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Estimating Demand of Turkish Energy Market: a Multivariate Regression Model[1]

SUMMARY

Energy is a fundamental factor for economic development. Although in recent years there is a development in studies on an energy economics they are focused on specific energy sources. In this study natural gas, electricity and oil consumption which are the energy sources that the greatest market share of world and Turkey are investigating. In this investigation multivariate linear regression model is used. MVR model is a system of linear regression equations having the same set of independent variables. In this model within–equation, linear restrictions are testable on an equation–by–equation basis using a standard F test. The aim of the study is estimating demand of these three energy sources which are mentioned above. For this purpose, the regression model estimated which has a natural gas, electricity and oil consumption as dependent variables and price of these sources, income and population as independent variables by using 2001:01–2010:06 monthly data. Except for oil prices, coefficients of the model are statistically significant in all models. Coefficients are interpreted economically and determined that supply and demand move peculiar to Turkish energy markets despite the general expectations.

KEYWORDS

Turkish Electricity Demand, Turkish Natural Gas Demand, Turkish Oil Demand, Multivariate regression, Energy Demand.

INTRODUCTION

As a one of the energy importer country, Turkey has five primary energy resources as petrol, natural gas, coal, hydroelectricity and renewable energy.

In the last twenty years Turkey went through three crises in 1994, 2000 and 2001, energy consumption fluctuated during these crises and showed a decreasing attitude [1].

While the dominant fuel in energy production was coal in 1950’s, its ratio in the total installed capacity which was 52.1% (212,6MW) decreased to 27.4% (348,3MW) in 1960’s. Supply for hydroelectricity reached 32.4% in total capacity in the same year. Increase in the natural gas consumption started in 1970’s. While the production rate of natural gas, the consumption rate of which was quite low until 1980’s, in the energy plants was 1.1% in 1985, it increased to 26.4% in 1999 [2].

The year 1984 is a milestone both for the economy of Turkey and for conducting energy planning and energy demand for next years. The World Bank proposed ETKB (Ministry of Energy and Natural Resources) to use MAED (Model for Analysis of the Energy Demand) and WASP (Wien Automatic System Planning Package) III models developed by IAEA (The International Atomic Energy Agency) to determine the energy and electricity demands [3].

Turkey as a mainly importer in terms of energy resources, met 74% of its energy supply from abroad, above 90% in petroleum and natural gas and about 20% in coal in year 2009. According to the data from 2008, 55.7% of the imported natural gas was used in electricity production, 22.2% was used in the houses and 22.0% was used in industry. Natural gas consumption of Turkey was an annual 35.6 billion cubic meters at the end of 2008, the consumption increased in the electricity sector and similarly decreased in the industry sector [4].

Consumption of natural gas started to be used in 1976. In 2006 it had 28.6% of total supply of primary energy and 52.8% of this supply was

1 This paper is a derived version of author’s Ph.D. thesis entitled ‘Türkiye Enerji Piyasasının Çok Değişkenli Doğrusal Regresyon Analizi ile İncelenmesi” defended at the Gazi University Institute of Social Sciences, October 2011.

used in electricity plants [5][2].

Electrical energy was first produced in 1906 in Tarsus by the Italian. The plant commissioned in Tarsus was a generator in 2kW capacity connected to a watermill. First major electricity plant in our country was established in Silahtar Ağa, İstanbul in 1913.

Coal, especially Brown coal is the most important local energy resource of Turkey. TTK (Turkish Coal Corporation), sustains its actual monopoly position in coal production, distribution and processing. While 55% of the Brown coal produced in 2003 was produced solely by TTK, only 10% was produced by private companies.

This study aims to estimate natural gas, electricity and petroleum demand for Turkey. The equation to be estimated with this aim is known as demand equation in the literature of economy.

There is wide literature about Turkish energy demand. [3] forecast energy demand of Turkey using Winters' exponential smoothing method and cycle analysis. [6] finds that price elasticity of coal is very low for the period 1987–2002 for Turkey. [7] shows that growth and investment have positive, consumption and prices have negative relationship in Turkey. [8] argues production effect, structural effect and intensity effect by using LMDI(Logarithmic Mean Divisia Index) approach on Turkish sectoral3 energy use then concludes that main source of the total effect is production effect. [9] finds that long–run and the magnitude of price elasticity is considerably larger than the income elasticity in Turkey. [10] investigate the Granger causality of GDP and energy consumption and find that direction of causality is GDP to energy consumption. [11] conclude that fossil fuels will continue to play a major role in the future energy mix of Turkey. Nonetheless Turkish energy system will be depended more on natural gas than on other fuels. Also [12] investigates electricity demand and finds that the price and income elasticity for electricity demand is very low in Turkey and asserts that the electricity market have to be regulated.

In this study, factors of the goods demand quantity of which is to be estimated are determined within the frame of traditional demand theory as the price of the good, the price of substitute goods and income. In this case, general demonstration of the model to be established is presented in the vectorial form as below as D is for demand, P is for price, G is for income, E is for electricity, NG is for natural gas and O is for oil:

[NGD, ED, OD]=f[NGP, EP,OP, G] (1)

It can be shown in vectorial form in (2) and also below:

$$NGD_{-t}=\beta_{01}+\beta_{11}\,NGP_t+\beta_{12}\,EP_t+{}_{13}\,O_t+\beta_{14}\,G_t+\varepsilon 1_t$$
$$ED_t=\beta_{02}+\beta_{21}\,NGP_t+\beta_{22}\,EP_t+\beta_{23}\,OP_t+\beta_{24}\,G_t+\varepsilon_{2t}$$
$$PD_t=\beta_{03}+\beta_{31}\,NGP_t+\beta_{32}\,EP_t+\beta_{33}\,OP_t+\beta_3 4\,Gt+\varepsilon_{3t} \quad (2)$$

GDP or GNP is used as the indicator of income level in the implementations of macroeconomics. GNP data is estimated in four terms by TÜİK(Turkish Statistical Institute) as quarterly data. In this paper monthly data are used therefore Industry Production Index is which is published monthly as income level variable.

The variables are in different measurements, i.e. natural gas consumption was obtained in Terajoule, electricity consumption was obtained in GWs, petroleum consumption was obtained in Kilotone yet to make all the measurements in the same type, all consumption values were converted into Terajoule. Price values were converted into fixed prices by deflating these values with PPI[4] . Also a correction was made on electricity data.

As known, electricity energy is obtained by using other energy sources. Natural gas and petroleum consumption data comprises petroleum and natural gas quantities used in electricity production. This situation causes a correlation among independent variables and also causes the same data to be calculated twice. Therefore, natural gas and oil quantities used in electricity production are excluded from electricity consumption quantities.

The dependent variables are NGD natural gas demand (Turkey, Gross Inland Deliveries (Observed) [in Terajoules] IEA Energy Statistics Ó OECD/ International Energy Agency, 2010), ED electricity demand (EC–EGN–ENP[5]), OD oil demand (Turkey (Total Products Demand as defined in the Oil Market Report [in KT] IEA Energy Statistics Ó OECD/ International Energy Agency, 2010). Independent variables are NGP natural gas price (TÜİK,CPI, Product Name, Natural Gas Fee,TL), EP electricity price (TÜİK,CPI, Product Name, Electricity Fee,TL), OP oil price (TÜİK,CPI, Product Name, Petrol Price, TL), IPI industrial production index (Monthly Industrial Production Index (1997=100), Total Industry, Manufacturing+Mining+Ohters)[6]. Economic expectations for the variables are discussed generally below.

When the price of energy resources increases, consumers alter it with another energy resource which is a substitute. Yet electricity, natural gas and petroleum are not exactly substitutes. An energy source for a machine used both in residents and industry for energy or heating is either cannot be replaced or it takes a long and/or expensive process to replace.

Petroleum is used more commonly in transportation diesel and LPG involved. Along with this, it takes part in production as an intermediate input. Impact of petroleum price on electricity is bidirectional. First impact is substitute impact and the second impact is the one it makes as complementary good. A part of electricity consumption is procured from petroleum and petroleum is a cost for electricity production. Increase in the price of petroleum price causes an increase in the cost of electricity consumption and therefore the more the price for petroleum is, the less the electricity consumption is. Direction of the impact will be determined depending on which of the two impacts is more dominant.

Along with this, there are losses and illegal use while this energy is transmitted to the consumers. Especially in electricity energy distribution, there is a high rate of losses and leaks. [13] mentions some reason of these causes such as there is no investment in this field and maintenance–repair works are not performed periodically. Illegal use in petroleum and electricity constitutes a major problem too.

In the petroleum market, especially since the middle of 2007, various substances have been sold and used in cans instead of diesel oil under the name of 10 number oil. According to [14] report, base oil import of Turkey increased in 210.000 tones between 20052007. According to [15] report, after fixed Special Consumption Taxes collected from certain fuel types were increased by the Ministry of Finance of Republic of Turkey, legal consumption of these fuels decreased and activities carried under the name of 10 number oil etc. considerably increased. It is estimated that market activities caused only by mixing base oils and waste oils in fuels is more than an annual 500 thousand tones and the tax loss caused by this situation is far above 600 million TRY/Year.

In this study, loss and illegal use rates do not take into account, official consumption data are used and the increase in the price is deemed to have a consumption decreasing impact by increasing the rate of illegal use.

MULTIVARIATE REGRESSION MODEL

In this paper multivariate regression model is used. [15] defined multivariate regression model that a system of linear regression equations having the same set of explanatory variables. Author stated that this technique mostly used in demand analysis and empirical asset pricing. If the individual equations of the system are classical regressions is used instead of using multivariate regression linear restrictions are testable on an equation–by–equation basis using a standard F test.

MVR is named as a multivariate regression model in [16], [17], [18], [19], multivariate linear regression in [20], [21], [24] and general linear multivariate model in [23].

In the MVR generalizes the univariate model by allowing more than one dependent variables to be measured on each independent sampling unit. Implicitly the model requires that the same design matrix apply to every dependent variable and every independent sampling unit have the same set of responses variables. The most important key difference is hypothesis testing which is far more complicated than multiple regression model [23].

Test problems in MVR model may also be found in seemingly unrelated regressions (SURE) and simultaneous equations. Also the MVR model can be interpreted as a SURE model with identical dependent variables across equations in other words the SURE model may be nested within an MLR framework, imposing exclusion constraints [24].

In MVR estimated coefficients and standard errors are identical to the estimates obtained from multiple regression model of the individual equations. The advantages of the MVR are in hypothesis testing since heteroscedasticity across equations and contemporaneous dependence of the distur-

2 World Energy Council. Turkish National Committee.

3 Agriculture, industry and service secotors were used.

4 In period 2001:01:2002:12 the data converted to 2003=100 indiced from 1994=100 indiced by authors.

5 EC Electricity Consumption (Turkey Gross Electricity Consumption [in GWs] , TEİAŞ), EGN Electricity Generation Natural Gas: Distribution of Turkey's Gross Electricity Generation by Primary Energy Resources, Natural Gas part (GWs), TEİAŞ, EGP Electricity Generation Petroleum: Distribution of Turkey's Gross Electricity Generation by Primary Energy Resources , Liquids (Fuel–Oil, Diesel, LPG, Naphta) (GWs), TEİAŞ

6 2001:01–2008:01 period 1997=100, 2009:01–2010:05 period 2005=100 indiced series are collected from data source. The period of after 2009:01is converted to 1997=100 indiced series.

bances are explicitly incorporated into the hypothesis tests [25].

Suppose that we have the response of the ith individual (i=1,…,n) is some quantitative measure of dependent variables observed at time points $t_1,\ldots,t_g$. The dependent variables depend on explanatory variables that are shown by . A MVR model for this dependent variables is below

$$Y_{ij}=\beta_{0j}+\sum^{p}_{l=1}\beta_{lj}X_{il}+\varepsilon_{ij} \quad i=1,\ldots,n,\ j=1,\ldots,q \qquad (3)$$

In the Equation 3 the coefficients of the explanatory variables depend on j . This accounts for the possibility that the pattern of influence of the explanatory variables may depend on the time of measurement. Also the observations of a given patient at different time points may be correlated. The error variance for the various time points may also be different. These variances and covariances may not be known at all [21]. In order to overcome these kind of problems the model with several dependent variables which is called MVR model is used.

Testing linearity is one of the main problem in MVR model like multiple regression model(MR). The advantage of MVR model over multiple regression model is that significance of independent variables can be tested in all models jointly. If we have collected data about several dependent variables and make separate MR model then we could make separate t tests. If more tests we conduct on the same data, the more we inflate the familywise error rate.

Imagine a situation in which there were three model and we would like to compare one independent variable between these three models separately. If we were to carry out t–tests on every pair of models, then we would have to carry out three separate tests: one to compare models 1 and 2, one to compare models 1 and 3, and one to compare models 2 and 3. If each of these t–tests uses a 0.05 level of significance then for each test the probability of falsely rejecting the null hypothesis (known as a Type I error) is only 5%. Therefore, the probability of no Type I errors is 0.95 (95%) for each test. If we assume that each test is independent then the overall probability of no Type I errors is 0.857 (0.95x0.95x0.95). Thus the probability of at least one Type I error is 0.143(1–0.857) or 14.3%. Therefore, across this group of tests, the probability of making a Type I error has increased from 5% to 14.3%. This error rate across statistical tests conducted on the same experimental data is known as the familywise or experimentwise error rate [26].

The most common tests which could be used to do these joint tests are Wilks' Lambda, Pillai's Trace, Hotelling –Lawley Trace and Roy's Largest Root statistics such as following:.

Wilks' Lambda:

$$\wedge = \prod_{i=1}^{s} \frac{1}{1+\lambda_i} \qquad (4)$$

Pillai's Trace :

$$V = \sum_{i=1}^{s} \frac{\lambda_i}{1+\lambda_i} \qquad (5)$$

Roy's Largest Root : λ_1 (6)

Hotelling –Lawley Trace is also known as a Hotelling T2 is below.

$$T = \prod_{1}^{s} \lambda_i \qquad (7)$$

where s number of variables and is eigenvalues.

[27] point out that the Roy test is weaker than other three test but if there is a one big eigenvalue it will be the most powerful test. Also they indicate that in a big sample Wilk's Lambda, Roy' Largest Root and Hotelling Lawley Trace tests statistics values are approximately same.

Other Model Testing Methods

[27] suggest these four graphs[7] to detect possible anomalies.

Residuals $\hat{\varepsilon}_i$ are plotted against the predicted values $\hat{Y}_i$. The graph is indicated the violating assumptions and has two interpretations and both of them means not equal variance:

a) The relationship between $\hat{\varepsilon}_i$ and $\hat{Y}_i$ may be increasing. A dependence of the residuals on the predicted value. The numerical calculations are incorrect or constant term has been omitted from the model.

b) The pattern of residuals may be funnel shaped. If this is the case, the variance error is not constant and transformation or a weighted least squares approach are required.

Residuals are plotted against independent variables or products of them. A systematic pattern in these plots suggests the need for more terms in the model.

Q–Q plots and histograms used to detect normality in residuals.

Residuals are plotted versus time. Although the assumption of independence is hard to check if the data are naturally chronological, a plot of the residuals versus time may reveal a systematic pattern. For instance, residuals that increase over time indicate a strong positive dependence.

EMPIRICAL APPLICATION

Table 1 shows descriptive statistics of the variables. Range of the consumption variables is quite high, the standard deviation of natural gas demand is 28736 terajoule and it indicates how great the increase in natural gas consumption is. Therefore, it was decided to take logarithm of the consumption variables.

It is seen that the price variables are not high in variance. Also, because the Industry Production Index is an index variable, it is not considered necessary to take logarithms of these variables.

Table I: Descriptive Statistics of Variables

	Variables							
	Dependent Variables				Independent Variables			
	NGD	EC	OD	ED	NGP	EP	OP	IPI
Mean	89128,68	49523,29	10468,11	24748,31	0,0038	0,0017	0,0244	91,2223
Median	90916,5	48610,8	10618,99	24709,14	0,0036	0,0016	0,0268	88,0709
Maximum	152633	66210,48	14418,06	34061,23	0,0087	0,0029	0,0404	127,1
Minimum	41547	34878,6	6154,664	17495,28	0,0011	0,0006	0,0059	61,2451
Std. Dev.	28735,84	8490,41	1296,867	3981,927	0,0017	0,0005	0,0087	18,6819

Before the logarithms of the variables are taken, it is necessary to investigate if they include seasonality or not. Seasonal Stacked Line graphics were used for this. When the graphics were examined it was seen that they included high levels of seasonality. With the effect of seasonality being low in price variables and PIPI, at first all variables are seasonally adjusted. Also, it would be seen from the graphs that the price of electricity was fixed for nearly 62 months. In this period comprising 2002:11–2007:12, the difference between the highest and the lowest price was 0.00242 TRY.

First, all variables were seasonally adjusted using moving averages method then logarithms of the high variable demand series were taken. The seasonally adjusted series are named by adding "MA" to the end of the abbreviation of the series and logarithm of the series are named by adding "L" to the beginning of the abbreviation of the series.

Before the model was estimated, to ensure the requirement that the residuals terms [28] and dependent variables [23] must be un–correlated, natural gas and liquid fuel quantities used in the electricity production were excluded from the electricity consumption quantity and the electricity consumption data from hydroelectricity and thermal plants were obtained. As described above, electricity is a secondary energy source and a part of the electricity is produced from natural gas and liquid fuels.

Table presents results of the MVR model. The model having LNGDMA dependent variable is the natural gas demand model, the model having LEDMA dependent variable is the electricity demand model and the model having the LODMA dependent variable is the petroleum demand model. It is seen that all of the estimated models are statistically significant in %1 significance level. When the R–squared of the models are interpreted, it is seen that the first model has %95 and the second model has %82 coefficient of determination. That the oil model has a low ratio of %29 indicates that either there are more important variables affecting the petroleum consumption or consumption does not move according to the price factors due to the illegal use rate in oil consumption in Turkey.

7 Illustration of graphs can be found in the book.

Table II: Results of the Model

		Variable	Constant	NGPMA	EPMA	OPMA	IPIMA
Dependent Variables	LNGDMA	Coefficient	10,4046	2,2183	–171,765	33,9871	0,0033
		F=587,1004 F–prob= 0,0000 R–squared = 0,9556					
	LEDMA	Variable	Constant	NGPMA	EPMA	OPMA	IPIMA
		Coefficient	9,6282	–27,4213	9,1451	16,9337	0,0012
		F= 132,5032 F–prob= 0,0000 R–squared= 0,8294					
	LODMA	Variable	Constant	NGPMA	EPMA	OPMA	IPIMA
		Coefficient	9,3875	21,5037	–194,069	3,2739	0,0003
		F= 11,00698 F–prob=0,0000 R–squared= 0,2877					

Error terms and coefficients should be tested before the estimated parameters of the independent variables are interpreted.

Testing Residuals

The independence of residuals were tested by Breusch Pagan (1980). Table 3 shows that the correlation between residuals is at most 13% that is to show there is no strong dependence between residuals. Also the null hypothesis of the B–P test which refers to the error terms are not related cannot be rejected.

Table III: Correlation matrix of residuals

Residuals of Model:	LNGDMA	LEDMA	LODMA
LNGDMA	1,0000		
LEDMA	–0,0796	1,0000	
LODMA	0,1460	0,0946	1,0000
Breusch Pagan Test		Test Stat.	Prob,
		4,173	0,2434

Joint Significance Test of Coefficients

It is main advantage of the MVR model that we can jointly test the coefficients across models. The results are below:

Table IV: Constant Term — Multivariable Significance Test Results

Test	Statistic	F Stat	Prob
F Testi	21676,50	–	0,0000***
Wilks' Lambda	0,0007	49627,4311	0,0000***
Pillai's Trace	0,9992	49627,4311	0,0000***
Roy's Largest Root	1378,5397	49627,4311	0,0000***
Hotelling–Lawley Trace	1378,5397	49627,4311	0,0000***

*** shows significance level in 1% .

The null hypothesis of constant terms are not significant in the MVR model is rejected in 1% significance level(Table 4).

Table V: NGPMA — Multivariable Significance Test Results

Test	Statistic	F Stat.	Prob.
F Test	2,88	–	0,0394**
Wilks' Lambda	0,9266	2,8248	0,0422**
Pillai's Trace	0,0733	2,8248	0,0422**
Roy's Largest Root	0,0791	2,8248	0,0422**
Hotelling–Lawley Trace	0,0791	2,8248	0,0422**

** shows significance in 5% level.

The null hypothesis of natural gas price variables are not significant in the MVR model is rejected in 1% significance level(Table 5).

Table VI: EPMA — Multivariable Significance Test Results

Test	Statistic	F Stat.	Prob.
F Test	20,74	–	0,0000***
Wilks' Lambda	0,6365	20,3629	0,0000***
Pillai's Trace	0,3634	20,3629	0,0000***
Roy's Largest Root	0,5709	20,3629	0,0000***
Hotelling–Lawley Trace	0,5709	20,3629	0,0000***

*** shows significance level in 1% .

The null hypothesis of electricity price variables are not significant in the MVR model is rejected in 1% significance level(Table 6).

Table VII: OPMA — Multivariable Significance Test Results

Test	Statistic	F Stat.	Prob.
F Test	153.55	–	0,0000***
Wilks' Lambda	0,1913	150,7293	0,0000***
Pillai's Trace	0,8086	150,7293	0,0000***
Roy's Largest Root	4,2260	150,7293	0,0000***
Hotelling–Lawley Trace	4,2260	150,7293	0,0000***

*** shows significance level in 1% .

Table 7 shows that the null hypothesis of oil price are not significant in the MVR model is rejected in 1% significance level.

Table VIII: IPIMA — Multivariable Significance Test Results

Test	Statistic	F Stat.	Prob.
F Test	8,44		0,0000***
Wilks' Lambda	0,8114	8,2849	0,0001***
Pillai's Trace	0,1885	8,2849	0,0001***
Roy's Largest Root	0,2322	8,2849	0,0001***
Hotelling–Lawley Trace	0,2322	8,2849	0,0001***

*** shows significance level in 1% .

At last there is no significant result to omit IPI variable from the model (Table 8).

Also all variables which are used in the MVR model can be tested by multivariate significance tests. In this situation the hypothesis is below:

$$H_0: \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \begin{bmatrix} \beta_2 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \begin{bmatrix} \beta_3 \\ \beta_3 \\ \beta_3 \end{bmatrix} = \begin{bmatrix} \beta_4 \\ \beta_4 \\ \beta_4 \end{bmatrix} = 0$$

Table 9 : Overall — Multivariable Significance Test Results

Test	Statistic	F Stat.	Prob.
F Testi	4,58x10–5	–	0,0000***
Wilks' Lambda	0,0206	78,8298	0,0000***
Pillai's Trace	1,3599	22,5966	0,0000***
Roy's Largest Root	29,6612	261,1836	0,0000***
Hotelling–Lawley Trace	29,6612	261,1836	0,0000***
*** shows significance level in 1% .			

The four independent variables in three models are significant to be in all models. In conclusion we cannot reject to include any variables into model.

Results of Other Model Testing Methods

1. The residuals against fitted values of models are given below. In the Figure 1, RNG, RE and RO shows natural gas, electricity and oil models residuals respectively and the abbreviation "FIT" in the graphs means fitted values of the series used.

Figure 1 : Residuals Against Fitted Values

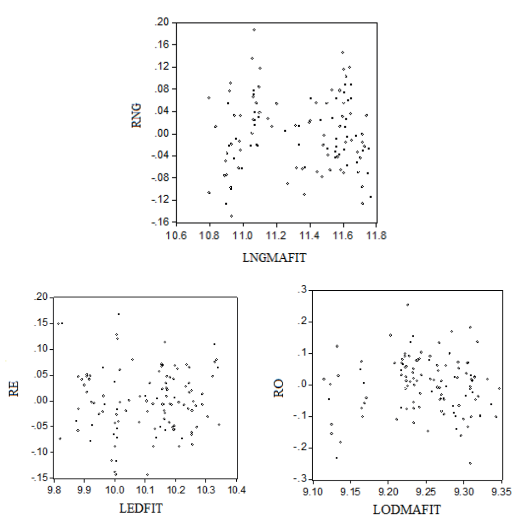

Figure 1 shows that there is no patter between residuals and fitted values.

2. Plotted residuals against independent variables are below and show that there is no pattern as required.

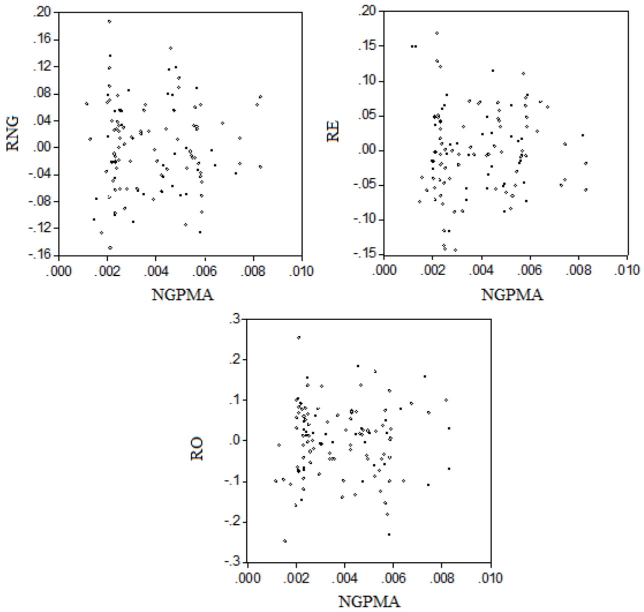

Figure 2: NGPMA — Residuals

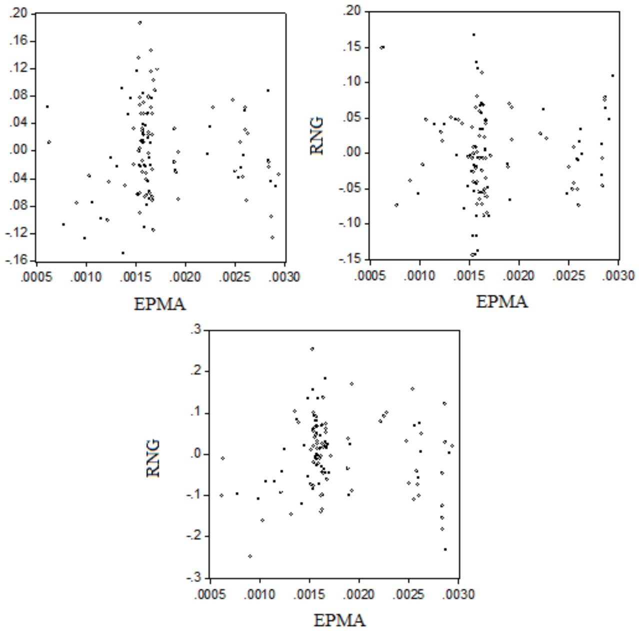

Figure 3: EPMA– Residuals

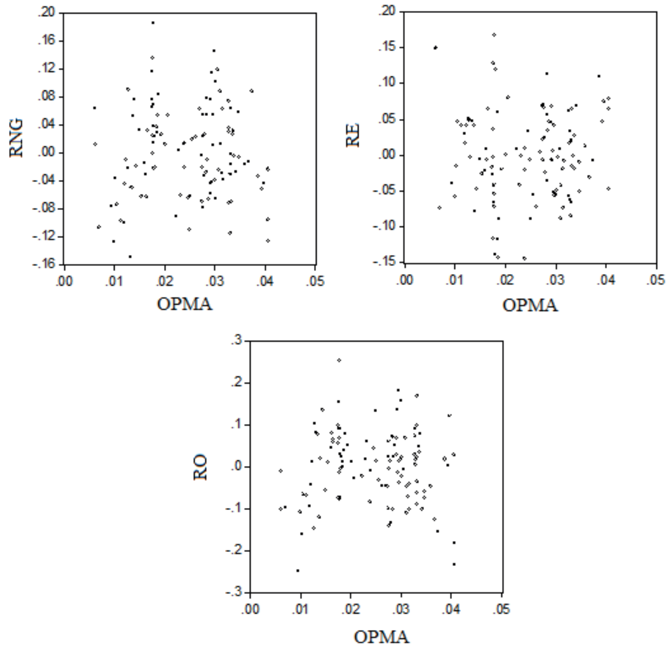

Figure 4 : OPMA– Residuals

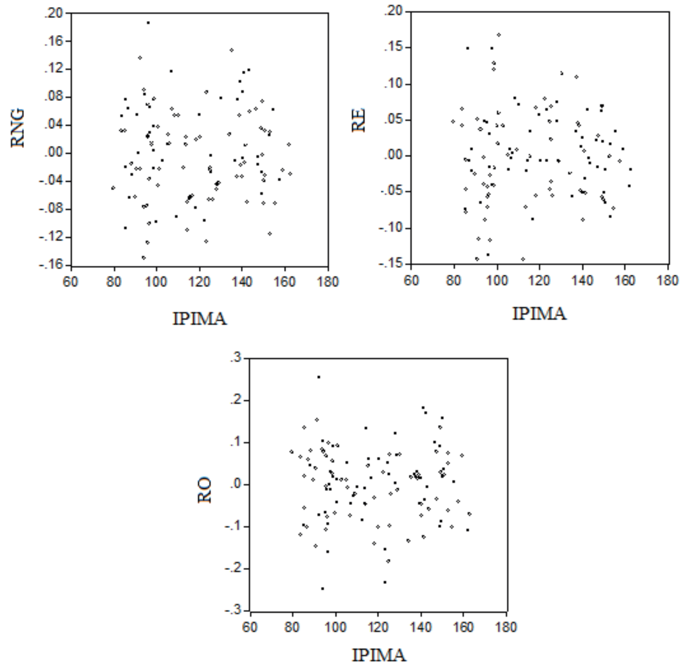

Figure 5 : IPIMA– Residuals

3. Figure 6 shows that the points on a normal Q–Q plot are reasonably well approximated by a straight line thus normal distribution hypothesis is plausible.

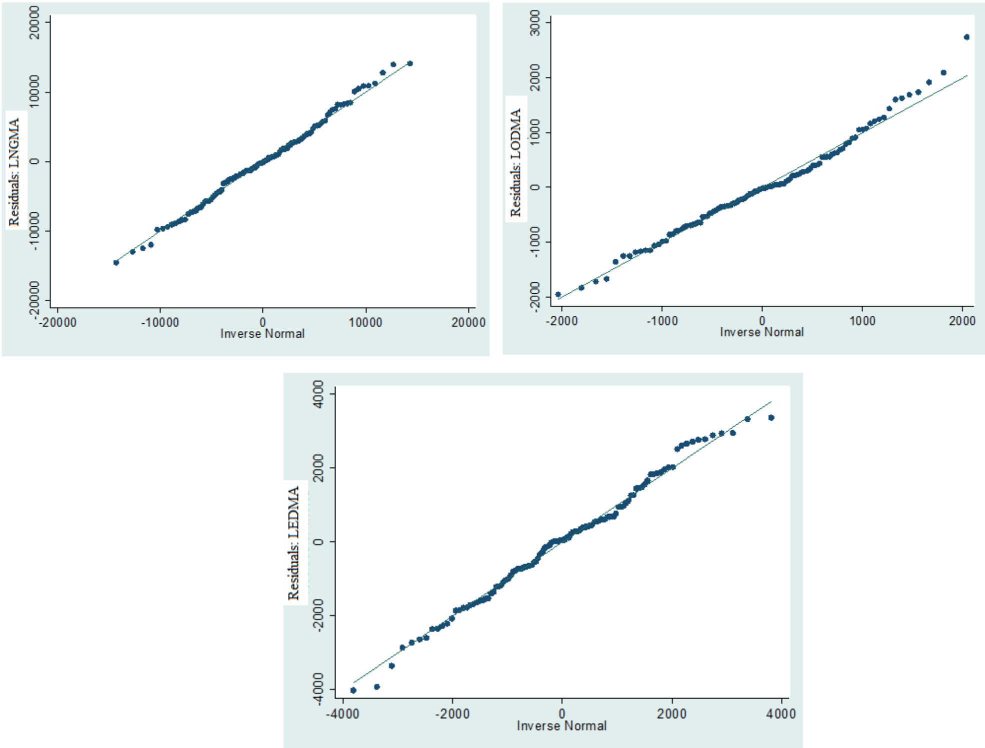

Figure 6: Q–Q plot of Residuals

4. The plots of residuals versus time have no systematic pattern and they show that no dependence on time.

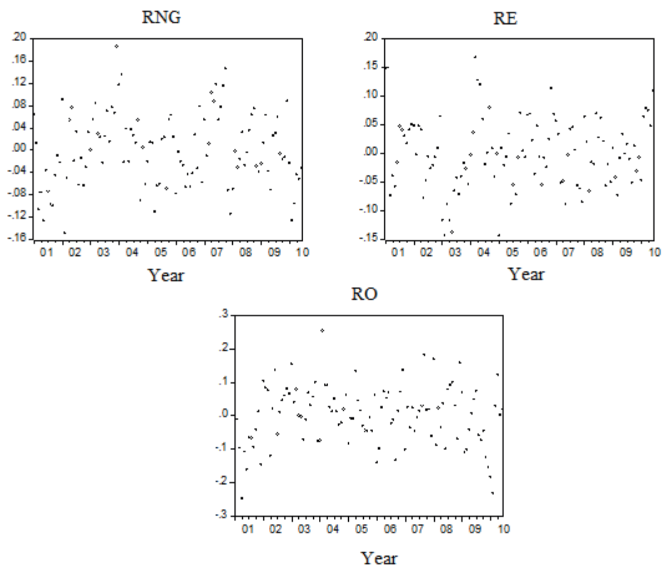

Figure 7: Residuals–Year

Testing Multicollinearity

The Variance Inflation Factor (VIF) is widely used measure of the degree of multicollinearity. If the VIF value is large, usually larger than 10 ([29], [30], [31]) indicate that a importance of multicollinearity.

Table X : VIF Values

Variable	VIF
NGPMA	9,16
EPMA	3,84
OPMA	5,95
IPIMA	7,36

Although Table 10 shows that there is no strong multicollinearity in the models natural gas prize has high VIF value.

After the goodness of fit tests of the model shows that the model statistically significant the model can be interpreted in terms of economics. When the first model in which the natural gas consumption is the dependent variable is examined, it is seen that the relation between the natural gas price and the natural gas consumption is in the same direction. Although a negative directional relationship is expected between price and consumption theoretically, demand increases continuously in terms of the use of natural gas both in residents and in real sector production. Also, because the pricing of natural gas is determined not based on the demand but based on the exchange rate and unit price factors of the natural gas obtained from different countries by the central government, change in demand is not a determinative factor in the price of natural gas.

In addition to these factors, that some part of the natural gas purchases Turkey obtains from abroad is in “purchase or pay” way, considering the annual purchases which will be paid even in it is not purchased, requires the extend the consumption of natural gas. That the natural gas consumption doesn’t decrease even if the price of it increases can be explained by this situation. Because nearly the half of the natural gas consumption is used in electricity production and production and consumption values shows an increasing trend every year. Also, thanks to the infrastructure investments realized, number of residents benefiting from the aforementioned energy source is similarly increases. According to the data from BOTAŞ, while 9 cities had Access to natural gas in 2002, this number increased to 61 in 2009.

Although the present consumers decrease the natural gas consumption, the increase in the number of consumers increases the consumption independently. Also, as stated in [32], in spite of the reforms and regulating institution the market structure couldn’t be liberalized and it is said that both not being able to strengthen the liberal market structure and not being able to realize the demand–price relationship are effective. Again in [1] study, a positive relation between the natural gas consumption used in electricity production sector and price was detected. It must be considered that nearly the half of the natural gas consumption used in the model established above is used in electricity production. The relation between the price of electricity and natural gas consumption is in reverse direction, in this context there is an important complementary effect between these two energy sources. The determinative factor here can be considered as the effect the natural gas has on electricity as complementary good. When the price of electricity increases, share of natural gas in electricity production decreases.

The results obtained indicate that the electricity and natural gas are not substitutes of each other but they are complementary goods. [33] detected in his study that the electricity price had a negative effect on the total energy demand of service sector and industry sector in the cointegration model estimated for the period of 1985–2004.

Natural gas and petroleum used mainly as a production input for the industry sector can be subject to a substitute effect as using the cheaper one to the extend the production process allows. Also, the relationship between the Liquid Petroleum Gas (LPG) and natural gas is parallel to this. Because LPG pricing is parallel with the raw petroleum pricing mechanism, the changes in petroleum prices in the world markets are more apparent on LPG pricing and the pricing of natural gas (as defined before) is determined by terms and free from market conditions by the central government. It is seen that the petroleum prices have a positive effect on natural gas consumption. Because petroleum and natural gas are used as substitutes especially in industry, it is an expected situation that when the price of petroleum increases the natural gas which is the substitute is preferred by the consumers.

The relation between the natural consumption and the Industry Production Index used as the representative of the income variable in the equation is marked in positive direction as expected. On the other hand it draws attention that the price of natural gas has a negative effect, electricity and petroleum prices have a positive effect and income has the same positive effect on electricity demand.

When considered in terms of the electricity demand (second equation), the increase in the natural gas price decreases the electricity consumption. Energy plants particularly using natural gas as input are determinative and because the price of natural gas used as input is determinative on electricity consumption costs, the increase in the price of natural gas used in electricity energy production decreases the electricity consumption.

Contrary to the expectations the relationship between the price of electricity and electricity consumption is positive. In the periods in which the economies expand, the populations increase thus the energy demand increases, the consumption of electricity, which is used as the primary energy input, increases regardless of the direction the price changes. In addition to this, because of the developments in the technology and enhancements in the purchase power, household people use electrical appliances more and these results in the increase in the electricity consumption in spite of the increase in the price. In this point, it shouldn't be forgotten that the electricity is not in a structure that can be priced in the market and thus the price of which can change in accordance with the changes in the input costs but it is also a "good" the price of which is determined by the public. As in the pricing of natural gas, pricing in the electricity does not change according to the demand increase; it is determined "externally" by the public as a means of policy. Also it should be considered that the price of electricity was hold fixed in nearly 40% of the investigated data period.

Table 2 shows that there is a relationship in the same direction between the petroleum prices and the electricity consumption, petroleum price increases the electricity consumption. İt is known that petroleum prices usually increases in periods on which economies expand and energy demands increase. The consumption of electricity, which is related to the expanding in world economies (incomes of the exporting countries) through the export channel and which is affected by the price changes in the energy market through import in energy consumption increases. This increase occurs also in Turkey's economy in parallel to the global economic expanding periods (when the crisis years which are incidental and occurred only in the domestic economy are excluded from the analysis) both because of the increasing household income and increasing industry and services production. Therefore, increase in the petroleum price and increase in the electricity production occur in overlapping periods. That the electricity consumption in residents does not have a substitute results in no effect of electricity price on consumption. On the other hand, the increase in the petroleum price and income has an increasing effect on electricity consumption. [1] stated that even though the natural gas costs are not determinative on electricity price, its reflection on the costs of the company would be determinative (cost–pass–through) in the estimation of the cost of the electricity produced in the electricity generation plants, in other words, the reason why the relationship between the price and the consumption is not negative as expected in the theory is that the plants generating electricity by burning natural gas sell the electricity they produce without reacting the increase in the natural gas prices on a determined tariff.

IPIMA coefficient indicates that the increase in the income increases the electricity consumption of the individuals (both by using present electrical appliances and by purchasing new electrical appliances).

The results of the last model, which is the petroleum consumption model shows that the relationship between the price of natural gas and petroleum consumption is in the same way and the increase in the natural gas price increases the petroleum consumption. This situation seems to verify the substitute effect between petroleum and natural gas explained in the first equation. Petroleum consumption increases as a result of increase in the natural gas price and the end users (either household people or company sectors) increase their petroleum consumption as a result of this increase.

The relationship between the price of petroleum and petroleum consumption is in the same direction it may be reason of the period of increase in the petroleum demand occurs in the expanding periods of economies thus two variables increase in same term. Petroleum, one of the most important inputs of the production and trade thus demand of this resource increases free from the price. That the IPIMA, coefficient indicating the relationship between the income and the petroleum consumption.

CONCLUSION

In this study, the demands of natural gas, electricity and petroleum, which are the primary energy source in Turkey and in the world, were estimated using MVR model. The aforementioned energy sources were discussed in many studies yet the examinations conducted usually focused on a single energy source. In this study, the three energy resources were investigated together.

Because the three energy sources were the substitutes or the complementary goods of each other, a MVR model used to deal with these variables simultaneously. Therefore a method that was capable of such examination needed to be used. These requirements were met by using MVR model.

It was concluded that there should be different variables to be considered especially in petroleum demand. Yet these variables were to be specific to petroleum demand and wouldn't be used in natural gas and electricity demands, which were the other two models. As expected in all estimated models, the effects of the income variable on the consumption of all three energy resources were in the same direction. When the incomes of the consumers increased, their energy consumptions, which was a part of their social and economic lives also increased.

As a result of the analyses conducted, it was observed that the effects of energy prices in Turkey's energy market didn't meet the classic economic expectations but they developed in accordance with the economic structure of Turkey. In a newly constituting market such as natural gas market, demand and supply increased continuously with an increasing trend and therefore changes in the price didn't have an effect on consumption. In the electricity market, competitive market conditions still didn't develop and production became dependent on natural gas. Therefore the complementary good effect of the natural gas, which actually should have been a substitute energy resource, was higher than its substitute good effect. Turkey, which was among the fastest developing countries in the world used petroleum as a main input in production process and many by–processes of production (such as transportation) and therefore the effect of petroleum prices on its consumption decreased. Also, it is decided that in the petroleum demands occurred due to the illegal use and use of similar goods instead of petroleum, not due to the petroleum prices.

In the light of these findings, it is suggested that the energy market should become a market having a stronger market structure.

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