value-added as an alternative variable which has a high correlation with the production level variable (Mohammadi and Mohtashemi, 2010). In the model, the coefficient of gas oil real price is -0.15, which indicates a complementary relationship with electricity. With increasing the gas oil prices, electricity consumption decreases in industrial sector. One of the reasons for this result is that industries that mainly uses electricity also use gas oil as an input in their production process. Increasing gas oil prices could reduce production in these industries and hence decrease electricity consumption. Refineries and power plants can be an important example of such industries. Also, the coefficient of cross-price electricity demand is insignificant to the price of natural gas. In other words, with changing the price of other energy carriers, the electricity consumer has no incentive to substitute between energy carriers. This is due to the difference in capacity utilization and technology of electrical equipment and the other energy carriers used in other capital equipment. By increasing the price of energy carriers, the industrial producer cannot simultaneously substitute the electricity with the other energy carriers.

5.2 Electricity Demand Model Estimation in Agriculture Sector

Electricity in the agricultural sector of Iran is used as one of the inputs of production. Electricity consumption in agricultural wells and the use of electrical equipment for heating and lighting in livestock and poultry centers and greenhouses are one of the main electricity consumers in the agricultural sector. By the end of 2014, approximately 230.9 thousand agriculture wells were equipped with electric pumps with an average electricity demand of 35 kW (Energy Balance, 2014).

For modelling of electricity demand function in the agricultural sector, economic variables such as prices and sectoral value-added are very important. Also, noneconomic variables such as rainfall are important because the higher of rainfalls during an agriculture year reduces agricultural water demand and thus reduces electricity consumption in this sector (Amadeh et al., 2014). According to the above mentioned, the demand function of electricity in the agricultural sector is proposed according to the following equation:

$$\ln CE_{it} = \beta_0 + \beta_1 \ln RPE_{it} + \beta_2 \ln RVA_{it} + \beta_3 \ln R_{it} + \varepsilon_{it} \qquad (10)$$

In the traditional specifications just discussed, RE is precise and quite flexible but is also likely to be biased. Alternatively, FE estimation is unbiased, but less flexible, less precise, and cannot be used to explore the effect of group-level characteristics. In this subsection, we explore one estimation variant meant to marry the two traditional estimators and take advantage of the best characteristics of each. This method is called the "within-between" estimator (Dieleman & Templin, 2014)

An estimation method in panel data that yields result similar to the LSDV method is to calculate the deviation from the mean of the series in each T-period group and then estimate the deviations from the mean of the dependent variable on independent variables. In this case, for each group, we have a quantity for the dependent and independent variable in which have a difference between groups ($\bar{Y}_{i0}$,$\bar{X}_{io}$). Hence, this method is called Between-group estimator. We have employed this method to estimate the electricity demand model in the Iranian agricultural sector. The estimated results are presented in Table (5).

Table 5: Between-Group Specification Panel Model for Agricultural Sector

Dependent Variable: ln CE				
Variables	**Coefficient**	**t-Value**	**Probability**	
$\ln RPE$	-0.6119	-1.25	0.220	Within=0.0052 Between=0.4268 F-statistic=6.70 Prob(F-statistic)=0.0016
$\ln RVA$	0.6052*	2.56	0.017	
$\ln R$	-0.3265*	-2.09	0.047	
C	0.2189	0.08	0.935	

Source: Authors' Calculation based on Stata 14.0
*The coefficient is significant at the confidence level of 5 %
**The coefficient is significant at the confidence level of 10 %

The real price electricity in this model is not significant. Therefore, the agricultural sector is not sensitive to changes in the price of electricity. This result can be explained by two reasons. First, due to consumption of electricity in the Iranian agricultural sector as an affordable input leads to the more consumption of electricity regardless of the efficient use of electricity. Second, equipment with new technology imports and applied in this sector, which is indirectly increased the electricity consumption as a rebound effect (Amadeh et al., 2014).

Also, the income elasticity of electricity demand is estimated at about 0.60. With increasing by one percent of the value-added of the agricultural sector, demand for electricity increases by 0.6 percent. Rainfall as a geographical parameter is also effective in reducing electricity consumption in agriculture. As noted above, rainfall (R) supplies water to produce agricultural products that reduce the demand for water and electrical pumping. As a result, electricity demand will be reduced in this sector. Additionally, Intercept of the model is not significant.

5.3 Electricity Demand Model Estimation in Service Sector

The service sector is one of the most important economic sectors in Iran. There is a direct relationship between the development of countries and the share of services production in GDP. Nowadays, due to the advancement of technology in the service sector and the diversification of production in this sector, clean energy such as electricity has replaced low quality fuels (Razavi and Shadmehri, 2015).

The service sector here is comprised of two commercial and public sectors. Due to the absence of the electricity service subscribers in electricity statistics individually, the weighted average of the commercial and public sector is used in this study. We now focus on the factors affecting the electricity demand in the Iranian service sector as equation (11).

$$\ln CE_{it} = \beta_0 + \beta_1 \ln RPE_{it} + \beta_2 \ln RVA_{it} + \beta_3 \ln RPNG_{it} + \varepsilon_{it} \quad (11)$$

As with the other sectors of this study, the most important factors affecting electricity demand are the real price of electricity and value-added at constant prices. The real price of natural gas as a substitute for electricity is considered. Now we are going to estimate the electricity demand of service sector between 31 Iranian provinces in the period of 2010-2014. For the first step, we determine whether the data can be panel or pool. For this purpose, Chow test is employed. If only intercepts are different across groups, this is a fixed effect model. The results of the Chow test are presented in table (6).

Table 6: Chow Test for Service Sector

Redundant Fixed Effects Tests **Test cross-section fixed effects**		
Statistic Test	**Statistic Value**	**Probability**
F	54.584*	0.000
Chi-square	364.723*	0.000

Source: Authors' Calculation based on Eviews 10.0

*The coefficient is significant at the confidence level of 5 %

Therefore, the null hypothesis, which means the absence of fixed effect model is rejected. Parameters in the consumption and demand of service electricity of one province are different to those of other provinces.

Another hypothesis that needs to be tested is the test of model estimation as a random effect, which is known as the Hausman test. To perform the Hausman test, you must first estimate a model with your random-effects specification. The results of this test present as the table (7).

Table 7: Hausman Test for Service Sector

Correlated Random-effects- Hausman Test Test cross-section random-effects		
Statistic Test	**Statistic Value**	**Probability**
Chi-square	16.257	0.0010

Source: Authors' Calculation based on Eviews 10.0
*The coefficient is significant at the confidence level of 5%.

Therefore, the null hypothesis as a random-effects model is rejected. Accordingly, the model would be estimated as a fixed effect. The results of estimating the fixed effects model in the service sector are presented in Table (8).

As the results shown in the table (8), all coefficients are completely significant in the confidence level of 5%. The price and value-added elasticities are equal to -0.48 and 0.53, respectively. With a one percent increase in the real price of electricity, demand for electricity would reduce by 0.48 percent, and with one-percent increase in the value-added of the service sector, demand for electricity would increase by 0.53 percent. The result of both mentioned elasticities indicates the necessity of electricity in the service section. Also, the cross-price elasticity is 0.38. This suggests that by increasing the price of natural gas by 1%, electricity demand will increase by 0.38%, which would confirm the substitution of natural gas and electricity in the service sector.

Table 8: Fixed Effect Specification Model for Service Sector

Dependent Variable: ln CE				
Variables	**Coefficient**	**t-Value**	**Probability**	
ln RPE	-0.4849*	-6.83	0.0000	R^2=0.9765 $\bar{R}^2$=0.9678 F-statistic=112.20 Prob(F-statistic)=0.000
ln RVA	0.5362*	4.86	0.0000	
ln $RPNG$	-0.3834*	5.66	0.0000	
C	-2.8050*	-3.26	0.0015	

Source: Authors' Calculation based on Eviews 10.0
*The coefficient is significant at the confidence level of 5 %.
**The coefficient is significant at the confidence level of 10 %.

6. Conclusion and Policy Recommendations

In this study, the factors affecting the electricity demand in various economic sectors (industry, agriculture, and services) between 31 Iranian provinces during the five-year period (2010-2014) consider and we analyzed the results based on panel data specifications. Value-added, own prices, and cross-price elasticities of demand electricity were estimated. The brief results of elasticities are presented in the table (9).

Table 9: Price and Value-Added Elasticities

Economic Sectors	**Price Elasticity**	**Value-Added Elasticity**
Industry	-0.14	0.39
Agriculture	Not Siginificant	0.60
Service	-0.48	0.53

Source: Authors' Research

As the results show:

1. Own price and value-added elasticity Estimated for all sectors are significant. This indicates that electricity plays an essential role in increasing the value-added of different Iranian Economic sectors. In other words, in the manufacturing sectors due to the necessity of electricity as a major input for production, the price changes of electricity have a significant effect on its demand. On the other hand, the trend of value-added (production) elasticity of electricity demand indicates that the supply of electricity has a significant effect on the growth of the mentioned economic sectors.

2. Evaluation of price elasticity of electricity demand shows that first, except the agricultural sector, the real price changes of electricity have a significant effect on electricity consumption. Therefore, policymakers can affect the electricity consumption by changing the real price of electricity. Because the most electricity consumption in the agricultural sector is related to electrical motors. So changing the price of electricity will make it easier for farmers to use diesel engines instead of electrical motors. Also, the price elasticity of electricity in the industrial sector is the lowest, which indicates that the production of the Iranian industrial sector is heavily dependent on electricity. So the changes in the price of electricity (for example, rising electricity prices) will not affect electricity demand for this sector. While the price elasticity in the service sector is relatively higher than the other sectors. This suggests that the service sector is less sensitive to changes in the electricity price comparing the others.

3. The estimation of value-added elasticities of electricity demand in manufacturing sectors indicates that the value-added of different economic sectors has a strong dependence on electricity consumption. Meanwhile, the value-added elasticity of agricultural sector is more than the other sectors. This fact highlights that electricity is important as a complementary commodity for the production of water through wells, and therefore the use of electrical motors plays a considerable role in the production of the agriculture sector. This is also the case for the other Iranian economic sectors.

But finally based on the overall results we can indicate that electricity as the most essential energy carrier in the Iranian economy plays a very important role in economic growth and production of the main economic sectors. Hence, economic planning for high growth rates needs to pay enough attention to securing electricity supply. For example, in order to achieve 10% economic growth in the industrial, agricultural and services sectors, electricity supply needs to be grown by almost 3.9%, 6%, and 5.3%, respectively. In other words, total electricity supply should be increased by about 15% totally. Therefore, policymakers need to focus on this evidence for setting short-term and long-term economic plans which means, for example, 10% economic growth requires an increasing electricity supply more than 10% to secure their economic plans.

Electricity security supply is very capital-intensive and it is not simply possible to provide and secure it for higher economic growth. Therefore, production and consumption of electricity should be efficient in order to meet the needs of electricity for different sectors of the economy.

Also, Policymakers should also pay attention to the negative externalities of production and supply of electricity. Therefore, the electricity supply from clean and renewable resources should be prioritized. Otherwise, increasing the electricity supply can reduce the intensity of economic growth and, in particular, sustainable growth and development.

According to the results of this study, electricity is demanded in almost all economic sectors, and the results of the value-added elasticities of the electricity demand are approximately similar. The cheapness of electricity in Iran, which leads to all industries are being energy intensive. Therefore, the government must prioritize the electricity supply, according to its plan and the elasticities of each economic sector.

References

Amadeh, H., Mehregan, N., Haqhani, M., & Haddad, M. (2014). Estimation of Structural Model of Electricity Demand in Agriculture Sector Using Implicit Trend Concept and Kalman Filter Algorithm. *Quarterly Journal of Energy Economics*, *10*(42), 109-134.

Asgari, A. (2002). Estimating the Demand for Electricity in the Sectors of Industry, Agriculture, and Services, and Estimating its Price Elasticity and Revenue. *Journal of Program and Budget*, *78*, 47-75.

Azarbaijani, K., Sharifi, A., & Satei, M. (2006). Estimation of the Electric Energy Demand Function in the Industrial Sector of Iran (1361-1386). *Journal of Economic Research, 73*, 133-166.

Bianco, V., Manca, O., & Nardini, S. (2009). Electricity Consumption Forecasting in Italy Using Linear Regression Models. *Energy, 34*(9), 1413-1421.

Bose, R. K., & Shukla, M. (1999). Elasticities of Electricity Demand in India. *Energy Policy*, *27*(3), 137-146.

Campbell, A. (2018). Price and Income Elasticities of Electricity Demand: Evidence from Jamaica. *Energy Economics*, *69*, 19-32.

Chang, Y., Kim, C. S., Miller, J. I., Park, S., & Park, J. Y. (2014). Time-varying Long-run Income and Output Elasticities of Electricity Demand with an Application to Korea. *Energy Economics*, *46*, 334-347.

Dieleman, J. L., & Templin, T. (2014). Random-Effects, Fixed-Effects and the Within-Between Specification for Clustered Data in Observational Health Studies: A Simulation Study. *Plos one*, *9*(10), 1-17.

Feehan, J. P. (2018). The Long-run Price Elasticity of Residential Demand for Electricity: Results from a Natural Experiment. *Utilities Policy*, *51*, 12-17.

Jalayee, A., Jafari, S., & Ansari Lari, M. S. (2013). Estimation of Domestic Electric Demand Function in Iran Using Provincial Panel Data. *Iranian Energy Economics Quarterly*, *2*(8), 69-92.

Kamerschen, D. R., & Porter, D. V. (2004). The Demand for Residential, Industrial and Total Electricity (1973-1998). *Energy Economics*, *26*(1), 87-100.

Latif, E. (2015). A Panel Data Analysis of the Demand for Electricity in Canada. *Journal of Applied Economics and Policy*, *34*(3), 192-205.

Mehrara, M., & Abdi, A. (2005). Estimation of Demand Functions for Construction Inputs: Case of Iran. *Quarterly Journal of Economic Research*, *5*(4), 112-189.

Mohammadi, H., & Mohtashemi, M. (2010). Investigating Factors Affecting Electricity Demand in the Industrial Sector. *Second National Conference on Electricity Consumption Pattern Modification, Khuzestan Regional Electricity Network*, Retrieved from https://profdoc.um.ac.ir/paper-abstract-1020641.html.

Mohammadi, T., Khorsandi, M., & Amir-Momeni, M. (2014). Modeling Demand for Electricity in Iran's Industrial Sector: Structural Time Series Model Approach. *Quarterly Journal of Economic Modeling Research*, *8,* 117-187.

Nazari, B., & Sadeghi, H. (2015). Estimation of Demand in the Industrial Sector of the Country. *International Conference on Management, Economics, and Accounting*, Retrieved from https://www.civilica.com/**.**

Saha, D., & Bhattacharya, R. N. (2018). An Analysis of Elasticity of Electricity Demand in West Bengal, India: Some Policy Lessons Learnt. *Energy Policy, 114*, 591-597.

Salavati Nejad, I., & Ismailnia Ketabi, A. A. (2014). Short-term and Long-run Factors Affecting the Demand of Electric Energy Among Different Economic Sectors of the Country. *International Conference and Online Green Economy,* Retrieved from https://www.civilica.com/.

Salimifar, M., Seifi, A., & Shoorri, S. (2017). The Study of the Effect of the Value-Added of the Industrial Sector on the Electricity Demand for This Sector and the Prediction of the Electricity Demand of the Industry in Light of Price Reforms. *Economic Research, 52*(2), 311-322.

Samadi, S., Shahidi, A., & Mohammadi, F. (2008). Power Demand Analysis in Iran Using the Concept of Co-integration and ARIMA Model (1336-1368). *Science and Development Magazine (Scientific-Research), 15*(25), 113-136.

Vahrami, V., & Movahedian, M. (2017). The Fitting of the Demand Function of the Domestic Electricity Sector of Selected Cities in Tehran Province Using Dynamic Panel Method. *Quarterly Journal of Economic Research (Sustainable Growth and Development)*, *17*(2), 121-144.