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COAL IN TURKEY: INCOME AND PRICE ELASTICITY OF COAL DEMAND IN ELECTRICITY GENERATION

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ABSTRACT

The aim of this study was to determine income and price elasticity of demand of coal used in electricity generation in Turkey. Coal demand for electricity generation was analyzed for short- and long-term effects using the ARDL bounds test. Both short- and long-term increases in coal prices reduced coal demand, while increases in per capita income increased coal demand. However, in the long-term, the effect of average temperature on coal demand was insignificant. The price elasticity of coal demand is estimated at less than 1 in both the short- (in a lagged period) and long-term. On the contrary, the income elasticity of coal demand is found larger than 1 in both the short- and long-term. In addition, firms that supply steam coal can increase their income through price increases. Therefore, it can be said that the increase in the price of coal used in electricity generation has no effect on reducing the demand for coal in this field.

JEL Classification: C22, D22, Q41

Key words: Electricity generation, Coal demand in Turkey, Coal income elasticity, Coal price elasticity, ARDL bounds test, Turkey

1. INTRODUCTION

According to the International Energy Agency (IEA) (2017a), coal meets one-third of the global energy needs and accounts for 40% of electricity generation. It also plays an important role in industries such as iron and steel. Despite concerns about air pollution and greenhouse gas emissions, coal use will continue to be important in the future. For this reason, governments and industries need to make more efforts to transform coal into a cleaner energy source over the next decade and adopt less polluting and more efficient technologies.

Statistics from the World Energy Council show that the total amount of processable coal reserve in the world is at 861 billion tonnes. Some 405 billion tonnes of these are categorized as anthracite and bituminous coal, 261 billion tonnes fall into sub-bituminous coal and 195 billion tonnes are lignite. According to the International General Coal Classification; coals having lower heat value on wet and ashless basis greater than 5,700 kilo calories / kilogram are classified as anthracite and steam coal; those with lower heat values between 4.165 kcal / kg and 5.700 kcal / kg are classified as sub-steam coal and those below 4.165 kcal / kg as lignite coal (T.R. Ministry of Energy and Natural Resources, 2013). Lignite is mainly used in electricity generation and industrial processes, and is traded widely internationally because it is cheaper to transport.

The main types of hard coal in international trade are steam coal and coking coal. Steam coal is mostly used for heating, electricity generation and industrial purposes (iron and steel, cement, sugar, soda-trona productions) while coking (metallurgical) coal is mainly used for integrated iron-steel production. Approximately 63% of the world's total coal production is used in electricity generation, 27% in industry including iron and steel production, 10% in heating and other fields (Taranto, 2014).

According to the IEA (2017a), coal will continue to be an important energy source in the future. However, coal is under pressure to be reduced in use in many regions of the world because it increases greenhouse gases. Therefore, in energy generation, natural gas, which is cheap and abundant, and renewable energy owing to its decreasing costs, has become more preferable to coal. Along with the recent declines in coal use, coal consumption has increased even more in the three largest coal markets (China, India and the US). This growth is expected to be temporary in China and the US, but is not the case for India. Despite advances in energy efficiency and the use of renewable energy, increasing energy needs for its economic growth and development will push India to extend coal use (IEA, 2017a). Coal accounts for 70% of China's primary energy sources and 80% of its electricity generation. Since the early 1990s, coal consumption had increased in China, and the share of coal in total energy consumption had fluctuated between 65% and 75%. However, in recent years, this share has fallen to the level of 60% (Hao et al., 2016).

In Table 1, coal production and consumption in some countries are given in million tonnes of oil equivalents. In general, all countries have an inequilibrium in terms of coal supply and demand. In Russia, South Africa, Australia and Indonesia coal supply exceeds demand while in other countries, coal supply cannot meet demand, which means that coal consumption exceeds production. Here, China is the most remarkable country. China leads the world in terms of both production and consumption. Both coal production and consumption had increased in China, India, Indonesia and South Korea from 2006 to 2015. On the other hand, in the US, Germany and UK both coal production and consumption have declined. In Russia and Australia, coal production had increased while consumption had decreased. In Japan, while coal production had declined, consumption had increased. In Turkey, coal production had increased in the period between 2006 and 2010, but decreased in 2015. However, there has been a continuous increase in coal consumption in Turkey. Although Turkey has an important worldwide role in terms of lignite reserves and production, its importance in terms of coal is not that much.

TABLE 1
Coal Production and Consumption of Some Countries
(Million Tonnes Oil Equivalent)

Country	Production			Consumption		
	2006	2010	2015	2006	2010	2015
Turkey	13.2	17.5	12.8	26.2	31.4	34.7
China	1328.4	1665.3	1825.6	1454.7	1748.9	1913.6
US	595.1	551.2	449.3	565.7	525.0	391.8
Germany	53.3	45.9	42.9	84.5	77.1	78.5
Russia	141.0	151.0	186.4	97.0	90.5	92.2
UK	11.4	11.4	5.4	40.9	30.9	23.0
South Africa	138.3	144.1	142.9	81.5	92.8	83.4
Australia	220.4	250.6	305.8	53.1	49.4	44.1
India	198.2	252.4	280.9	219.4	290.4	396.6
Indonesia	114.2	162.1	272.0	112.3	115.7	119.9
Japan	0.7	0.5	0.6	112.3	115.7	119.9
South Korea	5.4	5.0	3.9	54.8	75.9	85.5

Source: BP Statistical Review of World Energy (2017).

According to the Turkey Statistical Institute (TSI) (2018), when the total amounts of salable solid fuel production in December 2017 is examined, it is seen that hard coal is 89,124 tonnes, lignite is 6,333,780 tonnes and hard coal coke is 388,612 tonnes. The TSI statistics show that when solid fuel distribution according to delivery location is examined, it is seen that 49.4% of the hard coal is delivered to thermal power plants, 13.4% to coke plants and 5.1% to industry other than iron and steel; whereas 86% of lignite is delivered to thermal power plants and 7.3% to industry other than iron and steel. On the other hand, 97.4% of the hard coal coke was shipped to the iron and steel industry. Also, because heating value is low, a large portion of the lignite in Turkey, it is used more in thermal power plants. According to the Ministry of Energy and Natural Resources, by the end of July 2017, 34% of Turkey's electricity generation was obtained from natural gas, 31% from coal, 24% from hydraulic energy, 6% from wind, 2% from geothermal energy and 3% from other sources. Therefore, the largest share of electricity generation belongs to natural gas and coal. Nevertheless, Turkey, which is not rich in terms of natural gas reserves, is obliged to import natural gas. Accordingly, this constitutes a major problem in terms of current account deficit and balance of payments.

On account of the depleting world oil reserves and increasing energy demand, coal has become an important energy source. Coal might be widely used for electricity generation in Turkey, because it is also widely used in power plants and homes. Owing to the increased demand for electricity in Turkey in recent years, coal has become an efficient and inexpensive energy source for Turkey (Capik, Kolayli, and Yılmaz, 2013). According to World Bank (2018) data, in Turkey the share of energy import in net energy use has increased proportionally by year. Accordingly, the share of energy import, which was 65% in 2000, has risen to 75% by 2015.

The feedback that economic policy makers receive from the market are an important guide for determining the next policies to be implemented. For example; subjects such as when a tax is applied or tax is deducted how it will influence the market or how much of the tax burden will be charged by the producer or consumer, are important in terms of policy implementation. Elasticity plays an important role at this point, because the parties assume a different tax burden depending on the elasticity coefficient. In this study the income and price elasticity of coal which is used in electricity generation in Turkey are assessed. For this purpose, the Autoregressive Distributed Lag (ARDL) bounds test was used to determine the short- and long-term relationship between variables and their coefficients. This study consists of five sections. In the second section, after the introduction section, coverage is given to literature review about the subject. In the third section, data and methodology are explained. In the fourth section, empirical findings are presented. After the fourth section, the results are discussed.

2. LITERATURE REVIEW

According to Zhang, Ji, and Fan (2018), studies on demand elasticity can be classified into three methods. In the first method, a cost-sharing function is created, and then a linear logit cost-sharing function is used in order to examine price elasticity of demand. The second method examines the short-term demand elasticity through the error correction model and the long-term demand elasticity through the cointegration analysis. The third method examines the price and income elasticities of energy demand by creating an energy demand function. For Dahl (2009), elasticity is useful for policy analysis. Price elasticity determines whether total expenditure in a market has increased, whereas income elasticity determines whether a product’s share within the budget has changed. Demand elasticity may help to estimate the effect of a decay in energy supply on the price of another energy product.

In the literature, studies on the elasticity of energy demand can be grouped under different headings. In the studies, elasticity of the total energy demand (Ma and Oxley, 2011; Paramati et al., 2018), electricity demand (He et al., 2011; Schulte and Heindl, 2017), natural gas demand (Alves, 2003; Nicol, 2003; Erdoğdu, 2010; Zhang et al., 2018;), coal demand (Burke and Liao, 2015; Cattaneo, Manera and Scarpa 2011), oil demand (Askari and Krichene, 2010; Cooper, 2003; Nişancı, 2005;) and gasoline demand (Brons et al., 2008; Hughes, Knittel and Sperling, 2006) are examined.

Paramati et al. (2018) investigated the role of economic, financial and trade integration as a source of total energy demand in seven African countries, for the years 1991-2012. According to the empirical findings all variables, excluding foreign direct investment (FDI), increase energy consumption over the long term. However, the findings differ between countries; FDI, industrialization and trade openness index have negative effects in some countries. In the study, in which panel cointegration and Fully Modified Ordinary Least Squares (FMOLS) method is used, only one of the seven countries was found to have negative income elasticity of energy demand. Ma and Oxley (2011) searched the energy price movements in China between 1999-2005 period via quarterly data. In the study using Pedroni's cointegration test, the results showed a difference in the occurrence of energy price movements in the region. According to Ma and Oxley (2011), the energy market has significant global effects both in terms of future emission reduction and emission trade and also China’s trade negotiations. Cooper (2003) predicted both short- and long-term elasticities of crude oil demand in 23 countries. The estimates obtained show that the price elasticity of oil demand is highly inelastic in the short- term. In the study, in which short-run price and income elasticity of the gasoline demand in the United States is examined, Hughes et al. (2006) compared the 1975-1980 and 2001-2006 periods. They found that short-term price elasticities differ greatly varying between -0.034 and -0.077 for the years 2001-2006 and between -0.21 and -0.34 for the years 1975-1980. Moreover, when the short-term elasticities are estimated with the same models, they were shown to vary between 0.21 to 0.75 and there is no significant difference between the same two periods.

Schulte and Heindl (2017) estimated price and expenditure elasticities of residential energy demand in Germany by using 1993-2008 data. They estimated expenditure elasticity as 0.3988 for electricity and 0.4055 for heating. For electricity, the price elasticity was -0.4310, while it was -0.5008 for heating. Schulte and Heindl (2017) emphasize that household behavioral responses to energy price changes are weaker (stronger) for low-income (highest-income) households. He et al. (2011) examined the effect of electricity prices on electricity demand. They emphasized that the elasticity of sectors which consume more energy is relatively greater but the absolute values of price elasticities are less than one. They suggested that the price elasticity of electricity demand of industry and trade is about -0.018, of the housing sector is about -0.300, and of agriculture is about -0.066.

In their study on the elasticity of natural gas demand, Zhang, et al. (2018) concluded that the price and income elasticities of natural gas demand are different in different sectors. In the study based on the ARDL model, the long-term price elasticity of natural gas demand in sectors other than housing sector is bigger than 0. The demand for natural gas is complementary to coal in the industrial and electricity generation sectors and at the same time it differs from that of developed countries. Obtained results indicated that natural gas and oil are substitutes in the transport sector and natural gas and coal are substitutes in the service sector. Burke and Yang (2016) estimated price and income elasticities of natural gas demand in 44 countries for the period 1978-2011 by using panel data analysis. The average long-term price elasticity of natural gas demand is estimated at about -1.25 and the average long-term income elasticity of natural gas demand is estimated at 1. Bilgili (2014) examined income and price elasticities of natural gas demand for eight OECD countries in the period 1979-2006. Panel cointegration analysis, Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimators were used to obtain long-term parameter calculations. As a result of the FMOLS and DOLS analyses, it is found that estimated coefficients have the expected signs and the elasticity coefficients are slightly higher than the unit elasticity.

Research on coal demand has particularly focused on Chinese economy. Because, as shown on Table 1 in the Introduction, China is in the first place in coal production and consumption. Additionally, coal is vital to ensure China's economic development. Peter and Atakhanova (2017) estimated household coal demand in Kazakhstan for the period 2002-2012, by using dynamic panel data models. According to the results of the dynamic panel data, estimated short-term income elasticity of the coal demand was 0.37 while the short-term price elasticity was -0.58. Long-term income and price elasticities were 0.64 and -1.00, respectively. They stated that household coal demand depends on the outside temperature and the length of the heating season. Wahid, Ali, and ur Rahman (2017) examined the factors affecting coal consumption in Pakistan. This effect was examined for the period 1972-2015 by using ARDL and ARIMA techniques. Cointegration analysis shows that a long-term relationship exists between the variables. Error Correction Term results (ECT) confirmed that the long-term equilibrium is stable. In addition, ARIMA results projected an upward trend in coal consumption in the period 2016-2030. The ARDL model implementation showed the income elasticity of coal demand was 0.09. On the other hand, the price elasticity of coal demand was found insignificant because the price of the coal is not determined by market forces. Wahid et al. (2015) examined the determinants of coal consumption in Pakistan from 1972 to 2014 by using time series data. Johansen cointegration test, ECM, multiple regression and ARIMA models were employed as analysis method. The empirical results of the study revealed existence of a long-term relationship between the relevant variables. For coal consumption, the ECM technique confirms a stable long-term equilibrium based on short-term dynamics. The projection results of the ARIMA models reflect the forecast that coal demand will increase from 2015 to 2025. In addition, the results of the study show that coal consumption is not elastic with reference to income and energy prices. Income elasticity of coal demand was calculated as 0.0059 and price elasticity as -0.1010. The other variable, temperature is detected insignificant. Burke and Liao (2015) estimated the price elasticity of coal demand in China for the years 1998-2012 by using panel data analysis. They found that price elasticity for coal demand had been gradually increasing. They estimated that when the two-year responses are considered by 2012, this elasticity was in the range of -0.3 to -0.7 in the point estimate. Their estimates of income elasticity of coal demand vary between 1.2-1.7. They showed that these high figures are consistent with the rapid expansion of coal use in China. In the study on China, Cattaneo et al. (2011) examined the coal demand in province level for the years 1995-2002. Empirical results suggest that the fixed effect spatial ARDL model shows the interdependence between provinces. This model estimated that the average annual increase in coal demand for 2010 was about 2%. Zhang, Wang and Huang (2011) estimated the effect of carbon taxes on coal CO_2 emissions in 2020 by using the co-integration model and the VAR model. They found that in China, long-term price elasticity of coal is -0.34 and income elasticity is 1.90.

Jiao et al. (2009) researched short- and long-term relationships between coal demand, income, coal price and oil price for the years 1980-2006. The elasticity coefficients obtained are as follows in the long-term; the income elasticity of coal demand is 0.560, the price elasticity of coal demand is -1.161 and the cross-price elasticity of the coal demand with regards to oil price is 0.733. Short-term elasticities were calculated as 0.716, -0.067 and 0.017, respectively. Hang and Tu (2007) employed time series data to test price elasticity of energy in China for the years 1985-2004. According to the results, price elasticities of coal, oil and total energy were negative in both periods before and after 1995. The price elasticity of coal demand in the pre-1995 period was -0.28, whereas it was -1.59 in the post-1995 period. Masih and Masih (1996) obtained the estimates of elasticity of coal demand for China for the years 1953-1992 by using annual data. In their study, the Johansen and Juselius cointegration test, DOLS and Vector Error Correction Model (VECM) methods were used. By the DOLS method, long-term price elasticity was estimated at -0.99 and income elasticity at 1.07. Short-term price elasticity based on VECM was estimated at -0.82 and income elasticity was estimated at 0.58. Stevens, Blake, and

Williams (1979), stated that coal is a potential energy source to meet the increasing energy demand and also pointed out that there may be negative environmental and economic effects of coal production. Stevens et al. (1979) estimated the price elasticity of coal demand as inelastic (-0.40).

The number of studies on price and income elasticity of coal demand in Turkey is limited. As an example of these works, Çatık and Deliktaş (2016) found the income and price elasticities of demand for oil, coal and natural gas. According to findings which were obtained by use of Johansen and Juselius (1990) cointegration method, there is a long-term relationship between all types of energy, energy prices and income level. The results of the cointegration test indicate that in the long-term, natural gas demand is not elastic in terms of both price and income, whereas oil demand is not elastic in terms of price. Estimated income and price elasticity coefficients have the expected sign, but the elasticity and significance level of the parameters vary with respect to the models. When evaluated in terms of price elasticities, it is observed that natural gas demand is not elastic in reference to price in general and in industry. In the oil demand models, the parameter of the price variable is found insignificant both in industrial and total level. Therefore, it is not elastic with reference to price. Because the estimated coefficient is 1.717, the total oil demand is elastic with reference to the GDP. It is seen that income elasticity of oil demand at the industrial level is not elastic since it is smaller than one (0.639), so that the income growth cannot respond as much as the total petroleum demand. Capik et al. (2013) examined Turkey's hard coal, lignite and gas based energy demands. The study found that 70% of the primary energy consumption is met by imported energy sources. According to the authors these figures suggest that in the coming years, Turkey's foreign-source dependency will continue to increase in parallel with its economic growth. In addition, they stressed that Turkey should increase the use of domestic resources because this can minimize the its foreign-source dependency. Nişancı (2005) found short- and long-term elasticities of fuel demand in Turkey by using the cointegration and error correction model. The income elasticities of premium and unleaded gasoline are elastic in both short- and long-term. In case of diesel, income elasticity is smaller than one in both terms. Price elasticity of gasoline types other than unleaded gasoline and of diesel are inelastic in both terms. According to the result of error correcting term, it is indicated that the short-term disequilibrium will reach the re-equilibrium level in the long-term. Erdoğdu (2010) has estimated the natural gas demand for Turkey by using monthly data from the years 1988-2005. As a result of estimation, price elasticity of long-term natural gas demand was estimated to be -31.90 for households, -7.81 for industry and 1.85 for electricity generation sector. Tatli (2017) analyzed residential electricity demand in Turkey by the ARDL bounds test using annual data from 1990 to 2014. The long-term price elasticity of residential electricity demand is predicted as -0.122 and the income elasticity of electricity demand as 1.273. It was found that climate conditions influence residential electricity consumption, with a 1% rise in average temperature increasing residential electricity demand by 1.31%.

3. DATA AND METHODOLOGY

3.1 VARIABLES AND DATA

The data used for the empirical analysis of coal demand in electricity generation in Turkey cover the period 1991-2015. The data on the amount of steam coal used for electricity generation ($COAL$) and steam coal price used for electricity generation ($PRICES$) are acquired from the database of the IEA (IEA, 2017b) Additionally, real GDP per capita ($PerGDP$) is taken from the World Development Indicator (World Bank, 2017) database. Average temperature values ($ATEMP$) are taken from the World Bank Climate Change Knowledge Portal. The average temperature values for each year were obtained by taking the average of the Average Monthly Temperature 12-month values. The information on data are given in Table 2.

TABLE 2
Variables and Their Descriptions

Variable	Description	Sources
$COAL$	Use of Steam Coal for Electric Power Generation in Turkey, million tonnes	IEA
$PRICES$	Steam Coal Prices for Electric Power Generation in Turkey, $/tonne *	IEA
$PerGDP$	Real GDP per capita in Turkey (constant 2010 $)	World Bank Database
$ATEMP$	Average Monthly Temperature	World Bank Database Climate Change Knowledge Portal

Note: * deflated using the GDP deflator of the United States.

3.2 ESTIMATION TECHNIQUES

The model, which is generated for testing income and price elasticities of coal demand in electricity generation in Turkey is presented in logarithmic form in (1):

$$(1) \quad lnCOAL = \beta_0 + \beta_1 \ln PRICES + \beta_2 lnPerGDP + \beta_3 ATEMP + \varepsilon_t$$

Here, $lnCOAL$ refers to the amount of coal used for electricity generation (million tonnes); $InPRICES$ refers to the price of the coal used for electricity generation (\$/tonne) and $lnPerGDP$ refers to the real income per capita. $ATEMP$ indicates the value of average temperature (average of 12 months). Short- and long-term relationship among the analysis data have been investigated using the ARDL method. This method provides better results in small samples than other cointegration tests (Polat and Gemici, 2017).

Equation (1) can be written as follows within the frame of ARDL:

$$(2) \quad \Delta lnCOAL_t = \beta_0 + \sum_{i-1}^{n} \beta_{1i} \Delta lnCOAL_{t-i} + \sum_{i-0}^{n} \beta_{2i} \Delta lnPRICES_{t-i} + \sum_{i-0}^{n} \beta_{3i} \Delta l\Delta nPerGDP_{t-i} + \sum_{i-0}^{n} \beta_{4i} \Delta ATEMP_{t-i} + \delta_1 lnCOAL_{t-1} + \delta_2 lnPRICES_{t-1} + \delta_3 lnPerGDP_{t-1}$$

Here; Δ, is difference operator; ε_t, is standard error term. β_1, β_2, β_3, β_4 refer to short- term relationship whereas δ_1, δ_2, δ_3, δ_4 refer to long-term relationship. In the ARDL method, first of all, the existence of the cointegration between bounds test and the variables in the system is determined. Hence, *F*-test statistic is used to determine the existence of cointegration between variables. The *F*-test statistic is used to determine whether variables are cointegrating, by testing the common significance of lag level coefficients. For equation (2), $lnCOAL$ is the dependent variable. The null hypothesis which is in the form of $H_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$, hypothesizes that there is no cointegration relation, whereas the alternative hypothesis which is in the form of $H_1 = \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$, hypothesizes that there is cointegration. It is necessary to not accept the null hypothesis in the case of existence of cointegration. Asymptotic critical value limits of the *F*-test statistic, which were obtained by performing the bounds test, have a non-standard distribution which is provided by Pesaran et al. (2001).

If the calculated *F*-test statistic is higher than the upper critical bounds, the null hypothesis, which argues that there is no cointegration, is rejected, which means that there is a cointegration. If the calculated *F*-test statistic is below the lower critical bounds, the null hypothesis cannot be rejected, which means that there is no cointegration. If the calculated *F*-test statistic is between the upper and lower limits, it cannot be ascertained definitely whether or not cointegration occurs.

After the bounds test, optimal lag length of the variables was examined using the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQIC), in order to determine the appropriate lag time. Then short- and long-term models, which are based on the optimal lag lengths, are estimated. Therefore, the unrestricted error correction model (UECM) which will be estimated by the determination of the long-term relationship, is expressed as follows:

$$\Delta lnCOAL_t = \theta_0 + \sum_{i-1}^{n} \theta_{1i}\, \Delta lnCOAL_{t-i} + \sum_{i-0}^{n} \theta_{2i}\, \Delta lnPRICES_{t-i} + \sum_{i-0}^{n} \theta_{3i}\, \Delta lnPerGDP_{t-i} + \sum_{i-0}^{n} \Delta ATEMP_{t-i} + \varphi ECT_{t-1} + v_t \quad (3)$$

In Equation (3) φ, is the speed of adjustment parameter whereas ECT_{t-1} is one lagged error correction term. The coefficient for the error correction term indicates the rate of return to the equilibrium after the system shock and it should have a sign which is statistically significant and negative. For evaluating the diagnostic test results of the model, the Breusch-Godfrey LM test was used for autocorrelation testing, Jarque-Bera test for normality testing, Breusch-Pagan-Godfrey test for heteroscedasticity testing and Ramsey Reset test for testing correct use of the model. Finally, the CUSUM and CUSUMSQ graphs, which were built by Brown et al. (1975) were used for testing the stability of the ARDL long-term coefficients.

4. EMPIRICAL RESULTS

The basic assumption of the ARDL bounds test is that the variables are I (1) or I (0). The Augmented Dickey-Fuller (1979) and Phillips-

Perron (1988) unit root tests were used for the stability of variables and avoid the false results. The null hypothesis for these tests is that the series are not stationary while the alternative hypothesis is that the series are stationary. The results of unit root tests are given in Table 3.

TABLE 3
Unit Root Test Results

Variables	ADF		PP	
	Constant	Constand and Trend	Constant	Constand and Trend
$lnCOAL$	3.5800	0.5616	10.9832	2.5791
	(1.0000)	(0.9988)	(1.0000)	(1.0000)
$InPRICES$	-1.5024	-2.2191	-1.4901	-2.2191
	(0.5153)	(0.4586)	(0.5213)	(0.4586)
$lnPerGDP$	1.1942	-1.0621	1.1958	-1.0621
	(0.9971)	(0.9149)	(0.9970)	(0.9149)
$ATEMP$	-3.92276	-5.3839	-3.9227	-5.4204
	(0.0066)[a]	(0.0011)[a]	(0.0066)[a]	(0.0011)[a]
$ln\Delta COAL$	-2.9284	-4.2548	-2.9830	-4.3814
	(0.0574)[c]	(0.0146)[b]	(0.0515)[c]	(0.0108)[b]
$In\Delta PRICES$	-4.4176	-4.2252	-4.2656	-4.0387
	(0.0022)[a]	(0.0149)[b]	(0.0031)[a]	(0.0219)[b]
$ln\Delta PerGDP$	-4.0988	-4.4988	-4.0988	-4.4965
	(0.0046)[a]	(0.0084)[a]	(0.0046)[a]	(0.0084)[a]

Note: [a], [b] and [c] are respectively the 1%, 5% and 10% of the significant level.
Δ, indicates the first difference of the variables.

According to the results of ADF and PP unit root test, it is concluded that the $lnCOAL$, $InPRICES$ and $lnPerGDP$ variables are not stationary at the level I(0), but the variables became stationary when the first difference I(1) is taken. So these three variables are stationary at the first difference. On the other hand, it is resulted that the other variable $ATEMP$ is stationary in the level.

Given these results, cointegration between variables are tested by using the ARDL bounds test approach. In this study, optimal lag length is tried to be estimated by Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQIC). These three tests resulted in similar lag length. Consequently, it has been determined that the optimum lag length for the bounds test is 4. After the lag length is determined, it can be passed to the bounds test for determining whether there is a cointegration relationship between the variables. The results of this test are shown in Table 4.

TABLE 4
ARDL Bounds Test Result

	Critical Value Bounds	
Significance	Lower Bound-I(0)	Upper Bound-I(1)
10%	2.72	3.77
5%	3.23	4.35
1%	4.29	5.61
F-statistic	7.28	k=3

Note: k represents the number of independent variables.

In Table 4 the results of the F-test statistic are given. In Table 4 it is seen that the F-test statistic, calculated by consumption of $lnCOAL$, which is the dependent variable, is higher than the upper critical value in all 1%, 5% and 10% significance levels. In this case the H_0 hypothesis is rejected and it is decided that there is a long-term relationship between $lnCOAL$ and the other three variables ($InPRICES$ and $lnPerGDP$ and $ATEMP$). In other words, results show that a relationship exists between coal consumption and coal price, per capita income and the average tempreture value in the long-term.

After it was determined that there is a long-term relationship between the variables, short- and long-term relationships will be estimated by the ARDL model which is built by Pesaran et al. (2001). For this purpose, first of all, lag lengths of dependent and independent variables in the ARDL model will be selected according to the AIC information criterion and the appropriate ARDL model will be determined. Second, long-term coefficients will be obtained. Third, short-term relationships will be estimated by the ARDL error correction model. It is decided that ARDL (2, 4, 4, 0) model is the long-term estimation model.

In Table 5, results show that long-term coefficient values for coal prices and real income per capita in the long-term are statistically significant. Nonetheless, the long-term coefficient value of average temperature is not statistically significant. In the forecasted model, the price elasticity of long-term coal demand for electricity generation is estimated at -0.3759.

The model shows that in the long-term, a 1 percent increase in coal price will lead to a 0.3759 percent decrease in the coal demand for electricity generation, provided other conditions remain unchanged. On the other hand, coal demand has been increasing depending on the rise in per capita real income.

Long-term income elasticity of coal that is demanded for electricity generation is 4.9426. This result shows that a 1 percent increase in income per capita caused a 4.9426 percent increase in coal demand for electricity generation. While the change in the coal price affects the coal demand in a negative and statistically significant manner, the change in the per capita income affects the coal demand in a positive and statistically significant manner. According to these results, the price elasticity of coal demand is estimated as inelastic, whereas the income elasticity of the coal demand is estimated as greater than one.

Thereby, the price elasticity of coal demand is less than the income elasticity and it is concluded that the coal demand does not evenly respond to the increase in price. These results are consistent with the results of Zhang et al. (2011) and Masih and Masih (1996). When the coal demand is evaluated in terms of average temperature, the effect of the average temperature on coal demand is insignificant.

In addition, the coefficient of error correction term (ECT) is estimated as -1.3827. The sign of the error correction term is statistically significant and negative at the 1% significance level as expected. This result indicates that the system reaches equilibrium by fluctuating and in the long-term this fluctuation may reach equilibrium by decreasing at every turn (Narayan and Smyth, 2006). That is to say that if there is a deviation in the long-term equilibrium in the short-term, the system will reach the equilibrium in a shorter time than a quarter (1 / 1.38 = 0.72).

When the diagnostic test results of the model are assessed, according to the results of the Breusch-Godfrey LM test, there is no autocorrelation problem in the model; according to the results of Jarque-Bera test, the error term is normally distributed, and according to the results of the BPG test, there is no heteroscedasticity problem in the model and according to the Ramsey Reset Test, the model is established with the correct specifications. These results support that the estimation results obtained are reliable.

TABLE 5
Short- and Long-Term Coefficients (2, 4, 4, 0)

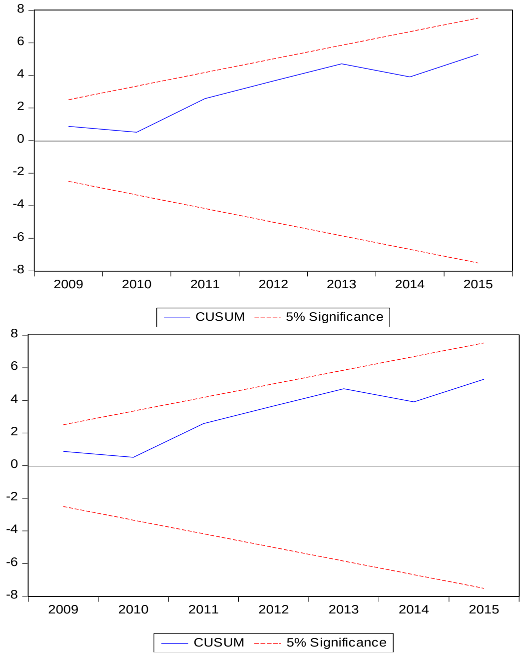
Variables	Coefficient	Std. error	*t*-Statistic
Constant	-61.8504	12.4554	-4.9737[a]
$lnCOAL$ (-1)	0.0203	0.2416	0.0842
$lnCOAL$ (-2)	-0.4030	0.1849	-2.1792[c]
$InPRICES$	0.8266	0.1872	4.4152[a]
$InPRICES$ (-1)	-0.9832	0.2181	-4.5079[a]
$InPRICES$ (-2)	0.2886	0.1869	1.5438
$InPRICES$ (-3)	-0.4791	0.1721	-2.7829[b]
$InPRICES$ (-4)	-0.1727	0.1410	-1.2249
$lnPerGDP$	3.0562	0.6359	4.8055[a]
$lnPerGDP$ (-1)	1.3304	0.6722	1.9792[c]
$lnPerGDP$ (-2)	0.9893	0.8461	1.1693
$lnPerGDP$ (-3)	-1.0359	0.9649	-1.0735
$lnPerGDP$ (-4)	2.4941	0.6649	3.7508[a]
$ATEMP$	0.0397	0.0468	0.8496
ECT(-1)	-1.3827	0.2984	-4.6324[a]
Long Run Coefficients			
Variables	Coefficient	Std. error	t-Statistic
Constant	-44.7306	2.1510	-20.7943[a]
$InPRICES$	-0.3759	0.1419	-2.6492[b]
$lnPerGDP$	4.9426	0.2244	22.0177[a]
$ATEMP$	0.0287	0.0325	0.8837
R^2	0.9968		
Adj R^2	0.9911		
F-statistic	172.7054[a]		
DW	2.3230		
Diagnostic Test Statistics			
Diagnostic test	Statistic	Prob.value	
χ^2 *NORMAL*	0.4767	0.7878	
χ^2 *SERIAL*	6.0314	0.1101	
χ^2 *BPG*	16.7500	0.2110	
χ^2 *RESET*	0.1742	0.8674	

Note: [a],[b] and [c] are respectively the 1%, 5% and 10% of the significant level.
χ^2 NORMAL, Jarque-Bera test for normality;
χ^2 SERIAL, Breusch-Godfrey Serial Correlation LM (autocorrelation) test;
χ^2 BPG, Breusch-Pagan-Godfrey heteroscedasticity test;
χ^2 RESET, Ramsey Reset test

Figure 1 displays the CUSUM and CUSUMSQ graphs in accordance with Brown et al. (1975) for testing the stability of the ARDL long-term coefficients.

According to the CUSUM and CUSUMQ test, if the curves, which are obtained as a result of the test statistics for the error terms, are within critical limits at the 5% significance level, the estimated parameters are stable. For this reason, the stability of long-term estimates has been confirmed.

FIGURE 1
CUSUM and CUSUMQ



5. CONCLUSION

Turkey's energy demand has been increasing with each passing day. Turkey's foreign-source dependency in terms of energy requirements has also been increasing. Moreover, in parallel with the increasing economic growth, the energy demand will continue to increase. As Dahl (2009) emphasizes, elasticity is useful for policy analysis. Thus, recognition of short- and long-term income and price elasticities of coal used in electricity generation in Turkey has importance for policy makers. In this context, in this study, short- and long-term income and price elasticities of steam coal, which had been used in electricity generation in Turkey is estimated for the years 1991-2015. The ARDL bounds test method was used for these estimates.

The price elasticity of demand of coal utilized in electricity generation is estimated as smaller than 1 and found to be statistically significant in both short- and long-term. On the other hand, the income elasticity of demand of coal used in electricity generation is determined as greater than 1 and found to be statistically significant in both short- and long-term. In terms of long term parameters, income elasticity and price elasticity of coal demand are estimated as 4.9426 and -0.3759 respectively. When the case was evaluated in terms of average temperature, the coefficient was found insignificant in both the short- and long-term. The fact that the coefficient of the average temperature variable is found to be insignificant supports the results of Wahid et al. (2015). In terms of the coefficient of income elasticity, the percentage change in income is larger than the percentage change in demand. Therefore, as income increases, the share of coal in the budget will increase. In terms of price elasticity, the percentage change in quantity demanded is less than the percentage change in price. In these circumstances, quantity demanded will decrease less over increases in price. On the other hand, consumers will pay a larger part of the applied tax because the price elasticity of the coal demand is smaller than one.

Expectations are that the share of renewable energy resources in total energy production will increase, while the share of fossil fuels will decrease, due to global climate change and policies for decreasing greenhouse gas emissions (CO_2, N_2O, etc.). However, coal production and consumption in the world, especially in China, is increasing day by day. Thus, for developing countries, coal consumption may become an important source of energy. In recent years, this situation has become a major issue also in the Turkish case. According to the coefficients obtained, income elasticity of coal demand for Turkey was estimated to be greater than 1. Hence coal is a luxury good in Turkey. Nevertheless, the price elasticity of coal demand is estimated to be less than 1. In this case, the price elasticity of coal demand in electricity generation in Turkey is inelastic. These results indicate that firms producing electricity using steam coal will respond less to coal price changes. Furthermore, the price and tax increase on steam coal can constitute a greater cost burden on small electricity producers. The positive sign of income elasticity indicates that an increase in the incomes of producers using steam coal in electricity generation will increase the demand for steam coal. Changes in coal prices and income will lead to changes in coal production and consumption. Therefore, firms can take into account the changes in their expenditures by taking into account the expected income and price elasticities.

ENDNOTES

1. This paper was presented as an oral presentation at the 7th World Conference on Business, Economics and Management (BEM-2018) symposium.

2. In Britain, bituminous coal is commonly referred to as “steam coal” while in Germany hard coal is used. In our work, data of steam coal, which is used in electricity generation, is used.

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