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ANKARA YILDIRIM BEYAZIT UNIVERSITY

THE INSTITUTE OF SOCIAL SCIENCES

THE DEPARTMENT OF ECONOMICS

MODELLING AND FORECASTING THE ENERGY DEMAND FOR TURKEY

PHD DISSERTATION

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DECEMBER 2018

MODELLING AND FORECASTING THE ENERGY DEMAND FOR TURKEY

A THESIS IS SUBMITTED TO

THE INSTITUTE OF SOCIAL SCIENCE

OF

ANKARA YILDIRIM BEYAZIT UNIVERSITY

BY

İSMAİL KAVAZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR

THE DEGREE OF DOCTORATE

IN

THE DEPARTMENT OF ECONOMICS

DECEMBER 2018

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I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work; otherwise I accept all legal responsibility.

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ABSTRACT

MODELLING AND FORECASTING THE ENERGY DEMAND FOR TURKEY

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PH.D., DEPARTMENT OF ECONOMICS

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DECEMBER 2018, 242 PAGES

This thesis analyses the elasticities of electricity and natural gas demand in Turkey in terms of sub-sectors and aggregate levels by using five econometric approaches, namely Engle-Granger Two-Step, Fully Modified Ordinary Least Squares, Johansen Cointegration, Auto Regressive Distributed Lag Bounds Testing and Structural Time Series Modelling method. In addition, by using the elasticity results and several scenario assumptions, Turkey's possible future energy demands are forecasted for all sectors up to 2025.

The results show that the price and income elasticities of industrial and aggregate electricity demand are lower than one in both short- and long-term. On the other hand, while the short-run residential income elasticities are also found as smaller than one, the long-run income elasticities are estimated as greater than one by conventional cointegration methods.

In terms of natural gas demand, while the industrial own-price elasticities are smaller than one in the short- and long-run, the residential and electricity generation sectors price elasticities are greater than one in absolute value, especially in the long-term. Furthermore, the electricity generation sector's own-price elasticities are found to be positive. In the context of income, on the other hand, the highest elasticities are estimated for the residential sector. Moreover, the short-term income elasticities of the industrial sector are greater than that of the long-term, whereas the exact opposite of this situation is observed in the residential and electricity generation sectors.

In this study, along with the elasticity estimations, the forecast results of Turkey’s electricity and natural gas demand are also presented. The reference scenario’s average estimations for the industrial, residential and aggregate electricity demand in 2025 are approximately 125 TWh, 97 TWh, and 345 TWh, respectively. Also, the average natural gas demands for the reference case are estimated as about 25 bcm, 22 bcm, 30 bcm and 90 bcm in terms of the industrial, residential, electricity generation sector and aggregate level, correspondingly.

The main motivation of this thesis is to compare the performances of several econometric techniques in modelling and forecasting Turkey’s energy demand. Considering the econometric methods used in this study, the Structural Time Series Modelling (STSM) method coupled with Underlying Energy Demand Trend (UEDT) concept has come into prominence, both methodologically and empirically. In addition, the prediction results of this approach are more stable than the conventional cointegration methods.

In summary, the conventional cointegration methods and STSM/UEDT approach are used in this thesis for modelling and forecasting Turkey’s energy demand in terms of electricity and natural gas. According to the findings of this research, in general, the STSM/UEDT method has given more consistent and significant results than other techniques. Consequently, since the STSM/UEDT approach uses a stochastic trend instead of the deterministic one, several factors that cannot be estimated by the conventional cointegration methods can be included in the model. In this way, the major structural changes in the energy demand trend can be determined. Therefore, for countries such as Turkey of which energy consumption changes over time, using the STSM/UEDT approach can provide advantages to observe the energy demand tendencies better.

Keywords: Energy Demand, Elasticity, Modelling and Forecasting, Turkey

ÖZET

TÜRKİYE İÇİN ENERJİ TALEBİ MODELLEMESİ VE TAHMİNİ

KAVAZ, İSMAİL

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ARALIK 2018, 242 SAYFA

Bu tez çalışması, Türkiye'de elektrik ve doğal gaz talebinin esnekliklerini Engle-Granger 2 Aşama (EG Two-Step), Tam Düzeltilmiş En Küçük Kareler (FMOLS), Johansen Eşbütünleşme (Johansen Cointegration), Gecikmesi Dağıtılmış Otoregresif Sınır Testi (ARDL Bounds Testing) ve Yapısal Zaman Serileri Modelleme (STSM) metotlarını kullanarak alt sektörler ile toplam seviyeler açısından analiz etmektedir. Ayrıca, esneklik sonuçları ve çeşitli senaryo varsayımları kullanılarak, Türkiye'nin gelecekteki olası enerji talebi tüm sektörler için 2025 yılına kadar tahmin edilmektedir.

Sonuçlar, sanayi sektörü ile toplam elektrik talebinin fiyat ve gelir esnekliklerinin kısa ve uzun dönemde 1'den az olduğunu göstermektedir. Diğer taraftan, konut sektörü gelir esneklikleri kısa vadede 1'den küçük olarak bulunurken, bu sektör için uzun dönem gelir esnekliklerinin geleneksel eşbütünleşme yöntemleri ile 1'den büyük olduğu tahmin edilmiştir.

Doğal gaz talebi açısından, sanayi sektörünün fiyat esneklikleri kısa ve uzun dönemde 1'den az iken, konut ve elektrik üretim sektörlerinin fiyat esneklikleri özellikle uzun dönemde mutlak değer olarak 1'den fazladır. Ayrıca, elektrik üretim sektörünün fiyat esneklikler pozitif olarak bulunmuştur. Öte yandan, gelir bağlamında ise en yüksek esneklikler konut sektörü için tahmin edilmiştir. Buna ek olarak, sanayi sektörü kısa dönem gelir esneklikleri uzun dönemden fazlayken, konut ve elektrik üretim sektörlerinde bu durumun tersi gözlemlenmektedir.

Bu çalışmada, esneklik hesaplamalarının yanı sıra Türkiye'nin elektrik ve doğal gaz talebinin tahmin sonuçları da sunulmaktadır. Referans senaryonun sanayi, konut ve toplam elektrik talebi için 2025 yılına ait ortalama tahminleri sırasıyla yaklaşık olarak 125 TWh, 97 TWh ve 345 TWh'dir. Ayrıca, yine referans durum için 2025 yılına ait ortalama doğal gaz talepleri sanayi, konut, elektrik üretim sektörü ve toplam seviye bakımından sırasıyla yaklaşık 25 bcm, 22 bcm, 30 bcm ve 90 bcm olarak tahmin edilmektedir.

Bu tezin ana motivasyonu, Türkiye'nin enerji talebinin modellenmesi ve tahmin edilmesinde çeşitli ekonometrik tekniklerin performanslarını karşılaştırmaktır. Bu çalışmada kullanılan ekonometrik yöntemler göz önünde bulundurulduğunda UEDT (Underlying Energy Demand Trend) konsepti ile birleşen Yapısal Zaman Serileri Modelleme (Structural Time Series Modelling-STSM) metodu hem metodolojik hem de ampirik olarak ön plana çıkmaktadır. Bununla beraber, söz konusu yaklaşımın tahmin sonuçları, geleneksel eşbütünleşme yöntemlerinden daha istikrarlıdır.

Özetle, Türkiye'nin enerji talebinin elektrik ve doğal gaz açısından modellenmesi ve tahmin edilmesi için bu tez çalışmasında geleneksel eşbütünleşme yöntemleri ile STSM/UEDH yaklaşımı kullanılmıştır. Bu araştırmanın çıktılarına göre STSM/UEDT yöntemi diğer tekniklerden genel anlamda daha tutarlı ve anlamlı sonuçlar vermiştir. Sonuç olarak, STSM/UEDT yaklaşımı deterministik yerine stokastik trendi kullandığından dolayı, geleneksel eşbütünleşme yöntemleri ile tahmin edilemeyen çeşitli faktörler modele dâhil edilebilir. Böylece, enerji talep eğilimindeki önemli yapısal değişiklikler belirlenebilir. Bu nedenle, Türkiye gibi enerji tüketiminin zaman içerisinde değiştiği ülkeler için, STSM/UEDT yaklaşımının kullanılması, talep eğilimlerinin daha iyi gözlemlenebilmesi bakımından avantajlar sağlayabilir.

Anahtar Kelimeler: Enerji Talebi, Esneklik, Modelleme ve Tahmin, Türkiye

TO MY FAMILY

ACKNOWLEDGEMENTS

First of all, I would like to express my sincerest gratitude to my supervisor, Prof. Dr. Erdal Tanas Karagöl, for his guidance, support and advices throughout my PhD study.

I also want to thank the thesis monitoring and examining committee members Prof. Dr. Ramazan Sarı, Prof. Dr. Murat Atan, Assoc. Prof. Dr. Fatih Cemil Özbuğday and Asst. Prof. Dr. Erhan Çankal for their helpful criticism and suggestions.

I would like to thank my wife, Şeyma Kavaz, for her support and efforts during this process. I also would like to thank my parents Leyla and İbrahim Kavaz for their valuable contribution and encouragement during my academic life.

Finally, I would like to extend my special thanks to all academic and administrative staff in Ankara Yıldırım Beyazıt University.

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LIST OF ABBREVIATIONS

ADF	: Augmented Dickey Fuller
AIC	: Akaike Information Criterion
ARDL	: Auto Regressive Distributed Lag
BCM	: Billion Cubic Meters
BOTAS	: Petroleum Pipeline Cooperation
ECT	: Error Correction Term
EG TWO-STEP	: Engle-Granger Two-Step
EMRA	: Energy Market Regulatory Authority
FMOLS	: Fully Modified Ordinary Least Squares
GWH	: Giga Watt Hours
IAEA	: International Atomic Energy Agency
IEA	: International Energy Agency
KPSS	: Kwiatkowski-Phillips-Schmidt-Shin
KTOE	: Kilo Tonnes of Oil Equivalent
KWH	: Kilo Watt Hour
MAED	: Model for Analysis of Energy Demand
MENR	: Ministry of Energy and Natural Resources
MW	: Mega Watt
OECD	: Organization for Economic Cooperation and Development
OPEC	: Organization of the Petroleum Exporting Countries
PP	: Phillips-Perron
PPM	: Parts Per Million
SIS	: State Institute of Statistics
SPO	: State Planning Organization

STSM	: Structural Time Series Modelling
TWH	: Terra Watt Hours
UEDT	: Underlying Energy Demand Trend
UNFCCC	: United Nations Conference on Climate Change
USA	: United States of America
ZA	: Zivot-Andrews

CHAPTER 1. INTRODUCTION

1.1. Introduction

Energy is used in all fields of life in today's world. Indeed, energy is one of the main components of social and economic progress from the early ages. Moreover, continuous and sustainable energy supply is necessary to achieve social and economic development. In this context, the energy consumption of societies has significantly risen together with the increase in income and social welfare. Therefore, one of the most important factors in meeting the need for energy is forecasting the future energy demand or consumption. In addition, elasticity estimates of energy demand can guide policymakers and consumers in taking their position to the price and income changes. In short, the calculation procedures of energy production and consumption trends are as important as energy itself.

Energy has started to be at the centre of the economic debates especially since the first oil shock in 1973. In this period, the oil-producing countries decided to increase the prices. As a result of this action, oil prices increased from 3.60 $/barrel to 12.21 $/barrel in two years (McMahon, 2017). This price increase in a very short period caused significant changes in the economies of oil-producing and consuming countries. While oil-producing countries earned high incomes, oil importing countries experienced a deep economic recession. After then, from 1979 through 1980, the world faced with the second oil crisis. Again, the Organization of the Petroleum Exporting Countries (OPEC) increased the oil prices. While the price was 14.95 $/barrel in 1978, it increased more than 65% and reached to the level of 25.10 $/barrel in 1979 and then went up to 37.42 $/barrel in 1980. Therefore, several developed and developing countries were faced with the international payment difficulties and finally external debt crises (Capistrano and Kiker, 1995).

On the other hand, in 1986, Saudi Arabia-led OPEC decided to decrease the oil prices for increasing their share of the oil market (Gately et al., 1986). The prices fell to the level of 12 $/barrel. In this instance, the price collapse caused great revenue losses for the OPEC. The prices have followed a fluctuation course up to 1990. In 1990, the Gulf War started. In this period, even though the oil prices increased slightly, they decreased one year later again to the level of 20 $/barrel. In the 1990s, the oil prices stayed stable between 15-20 $/barrel, except 1998. The Asian financial crisis occurred in 1998 and the effects of this crisis on the global energy markets caused to decrease the oil prices to 12 $/barrel.

In the 2000s, the upward trend of oil prices proceeded, until the global economic crisis in 2009. The US-based economic recession influenced the global economy in a short time and the international trade volume contraction occurred. For this reason, energy markets were also affected negatively, and the supply-demand equilibrium was destroyed. In 2014, on the other hand, the oil prices decreased by more than 50%. The first reason behind this situation is that the shale gas and oil industry in the USA has grown rapidly since the beginning of the 2000s, and recently the USA has increased the global oil supply. Therefore, the prices have decreased. Secondly, the OPEC decided to lower the production quota and expected to raise the price level. However, the economic slowdown in China caused to continue the downward trend of the oil prices.

Considering the issues mentioned above, the importance of energy demand studies become clear once again. Since societies become more energy dependent, estimating the energy production and consumption tendencies play a significant role for policymakers and actors in energy markets. Therefore, the number of energy demand studies have been continuing to increase since the first oil shock in 1973.

On the other hand, shocks or economic crises are not the only factors that affect the global energy demand. With increasing concerns about climate change and global warming, the energy consumption patterns have changed dramatically in the recent period. To organize these patterns, the policymakers of countries have cooperated and have taken decisions for the future of the world. The first serious attempt was the Kyoto Protocol, and 150 nations have entered into this agreement on December 11, 1997, in the United Nations Conference on Climate Change (UNFCCC). In 2009, the number of countries that signed the Protocol increased to 187 and 37 of these were developed countries. The representatives of countries committed to reduce Carbon Dioxide (CO_2) emissions to the amount that specified in the Kyoto Protocol by the end of 2012 (UNFCCC, 1998).

After the Kyoto Protocol, there were other attempts to develop the climate action plans around the world. The 2009 Copenhagen Summit, the 2010 Cancun Summit and, the 2011 Durban Summit can be shown as examples to these attempts. However, these meetings did not result in any legal obligations, and thus they can be qualified as unsuccessful summits.

In November 2015, the Paris Climate Conference was held in France with the participation of 195 countries and in November 2016, the Paris Agreement entered into force. The main aim of this agreement is holding the increase in the global average temperature to below 2 degrees Celsius above pre-industrial levels and limiting the temperature increase further to 1.5 degrees Celsius (UNFCCC, 2015). These obligations were accepted by all nations that were participating in the Conference for reducing the risks and negative impacts of climate change. The Secretary-General of the United Nations was determined as the Depositary of the Paris Agreement and was tasked with controlling the conditions of obligations determined by the countries.

The purpose of the above-mentioned agreements was qualified as limiting the global emission of greenhouse gas from mainly the consumption of fossil fuels. In this context, it can be said that the climate change problem is mainly related to energy consumption. In other words, the level of CO_2 emission in the atmosphere is closely linked with the climate change and global warming. In the recent period, the level of CO_2 in the atmosphere is more than 400 parts per million (ppm), and fossil fuel consumption plays an important role in this amount (WMO, 2017). Therefore, at the present time, the energy consumption patterns have been reconsidered by nations and organizations around the world.

There are several policies that discussing to reduce the primary and secondary fossil fuel consumption and greenhouse gas emissions. In the electricity generation industry, fossil fuels are commonly used, and as a result of this usage, the greenhouse gas emissions damage the nature. Therefore, to reduce the fossil fuel consumption especially in power generation, alternative and nature-friendly energy resources are encouraged to use. In recent years, the usage of renewable energy sources, such as wind, solar, geothermal and biomass are increased around the globe. In addition, there are attempts around the world to apply the carbon taxation models and to use energy efficiently. These policies should be paired with the energy demand since the consumption trends of energy are closely associated with these policies. In order to implement effective policies to reduce the CO_2 emissions, the structure of energy demand needs to be understood in detail. Therefore, the energy demand studies are not only significant for estimating the elasticities and predicting the possible future energy needs, but also for protecting the nature and minimising the damage of greenhouse gas emissions in the earth.

On the other hand, estimating energy demand is also important in terms of energy security and external dependency issues. The countries that are dependent on external energy resources are faced with the energy supply security problem. To overcome this issue, energy demand analyses should be done very carefully. Turkey's current energy dependency rate is almost 75%, and this condition generates politic and economic risks to the country. Therefore, the energy demand predictions must be made very sensitively in Turkey. In this sense, one of the main purposes of this thesis is to analyse energy demand trends in Turkey in terms of electricity and natural gas. By doing this, it is aimed to assist the policymakers in understanding the energy demand behaviour and possible future energy consumption in Turkey.

Electricity is one of the most preferred energy resources in Turkey as in the other countries and the demand for electricity has been growing due to the population growth, raising living standards, rapid industrialization, and economic progress. Therefore, the studies, especially in energy economics literature, focus on electricity demand trend in terms of estimating the elasticities and forecasting the potential of future consumption. In Turkey, the electricity generation process mainly depends on external energy resources, such as natural gas and imported coal. Therefore, the structure of electricity production affects the consumption behaviour in the country. Electricity production costs increase due to this high dependency on external sources in Turkey and the increase in price is directly reflected in final tariffs. In other words, the end-user bears the costs since the cost-pass-through principle is adopted in the electricity generation sector in Turkey. Consequently, the electricity sector should be taken up comprehensively to understand the structure and tendency of Turkey's energy demand. Therefore, this research investigates Turkey's industrial, residential and aggregate electricity demand in detail.

In addition to the electricity demand, the natural gas demand of Turkey is also examined in this study. Since Turkey is almost fully dependent to the external suppliers on natural gas, the demand analyses of the country should be performed in detail. In this context, public institutions, private energy companies, regulatory authorities and scientists are working on estimating reliable natural gas demand of Turkey. Therefore, it is aimed to analyse the industrial, residential, electricity generation sector and aggregate natural gas demand in this thesis.

In Turkey, energy demand studies have increased especially after the 1990s. These studies are categorized into three groups. In the first group, there are studies that investigate the causality relationships between energy consumption and economic indicators (Altinay and Karagol, 2005; Jobert and Karanfil, 2007; Soytas and Sari, 2007; Lise and Montfort, 2007; Erdal et al., 2008; Karanfil, 2008; Erbaykal, 2008). These studies mainly used methods such as Granger Causality, Vector Auto Regression, Johansen Cointegration and Vector Error Correction. In the second group of the energy demand studies, there are relationship researches. These studies analyse the relation among energy demand, the price of energy and income (Birol and Guerer, 1993; Bakirtas et al., 2000; Altinay, 2007; Erdogdu, 2007; Halicioglu, 2007; Dilaver and Hunt, 2011a, 2011b, 2011c; Arisoy and Ozturk, 2014; Yalta and Yalta, 2016). In addition, the magnitude of this relation is also examined. The methods that used in these studies are Engle-Granger Two-Step, Partial Adjustment, ARDL Bounds Testing, Structural Time Series Modelling and Time-Varying approaches. Finally, the prediction studies are located in the third group. These studies mainly focus on forecasting possible future energy demand (Yumurtaci and Asmaz, 2004; Erdogdu, 2007; Ediger and Akar, 2007; Bilgili et al., 2012; Kiran et al. 2012; Melikoglu, 2013; Boran 2015). The basic methods utilized in these studies are Grey Prediction, Genetic Algorithm, Artificial Neural Networks, Artificial Bee Colony Algorithm, Swarm Intelligence and Autoregressive Integrated Moving Average.

In this thesis, for comparing some of the above-mentioned econometric methods, Engle-Granger Two-Step (EG Two-Step), Fully Modified Ordinary Least Squares (FMOLS), Johansen Cointegration, Auto-Regressive Distributed Lag (ARDL) Bounds Testing, and Structural Time Series Modelling (STSM) approaches have been used. These methods have been applied to the electricity and natural gas sectors of Turkey. In terms of electricity demand, industrial, residential and aggregate electricity demands are analysed. On the other hand, the industrial, residential, electricity generation sector and aggregate natural gas demands are examined for indicating Turkey’s natural gas situation. In this context, this study aims to investigate Turkey’s electricity and natural gas demand trends with regards to both aggregate levels and sub-sectors. As far as is known, this study is the first attempt at analysing Turkey’s electricity and natural gas demands by using such different econometric methods together. Therefore, this thesis covers many aspects of Turkey’s energy demand modelling and forecasting researches since it considers different sectors and different energy types for Turkey. In addition, the results of this study provide valuable information to the policymakers, energy institutions, actors in the energy markets and scientists. In the next section, research questions and main aims of this study will be introduced.

1.2. Research Questions and Objectives of the Study

The main research questions within the context of elasticity estimations and predictions can be organized as follows:

In the context of elasticity estimations:

- What are the short-term price and income elasticities of electricity demand for Turkey?
- What are the long-term price and income elasticities of electricity demand for Turkey?
- What are the short-term price and income elasticities of natural gas demand for Turkey?
- What are the long-term price and income elasticities of natural gas demand for Turkey?
- Do the price and income elasticities vary across the methods that used in short- and long-term?
- Are there any advantages of using the STSM/UEDT concept rather than the conventional cointegration techniques?
- What is the main difference of using stochastic trend instead of deterministic one in terms of estimating elasticities of energy demand?
- What is the best method and the most convenient specification for estimating Turkey's energy demand models?

In the context of forecasts:

- What are Turkey's future sectoral and aggregate electricity demand?
- What are Turkey's future sectoral and aggregate natural gas demand?
- Do the prediction results differ based on the methods that used?

Given the research questions above, the main aim of this study is to find appropriate and consistent answers to these questions. Furthermore, to do so, it is necessary to obtain certain and reliable income and price elasticity estimates for Turkey's electricity and natural gas demand models. This condition is also very important to make accurate predictions of Turkey's possible future energy demand. In addition, one of the main reasons for using different econometric techniques is to compare the performances of these methods in estimating the electricity and natural gas demand of Turkey. Moreover, it is aimed to investigate the most appropriate method for modelling Turkish energy demand equations.

1.3. The Outline of the Study

The outline of the thesis is as follows:

Chapter 1: In this chapter, the importance of energy demand studies is given mainly in terms of climate change, energy security and energy dependency. The methods used in the energy demand literature and this study are mentioned briefly. Finally, the research questions and objectives of this thesis are listed.

Chapter 2: This chapter introduces the general concept of energy demand. The main determinants of energy demand (price and income) and the other determinants that affect the energy demand are explained. Furthermore, the methods of energy demand modelling in terms of different disciplines are given. The main characteristics of energy demand models are also showed in this chapter.

Chapter 3: In Chapter 3, the general energy situation of Turkey is given. Furthermore, the overview of Turkey's electricity and natural gas demand trends are examined on a sectoral basis.

Chapter 4: In this chapter, the empirical energy demand modelling literature is reviewed for both selected countries and Turkey separately.

Chapter 5: The methodologies that used in this thesis are given comprehensively in Chapter 5. In addition, the data that utilized are also introduced in here.

Chapter 6: The results of elasticity estimates and forecasts are presented in this chapter.

Chapter 7: The final chapter summarises and concludes the thesis. Answers to the research questions are shared in this chapter. Moreover, at the end of the chapter, inferences for policymakers and recommendations for the future research are discussed.

CHAPTER 2. ENERGY DEMAND

2.1. Introduction

Energy is crucial for modern economies. Especially in the industrialized countries, energy is needed for sustainable economic growth. For this reason, secure and continuous energy supply should be provided. In the case of insufficient generation of energy, economic activities would slow down, and life quality would reduce. In this context, it is necessary to produce sufficient energy resources to obtain economic and social development. Therefore, actors in the energy markets want to know the amount of energy that would be consumed. In other words, estimating the quantity of energy demanded is very important for countries, institutions, and individuals.

Energy demand is the quantity of energy required by individuals and institutions for the realization of consumption and economic activities (Adacay, 2014). Bhattacharya and Timilsina (2009) define energy as a derived demand. That is, energy is not demanded for its own sake. It is demanded for the services it provides like heating, lighting, and power. When considered from this point of view, energy is a demand for the services it generates with the capital stock at a certain period.

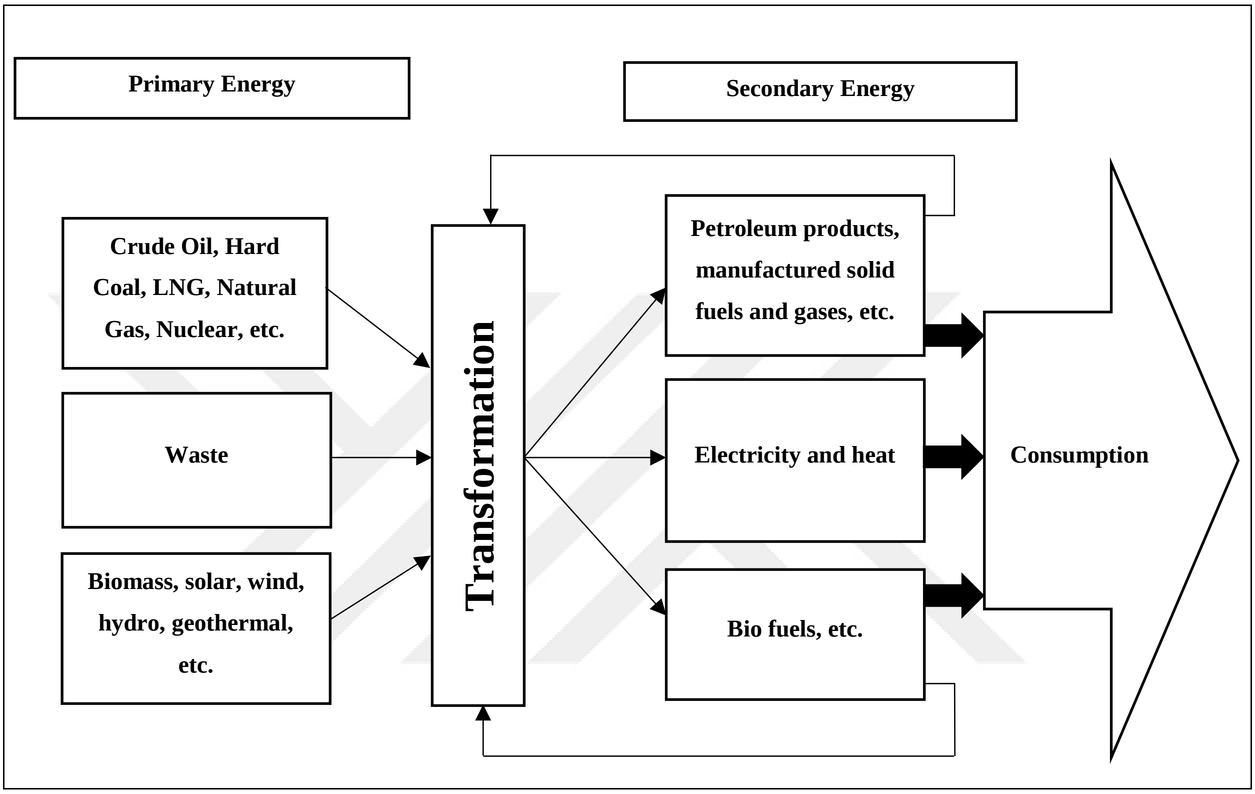
Indeed, energy demand is a wide concept that needs to be revealed before analysing the models used for demand estimation and prediction. In general terms, energy demand can be classified under two headings: the primary energy demand and the secondary energy demand.

The primary energy demand represents the country's total energy demand (such as the total quantity of gas, oil, coal, lignite, biomass, hydro and other primary energy sources used in the country). The primary energy demand is estimated as the final energy demand plus the demand for energy transformations, mainly for power generation (IEA, 2004).

The secondary energy demand is defined as the demand coming from end-use sectors, such as industry, transport, residential, services (public and commercial) and agriculture. The secondary energy demand includes the demand for electricity, natural gas, oil products, coal, biomass and so forth (European Environmental Agency, 2015). This energy demand depends on the economic structure, lifestyles and technological improvements in terms of energy efficiency.

The difference between the primary and secondary energy is summarized in Figure 2.1.

Figure 2.1. Difference between the Primary and Secondary Energy



Source: Øvergaard, 2008

The most important difference between primary and secondary energy is the transformation process which means changing the energy from one form to another. A primary energy source is obtained directly from natural resources. On the other hand, secondary or final energy source is captured from a primary energy source via the transformation process. For instance, natural gas, coal or renewable energy sources are classified as primary energy, which can be used for producing electricity or heat as secondary energy. After the transformation and secondary energy production operation finish then the consumption process can start.

As it is mentioned above, energy is an indirect demand, and it is demanded for providing benefits from its consumption. In terms of energy demand, individuals consume the secondary energy resources. In this regard, it can be said that individuals or institutions want to use the energy sources which they will utilize in terms of heating, transportation, production, etc. Therefore, the transformation process is very significant in the energy sector and without this process energy cannot be used in the daily life.

Like all kinds of demand for goods and services, there are factors, elasticities, and determinants that are affecting the energy demand in short and long terms. The most important ones of these determinants are price and income levels. In addition to this, technological improvements, the efficient usage of energy, and weather conditions have significant effects on energy demand (Bhattacharya and Timilsina, 2009).

In this chapter of the study, after briefly introducing the types of energy, determinants of energy demand are explained in detail in the context of price and income. After that, the energy demand modelling methods and the theoretical background related to this issue are given. Lastly, the summary section is presented.

2.2. Determinants of the Energy Demand

The traditional economic theory states that the demand for goods and services with given budget constraint and determined price can be generated by two reasons; minimize the costs and/or maximise the utilities. In terms of energy, while households demand it to maximize their utility, for producers it is an important factor for cost minimizing or profit maximizing. In fact, both cases (minimizing the costs and maximizing the utility) are interrelated in energy demand process. On the other hand, Jones (1994) indicates that even though the price and income variables affect the cost and utility (profit), there are other factors that determine the quantity of energy demanded, such as regulations, technology, efficiency standards, air conditions, consumer behaviours, population, expectations, etc.

Analysing energy demand depends on historical consumption trend and the connection of this trend with other indicators, such as economic, demographic, climatic, etc. (Egelioglu, 2001). In parallel with this argument, there are mainly two determinants of energy demand. First one is the price. Price of one good or service certainly affects the quantity of consumption. Therefore, the demand for energy sources responds to the price changes as well as all economic products. The second one, on the other hand, is income. Income is an important factor that determines the quantity of demand. Although other factors are affecting the consumption such as consumer behaviour, air temperature, and efficiency, the price and income are considered as the most significant variables of energy demand pattern.

It must be known that energy is a necessity good and it is compulsory to consume the energy in today's world. Because of this characteristic of energy, the price, income, and other factors on energy demand should be analysed in detail. The energy demand theory claims that price and income are two major determinants (Bohi, 2013). Therefore, in the next sections of the study, price and income variables of energy demand and the factors that are affecting these two determinants are introduced in detail.

2.2.1. Price

In economic theory, it is expected that an increase of one commodity's price decreases the demand of this commodity, ceteris paribus. The sensitivity in demand against the price changes is defined as the price elasticity of demand. In other words, assuming all factors on demand remain constant, the own-price elasticity of demand can be defined as the percentage change in quantity demanded in response to the change in the percentage of related product's price. In general, it can be said that there is an inverse proportional relationship between price and demand (Uddin and Sano, 2012).

The estimated elasticities can be classified into three categories (Mankiw, 2012). The price elasticity of demand is defined as inelastic if it is less than one in absolute term, as unit elastic if it is one and as elastic if it is greater than one. This classification reflects the demand behaviour of consumers on a good related to the price changes. For instance, if the demand elasticity is found as inelastic then the expenditure will be affected negatively to the price variations, or if the demand elasticity is elastic, then the expenditure will be influenced positively to the price changes.

On the other hand, cross-price elasticity can be identified as the estimation of the consumer reactions to the changes of the related commodity's price. In terms of the energy demand, the cross-price elasticity is considerably significant in determining the difference between substitutes and complements since various resources can be utilized for the same objective in the energy market (Mansfield, 1997). For example, the electricity can be produced by using natural gas, coal or renewable energy sources in the electricity generation sector. For this reason, the cross-price elasticity estimation is vital for the energy sector to decide which sources would be used or consumed.

Energy is a commodity and individuals change their attitudes based on the price signals. Hasanov (2015) argues that the price elasticities of energy sources affect the economy in many ways such as consumption trends and tax rates. Furthermore, the price elasticity is fundamental for arranging ideal tax rates on energy demand. Under this circumstance, it is expected that some economic parameters such as tariffs and incentives can have impacts on energy using behaviour and energy investments. Therefore, estimating reliable price elasticities of energy demand is crucial for all actors in energy markets. These actors take their position in response to price variations and want to maximize their utility. In this sense, developing an efficient energy market system is necessary to ensure the price stability and foreseeability. As a result, since price affects the energy demand, designing a properly arranged price mechanism is one of the major factors to create a reliable energy market.

On the other hand, there are also some other factors that affect the price changes in energy markets. For instance, technological changes have an important effect on the price. Energy efficient devices decrease the costs of energy and the usage of these kinds of devices increases in parallel with the technological developments. Therefore, the use of energy as efficiently affects the energy consumption and hence the relative prices of energy can change.

In addition, the sectoral differences have important impacts on energy prices. As it is well known, the price of energy differs from one sector to another. For instance, the price of electricity in the industry may be lesser than residential. Furthermore, the prices are sometimes transferred to the final consumer, such as in the electricity generation sector. The cost-pass-through principle is used in this sector, and the price is directly reflected in final tariffs. Therefore, when modelling the energy demand, sectoral differences should be considered carefully.

Moreover, the price elasticities can be different among sectors. Consumers in the residential sector may be more sensitive to the price changes than that of the other sectors, such as industrial and commercial. In addition, the type of energy can be a significant determinant in terms of price variations. For example, the price elasticity of electricity demand may differ than that of the natural gas. For these reasons, the outcomes of the demand models are interpreted by taking account of the sectoral structures and the types of energy that used.

Consequently, there are a lot of factors affecting the energy prices. Therefore, the above-mentioned determinants should be considered carefully while establishing the energy demand models. Since the price signals are significant for consumers to make their decision, causes for the price changes need to be followed closely in energy markets. In brief, the price is an important determinant of energy demand, and it affects the economy entirely in terms of policy implementations and planning strategies.

2.2.2. Income

Income is another major determinant of the energy demand. Changes in the income level affect the amount of energy consumption. From this point of view, the factors that are variating the income can be indirectly effective on the energy consumption. For example, the productivity level has an important impact on income, and thus the energy demand is naturally affected by it. In addition, population or changes in the population determines the demand for energy. Migration and active employed population are also considered as significant factors of energy demand. Furthermore, the government policies, such as income taxes and subsidies can change the amount of energy that demanded.

In addition, the factors, such as economic structure, consumer preferences, lifestyles, and future expectations have also a significant influence on the current income level. For instance, the aggregate energy demand can decrease in a country in the economic recession periods. Moreover, the consumption patterns of individuals or institutions can change due to the uncertainties. Even the lifestyles affect the energy using behaviour. Urban life force persons to consume energy in their daily life more than the people lives in rural areas. All these factors can determine the income level and also the amount of energy demand. Therefore, the energy demand theory states that while analysing the energy demand not only the income or price variables but also other determinants, such as technological progress, consumer tastes, economic structure and environmental regulations that affect the demand should be examined carefully (Dilaver and Hunt 2011a).

The income elasticity of demand states the relationship between income changes and quantity demanded. In other words, holding all other determinants of demand constant, the percentage change in the income level that affects the percentage change in the quantity demanded can be defined as the income elasticity of demand (Enz et al., 2009). If the income elasticity of goods is positive, then this commodity is identified as a normal good (Bhattarai, 2004). The normal goods consist of two parts such as necessity and luxury goods. A commodity is qualified as necessity goods when the income elasticity is between zero and one, and as luxury goods when the elasticity is greater than one (Haque, 2006). On the other hand, if the income elasticity of demand is negative, the goods are categorized as inferior goods, which means when the income increases, the demand for these goods decreases (McEachern, 2011).

The direct proportion of income on energy demand has been widely discussed in the economic literature. In general terms, an increase in the income level will cause an increase in the amount of energy demand. However, since the energy is defined as a necessary goods in today's world, a decline in the income level may not always lead to a decrease in the energy demand. Due to this reason, it is important to understand why this asymmetry appears when modelling the energy demand (Medlock, 2009: 96).

2.3. Modelling of the Energy Demand

Modelling the energy demand is highly important in terms of countries, institutions, and individuals. Therefore, there is a considerable amount of energy demand modelling studies in the literature. Since the first oil shock in 1973, energy demand modelling and forecasting studies have been developing, and the disciplines such as economics, econometrics, and engineering have made significant contributions in these fields (Wirl and Szirucsek, 1990).

Ryan and Plourde (2009) claim that there is no single 'right' method for energy demand modelling. On condition that the terms and key drivers of energy demand might change, the main strategy or motivation of modelling energy demand is to estimate the elasticities and to forecast the possible future consumption. Therefore, the variety of the approaches in this field enriches the literature and make significant contributions to the policies. The main methods of energy demand estimation can be categorized into two groups as econometric and engineering modelling.

The econometric modelling techniques are quantitative approaches. They use historical data to analyse the statistical relationship between dependent and independent variables based on the economic theory. In econometric techniques, the identified relationships can be utilized for analysing the past. In addition, the econometric approaches are preferable for measuring the possible changing effects of the independent variables on the dependent variable and for forecasting the future.

The econometric techniques, such as Engle-Granger, Fully Modified Ordinary Least Squares and Johansen methods have been frequently utilized in modelling and forecasting the energy demand in the period between 1980 and 2000. After the 2000s, the Autoregressive Distributed Lag Bounds Testing method which introduced by Pesaran et al. (2001) have started to use in the energy demand researches. Next periods, rather than conventional cointegration techniques, the models that considering the structural changes in the series are used in analysing energy demand. Hunt et al. (2000, 2003a and 2003b) introduced the Underlying Energy Demand Trend concept to Harvey's (1989) Structural Time Series Modelling method. In addition, Park and Zhao (2010) applied the Time-Varying Parameters approach firstly in the energy demand analyses. The main difference between these approaches and the conventional ones is using the stochastic trend instead of the deterministic trend when establishing the energy demand models.

On the other hand, there are remarkable studies on energy demand in the engineering discipline. In this field, the researchers have concentrated on predicting the future energy demand, and the elasticity estimates have been left aside. The main methods that used in the engineering area are fuzzy logic, artificial neural network, and grey prediction. As it is mentioned, these techniques are generally utilized for forecasting possible future energy demand rather than estimating the price and income elasticities.

No matter which estimation technique is used for evaluating, there are also some other dynamics of the energy demand modelling. Bohi and Zimmerman (1984) argued that energy demand models show differences regarding some characteristics as follows:

- The level of aggregation in the data can change the estimation results. In some industrial production processes, different energy resources are used. Establishing the energy demand models for these kinds of industries without separating or aggregating the energy resources may yield some misleading results. Furthermore, the data about electricity generation sector should be analysed in detail since different types of energy are used in this sector such as natural gas, coal, and renewables. Therefore, the aggregation level of the energy series should be considered carefully when modelling the energy demand.

- The second important identification problem in energy demand models is supply considerations. When modelling, it is significant to decide whether the model is for estimating supply or demand. Demand and supply are two determinants in the economy that closely related to each other. Therefore, in the demand models, some restrictions should be introduced in the equations to eliminate the influence of supply considerations. In other words, the selected exogenous variables should be included in the equation to separate the supply and demand effects on the model. By doing so, it is assumed that a perfectly elastic supply is obtained.

- Measurement issues are another characteristic of energy demand modelling process. For instance, heating and cooling degree days are significant in terms of electricity and natural gas demand. These measurements can give information about regional weather differences. Therefore, the energy demand may change from one place to another. In addition, the household's income data can be generated by earnings or expenditures, and in establishing the residential energy demand model, it is very important to distinguish the individual's income data. Furthermore, deciding the use of marginal or average value is another measurement problem in terms of the price variable. That is to say; the measurement issue is crucial in modelling energy demand.

- The functional form of energy demand models is another specific decision. Log-linear, linear and trans-log options are popular in econometric models. The log-linear models are suitable to give information about elasticities directly. On the other hand, the linear forms are mostly used in a single equation models and preferable to obtain the constant elasticities. As for the trans-log models, they mostly used in the demand systems since they are flexible functional forms. However, the trans-log models are static, and thus, it is unlikely to estimate the demand relationships among past, present, and future. For these reasons, before establishing the energy demand models, specifying the functional form is very important since it affects the results of the equations.

- The estimation techniques also make a difference in terms of energy demand models. The econometric methods use statistical techniques, while the engineering approaches utilize procedures, such as templates and bottom-up approaches. The variables and data types change based on the equation techniques. For instance, the econometric models use the historical data such as GDP, consumption, and population. On the other hand, the engineering techniques generally use the surveys or technical studies. Therefore, the results of different estimation techniques can be inconsistent with each other in many cases. Consequently, each discipline has its own techniques or rules and therefore, before starting the modelling procedure the estimation techniques should be decided carefully.

As it is understood from the features mentioned above, modelling and forecasting processes of the energy demand are crucial for all segments of the society, and thus, it is necessary to be very careful and sensitive while estimating the energy demand. In addition to that, Hunt and Witt (1995) state three reasons corresponding with the importance of estimating the energy demand. First, modelling the energy demand give information for the possible future energy consumption. Second, being aware of the amount of energy demand in an economy provides great convenience to the policymakers and third, knowing how much energy that being consumed is very significant for the climate and environmental agenda. In brief, predicting the energy demand is highly important in terms of knowing the future energy consumption, policy-making and environmental issues.

Furthermore, energy demand modelling and forecasting are very important in terms of energy security and planning the future policies. Energy is one of the fundamental drivers of economy and policymakers focuses on energy security issue for sustainable economic growth. The main point related to this issue is to access sufficient energy resources at a reasonable cost. In other words, whether or not the energy supply will be enough to meet the possible future demand at a reasonable price is one of the main questions that need to be answered in energy markets. Consequently, energy demand modelling process contributes to the long-term planning by developing strategies for the future energy consumption attitudes. At this point, the estimated elasticities are crucial for policymakers, consultant organizations, and scientists. Therefore, it is extremely important to estimate these values as precise as possible, since they are used in several policies, analyses, and long-term energy planning activities.

2.4. Summary

This chapter has examined the theoretical framework of energy demand modelling. In this context, the motivations and main determinants of energy demand are presented. Furthermore, the characteristics of demand models and the importance of estimation the energy demand are introduced.

The level of aggregation, identification problems, measurement issues, functional forms and equation methods are considered as the major dynamics of energy demand modelling. In the modelling processes of energy demand, the specification patterns are very significant since it affects the estimation results. A misspecified model can cause interpretation errors in terms of estimated elasticities. In addition, this estimation results can mislead the policies that will be applied. For instance, when the income elasticity is overestimated due to misspecification and because of this, the government might apply a high tax policy on energy consumption to decrease the demand for achieving the target of economic growth even though the tax is unnecessary. As a result of this policy implementation, the consumers will bear large costs which are not necessary, and policymakers will be affected in many aspects.

Energy is closely associated with the policies because it is very important in terms of economic and social development. Having information about possible future energy consumption would assist the form or determination of the policies. Not only the public but also the private sectors attach particular importance to energy demand modelling since they develop their strategies through the predicting results. The cost-benefit analysis of firms, the macroeconomic performance of energy importing countries and the budget planning of households are strongly correlated with energy or more specifically energy expenditures. Therefore, it can be said that the energy issues have somehow been examined by every segment of the society.

In addition to these, energy security and environmental issues have also been debated frequently within the context of energy policies. On the one hand, for sustained and continuous energy supply, the energy security factor plays a critical role. On the other hand, it is very important to figure out the balance between economic welfare and damaging the environment while using the energy sources. The choice of energy types that used is one of the key elements of this balance. In this sense, the significance of energy demand modelling arises once again. The relative price elasticity estimates can give some clues about the consumption patterns, and new policies can be developed for both short and long terms. For instance, the final decision for energy use might be made by taking into consideration the change in the relative prices of renewable energy sources and fossil fuels.

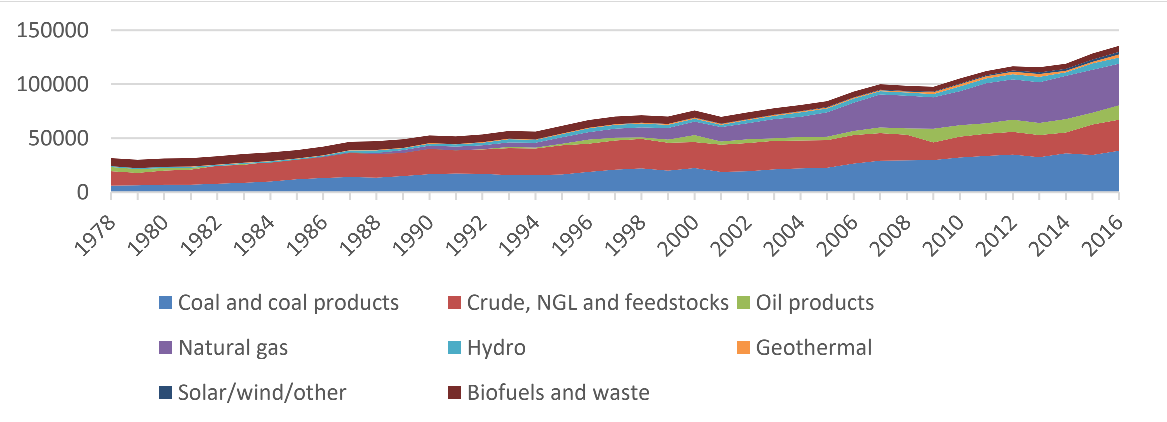
In short, the theory is extremely significant in terms of modelling and forecasting the energy demand since it shows the underlying facts of the policies. In addition, for the effective policies in energy markets, the convenient specification of energy demand models plays a crucial role. Therefore, the importance, features, and dynamics of energy demand modelling are focused in this part of the study to consider the issue from various aspects.

CHAPTER 3. OVERVIEW OF ELECTRICITY AND NATURAL GAS DEMAND IN TURKEY ON SECTORAL BASIS

3.1. Introduction

Developing countries primarily aim to provide sustainable, reliable, efficient, cost-effective and clean energy supply. In addition, for ensuring sustainable economic growth, energy policies are tried to be rearranged as effective as possible to provide sufficient energy supply to the sectors, such as industry, residential, public and private (Ediger and Tatlidil, 2002). In Turkey, as a developing country, the energy policies have been developed within the context of providing sufficient and reliable energy supply to support the economic and social development (MENR, 2014). In this regard, Turkey's domestic primary energy production has been shown dramatic changes since in the middle of the 1980s (Figure 3.1). Before the 1980s, the energy portfolio of Turkey mainly consists of coal, oil, and biofuels, whereas with the beginning of the 1990s, natural gas has started to use. Furthermore, the share of hydropower and oil products have increased in the primary energy production. On the other hand, the usage of biofuels and waste have been lowered gradually. Starting from the 2000s, energy production from renewable sources have shown an increasing trend in Turkey. Recently, the total primary energy production of Turkey is roughly 135000 ktoe.

Figure 3.1. Primary Energy Supply of Turkey (1978-2016, ktoe)

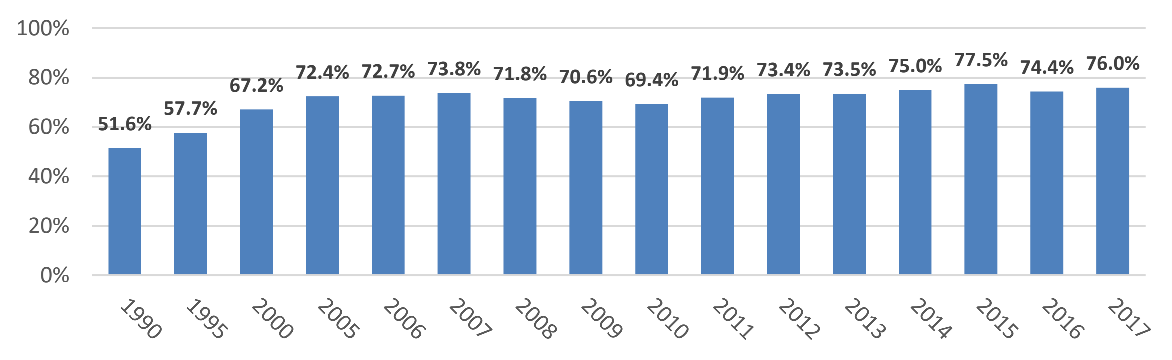


Source: IEA, 2017a

In addition, energy production by using the domestic resources is prioritized in Turkey to decrease the external energy dependence. However, the dependency rates are still very high (Figure 3.2). While the dependence on external suppliers ranges from 51.6% to 67.2%

between 1990 and 2000, it exceeded 70% in the 2000s. This share is approximately 75% in the recent period. In other words, the three out of four of Turkey's energy need is met from the external suppliers.

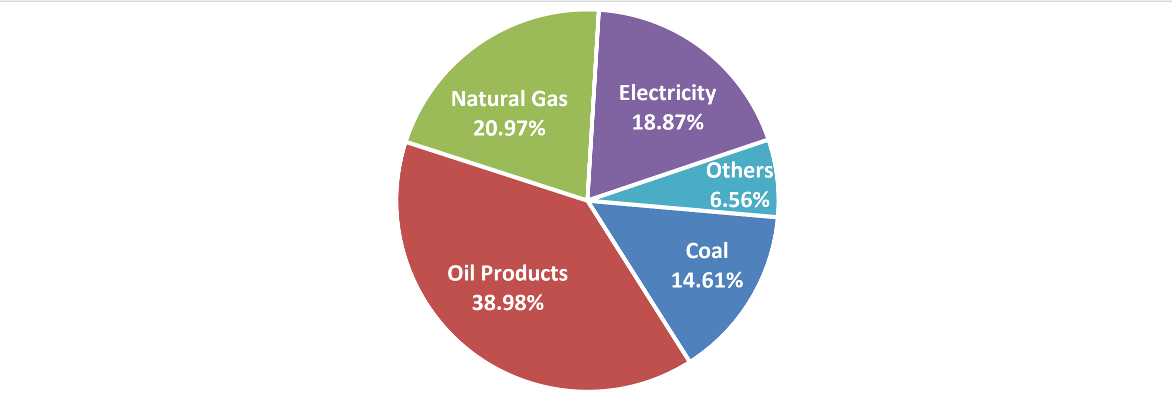
Figure 3.2. External Dependence Shares of Turkey's Energy Demand (1990-2017)



Source: MENR Balance Sheets

On the other hand, Turkey's total final energy consumption increased by 5% one year before and reached 104576 ktoe in 2016 (IEA, 2017a). In terms of energy types, the total consumption consists of 40765 ktoe (38.98%) of oil products, 21932 ktoe (20.97%) of natural gas, 19733 ktoe (18.87%) of electricity, 15282 ktoe (14.61%) of coal and coal products and 6864 ktoe (6.56%) of other energy resources (Figure 3.3). As it is seen, after the oil products, natural gas and electricity are two major energy types that consumed in Turkey, and thus, this study mainly analyses the electricity and natural gas demand.

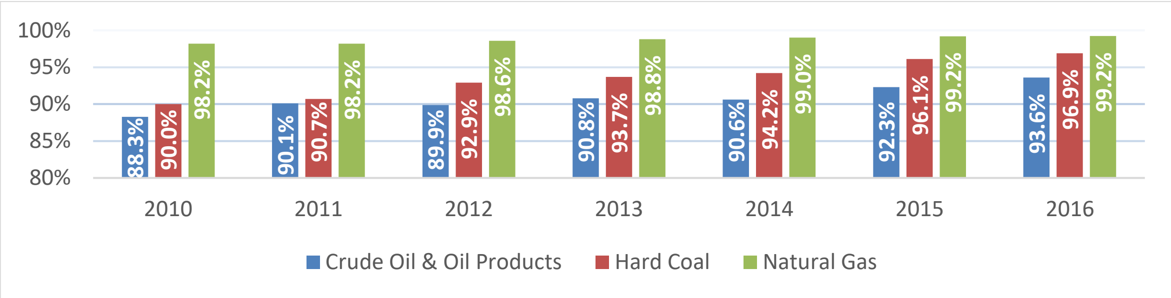
Figure 3.3. Total Final Energy Consumption Shares of Turkey by Energy Types (2016)



Source: MENR Balance Sheets

In terms of energy resources, the external dependence of Turkey arises mainly from three energy types: natural gas, hard coal, and oil products (Figure 3.4). The lack of fossil fuels is the most important factor in Turkey's dependency on external energy sources. Almost the whole of the natural gas demand of Turkey has been imported from foreign countries. Furthermore, 96.9% of hard coal and 93.6% of oil was supplied from abroad in 2016. In short, Turkey heavily depends on external resources in terms of natural gas, coal and oil products.

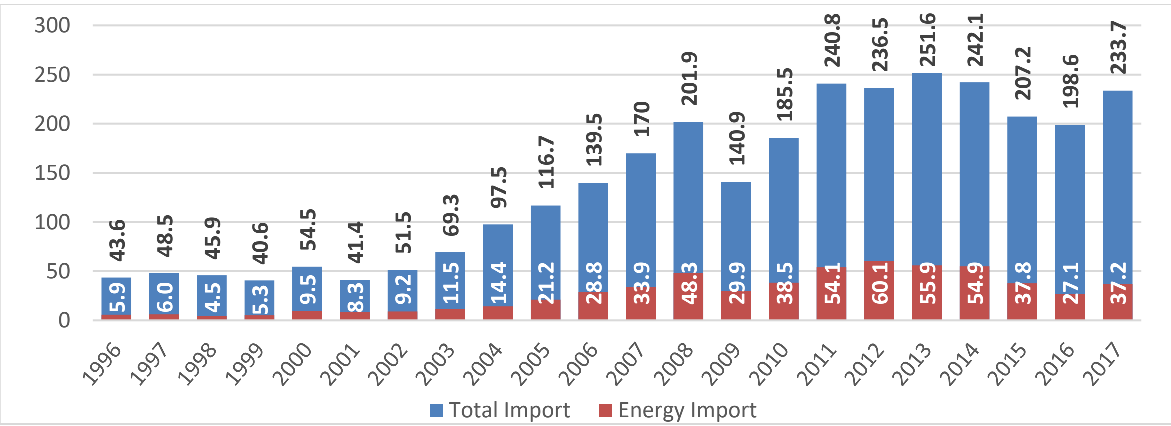
Figure 3.4. Turkey's External Dependence by Energy Resources (2010-2016, %)



Source: MENR Balance Sheets

The high level of external dependence on energy resources has caused significant pressure on the balance of the Turkish economy. The energy expenditures have increased the current account deficit of Turkey. In the period of 2011-2014, the energy expenditures of Turkey varied between 55 and 60 billion dollars and starting from 2015 this amount was decreased to the level of 37.8 billion dollars (Figure 3.5). One of the most significant factors decreasing the energy expenditures of Turkey in recent years is the reduction of the oil prices in the global energy markets. However, the amount of energy expenditure in Turkey's total imports is still considerably high, and these amounts consist the top values in Turkey's budget items.

Figure 3.5. The Amount of Energy Expenditures in Turkey's Total Imports (1996-2017, billion dollars)



Source: TURKSTAT

All in all, the energy infrastructure of Turkey is highly dependent on fossil fuels, and this situation leads to increasing external dependence on energy resources gradually. The share of external dependence that almost 75% causes energy expenditures to increase and thus the budget balance of Turkey is affected negatively.

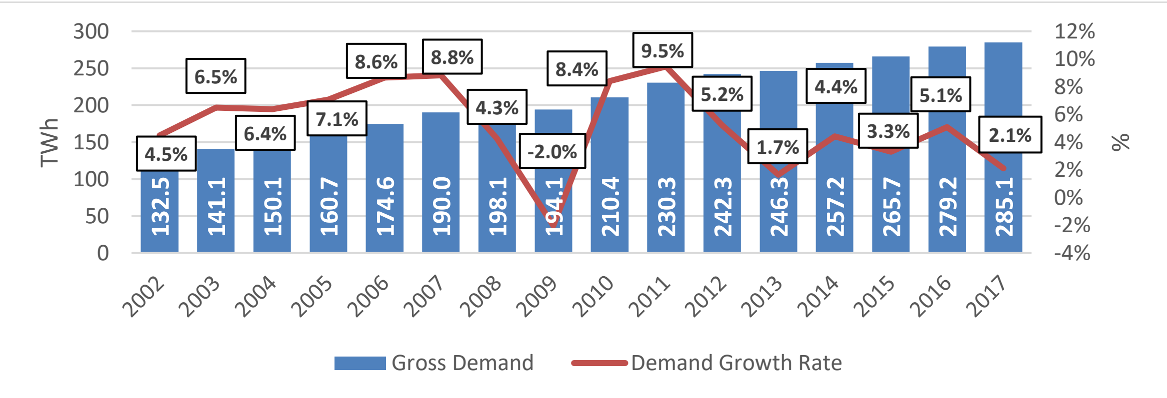
The existing general energy situation of Turkey has given in the above. In order to observe the sectoral structure in more detail, electricity and natural gas demand trends are introduced in the next sections.

3.2. Electricity Demand

Electricity is one of the commonly used energy types in Turkey. It is utilised in industry, residences, commercial, manufacturing, and transportation sectors. In other words, electricity, as an energy type, is used in almost all fields of life in Turkey as well as in the world. Therefore, the production, consumption and demand trends of electricity should be analysed very carefully.

Turkey's electricity sector has been developing especially since 2002. While the gross electricity demand was 132.5 TWh in 2002, it increased more than two times and reached the level of 285.1 TWh in 2017 (Figure 3.6). Although the demand growth rate has fluctuated in this period, the amount of gross demand has increased consistently except in the year 2009. In addition, the highest and lowest growth rates were observed in 2011 by 9.5% and in 2009 by -2%, respectively.

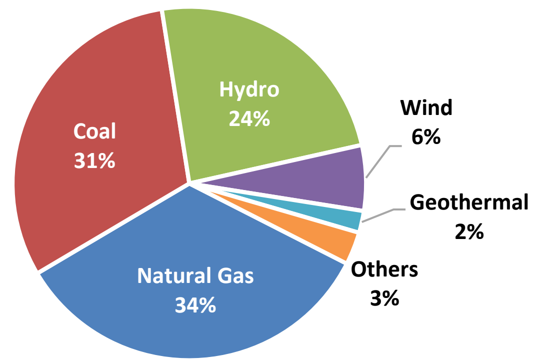
Figure 3.6. Turkey's Electricity Gross Demand Growth Changes (2002–2017, TWh, %)



Source: TEİAŞ, 2018

In parallel with the above demand trend, the electricity production of Turkey is estimated as 280.4 billion kWh by the end of November in 2017 which increased 2.2% more than the same period of the previous year (TEİAŞ, 2017b). In terms of the share of electricity production by primary resources, while natural gas is placed on the top by 34%; coal (31%), hydro (24%), wind (6%) and geothermal (2%) follow natural gas, respectively (Figure 3.7). That is to say; Turkey is particularly dependent on external energy resources to produce electricity.

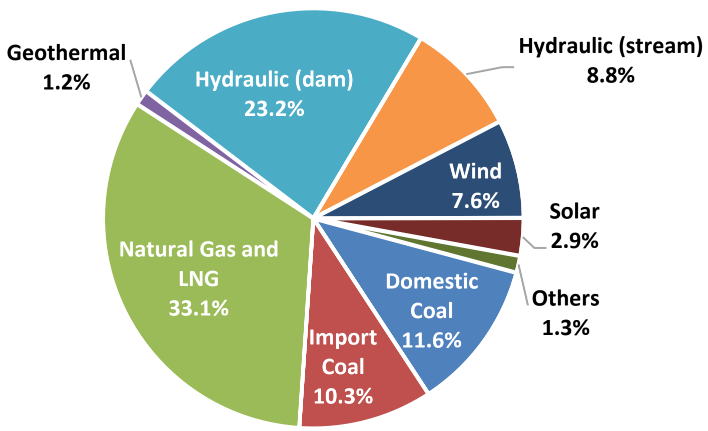
Figure 3.7. The Share of Turkey's Electricity Production by Primary Energy Sources



Source: MENR

Furthermore, the installed power was increased approximately 6700 MW in the recent year (2017). The greatest proportionately improvement was occurred in the field of solar power (from 819.6 MW to 3402.8 MW) as almost 420% (TEİAŞ, 2017a). However, the share of solar and renewable energy sources, as a whole, are still at low levels. Natural gas plays a critical role in the installed power of Turkey, and the share of natural gas was 33.1% of the total in 2017 (Figure 3.8). After natural gas, hydraulic power takes the second place by 32.0%. Thirdly, coal constitutes 21.9% of the electricity installed power.

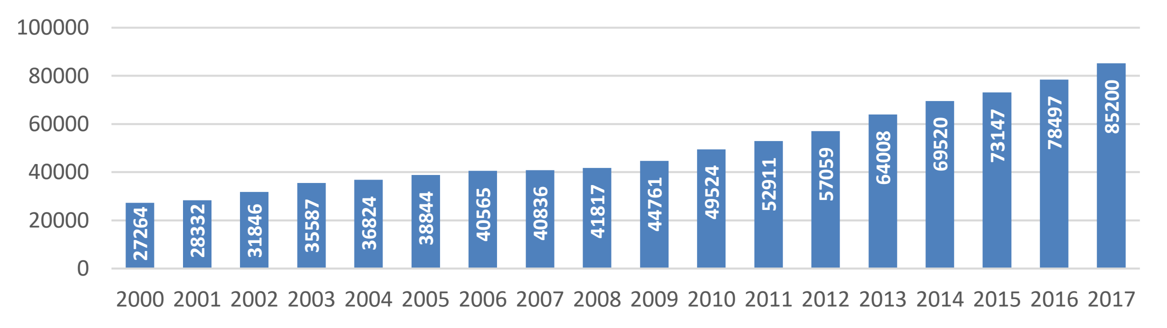
Figure 3.8. Electricity Installed Power of Turkey (2017, %)



Source: TEİAŞ, 2017a

Moreover, in 2017, Turkey's total electricity installed power was estimated as 85200 MW (TEİAŞ, 2017a). As it is seen from Figure 3.9, the development of installed power showed increasing trend progressively between 2000 and 2017. While the installed power of electricity was roughly 27000 MW in 2000, it has exceeded 85000 MW in 2017.

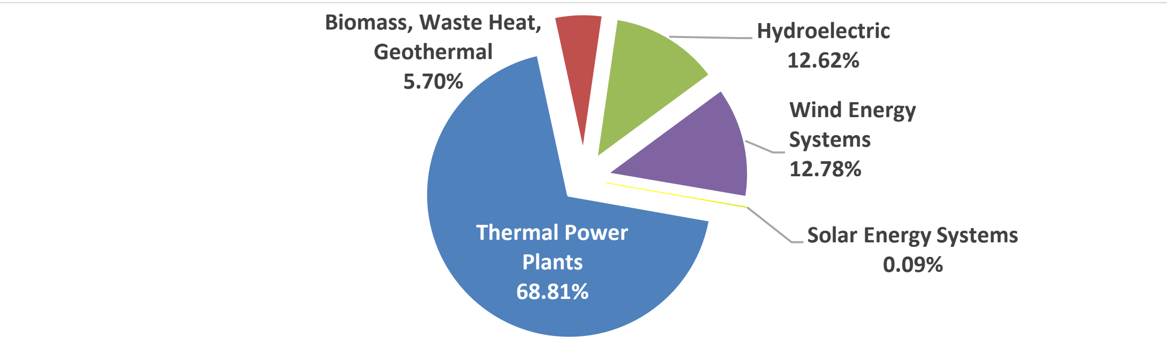
Figure 3.9. Development of Installed Power in Turkey (2000-2017, MW)



Source: TEİAŞ, 2018

In parallel with the above-mentioned developments in production, consumption and installed power capacity, the investments in the electricity sector were also increased in the recent years. In 2017, the electricity investments of Turkey have centred especially on thermal power plants. Almost 70% of the total annual investments were made in thermal plants (Figure 3.10). While the investment rates of hydroelectric (12.62%) and wind energy systems (12.78%) are close to each other, the amount of investment in solar energy systems (0.09%) is very little.

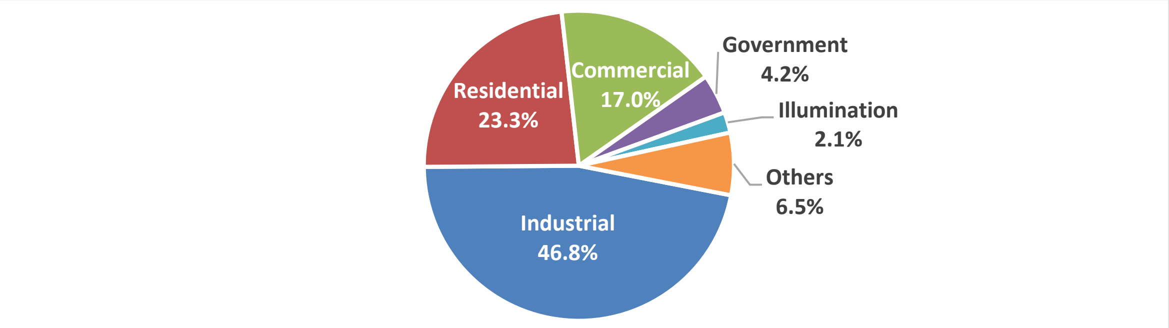
Figure 3.10. Electricity Investments of Turkey in 2017 (%)



Source: MENR, 2017a

Finally, since industrial, residential and aggregate electricity demand trends set the framework of this study, the information about them will be given below in detail. In terms of sectoral demand, industrial net electricity consumption consists 46.8% of total consumption with regard to ten years average (Figure 3.11). Furthermore, while on average 23.3% of the total electricity was consumed by the residential, that of 17% was used by the commercial sector. The rest of the ten years average net electricity consumption is made by the government (4.2%), illumination (2.1%) and others (6.5%). From this point of view, it can be said that industry is the most electricity consuming sector in Turkey and then residential, commercial sector, government, and illumination follow the industrial sector, respectively.

Figure 3.11. Ten Years Average Distribution of Net Electricity Consumption by Sectors (2008-2017, %)

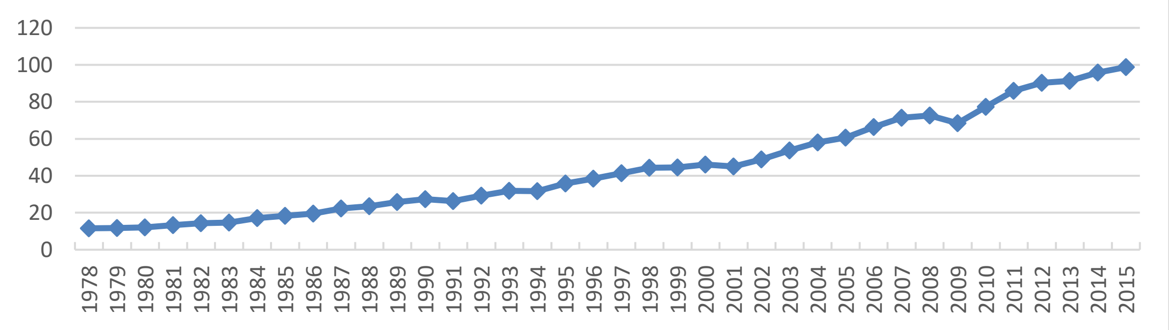


Source: TURKSTAT

3.2.1. Industrial Electricity Demand

The export-led growth policies were applied in Turkey after the 1980s and, thereby, the industrial sector in Turkey has had a significant change (Taban and Aktar, 2008). In parallel with this development, the industrial electricity demand increased continuously over the period 1978 to 2015 except in 2001 and 2009 (Figure 3.12). These two years were economic crisis periods in Turkey. Thus, the industrial electricity demand was affected negatively and decreased.

Figure 3.12. Turkey's Industrial Electricity Demand (1978-2015, TWh)



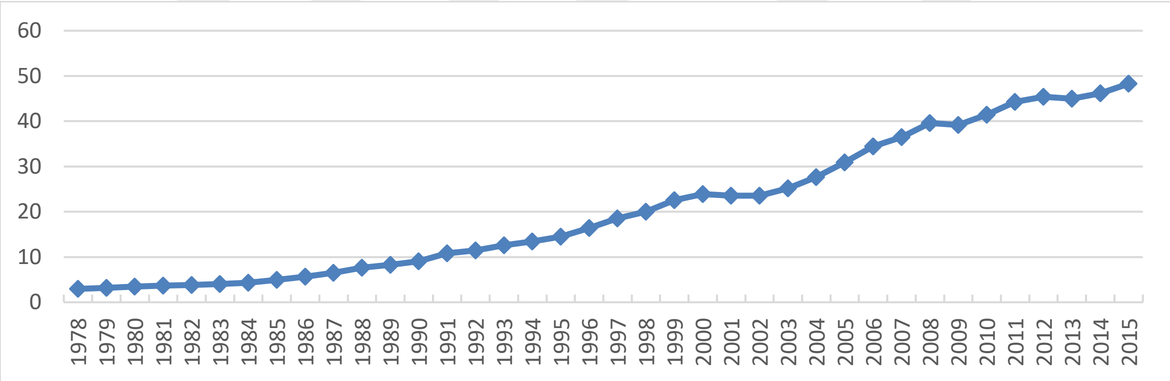
Source: IEA, 2017b

Turkey's total industrial electricity consumption was 98.7 TWh in 2015 which was increased almost ten times since 1980 (IEA, 2017b). On the other hand, while the share of industrial electricity demand on total electricity consumption was approximately 60% up to 1990, this share decreased to 45% level in 2015. This shows that instead of electricity, the usage of other energy sources, such as natural gas and coal was increased in the industrial sector over time.

3.2.2. Residential Electricity Demand

The electricity consumption trend in the residential sector was smoother than the industry sector in Turkey for the period between 1978 and 2015. In other words, there were no sharp increases or decreases in the residential sector's electricity consumption. The most remarkable change in residential electricity demand was seen after the 2000s. The usage of electricity in this sector was started to increase rapidly. While the residential electricity consumption was 23.89 TWh in 2000, it increased by above two times and reached the level of 48.29 TWh in 2015 (Figure 3.13).

Figure 3.13. Turkey's Residential Electricity Demand (1978-2015, TWh)



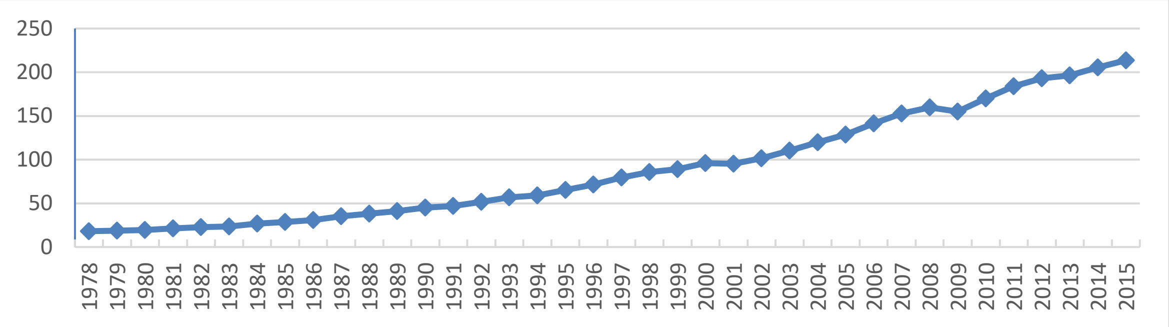
Source: IEA, 2017b

The share of residential electricity demand in total consumption was 16-17% in the 1980s. After the 1990's this share increased and reached approximately to 22-23% at the end of the examined period. In other words, more than one-fifth of total electricity consumption was made by households in recent years.

3.2.3. Aggregate Electricity Demand

An upward trend has been observed in aggregate electricity demand of Turkey as in industrial and residential sectors. The only decrease has been occurred in 2009 due to the economic recession during that period (Figure 3.14). The aggregate electricity consumption was estimated as 19.55 TWh in 1980, 44.96 TWh in 1990 and 95.89 TWh in 2000. Recently, it has exceeded 200 TWh and reached 213.57 TWh in 2015.

Figure 3.14. Turkey's Aggregate Electricity Demand (1978-2015, TWh)



Source: IEA, 2017b

The development in Turkey's electricity sector has been in line with the sustainable economic growth. Therefore, the policymakers concerned with the electricity sector not only for maintaining the economic growth but also for raising the living standards of the people. In this context, one of the main motivations of this study is assisting policymakers and actors in the energy market to understand the main features and key drivers of electricity demand trend for both past and future.

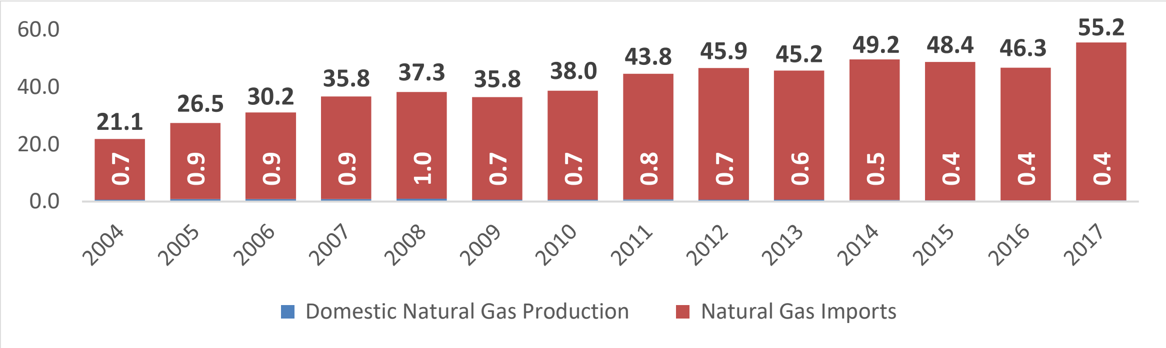
3.3. Natural Gas Demand

Natural gas is another important resource for Turkey's energy infrastructure. It is used in a wide variety of sectors such as, industrial, residential, electricity generation sector and transportation. Approximately 20% of Turkey's total final energy consumption consists of natural gas (for the details see Figure 3.3). However, the dependence of external natural gas resource is presently very high in Turkey. Almost all the required natural gas is imported from abroad (for the details see Figure 3.4).

Turkey's domestic natural gas reserves were first discovered in 1970, and the drilling activities were started in 1976 (EMRA, 2012). In the 1980s, new reserve areas were founded, and domestic natural gas production increased in Turkey. In the next periods, due to the reserve areas that found were not rich enough, the natural gas production could not meet the domestic demand. Therefore, tending to the external natural gas resources has started, and the first attempt of importing natural gas was made by the Russian Federation in 1986.

In Turkey, the coverage ratio of domestic production to total demand is approximately 1%. In other words, Turkey is almost fully dependent on the external suppliers in natural gas. For instance, while the domestic natural gas production was 0.4 bcm in 2015, 2016 and 2017, the amount of total natural gas consumption was much more than this production (Figure 3.15). This situation can be qualified as a major risk in terms of meeting the natural gas demand since Turkey's natural gas demand or consumption has a tendency to increase.

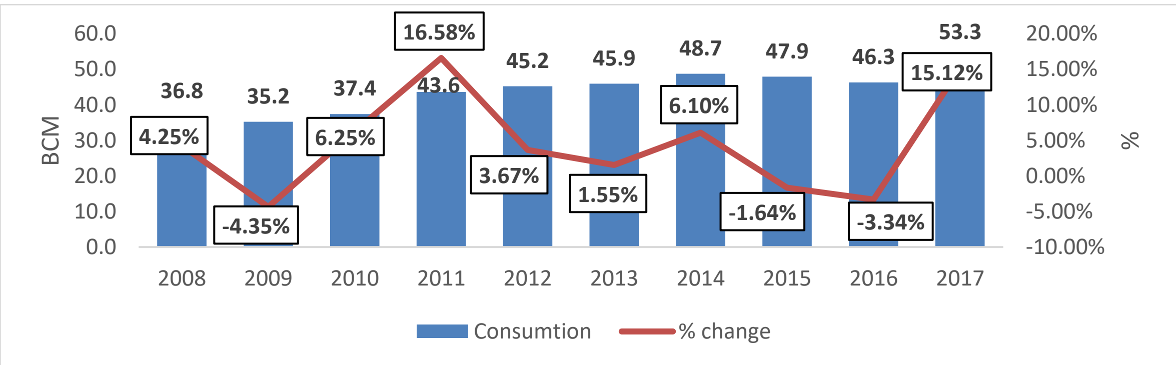
Figure 3.15. Turkey's Domestic Natural Gas Production and Natural Gas Imports (2004-2017, bcm)



Source: EMRA, 2018

As it is seen in Figure 3.16, the natural gas demand growth trend has followed a fluctuating course between 2008 and 2017. However, the consumption trend has generally increased. In 2011 and 2017 the demand growth reached the peak. In fact, Turkey has had the largest increase in energy demand growth rate among the OECD countries in the recent period (Toptas, 2015). From this point of view, it can be said that Turkey's demand for natural gas will increase in the future. However, as stated above, the high rate of dependency on external suppliers poses challenges in terms of Turkey's energy security and economic situation.

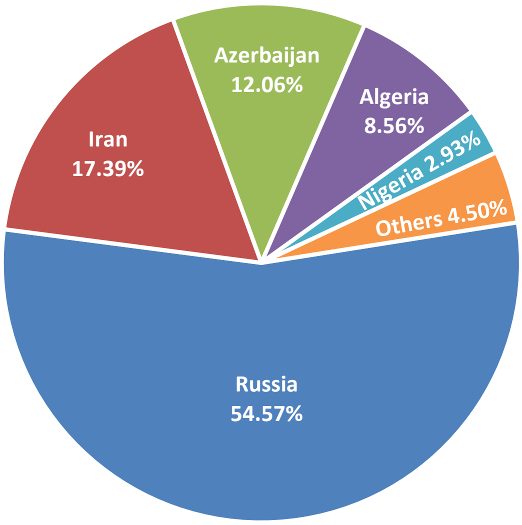
Figure 3.16. Natural Gas Demand Growth Changes of Turkey (2008–2017, bcm, %)



Source: EMRA, 2018

That being said, the country diversification in natural gas import is one of the most significant topics with regard to energy supply security. Natural gas importing countries want to minimize the risks by increasing the number of external suppliers. However, on average, Turkey has provided more than half of the total imported natural gas from Russia (Figure 3.17), which has one of the greatest natural gas reserves in the world. In addition, the transmission of natural gas from Russia to Turkey is cost-efficient. Therefore, Turkey demands the Russian natural gas more than the other suppliers. After Russia, Turkey has imported natural gas from Iran (17.39%), Azerbaijan (12.06%), Algeria and Nigeria (2.93%), respectively.

Figure 3.17. The Average Shares of Imported Natural Gas by Countries of Origin (2013-2017, %)

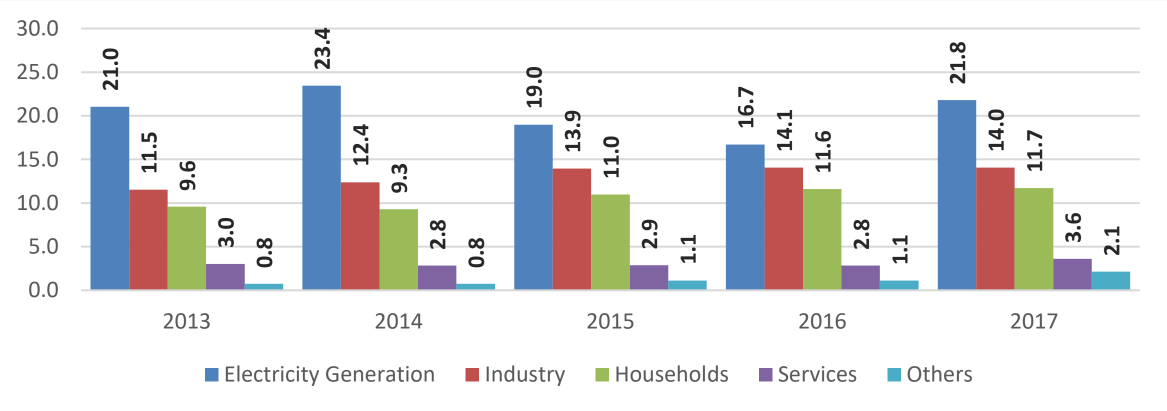


Source: EMRA, 2018

On the other hand, when sectoral natural gas consumption is considered the most remarkable outcome is seen in the electricity generation sector. The shares of natural gas consumption have been at the top level in generation electricity (Figure 3.18). In other words, natural gas has been mostly used in the field of electricity generation in Turkey (for the details see Figure 3.7). In industry, natural gas has been consumed between 11.5 and 14.1 bcm for the period of 2013-2017. Moreover, on average a total of 10-11 bcm natural gas have been used in the residential sector between 2013 and 2017. The services and other sectors have little share in Turkey's total natural gas consumption.

In this sense, to explain Turkey's sectoral natural gas situations in detail, the industrial, residential, electricity generation sector and aggregate natural gas demand trends will be given in the next section.

Figure 3.18. Turkey's Sectoral Natural Gas Consumption (2013-2017, bcm)

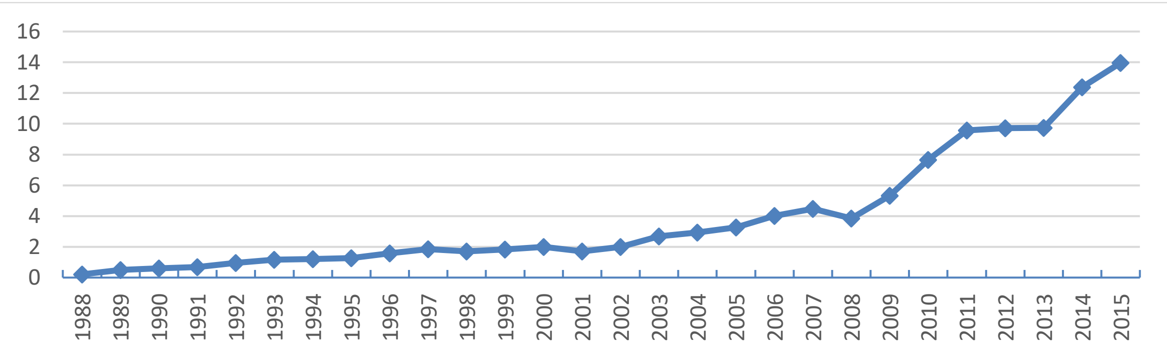


Source: EMRA

3.3.1. Industrial Natural Gas Demand

Natural gas is one of the major energy resources in Turkey and thus, it has been used intensively in the Turkish industrial sector. The first usage of natural gas in Turkey's industry was in 1982 (Demirbas, 2001). In the 1980s, the level of natural gas consumption was quite low in this sector. However, starting in 1990, the natural gas consumption has increased and reached almost 2 bcm in 2000 (Figure 3.19). After then, the upward trend has continued till 2015, except 2008. At the end of the examined period, industrial natural gas consumption reaches the level of 14 bcm.

Figure 3.19. Turkey's Industrial Natural Gas Demand (1988-2015, bcm)



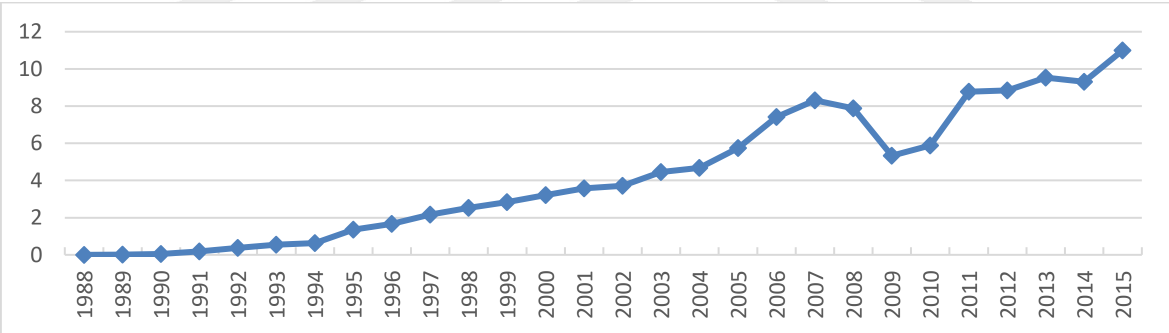
Source: IEA, 2017c

The share of industrial natural gas demand on total consumption was approximately 18% in the 1990s, and it decreased to 12.37% on average between 2000 and 2010 (IEA, 2017c). In 2011, this share reached the level of 20%, and in 2015 it approached 30%. In other words, in the recent period, nearly one-third of Turkey's total natural gas consumption is made by the industrial sector.

3.3.2. Residential Natural Gas Demand

Households usually consume the natural gas for heat generation. In Turkey, natural gas was firstly used in houses by the year 1988. Natural gas demand was accelerated in the residential sector after 1995 and achieved the level of 3 bcm in 2000 (Figure 3.20). This incensement in households' natural gas consumption continued up to 2007. Households were affected by the global economic crises in 2009, and the natural gas consumption decreased to 5.34 bcm in this period which is the level of 2004. After 2009, the recovery process was started in the economy, and so natural gas consumption trend gradually progressed upward again. In 2015, the Turkish residential natural gas demand reached 11 bcm.

Figure 3.20. Turkey's Residential Natural Gas Demand (1988-2015, bcm)



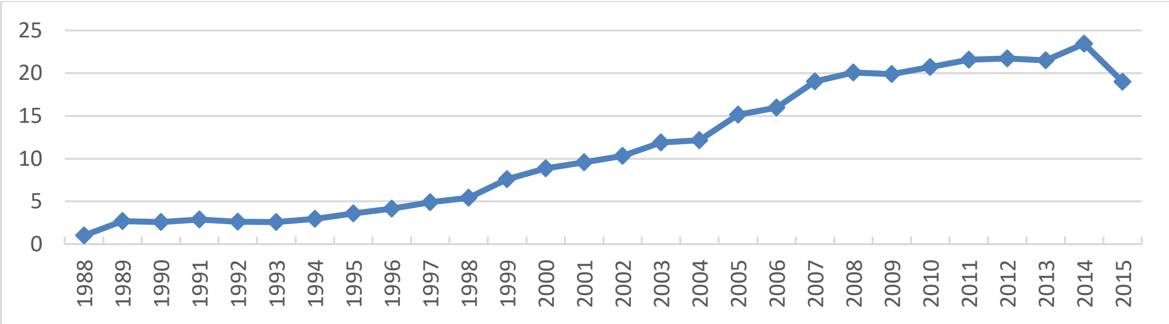
Source: IEA, 2017c

Households consume approximately 20% of the total natural gas in Turkey (IEA 2017c). This share was 10% at the beginning of the 1990s and then reached the level of 20-25%. In 2009 and 2010 while the share of residential natural gas demand on total consumption decreased to 15%, it again increased to 20% level in the recent period.

3.3.3. Electricity Generation Sector Natural Gas Demand

Natural gas is the most commonly used energy resource in Turkey's electricity generation sector. By the end of the 1990s, the natural gas consumption was below 5 bcm, and it reached 15 bcm level in the middle of the 2000s (Figure 3.21). As for the 2010s, the natural gas demand on electricity generation sector increased to 20 bcm and this level has been preserved in the recent years.

Figure 3.21. Turkey's Electricity Generation Sector Natural Gas Demand (1988-2015, bcm)



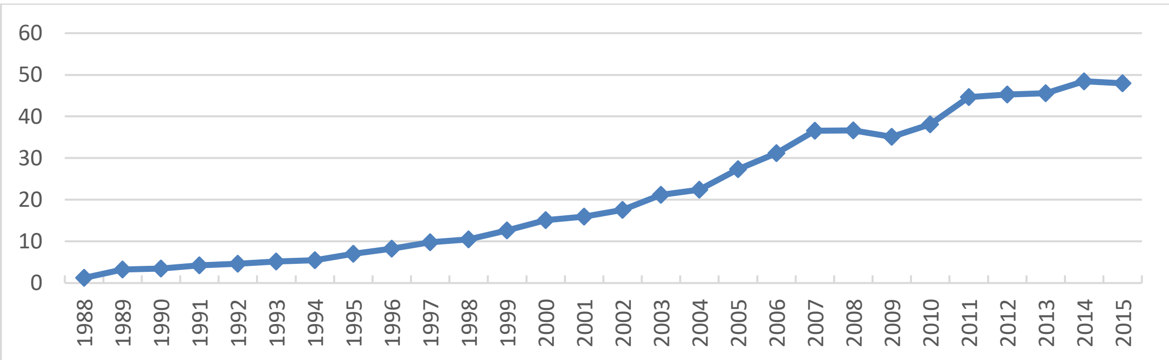
Source: IEA, 2017c

In the 1980s, almost all of the produced or imported natural gas was used in the electricity generation sector. Starting from the 1990s, this share decreased, and recently it remains at the level of 45-50% (for the details see Figure 3.18). The high share of natural gas usage in Turkey's electricity generation is wanted to decrease since it is imported from abroad and policymakers have given priority to generate energy by local resources.

3.3.4. Aggregate Natural Gas Demand

In general, Turkey's aggregate natural gas demand showed an increasing tendency for the period of 1988-2015. The only fall in natural gas consumption occurred in 2009. (Figure 3.22). At the end of the examined period (in 2015), Turkey's total natural gas consumption reached the level of 50 bcm. This amount indicates that the total natural gas demand increased more than two times in ten years.

Figure 3.22. Turkey's Aggregate Natural Gas Demand (1988-2015, bcm)



Source: IEA, 2017c

The large majority of this natural gas demand has been met by external resources, and it can be said that this situation is not sustainable. In this context, national energy policies have been applied in Turkey, and high dependency on external natural gas resources has been wanted to decrease as soon as possible. This high dependency is not only risky in terms of energy supply security but also generates pressure on Turkish economy because of excessive energy expenditures.

3.4. Summary and Conclusion

This chapter presents the current energy situation in Turkey in terms of electricity and natural gas. These two energy types are analysed since they are the main topics of this thesis. In this regard, electricity and natural gas production and consumption trends in Turkey are introduced in detail. Furthermore, the energy dependence of Turkey and the possible negative outcomes of this dependency on the Turkish economy in terms of energy expenditures are given.

Turkey is dependent on external sources in energy at the rate of approximately 75%, and this circumstance affects the Turkish economy negatively because the energy expenditure of Turkey is about 45 billion dollars on average in last ten years. In terms of energy resources, Turkey is almost fully dependent on the external suppliers of natural gas, hard coal, and oil products. Therefore, both economically and politically, Turkey's security of energy supply is under some risks.

On the other hand, national and domestic energy policies have recently been implemented in Turkey. Domestic resources, such as renewables and local coal have been encouraged to use in order to decrease Turkey's external energy dependency. In addition, projects have been developed to bring the potential of nuclear energy into the Turkish economy. Furthermore, exploration and drilling works have been promoted to increase the potential of domestic oil and natural gas reserves in Turkey. All these activities have been done for decreasing energy dependency on external sources, providing the security of energy supply, increasing the use of domestic resources and consequently ensuring the sustainable economic growth in Turkey.

In this context, the prominent energy policies of Turkey for decreasing the external dependence, providing the security of supply and ensuring the sustainable energy provision can be summarized as follows:

- Increasing country diversification on imported resources: More than half of the natural gas imports of Turkey is provided by Russia. This high dependence on a single supplier not only being risky in security of energy supply but also having negative effects on price stabilization.

- Increasing transfer diversification of imported resources: It is necessary for Turkey to import energy sources not only via pipelines but also the derived sources, such as LNG for providing the security of supply and meeting the demand in peak periods.

- Encouraging the domestic energy production and consumption tendencies in the country: Turkey is aiming to increase the usage of domestic sources, such as local coal, nuclear and renewable energy instead of imported resources as a part of localization strategy.

- Finally, being an "energy trade hub": Turkey ties together the producers and the demanders of the energy resources as a natural bridge. The geographical location of Turkey provides advantages in terms of being a trade centre and eliminates the disadvantages of being lack of fossil resources.

As a result of these policy implications and the strategies that followed, the Turkish energy infrastructure has been developing. In this sense, the current conditions of Turkey's electricity and natural gas sectors are analysed specifically in this chapter, related to the main subjects of this thesis.

In the electricity sector, one of the main developments is seen in the installed power. While the electricity installed power was about 27000 MW in 2000, it increased more than three times and reached 85200 MW in 2017. In addition to this, Turkey's gross electricity consumption increased from 132.5 TWh to 285.1 TWh between 2002 and 2017. Considering that the share of energy types on electricity installed power; natural gas, hydraulic power, coal and renewable sources have come into prominence in recent years. Hence, the electricity investments in Turkey has concentrated on thermal power plants over the last years. However, the investments in renewable energy resources, such as solar and wind have also increased recently. In terms of the sectoral energy demand, on the other hand, the industrial sector has consumed the majority of total electric energy in Turkey. Moreover, the residential sector, commercial sector, government, and illumination are situated in the second, third, fourth and fifth places, respectively, following the industrial sector.

In the natural gas sector, the projects regarding of being energy trade hub have been proceeded on the one hand, while the storage and exploration activities have been carried out on the other hand. Approximately the 20% of Turkey's total final energy consumption is met by natural gas. The natural gas demand of Turkey has reached nearly to 55 bcm in 2017, which was at the level of 20 bcm in 2004. This means that the natural gas demand has been increasing in the recent period. Moreover, almost one-fifth of the total natural gas has demanded in the electricity generation sector in Turkey. The rest has consumed in the industrial sector, residential sector, services sector, and other sectors, correspondingly. On the other hand, the external dependence on natural gas is very high in Turkey. The 99% of total natural gas supply is imported from foreign suppliers. In addition, Turkey has imported the majority of natural gas that needed from Russia. This situation causes a number of risks and disadvantages in terms of energy supply security, economic instability, and political independence.

In brief, Turkey's last period energy strategies can be specified as reducing external energy dependency, ensuring energy supply security, increasing resource diversity, encouraging the use of domestic and renewable energy resources, providing sustainable energy supply and becoming an energy trade centre. Moreover, these strategies affect many areas in Turkey, such as the economy, prosperity, security, and policy. Therefore, Turkey is expected to act in accordance with the national interests on behalf of reorganizing the political and economic stability in the region. Within the scope of these policies and strategies, Turkey will decisively achieve its future targets.

CHAPTER 4. LITERATURE REVIEW

4.1. Introduction

After the first oil shock in 1973, the importance of energy for the economies has begun to be understood better by the individuals and institutions. Since then, there have been remarkable improvements especially in the field of energy demand researches to formulate energy policies and to analyse their impact on economies (Bhattacharyya, 1996). Wirl and Szirucsek (1990) indicated that not only economists but also engineers made an important contribution to the energy demand literature and due to the efforts of the scientists in this area, energy demand modelling and forecasting studies have been showing a significant development.

According to Bhattacharyya and Timilsina (2009), energy demand is a derived demand that it is not demanded for its own sake. Individuals and institutions demand energy for the services it produces. Therefore, the energy demand depends on the type of energy used in appliances. In addition, it can be affected by some other factors such as; the price of energy type, the cost of device, income, preferences, demand for energy substitutes, etc. (Bohi, 2013). For this reason, when analysing energy demand, the fields that it is demanded and the factors that it is influenced should be considered carefully.

Since the early 1950s, the econometric techniques have been started to use in modelling and forecasting energy demand. The first studies in this area are Houthakker (1951), Fisher and Kaysen (1962), Wilson (1971), Halvorsen (1975) and Pindyck (1979). These studies were mainly focused on electricity demand. In addition, the studies related to energy like determining the causality between energy consumption and economic growth were started with the early work of Kraft and Kraft (1978). Indeed, Kraft and Kraft (1978) can be classified as the introduction of cointegration analyses. After the paper of Engle and Granger (1987), besides the analyses using econometric approaches, the cointegration, and causality studies increased in both energy demand and energy-growth nexus.

The importance of energy demand, in terms of developed and developing countries, still holds the validity in both theoretical and empirical literature. Over the last decades, many empirical studies have examined the impact of energy on countries' economic development by different methods. Some selected studies will be mentioned in the next pages.

In this chapter, a selected literature review related to energy demand modelling will be presented. Econometric modelling techniques will be used in this thesis, and thus the studies used econometric approaches will be examined in more detailed. Furthermore, researches about energy demand conducted in the engineering discipline will be mentioned briefly. The structure of this chapter is as follows. Firstly, the selected previous electricity demand studies will be presented, and then some natural gas demand studies will be discussed. After this, the studies related to gasoline demand will be reviewed briefly and finally aggregated energy demand studies will be mentioned. Summaries of the studies will be presented below in Table 4.1, Table 4.2, Table 4.3 and Table 4.4. At the end of this chapter, previous energy demand studies for Turkey will be introduced, and a detailed summary of these studies will be presented in Table 4.5. Finally, in section 4.7, the summary of the chapter will be given.

4.2. Electricity Demand Studies

One of the first studies in the field of energy demand analysing belongs to Houthakker (1951), in which the British residential electricity demand was examined. He used cross-sectional observations on 42 provincial towns and investigated monthly changes in power generation for the period of 1937-1938. Income and price elasticities were found as 1.17 and -0.89, respectively, by employing a double-log model. Different from Houthakker's (1951) paper, Fisher and Kaysen (1962) examined both industrial and residential sector and also, they analysed the short- and long-run energy demand in these sectors. Fisher and Kaysen (1962) showed the differences between the income and price elasticities in short- and long-term for the United States in their study. In the short-run, the effects of two factors (income and price of electricity) on energy consumption were estimated. In the long-run, besides income and price of energy, the other factors like the stock of consumer appliances were analysed (Fisher and Kaysen, 1962). They used multiple regression and covariance analysis techniques to estimate the price and income effect on electricity demand for the period of 1946-1957. Eventually, Fisher and Kaysen (1962) found the short-run price and income elasticities between the range of -0.16 to -0.25, and 0.07 to 0.33, respectively. As a conclusion, the authors indicated that non-economic factors are as important as economic ones in terms of energy demand, and the effect of price on energy demand decreases gradually.

Wilson (1971) designed a static equilibrium model for 77 cities of the US to analyse residential electricity demand and demand for 6 different categories of appliances between 1960 and 1970. He used cross-sectional data to estimate the effects of households' attitudes and prices on electricity consumption patterns. Wilson (1971) found the long-run price and income elasticities as -1.33 and -0.46, respectively. He concluded that price is the main factor of households' demand for electricity. On the other hand, Halvorsen (1975) employed two-stages least squares model to estimate the structural demand and price equations for nearly the same period (between 1961 and 1969) as Wilson (1971). He also focused on price and income elasticities of residential electricity demand. He found the own-price elasticity of electricity demand within the range -1.00 to -1.21, which shows that the long-run price elasticity was nearly one. On the other hand, Halvorsen (1975) estimated the direct income elasticities between 0.47 and 0.54. These results demonstrate that the price elasticity of residential electricity demand is equal to at least one, and this shows in contrast to the general hypothesis that the demand is not responsive to the price. The common point of the above studies is that they all used aggregate data sets (state or city level). After the 1980s, energy demand studies have utilized aggregate data sets as well as disaggregate series.

Beenstock et al. (1999) analysed the period between 1962 and 1994 with quarterly time series data. They used a dynamic regression model and cointegration analysis to estimate the electricity demand for the industrial sector in India. By employing different techniques, Beenstock et al. (1999) found long-run income and price elasticities of 0.99 to 1.12 and -0.31 to -0.44, respectively. Bose and Shukla (1999), on the other hand, estimated the elasticities of electricity demand in India with respect to different sectors, such as; residential, commercial, agriculture, and different size of industries (small, medium and large). They used time series data between 1985 and 1994 for analysing the electricity demand trends of 19 states in India. The income elasticities varied: 1.27 in commercial sector, 1.06 in large industries, 0.88 in residential sector, 0.82 in agricultural sector, and 0.49 in small industries, while the price elasticities were -1.35 in agriculture sector, -0.65 in residential sector, -0.26 in commercial sector, -0.32 in industrial sector (Bose and Shukla, 1999).

Handroyiannis (2004) investigated residential electricity demand for Greece by using monthly data between 1986 and 1999. He found the average long-run income and price elasticities as 1.56 and -0.41, respectively, by using an error correction model and Johansen cointegration techniques. The author concluded that the income elasticity was changing over time and the elasticities of income among the residential and industrial sectors were different significantly.

In 2010, Athukorala and Wilson (2010) estimated short- and long-run residential electricity demand elasticities for Sri Lanka over the period of 1960 to 2007. By using cointegration and error correction models, they found the short-run price and income elasticities as -0.16 and 0.32, whereas the long-run elasticities of the same variables were calculated as -0.62 and 0.78, respectively. They concluded that the price of electricity was not effective as much as the other components of electricity consumption in Sri Lanka. In addition, the long-run income elasticity of electricity demand showed that if the household's incomes increase in the future, the demand for electricity will also increase (Athukorala and Wilson, 2010).

On the contrary to Athukorala and Wilson (2010), Bianco et al. (2010) analysed the non-residential electricity consumption. They used partial adjustment model specification to estimate price and income elasticities for Romania between 1975 and 2008. In addition, they forecasted the non-residential electricity demand for the year 2020 via Holt-Winters exponential smoothing method and trigonometric grey model with a rolling mechanism. The short-run approximate income and price elasticities were found as 0.136 and -0.0752, respectively. The long-run income elasticity was 0.496 and that of the price elasticity was -0.274.

Zaman et al. (2012) investigated the factors that affect the electricity consumption function in Pakistan by using the Bounds Testing procedure for cointegration over the period from 1975 to 2010. The authors analysed both the short- and long-run to determine the causality among the variables. They used electricity consumption as the dependent variable, whereas foreign direct investment, GDP per capita and population growth as independent variables. By employing the ARDL model, Zaman et al. (2012) found the short-term and long-term income elasticities as 0.343 and 0.973, respectively. There is no information about the price elasticities in the study since the price variables were not included in the model. Zaman et al. (2012) concluded that an increase in the income, foreign direct investment, and population growth cause a rise in electricity consumption in Pakistan.

One recent study by Bernstein and Madlener (2015) analysed the short- and long-run electricity demand elasticities for eight subsectors (food and tobacco, textile and leather, wood and wood products, pulp, paper and printing, chemicals chemical products, non-metallic minerals, metal and machinery, and transport equipment) of German manufacturing industry by using annual data between 1970 and 2007. They employed different models like error correction, cointegrated VAR, Granger causality, and impulse response analysis to investigate the relationship among these subsectors and to estimate the economic activity (income) and price elasticities of electricity demand. They first checked the non-stationarity of the variables by unit root tests and then specified a VAR model for each subsector. As a result of cointegration test, they found a valid long-run relationship for five (food and tobacco, pulp and paper, chemicals, non-metallic minerals, and transport equipment) of the eight sectors. Bernstein and Madlener (2015) estimated long-run income and price elasticities in the ranges of 0.70 to 1.90 and 0 to -0.52, respectively. By using the Granger causality test, they found the way of the causality from value added and price to electricity consumption in the long-run. To determine the short-run elasticities, the authors used the estimated cointegration vectors in the estimation of the ECMs. They also applied CUSUM and CUSUMQ tests to check the stability of the parameters. The estimated short-run elasticities of electricity demand were between 0.17 and 1.02 for economic activity and between -0.31 and -0.57 for the price. Consequently, the average economic activity elasticities were found slightly above unity while the average price elasticities were estimated as negative and inelastic.

Table 4.1. Summary of Electricity Demand Studies

Author(s)	Period	Country/ Region	Methods Used	Focus of Study	Price Elasticities		Income Elasticities	
					Short-Term	Long-Term	Short-Term	Long-Term
Houthakker (1951)	1937-1938	UK	Double-Log Model	Residential Electricity Demand	-	-0.89	-	1.17
Fisher and Kaysen (1962)	1946-1957	US	Multiple Regression and Covariance Analysis Techniques	Industrial and Residential Electricity Demand	-0.16 to -0.25	-	0.07 to 0.33	-
Wilson (1971)	1960-1970	US	Static Equilibrium Model / Linear, Log-linear	Residential Electricity Demand	-	-1.33	-	-0.46
Halvorsen (1975)	1961-1969	US	Two-stage Least Squares	Residential Electricity Demand	-1.15		0.51	
Beenstock et al. (1999)	1962-1994	India	Dynamic Regression Model and Cointegration	Industrial Electricity Demand	-	-0.31 to -0.44	-	0.99 to 1.12
Bose and Shukla (1999)	1985-1994	India	Pooled Regression	Residential, Commercial, Agriculture, and Different Size of Industries Electricity Demand	-0.32 to -1.35		0.49 to 1.27	
Hondroyiannis (2004)	1986-1999	Greece	Error Correction Models and Cointegration	Residential Electricity Demand	-0.41		1.56	
Athukorala and Wilson (2010)	1960-2007	Sri Lanka	Error Correction Models and Cointegration	Residential Electricity Demand	-0.16	-0.62	0.32	0.68
Bianco et al. (2010)	1975-2008	Romania	Partial Adjustment Model	Non-residential Electricity Demand	−0.0752	−0.274	0.136	0.496
Zaman et al. (2012)	1975-2010	Pakistan	ARDL Bounds Testing, ECM	Electricity Demand	-	-	0.34	0.97
Bernstein and Madlener (2015)	1970-2007	Germany	Error Correction, Cointegrated VAR, Granger Causality and Impulse Response Analysis	Manufacturing Industry Electricity Demand	-0.31 to -0.57	0 to -0.52	0.17 to 1.02	0.70 to 1.90

4.3. Natural Gas Demand Studies

One of the first attempts to analyse the elasticities of natural gas demand was made by Balestra and Nerlove (1966). They estimated natural gas demand elasticities for 36 states of the U.S. by using ordinary least squares method over the period from 1957 to 1962. They found the long-run price and income elasticities as -0.63 and 0.62, respectively. In addition, Houthakker and Taylor (1970) used a distributed lag model to find the natural gas demand elasticities for the US between 1929 and 1970. They determined the short- and long-run elasticities in the ranges of -0.25 to -0.65 for the price and 0.42 to 1.01 for the income. In 1976, Joskow and Baughman (1976) also analysed the natural gas demand in the U.S. and they extended the number of states to 48. For the period between 1968 and 1972, the authors calculated the short-run income elasticity as 0.08, and short-run price elasticity as -0.15. Their long-run estimates were -1.01 for the price elasticity, and 0.52 for the income elasticity. When compared to the study of Balestra and Nerlove (1966), Joskow and Baughman (1976) estimated higher long-run price elasticity.

Griffin (1979) analysed the price elasticity of natural gas demand for 18 OECD countries between 1955 and 1974, by using different estimation techniques like; Ordinary Least Squares, the iterative Zellner efficient approach, and Tobin's estimation approach. He found the price elasticities between the ranges of -0.83 and -1.60 for countries, namely Austria, Belgium, Canada, Denmark, France, West Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, United Kingdom and the US. He concluded that the price and income elasticities differed based on estimation technique, countries' economic conditions, and geographical positions.

Estrada and Fugleberg (1989) applied a trans-log method to analyse the price elasticities of natural gas demand for West Germany and France over the period 1960-1983. They investigated the two periods (before and after the oil shock) to show the changes in the structure of the economy. According to Estrada and Fugleberg (1989), great and fast price fluctuations occurred following the first oil price shocks in the early 1970s, and they indicated that as a result of these price fluctuations, the consumers' behaviours completely changed. The authors found the price elasticities in the range from -0.75 to -0.82 for West Germany and -0.61 to -0.76 for France.

Eltony (1996) examined the demand elasticities for natural gas in Kuwait over the period between 1975 and 1993. He used two different econometric models: Partial Adjustment Model (PAM) and Error Correction Model (ECM). The results based on ECM showed that the income elasticities in the short- and long-run were found as 0.45 and 0.82, respectively. On the other hand, he estimated the price elasticity as -0.17 in the short-run, and -0.34 in the long-run. Eltony (1996) stated that the price and income elasticities of natural gas demand were inelastic for Kuwait both in the short- and long-term.

Maddala et al. (1997) compared OLS and Bayesian shrinkage estimation method to analyse the performance of these two models in estimating the elasticities of residential natural gas demand. They used panel data from 49 U.S. states between 1970 and 1990. As a result of the analyses, they suggested the shrinkage estimation method because of giving more consistent outcomes. The authors used the real personal income per capita, real residential natural gas prices, real residential electricity prices, and heating and cooling degree days as independent variables to find the residential natural gas demand. Based on the Bayesian shrinkage estimation method, the average short-run price elasticity was -0.99, and the average long-run price elasticity was -0.273. On the other hand, the average short- and long-run income elasticities were found as 0.280 and -0.057, respectively. The explanation for negative income elasticity estimation they made is that as the income of households rises, they can change their consumption or energy using behaviour. For example, Maddala et al. (1997) have claimed that instead of using gas-operated devices, the usage of electrical appliances can increase in parallel with the rise in income.

Asche et al. (2008) estimated price and income elasticities of the residential natural gas demand for 12 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Switzerland and the UK) by using heterogeneous OLS and shrinkage estimator methods. They stated that the shrinkage method enabled them to observe the differences among countries. According to the results obtained from the shrinkage method, the short-run average income and price elasticities were 0.808 and -0.030, respectively. In the long-run, while the price elasticity was -0.099, the income elasticity was 3.324. On the other hand, the authors found smaller average price and income elasticities by OLS using method. In conclusion, Asche et al. (2008) indicated that there were differences structurally among European countries in terms of residential natural gas demand.

Bernstein and Madlener (2011) also analysed residential natural gas demand. They used Autoregressive Distributed Lag (ARDL) Bounds Testing procedure to find the income and price elasticities for 12 OECD countries (Austria, Finland, France, Germany, Ireland, Japan, Luxembourg, the Netherlands, Spain, Switzerland the UK and the US) between 1980 and 2008. They also calculated the effect of the weather conditions on natural gas demand by adding heating degree days to the model as a control variable. Furthermore, CUSUM and CUSUMQ tests were employed to test the stability of the parameters. The authors estimated the long-run price, income and weather conditions elasticities as -0.51, 0.94 and 1.35, respectively. The short-run elasticities were found nearly half of the long-run elasticities. As in Bernstein and Madlener (2011), Payne et al. (2011) also employed ARDL Bounds Testing approach to analyse the residential natural gas demand for Illinois, US. By using annual data between 1970 and 2007, they estimated the short- and long-run price elasticities as -0.185 and -0.264, respectively. In comparison with Bernstein and Madlener (2011), Payne et al. (2011) found lower price and income elasticities for the United States. In addition, Payne et al. (2011) calculated the long-run elasticity for heating degree as 0.626, which shows that a 1% increase in heating degree days rises residential natural gas consumption by 0.626%.

Recently, Bianco et al. (2014) introduced a regression model to analyse and forecast non-residential natural gas demand in Italy. They used natural gas consumption, natural gas price, GDP, population and temperature data for the period from 1990 to 2011. They found that GDP per capita had more influence on consumption than the price both in the short- and long-term. Twenty-four consumption scenarios were built to forecast the non-residential natural gas consumption in Italy. The results from these scenarios showed that the average natural gas demand would be between 32 and 46 bcm (billions of cubic meters) in 2030 (Bianco et al., 2014).

Table 4.2. Summary of Natural Gas Demand Studies

Author(s)	Period	Country/ Region	Methods Used	Focus of Study	Price Elasticities		Income Elasticities	
					Short-Term	Long-Term	Short-Term	Long-Term
Balestra and Nerlove (1966)	1957-1962	US	OLS	Natural Gas Demand	-	-0.63	-	0.62
Houthakker and Taylor (1970)	1929-1970	US	Distributed Lag Model	Natural Gas Demand	-0.25 to -0.65		0.42 to 1.01	
Joskow and Baughman (1976)	1968-1972	US	OLS	Natural Gas Demand	-0.15	-1.01	0.08	0.52
Griffin (1979)	1955-1974	18 OECD Countries	OLS, Zellner Efficient Approach and Tobin's Estimation Approach	Natural Gas Demand	-0.83 to -1.60		-	
Estrada and Fugleberg (1989)	1960-1983	West Germany and France	Trans-log Method	Natural Gas Demand	-0.75 to -0.82 (for West Germany) -0.61 to -0.76 (for France)		-	
Eltony (1996)	1975-1993	Kuwait	Partial Adjustment Model and Error Correction Model	Natural Gas Demand	-0.17	-0.34	0.45	0.82
Maddala et al. (1997)	1970-1990	US	OLS and Bayesian Shrinkage Estimation Method	Residential Natural Gas Demand	-0.99	-0.273	0.280	-0.057
Asche et al. (2008)	1978-2002	12 European Countries	OLS and Shrinkage Estimator Method	Residential Natural Gas Demand	-0.030	-0.099	0.808	3.324
Bernstein and Madlener (2011)	1980-2008	12 OECD Countries	ARDL Bounds Testing Approach	Residential Natural Gas Demand	-0.24	-0.51	0.45	0.94
Payne et al (2011)	1970-2007	US (Illinois)	ARDL Bounds Testing Approach	Residential Natural Gas Demand	-0.185	-0.264	-	0.024
Bianco et al. (2014)	1990-2011	Italy	Regression Model	Non-Residential Natural Gas Demand	-0.11	-0.28	1.09	2.71

4.4. Gasoline Demand Studies

As in the other energy demand studies, the researches related to estimating gasoline demand elasticities have increased after the first oil shock. Houthakker et al. (1974) is one of the important papers and analysed the gasoline demand for the U.S. states by using quarterly time series data. They employed error components techniques to model the dynamic form of gasoline demand in the period before the oil shock and found the price and income elasticities. Mehta et al. (1978) also investigated gasoline demand for 48 U.S. states and the District of Columbia before the first oil price shock (1963-1973). They used linear flow-adjustment model with error components and estimated the price and income elasticities of demand for gasoline as -0.04 and 0.87, respectively. Although these two studies analysed the same period, Mehta et al. (1978) found the estimated long-run price elasticity quite different from Houthakker et al. (1974).

Baltagi and Griffin (1983) analysed the gasoline demand for 18 OECD countries between 1960 and 1978. They use three different model specifications: static logarithmic, partial adjustment, and polynomial lags. The estimated price and income elasticities were different from each other countries. They found the price elasticities in the range of -0.06 to -0.79, and the income elasticities in the range of -0.05 to 1.07. In the light of these results, they concluded that the price and income elasticities of gasoline demand could change with respect to the model used.

Dahl and Sterner (1991) reviewed income and price elasticities of past gasoline demand studies by using monthly, quarterly and yearly data. They used 10 different model types such as static, dynamic (lagged endogenous), vehicle models and other dynamic models. The results showed differences in terms of selected time-frequency and models. For instance, where the average income and price elasticities correspondingly were found as 1.16 and -0.53 by using annual data in static models, the average short- and long-term price elasticities are -0.24 and -0.80, and the income elasticities are 0.45 and 1.31, respectively, in dynamic models (Dahl and Sterner, 1991). In addition, the authors indicated that the difference between annual and seasonal data is remarkable. As Dahl and Sterner (1991), Espey (1998) used a series of econometric models to re-examine hundreds of gasoline demand studies. She found that short-run price elasticities range from 0 to -1.36 and long-run price elasticities range from 0 to -2.72. On the other hand, short- and long-term income elasticities were between the ranges of 0-2.91 and 0.05-2.73, respectively (Espey, 1998).

Alves and Bueno (2003), Polemis (2006) and Hughes et al. (2008) are some other studies related to gasoline demand. All of these studies used a log-linear form in specifying the gasoline demand model for different countries. Alves and Bueno (2003) analysed the cross-price elasticities of gasoline and alcohol in Brazil. They found that gasoline and alcohol are imperfect substitutes. They also used real per capita income, real gasoline price and real alcohol price to estimate gasoline demand for the period between 1974 and 1999. In the study of Polemis (2006), the cointegration techniques and vector auto-regression (VAR) model were used to calculate gasoline and diesel demand (road energy demand) for Greece between 1973 and 2003. The author determined the price and income elasticities of gasoline demand as inelastic in the long-run. On the other hand, price and income elasticities of diesel demand were found as inelastic and elastic, respectively. Hughes et al. (2008) analysed price and income elasticities of US gasoline demand by using aggregate monthly data for two periods (1975-1980 and 2001-2006). They employed double-log model and found no statistically significant differences in the income elasticity between these two periods, on the other hand, the short-run price elasticities were in the range of -0.21 to -0.34 between 1975 and 1980, and -0.034 to -0.077 between 2001 and 2006. As a conclusion, the authors indicated that the short-run price elasticity is more inelastic in the recent period compared to the previous period.

Park and Zhao (2010) estimated the United States gasoline demand for the period of 1976 to 2008 by time-varying cointegration approach. Rather than the cointegration relationship, they used an error correction model to show the changes in the short-run. As a result, the authors found that the income and price elasticities of gasoline demand in the US increased between 1976 and 1980, and decreased until 1987. After 1987, there were increases and decreases for 13 years, and the elasticities increased again after 2000. The average price and income elasticities were calculated as -0.247 and 0.073, respectively (Park and Zhao, 2010). In conclusion, they indicated that income and price elasticities in the US were changing over time and the change in the income elasticities was lower than that of the price elasticities.

The case of gasoline demand has been considered by the researchers many times by using different methodologies. For instance, Ramanathan (1999) investigated the relationship among gasoline demand, income and gasoline prices for India between 1972 and 1994 by using cointegration approaches. The author estimated the elasticities of gasoline demand for both short- and long-term. In the short-term, the income and price elasticities were 1.178 and

-0.209, whereas in the long-run the income and price elasticities were 2.682 and -0.319, respectively. Akinboade et al. (2008) used the Autoregressive Distributed Lag (ARDL) model to determine the aggregate demand for gasoline in South Africa over the period 1978-2005. The estimated long-run income and price elasticities were found to be 0.36 and -0.47, respectively. The authors concluded that the gasoline demand was inelastic in South Africa. On the other hand, Sene (2012) estimated the aggregate gasoline demand for Senegal between 1970 and 2008. He used the log-linear model and found the short-run income and price elasticities as 0.46 and -0.12. Moreover, the long-run income and price elasticities were calculated as 1.14 and -3.01, respectively. According to these results, the author stated that in both short- and long-term, the price and income elasticities of gasoline demand were inelastic for Senegal. The common features of these studies are that they all analyse the gasoline demand of developing countries plus positive income elasticities and negative price elasticities of gasoline demand are found in the long-run.

More recently Chang and Serletis (2014) analysed gasoline demand for Canada between 1997 and 2009. They used three locally flexible functional forms and based on Minflex Laurent model which is the only consistent model among others to estimate the demand for gasoline in Canada. Chang and Serletis (2014) calculated the own-price elasticity of gasoline demand as between -0.570 and -0.738. The results show that the price elasticity of gasoline demand in Canada was inelastic.

Table 4.3. Summary of Gasoline Demand Studies

Author(s)	Period	Country/ Region	Methods Used	Focus of Study	Price Elasticities		Income Elasticities	
					Short-Term	Long-Term	Short-Term	Long-Term
Houthakker et al. (1974)	1963-1972	US	Error Components Technique	Gasoline Demand	-0.075	-0.24	0.303	0.98
Mehta et al. (1978)	1963-1973	US and District of Columbia	Linear Flow-Adjustment Model with Error Components	Gasoline Demand	-0.04		0.87	
Baltagi and Griffin (1983)	1960-1978	18 OECD Countries	Static Logarithmic, Partial Adjustment, and Polynomial Lags	Gasoline Demand	-0.06 to -0.79		-0.05 to 1.07	
Ramanathan (1999)	1972-1994	India	Cointegration	Gasoline Demand	-0.209	-0.319	1.178	2.682
Alves and Bueno (2003)	1974-1999	Brazil	Engle and Granger Two-Step Procedure	Gasoline Demand	-0.464		0.1217	
Polemis (2006)	1978-2003	Greece	Cointegration	Gasoline and Diesel Demand	-0.38(for gasoline) -0.44 (for diesel)		0.79 (for gasoline) 1.18 (for diesel)	
Hughes et al. (2008)	1975-1980 and 2001-2006	US	Double-log Model	Average per capita Gasoline Demand	0.21 to -0.34 (for 1975-80) 0.034 to -0.077 (for 2001-06)		0.21 to 0.75 (for 1975-80 and 2001-06)	
Akinboade et al. (2008)	1978-2005	South Africa	Autoregressive Distributed Lag Model	Aggregate Gasoline Demand	-	-0.47	-	0.36
Park and Zhao (2010)	1976-2008	US	Time-varying Cointegration Model	Gasoline Demand	-0.247		0.073	
Sene (2012)	1970-2008	Senegal	Log-linear Model	Aggregate Gasoline Demand	-0.12	-3.01	0.46	1.14
Chang and Serletis (2014)	1997-2009	Canada	Minflex Laurent Model	Gasoline Demand	0.570 to -0.738		-	

4.5. Aggregate Energy Demand Studies

Pindyck (1979) was one of the pioneers to analyse industrial and commercial energy demand. He estimated the price elasticities of ten developed countries by using an econometric model. In this study, the international differences in price elasticities of energy demand were determined. In addition, he was aiming to measure the level of substitution effects among capital, labour, and energy inputs. For the period of 1963-1973, the own electricity price elasticities were calculated in the range between -0.54 and -0.63 in the countries such as Canada, France, Italy, Japan, Netherlands, Norway, Sweden, UK, US, and West Germany (Pindyck, 1979). Furthermore, the author found the own-price elasticities of coal and natural gas for these countries as in the ranges of -1.29 to -2.24 and -0.41 to -2.34, respectively.

Using the data between 1960 and 1982, Prosser (1985) investigated aggregate final energy demand for seven OECD countries (USA, Canada, Germany, France, UK, Italy and Japan). By employing time series model with Koyck lag formulation, he found the average income elasticity as 1.02, while the short- and long-run price elasticities were estimated as -0.22 and -0.40, respectively. Two years later from Prosser (1985), Fiebig et al. (1987) developed a cross-country demand system to find the income and own-price elasticities of energy demand for 30 countries based on 1975 ICP's (International Comparison Program) data. They estimated the elasticities for 11 commodities, such as; food, beverages and tobacco, clothing and footwear, gross rent, energy, household furnishing and operations, medical care, transport and communications, recreation, education and other. The income elasticities are calculated between 1.24 and 1.64, and the own-price elasticities were in the range of -0.66 to -0.88 (Fiebig et al., 1987). These numbers indicate that income elasticities are greater than one for all countries which means that they are elastic. On the other hand, the own-price elasticities are found as inelastic.

As it is mentioned above, after the first oil shock, there has been a substantial increase in the number of energy demand studies. Kleijweg et al. (1990) is one of these studies, and they investigated the aggregate energy demand for the manufacturing sector in the Netherlands from 1978 to 1986. They used panel data and trans-log functional form to estimate the overall price and output elasticities of Dutch firms. The authors found long-run price and output elasticities as -0.5 and 0.6, respectively. In conclusion, they stated that small size firms were more sensitive than the large firms in terms of adjustment to the price changes and large firms could lower the costs of energy more in comparison to small firms. In addition, Kleijweg et al. (1990) noticed that within the industries there were no differences between small and large firms in terms of output elasticities while the price elasticities varied.

Bentzen and Engsted (1993) used cointegration and error-correction models to find Danish short- and long-term aggregated energy demand elasticities for the period 1948-1990. They estimated short-run own-price elasticities as -0.13, and short-run income elasticities as 0.66. In addition, long-run price and income elasticities were calculated as -0.46 and 1.21, respectively. As a consequence of these results, the authors found no evidence of a structural break in energy demand due to the dramatic increase in real energy prices after the first oil shock.

After the 2000s, researchers have developed different approaches to analyse the issue of energy demand. Agnolucci (2009) was one of them who investigated energy demand for British and German industrial sectors by using the panel data over two periods (1978-2004 and 1991-2004). The author used a panel approach because he claimed that rather than time series models, panel techniques allow finding the variation among subsectors and this provides a significant advantage to estimate the price elasticities. In this study, the income and price elasticities of aggregate energy demand for the industrial sector were found as 0.52 and -0.64, respectively (Agnolucci, 2009).

Sa'ad (2011) employed Harvey's structural time series modelling approach with the underlying energy demand trend (UEDT) concept in estimating the aggregate energy demand for South Korea and Indonesia. In this approach, the UEDT enables to include technical change and the change in energy efficiency to the model in a non-deterministic way. As a result, the variations in consumer tastes and economic structure can be easily observed. In addition, the price and income elasticities can be found as unbiased (Sa'ad, 2011). By using this method, the author estimated the corresponding long-run price and income elasticities of aggregate energy demand as-0.11 and 1.15 for South Korea, and -0.35 and 1.13 for Indonesia.

Filippini and Hunt (2011) used a stochastic frontier analysis to model the aggregate energy demand in 29 OECD countries by utilising the data between 1978 and 2006. Different from the usual energy demand models, they estimated energy efficiency for each country, and as a result of this estimation, they stated that energy intensity was not a sufficient indicator of energy efficiency. In their estimation, aggregate energy consumption per capita was added to the model as a dependent variable, whereas per capita GDP, real energy prices, dummy for cold climate, the area size of a country, and the value added of both industrial and service sector were used as independent variables. They found the approximate income and price elasticities 0.90 and -0.27, respectively for the countries that investigated. In 2012, Filippini and Hunt (2012) repeated the same method (a stochastic frontier analysis) for 48 states of the US to calculate aggregate residential energy demand. By using panel data from 1995 to 2007, they employed three models, such as; Pooled Model (PM), Random Effects Model (REM), and Mundlak version of the REM. As a result of this classifications, they found inelastic price and income elasticities with respect to PM, REM, and MREM.

Karimu and Brännlund (2013) compared parametric and nonparametric econometric approaches in their study with regards to linear, log-linear and trans-log functional forms and decided which of these methods was more appropriate to estimate the aggregate energy demand models. They investigated the aggregate energy consumption for 17 OECD countries from 1990 to 2006 and indicated that the nonparametric estimation gave better results than the parametric approach for the examined sample and period. As a result of their analysis, the own-price elasticity was found in the ranges of -0.18 to -0.19. The income elasticity was estimated between 0.4 and 2.2. The authors concluded that by using nonparametric approach the effect of income variable was found as nonlinear and the effect of price variable was observed as linear but not constant, which shows that the income elasticity of aggregate energy demand was varying more than price elasticity over time.

Adeyemi and Hunt (2014) modelled industrial energy demand for 15 OECD countries (Austria, Belgium, Canada, France, Greece, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the USA) by using the data between 1962 and 2010. They used Structural Time Series Modelling (STSM) approaches with the concepts of asymmetric price responses (APR) and underlying energy demand trend (UEDT). In APR framework they included the technical progress to the model endogenously, whereas in UEDT concept the technical progress and other factors were modelled exogenously. They suggested both asymmetric price responses and underlying energy demand trend as preferred approaches for the OECD industrial energy demand. The authors found long-run price elasticities in the range of -0.06 to -1.22. Moreover, the long-run income elasticities were estimated between 0.34 and 0.96.

Table 4.4. Summary of Aggregate Energy Demand Studies

Author(s)	Period	Country/ Region	Methods Used	Focus of Study	Price Elasticities		Income Elasticities	
					Short-Term	Long-Term	Short-Term	Long-Term
Pindyck (1979)	1963-1973	10 OECD Countries	Structural Form Model	Industrial and Commercial Energy Demand	-0.54 to -0.63		-	
Prosser (1985)	1960-1982	7 OECD Countries	Time Series Model with Koyck Lag Formulation	Aggregate Final Energy Demand	-0.22	-0.40	1.02	
Fiebig et al. (1987)	1970-1980	30 Countries	Cross Country Demand Model	Per Capita Energy Demand	-0.66 to -0.88		1.24 to 1.64	
Kleijweg et al. (1990)	1978-1986	Netherlands	Trans-log Method	Manufacturing Sector Energy Demand	-	-0.5	-	0.6
Bentzen and Engsted (1993)	1948-1990	Denmark	Error Correction Models and Cointegration	Aggregate Energy Demand	-0.13	-0.46	0.66	1.21
Agnolucci (2009)	1978-2004 and 1991-2004	UK and Germany	Panel Approach	Aggregate Industrial Energy Demand	-0.64		0.52	
Sa'ad (2011)	1973-2008	South Korea and Indonesia	Structural Time Series Modelling Approach with UEDT	Aggregate Energy Demand	-	-0.11 (for SK) -0.35 (for I)	-	1.15 (for SK) 1.13 (for I)
Filippini and Hunt (2011)	1978-2006	29 OECD Countries	Stochastic Frontier Analysis Approach	Aggregate Energy Demand	-0.27		0.90	
Filippini and Hunt (2012)	1995-2007	US	Stochastic Frontier Analysis Approach	Aggregate Residential Energy Demand	-0.066 (PM) -0.108 (REM) -0.118 (MREM)		0.394 (PM) 0.166 (REM) 0.218 (MREM)	
Karimu and Brännlund (2013)	1990-2006	17 OECD Countries	Parametric and Nonparametric Models	Aggregate Energy Demand	-0.18 to -0.19		0.4 to 2.2	
Adeyemi and Hunt (2014)	1962-2010	15OECD Countries	STSM Approach with APR and UEDT Concepts	Industrial Energy Demand	-	-0.06 to -1.22	-	0.34 to 0.96

4.6. Previous Energy Demand Studies for Turkey

The first official attempts to determine energy demand for Turkey were started after 1984 by the authorized institutions such as State Planning Organization (SPO) and Ministry of Energy and Natural Resources (MENR). Initially, mathematical modelling approaches were used by SPO and MENR in the 1960s and 1970s. They used various best fit curves method for the period of 1966 to 1978, and as a result of their estimation, the predicted energy demand was found much higher than the actual consumption (Ediger and Tatlidil, 2002). After the mid of the 1980s, the models that described below were officially started to be used by the Ministry to forecast the energy demand in Turkey.

In 1984, the World Bank offered MENR two models developed by the International Atomic Energy Agency (IAEA), namely MAED (Model for Analysis of Energy Demand) and WASP III (Wien Automatic System Planning). These models were constituted for determination of the general energy demand. This has been the beginning point for energy planning and forecasting of future energy demand in Turkey. In this period, Kouris' correlation and Balance-Impact models were also used by MENR for the short- and long-term energy projections (Ediger and Tatlidil, 2002). In addition, for the period between 1981 and 1985, the energy demand model called EFOM-12 C Mark I (Energy Flow Optimization Model) developed by the commission of the European Union was applied in Turkey (Ercan et al., 1988). Furthermore, the SPO and the SIS (State Institute of Statistics) employed their own models. On the one hand, the SPO statistically estimated sectoral energy demands for different consumer groups. On the other hand, the SIS modelled the relationship between demographic indicators and economic parameters with primary energy demand by using the Durbin-Watson statistical test. Both two methods found a strong correlation between GDP and energy demand, and they reached similar results with MAED (Ediger and Tatlidil, 2002).

In the case of energy demand projection, there are several methods different from stated above. As an individual or institutional, the main aim is to forecast more reliable and consistent energy demand for the future. However, the estimation by MAED, WASP III, and EFOM-12 C Mark gave much higher results than the actual energy demand (Ediger and Tatlidil, 2002). Recently, remarkable methods, such as fuzzy logic, artificial neural network, grey prediction, input-output models, end-use models and some econometric techniques have been developed by the scientists in the fields of engineering, economy and other disciplines to obtain more reliable results. In this context, the studies related to Turkish energy demand modelling and/or forecasting have been continuously increasing since the 1990s. In this section, the more recent studies (especially after the 2000s) on modelling energy demand in Turkey are reviewed in a general framework, and a detailed summary of these studies is presented below in Table 4.5.

In Turkey, one of the most investigated subjects in the field of energy demand modelling and forecasting is electricity demand. The electricity demand studies for Turkey have first begun in the 1990s, and they have increased significantly until today. Some of these empirical studies are mentioned below.

Using annual data from 1962 to 1996, Bakirtas et al. (2000) analysed the short- and long-run relationship between electricity demand per capita, income per capita and prices by employing Engle and Granger Two-step procedure and error correction modelling. The authors used electricity consumption, income, electricity prices and population data. They found the price effect as insignificant and argued that this is because of the energy prices are subsidized in Turkey. On the other hand, they determined the short- and long-term income per capita elasticities as 0.692 and 3.134, respectively. In addition, Bakirtas et al. (2000) used univariate ARMA model in order to forecast the electricity consumption between 1997 and 2010, and these forecast results indicated that electricity consumption would increase about 60% in the following years.

Yumurtaci and Asmaz (2004) used the data between 1980 and 2002 to forecast the period of 2003-2050 by employing a linear regression model. As a result of this empirical analysis, in 2050, Turkey’s total electric energy demand would be 1173 TWh, and electricity consumption per capita would be 10197 kWh, based on the population increase and energy consumption increase rates per capita (Yumurtaci and Asmaz, 2004). They concluded that the energy need of Turkey would increase year by year and renewable resources, such as wind, solar, biomass, hydrogen, and sea originated energy should be used until 2050.

Halicioglu (2007) used residential electricity consumption per capita, electricity prices, GDP per capita and urbanization rate to estimate income and price elasticities of the residential electricity demand of Turkey for the period of 1968-2005. He employed bounds testing (or ARDL) approach, and in addition to this, an augmented form of Granger causality test was used to investigate the relationship among variables (Halicioglu, 2007). As a result of the

ARDL procedure, Halicioglu (2007) found short- and long-run price elasticities as -0.33 and -0.52, respectively. On the other hand, income elasticities were estimated 0.44 in the short-run and 0.70 in the long-run, depending on the number of lags chosen (Halicioglu, 2007).

In 2007, Akay and Atak (2007) proposed a Grey Prediction Model with Rolling Mechanism to estimate Turkish industrial and aggregate electricity demand. They used the annual data between 1970 and 2004 to forecast Turkey's industrial and total electricity consumption for the period of 2006-2015. Akay and Atak (2007) calculated the industrial and total electricity consumption as 140.37 TWh and 265.7 TWh for 2015, respectively. In addition, they argued that Grey Prediction Model performs better results than official studies carried out by the Turkish Ministry of Energy and Natural Resources for both total and industrial sector's electricity demand estimation. In the same year, Ediger and Akar (2007) estimated the future primary energy demand of Turkey from 2005 to 2020 by using historical data between 1950 and 2003. ARIMA and seasonal ARIMA were used in this study to forecast the future energy demand. They found that total primary energy demand would decrease in all cases between 2005 and 2020. In addition, Ediger and Akar (2007) stated that the average annual increase rate of total primary energy demand decreases from 4.9% (between 1950 and 2005) to 3.3% between 2005 and 2020.

Erdogdu (2007) applied the Partial Adjustment Model (PAM) and ARIMA approach to estimate and forecast the electricity demand for Turkey by using quarterly data between 1984 and 2004. Firstly, PAM was applied to calculate the price and income elasticities of electricity demand. The author determined the short- and long-term price elasticities as -0.041 and -0.297, respectively. In addition, income elasticity was found as 0.057 in the short-term and 0.414 in the long-term. Secondly, with the aim of being able to forecast the future electricity demand of Turkey for the period of 2004-2014, Erdogdu (2007) employed the ARIMA modelling approach by using the annual data between 1923 and 2004. The result of this estimation shows that the average annual percentage increase in electricity consumption is 3.3% during the forecasted period (Erdogdu, 2007).

Tatlidil et al. (2009) examined the long-run relationship among Turkey's electricity consumption per capita, GDP per capita and electricity prices by using the Bounds Testing procedure for the period 1978-2003. They used the ARDL model to analyse the long-run effect of GDP per capita and electricity prices on electricity consumption per capita. Tatlidil et al. (2009) found an insignificant price impact on energy consumption. On the other hand, they determined that GDP per capita have a statistically significant effect on electricity consumption per capita both in short- and long-term.

In 2011, Dilaver and Hunt (2011a, 2011b, and 2011c) investigated Turkish industrial, residential and aggregate electricity demand, respectively. Firstly, they employed the Structural Time Series Model with Underlying Energy Demand Trend (UEDT) concept to estimate Turkish industrial energy demand by using annual data between 1960 and 2008 (Dilaver and Hunt, 2011a). In addition, they forecasted the industrial electricity demand for the period of 2009-2020 by implementing three scenarios, namely ‘low’, ‘reference’ and ‘high’. Dilaver and Hunt (2011a) found output (industrial value added) and price elasticities as 0.15 and -0.16, respectively. Moreover, electricity demand for Turkish industrial sector was forecasted to be 97 TWh, 121 TWh, and 148 TWh by 2020 in terms of low, reference and high scenarios, respectively (Dilaver and Hunt, 2011a). On the other hand, Dilaver and Hunt (2011b) forecasted Turkish residential electricity demand for the period of 2009-2020 by using annual data between 1960 and 2008. Initially, they calculated the short- and long-term total final consumption expenditure elasticities as 0.38 and 1.57, respectively. In addition, the corresponding short- and long-run price elasticities were calculated to be -0.09 and -0.38. Then Dilaver and Hunt (2011b) estimated the future residential electricity demand based on three different scenarios. As a result of this prediction, the authors found that the electricity demand would be 48 TWh, 64 TWh and 80 TWh in 2020 according to low, reference and high scenarios, respectively. Finally, Dilaver and Hunt (2011c) aimed to forecast Turkish future aggregate electricity demand based on different scenarios. In order to estimate this demand, Dilaver and Hunt (2011c) formed an aggregate electricity demand function by using the structural time series approach for Turkey over the period 1960 to 2008. They found income and price elasticities as 0.17 and -0.11, respectively. In addition, the forecast results show that in 2020, Turkish aggregate electricity demand would be 259 TWh, 310 TWh and 368 TWh based on low, reference and high scenarios, respectively (Dilaver and Hunt, 2011c).

Maden and Baykul (2012) investigated Turkey’s price and income elasticities of electricity demand by using yearly data from 1970 to 2009. They used the Johansen cointegration method to analyse the relationship between electricity consumption, GDP and electricity prices. According to the estimation results, while income and price elasticities are 0.168 and -1.440 in the short-run, they are 0.928 and -6.85 in the long-run, respectively.

Bilgili et al. (2012) used the artificial neural network (ANN), linear regression (LR) and nonlinear regression (NLR) methods to forecast the electricity consumption of the residential and industrial sectors in Turkey. They compared the performances of the methods used in the study with two different scenarios (powerful and poor), and as a result of this comparison, the performance values of ANN method were found to be better than the performance values of the LR and NLR methods. The data between 1990 and 2003 were used to forecast electricity consumption for the period of 2008-2015. Consequently, Bilgili et al. (2012) found that according to the ANN model with the poor scenario, the electricity consumption of Turkey's residential and industrial sectors would increase to 140.64 TWh and 124.85 TWh, respectively, in 2015.

Kıran et al. (2012) applied a different approach in forecasting energy demand. They used Artificial Bee Colony and Particle Swarm Optimization methods to estimate Turkey's electricity demand for the period of 2007-2025. In addition, the authors used three scenarios and two forms (linear and quadratic) to propose the models. As a result, quadratic form models show better results than that of linear forms since the fluctuations of the economy can be considered in them (Kıran et al., 2012). According to the three scenarios, Kıran et al. (2012) found that the electricity demand in Turkey would be expected to be between 167 TWh and 435 TWh averagely, in 2025.

Recently, Arisoy and Ozturk (2014) analysed the elasticities of industrial and residential electricity demand for Turkey by using annual data between 1960 and 2008. They used a time-varying parameters model based on the Kalman filter. The income elasticity of industrial and residential electricity demand was found to be 0.979 and 0.955, respectively. On the other hand, the price elasticity of industrial energy demand was estimated as -0.014 and the price elasticity of residential energy demand was forecasted as -0.0223. As a conclusion, Arisoy and Ozturk (2014) indicated that the elasticities found for the income is lower than 1 and therefore a rise in per capita energy consumption is lower than a rise in per capita income. In addition, the results for the price elasticities were interpreted by the authors as the price increase has not a strong effect on residential and industrial electricity demand

(Arisoy and Ozturk, 2014). In other words, since electricity is a necessary good, consumers would give a small reaction to changes in the industrial and residential electricity prices.

In the context of natural gas demand, there are important studies made for Turkey. Due to the fact that natural gas has a significant role in the production process of electricity, the governments and researchers have attached great importance to this subject. In Turkey, the share of natural gas on electricity production was 43.8% in 2013, whereas in 2014 this percentage increased to 47.9 (Turkish Electricity Transmission Company-TEIAS, 2014). Today, this percentage is almost 40%. In brief, the maximum share on electricity production belongs to natural gas, but more than 99% of natural gas supply meet by imports in Turkey (Energy Market Regulatory Authority-EMRA, 2016). Therefore, the natural gas demand estimation procedure is very crucial for Turkey. The selected natural gas demand studies are reviewed in the next pages.

Erdogdu (2010) analysed price and income elasticities of sectoral natural gas demand for Turkey by using quarterly data between 1988 and 2005. He used the partial adjustment model to estimate these elasticities. As a result of this estimation, price and income elasticities were found for electricity generation sector, households, and industry sector as follows:

For the electricity generation sector;

- Short- and long-run price elasticities of 0.11 and 1.85, respectively.
- Short- and long-run income elasticities of 0.31 and 5.11 respectively.

For the households;

- Short- and long-run price elasticities of -7.82 and -31.90, respectively.
- Short- and long-run income elasticities of 1.70 and 6.92, respectively.

For the industry sector;

- Short- and long-run price elasticities of -0.78 and -7.81, respectively.
- Short- and long-run income elasticities of 0.47 and 4.73, respectively.

According to these results, Erdogdu (2010) stated that households price and income elasticities were more elastic than all other sectors for both short- and long-term and industry sector natural gas demand was more elastic than that of electricity generation sector. In addition, Erdogdu (2010) forecasted the future growth of demand using ARIMA modelling, and he compared the results with official projections. He used monthly data from 1987 to 2007 and forecasted the period of 2008-2030. The prediction results showed that there would be a 4% average annual increase in natural gas consumption during the period between 2008 and 2030 (Erdogdu, 2010).

Melikoglu (2013) introduced a new model for predicting natural gas demand in Turkey. He criticised the use of the same models such as ARIMA, SARIMA, etc., repeatedly. In his study, two semi-empirical models based on econometrics, namely the logistic model which can be used to estimate long-term natural gas demand, and the linear equation which can be used to forecast medium-term demand, were employed. According to the results from these models, natural gas demand in 2030 was estimated as 76.8 bcm by using the linear model and 83.8 bcm by using the logistic model (Melikoglu, 2013). He concluded that the results obtained from the linear model were in parallel with the official Turkish Petroleum Pipeline Cooperation (BOTAŞ) forecast outcomes of 76.4 bcm (Petroleum Pipeline Cooperation, 2008).

Goncu et al. (2013) aimed to forecast future residential and commercial natural gas demand for Istanbul, Turkey by using stochastic temperature model. They used daily data from January 1, 2004, to October 18, 2011, and modelled demand and temperature process separately to estimate the natural gas demand with changing temperature conditions. Then, the authors used a Monte Carlo simulation method to estimate natural gas consumption in Istanbul. For the investigated period, Goncu et al. (2013) found the price elasticity of natural gas demand as 0.16. They stated that since the Turkish natural gas price is controlled by the government, it did not fluctuate throughout the examined period and the power of natural gas price on consumption is therefore low. As a conclusion, they indicated that change of temperature is one of the main factors on natural gas demand.

Bildirici and Bakirtas (2014) investigated the causal relationship between economic growth, coal, natural gas and oil consumption by using the ARDL Bounds Testing approach for the period of 1980 to 2011 in six countries (Brazil, China, India, Russia, South Africa and Turkey). The authors used oil consumption, coal consumption, natural gas consumption and real GDP per capita variables in this study and employed the ADF unit root test, Johansen cointegration test, ARDL method and Granger causality test, respectively. For Turkey, they found income elasticity of natural gas demand as 2.578 in the long-run and they categorized natural gas as a luxury good. In the short-run, the income elasticity was estimated as 0.6145. The result of the Granger causality test demonstrated that there was bidirectional causality between natural gas consumption and economic growth for Turkey in both short and long terms (Bildirici and Bakirtas, 2014).

Boran (2015) estimated natural gas consumption in Turkey by using grey prediction with rolling mechanism (GPRM) approach. In this study, the data between 1987 and 2012 were used to forecast the period of 2014 to 2018. Boran (2015) claimed that the GPRM method was never used before to forecast the natural gas consumption in Turkey. The grey prediction model is based on the first-order differential method, and the results of the model are examined with the least squares method. In addition, he argued that GPRM is very simple and effective way to investigate the future changes of time series. Boran (2015) concluded that the natural gas consumption has varied over time due to the economic structure of the country and the other factors. For the forecasted period, he found that the natural gas consumption will increase from 1.68 billion cubic feet in 2014 to 2.15 billion cubic feet in 2018.

Recently, Altinay and Yalta (2015) analysed the residential natural gas demand in Istanbul, Turkey by using monthly data between January 2004 and June 2012. They used fixed-width rolling windows framework with maximum entropy resampling method. By this method, not only the elasticity estimates can be observed, but also more efficient and robust results can be obtained in small samples (Altinay and Yalta, 2015). According to the authors, the main reasons of being chosen Istanbul as a case study is that average 60% of Turkey's total residentials are located in that city, and 12% of total natural gas is consumed in that region for the period observed. The variables of real GDP, real prices of natural gas and electricity, average temperature and number of consumers were used to find the natural gas demand. They divided the investigated period into three sub-periods, namely boom period up to 2008, the recession period between 2008 and 2009, and the unusual weather changes after 2010. The price elasticity in the boom period was positive and inelastic with an average of 0.5, and the elasticity reached its highest level of -1.5 at the end of 2008, and then it again turned out to be negative but close to zero. For the boom period the income elasticity of residential natural gas demand was around 2, and after 2008 it became very inelastic and closed to zero. During the period of change in weather conditions, the income elasticity remained around zero again. In conclusion, Altinay and Yalta (2015) stated that the own-price elasticity remained around zero and the income elasticity was affected negatively by both recession period and unusual weather changes. All in all, they indicated that the elasticities of residential natural gas demand did not remain constant for the observed period and these elasticities are affected by the economic situation plus weather changes.

In addition to the natural gas studies, there are also some researches that are examining the fuel demand in Turkey. Studies analysing Turkish fuel demand functions have generally concentrated on gasoline and diesel demand. The price and income elasticities of transport fuels are very important for policy authorities, firms and individuals. Therefore, researchers have interested in this subject for a long time. Some of the fuel demand studies related to Turkey are given below.

Birol and Guerer (1993) investigated transport sector fuel demand for six developing countries (Turkey, Thailand, Pakistan, Morocco, Tunisia, and Malesia) over the period 1970-1990 and forecasted the gasoline and diesel demand for these six countries until 2010. They used a partial adjustment model and OLS method. For Turkey, the estimated short-run price and income elasticities of gasoline demand were found as -0.18 and 0.39, whereas, the long-run price and income elasticities were calculated as -0.75 and 1.63, respectively. On the diesel demand side, their results for price elasticity are close to zero for both short- and long-term. The income elasticities of diesel demand were estimated to be 1.17 in the short-term and 3.0 in the long-term.

Turkekul and Unakitan (2011) discussed the energy demand issue from a different aspect. They investigated the agricultural energy demand for Turkey in terms of the consumptions of diesel and electricity. They used annual GDP, per capita income, rural population, per capita diesel plus electricity consumption and prices to estimate the elasticities of demand over the period 1970 to 2008. By employing cointegration and error correction model, the authors found the corresponding long-run price and income elasticities for diesel demand as -0.38 and 1.47, whereas the price and income elasticity of electricity demand were -0.72 and 0.19, respectively. She investigated 120 countries including Turkey for the period of 1990-2007.

Dahl (2012) used static and dynamic demand models to estimate the price and income elasticities of demand for gasoline and diesel fuel. She investigated 120 countries including Turkey for the period of 1990-2007. Turkey's average price and income elasticities for the gasoline demand were found as -0.19 and 1.10, respectively (Dahl, 2012). For the diesel fuel demand, the average price elasticity was -0.13, and the income elasticity was 2.27. As a result, the price elasticity of transport fuel demand was computed as inelastic in Turkey.

Recently, Erdogdu (2014) analysed motor fuel prices for Turkey by using quarterly data between 2006:Q2 and 2010:Q4. By employing a partial adjustment model, he estimated demand functions for gasoline, diesel and liquefied petroleum gas (LPG). The estimated own-price elasticities of all three fuels are statistically insignificant from zero. In addition, Erdogdu (2014) investigated the cross-price elasticities among gasoline, diesel, and LPG. His results suggest that the cross-price elasticity of gasoline demand with respect to diesel and LPG are 0.64 and -1.22, respectively. These results are statistically significant and indicate that the gasoline and diesel are substitute goods, while gasoline and LPG are complementary goods. Erdogdu (2014) concluded that motor fuel demand in Turkey was inelastic and the price changes due to the taxes did not affect the demand.

More recently, Hasanov (2015) and Yalta and Yalta (2016) investigated gasoline and diesel demand for Turkey. Hasanov (2015) used quarterly time series data between 2003:Q1 and 2014:Q3. He employed four different models namely, a partial adjustment model, a distributed lag model, an autoregressive distributed lag model, and an error correction model to estimate gasoline and diesel demand functions. The author estimated the short- and long-run price elasticities of diesel demand as -0.021 and -0.278, respectively. He also found the income elasticities as 0.182 in the short-run and 1.471 in the long-run. Consequently, Hasanov (2015) stated that the income and price elasticities of diesel demand in Turkey were elastic and inelastic, respectively. He determined an invalid long-run relationship among gasoline demand, income and gasoline price. On the other hand, gasoline price and demand are found as correlated, but income and demand are uncorrelated in the short-run (Hasanov, 2015).

Yalta and Yalta (2016) employed a fixed-width rolling windows framework with maximum entropy resampling method to analyse road fuel demand for Turkey over the period 2003-2012. They estimated the price and income elasticities of diesel and gasoline demand as follows:

- Short-run, price and income elasticities for diesel demand are -0.28 and 0.34, respectively.

- Long-run price and income elasticities for diesel demand are -0.14 and 0.31, respectively.

- Short-run, price and income elasticities for gasoline demand are -0.19 and 0.12, respectively.

- Long-run, price and income elasticities for gasoline demand are -0.18 and 0.11, respectively.

The stability of the parameters was determined by using CUSUM and CUSUMQ tests. In addition, they added control variables to the model with regard to the general economic outlook in order to obtain unbiased estimators of income and price elasticities. Eventually, Yalta and Yalta (2016) concluded that short-run price and income elasticities were more dynamic than that of long-run, and these results demonstrate that diesel and gasoline demand can be more sensitive to the changes on income and price in the short-term than in the long-term.

Along with gasoline and diesel demand, studies related to the crude oil import demand have also been done in Turkey in recent years. Crude oil is one of the main energy sources and plays a critical role in the economic development of Turkey. Therefore, from the mid-2000s onwards, the number of crude oil import demand studies has increased in Turkey. The main ones of these studies are presented below.

Altinay (2007) used the ARDL Bounds Testing approach to estimate the short- and long-run price and income elasticities of import demand for crude oil in Turkey. First, the long-run parameters were estimated by ARDL method and then the short-run variables were estimated by the error correction model. Moreover, diagnostic tests were employed to analyse serial correlation, heteroscedasticity, functional form misspecification, and non-normal errors. In addition, Altinay (2007) used CUSUM and CUSUMQ tests to check the stability of the model. For the period between 1980 and 2005, he found the short- and long-term income elasticities as 0.635 and 0.608, while the short- and long-run price elasticities were calculated as -0.104 and -0.182, respectively. Altinay (2007) stated that the income and price elasticities of import demand for crude oil were inelastic for both short- and long-term in Turkey.

Similar to Altinay (2007), Solak and Beskaya (2013) also modelled the ARDL approach to cointegration for estimating the short- and long-run price and income elasticities of net oil imports in Turkey. By using the data between 1970 and 2010, they first used Augmented Unit Root test to analyse the stationarity of the series and then the ARDL Bounds Testing to cointegration method was employed. They found the short-run relationship by ARDL error correction model. Furthermore, they utilised CUSUM and CUSUMQ tests to examine the stability of the parameters. As a result, the short- and long-term income elasticities were estimated as 1.11 and 0.67, respectively. The price elasticities in both the short- and long-run were found to be negative and statistically insignificant. The authors concluded that the price did not affect the net oil imports in Turkey over the period 1970 to 2010.

More recently, Yaprakli and Kaplan (2015) re-examined the long-run price and income elasticities of Turkish crude oil import demand by using a different method, namely multi-structural breaks analysis. The quantities of imported crude oil were used as a dependent variable, and nominal prices of crude oil and GDP were used as independent variables. They first checked the variables for unit roots and as a result of unit root test they employed cointegration test. These two tests supported strong evidence of structural breaks. Finally, they adopted dynamic ordinary least squares method to estimate the long-run elasticities. For the period between 1970 and 2013, Yaprakli and Kaplan (2015) estimated the long-run price and income elasticities for Turkey to be -0.25 and 0.18, respectively. Like Altinay (2007), they concluded that the price and income elasticities of demand for crude oil import were inelastic in the long-run.

To sum up, different methods have been applied to model and forecast energy demand in Turkey. Economists, engineers, and other scientists employed several approaches to develop a more consistent model that provide empirically better results. As Wirl and Szirucsek (1990) stated that not only economists but also engineers made an important contribution to the field of energy demand. Due to the fact that economic and econometric approaches will be used in this study, they are examined in more detailed. Moreover, energy demand researches in engineering discipline are mentioned briefly. For instance, Birol and Guerer (1993), Bakırtas et al. (2000), Altinay (2007), Erdogdu (2007), Halicioglu (2007), Tatlidil et al. (2009), Erdogdu (2010), Dilaver and Hunt (2011a, 2011b and 2011c), Turkekul and Unakitan (2011), Dahl (2012), Maden and Baykul (2012), Goncu et al. (2013), Solak and Beskaya (2013), Arisoy and Ozturk (2014), Bildirici and Bakırtas (2014), Erdogdu (2014), Altinay and Yalta (2015), Hasanov (2015), Yaprakli and Kaplan (2015), and Yalta and Yalta (2016) investigated energy demand issue economically, whereas Yumurtaci and Asmaz (2004), Akay and Atak (2007), Ediger and Akar (2007), Bilgili et al. (2012), Kıran et al. (2012), Melikoglu (2013), Boran (2015), analysed the same subject in terms of engineering discipline. The main difference between these two science fields is that the studies adopted economic approaches generally estimate price and income elasticities while the studies in the field of engineering usually investigate energy demand forecasting.

Except Maden and Baykul (2012), the studies related to electricity demand found generally small and negative price elasticity for Turkey (Bakırtas et al., 2000; Halicioglu, 2007; Erdogdu, 2007; Tatlidil et al., 2009, Dilaver and Hunt, 2011a, 2011b, 2011c; and Arisoy and Ozturk, 2014). Maden and Baykul (2012) found a statistically significant and elastic price elasticity of electricity demand. On the other hand, considering all of the studies related to Turkish electricity demand, the income elasticities are observed to be in the ranges of 0.06 to 3.1. These results are, of course, depend on the period that investigated, methods that applied, sectors that analysed and some other factors. However, the income elasticities are more consistent and significant in Turkey rather than the price elasticities of electricity demand. One possible reason for these results is that the energy prices are under the control of the government and subsidized in Turkey.

In the context of electricity demand forecasting studies, Akay and Atak (2007) and Bilgili et al. (2012) estimated industrial, residential and total electricity consumption for 2015 and they obtained similar results in comparison with the actual consumption in 2015 (Turkish Electricity Transmission Company-TEIAS, 2015). In addition, Yumurtaci and Asmaz (2004) and Kıran et al. (2012) forecasted the electric energy demand up to 2025 and 2050, respectively.

Natural gas demand studies in Tukey also analysed the price and income elasticities plus demand forecasts. The price elasticities were calculated to be around zero, except Erdogdu's (2010) estimation on the residential sector. He found very inelastic price elasticity for households' natural gas demand. It can be said that since Turkish natural gas prices are controlled by the government, the price fluctuations cannot be seen and the price power on natural gas consumption is limited. In addition, Altinay and Yalta (2015) stated that economic situations and weather conditions could affect the price and income elasticities of natural gas demand in Turkey.

Studies with regard to Turkish fuel demand have usually analysed gasoline and diesel demand. The price elasticities of gasoline and diesel demand are found to be near-zero in these studies (Birol and Guerer, 1993; Turkekul and Unakitan, 2011; Dahl, 2012; Hasanov, 2015; Yalta and Yalta, 2016). These results indicated that diesel and gasoline consumption in Turkey does not show an extreme reaction to the price changes. According to Yalta and Yalta (2016), diesel and gasoline demand can be more sensitive to the changes in income and price in the short-term than in the long-term. On the other hand, Birol and Guerer (1993) and Dahl (2012) were estimated significant income elasticities for transport fuel demand, whereas Erdogdu (2014), and Hasanov (2015) found income elasticity indifferent from zero for gasoline demand, but they calculated significant income elasticities for the long-run diesel demand. Furthermore, Turkekul and Unakitan (2011) determined the income elasticity of agricultural diesel demand as elastic.

In addition to the fuel demand, some studies analyse the crude oil import demand in Turkey. The primary ones of these researches are Altinay (2007), Solak and Beskaya (2013) and Yaprakli and Kaplan (2015). All of these studies found the price elasticities of crude oil import demand as negative and close to zero. On the other hand, while Solak and Beskaya (2013) estimated the income elasticity as elastic, the other two calculated as inelastic. Consequently, the main argument of these papers is that price does not affect the crude oil import in Turkey.

All in all, when the previous Turkish energy demand modelling and forecasting studies are analysed as a whole, it can be said that various methods were employed in estimating Turkey's energy demand trends. By using several approaches, the main motivation of those studies is to develop more consistent models that provide empirically better results. Thus, especially for policymakers, these results can provide some advantages, such as efficient energy planning tools, opportunities, the utilization of new technologies, evaluation of energy generating capacity, etc. (McVeigh and Mordue, 1999). In addition, the knowledge of price and income elasticity plus future energy demand help to reduce the risks and uncertainties in the economy. Moreover, they guide the long-term energy planning activities for sustainable economic growth.

Table 4.5. Literature Summary of Previous Energy Demand Studies for Turkey

Author(s)	Period	Methods Used	Focus of Study	Results
Birol and Guerer (1993)	1970-1990	Partial Adjustment Model and OLS	Gasoline and Diesel Demand	For gasoline demand the short- and long-run price elasticities are -0.18 and -0.75. For gasoline demand the short- and long-run income elasticities are 0.39 and 1.63. For diesel demand the short- and long-run price elasticities are 0.06 and 0.15. For diesel demand the short- and long-run income elasticities are 1.17 and 3.0.
Bakirtas et al. (2000)	1962-1996	Engle-Granger Two-Step Procedure & ARMA	Total Electricity Consumption per capita	Short-run and long-run income per capita elasticities are 0.692 and 3.134 respectively. Price elasticity is insignificant.
Yumurtaci and Asmaz (2004)	1980-2002	Linear Regression Model	Electricity Consumption	In 2050 Turkey's total electric energy demand will be 1173 TWh and electricity consumption per capita will be 10197 kWh.
Halicioglu (2007)	1968-2005	Bounds Testing Cointegration Approach	Residential Electricity Consumption per capita	- Short- and long-run price elasticities are -0.33 and -0.52, respectively. - Short- and long-run income elasticities are 0.44 and 0.70, respectively.
Akay and Atak (2007)	1970-2004	Grey Prediction with Rolling Mechanism	Industrial and Total Electricity Consumption	Industrial and total electricity consumptions are estimated as 140.37 TWh and 265.7 TWh for 2015, correspondingly.
Erdogdu (2007)	1984-2004	Partial Adjustment Model, Cointegration Approach & ARIMA	Electricity Consumption per capita	Price elasticities in the long- and short-term are -0.041 and -0.297, respectively. Income elasticity is 0.057 in short-term and 0.414 in the long-term. The average annual percentage increase in electricity consumption is 3.3% between 2004 and 2014.
Ediger and Akar (2007)	1950-2003	ARIMA	Primary Energy Demand	Total primary energy demand would decrease in all cases between 2005 and 2020.
Altinay (2007)	1980-2005	ARDL Bounds Testing Approach	Crude Oil Import Demand	The short- and long-run income elasticities are 0.635 and 0.608, while the short- and long-run price elasticities are -0.104 and -0.182, respectively.
Tatlidil et al. (2009)	1978-2003	Bounds Testing Cointegration Approach	Electricity Consumption per capita	Insignificant price effect. GDP per capita have statistically significant impact on electricity consumption per capita. The income elasticities are found to be 0.064 in the short-run and 0.1759 in the long-run.
Erdogdu (2010)	1988-2005	Partial Adjustment Model & ARIMA	Sectoral Natural Gas Demand	Price and income elasticities are found in sectoral basis (electricity generation sector, households and industry sector). The households have more elastic demand than all other sectors. The natural gas demand will reach 86.4 bcm in 2030.

Dilaver and Hunt (2011a)	1960-2008	Structural Time Series Model	Industrial Electricity Demand	Output (industrial value added) elasticity is 0.15 and price elasticity is -0.16. Turkish industrial electricity demand will be 97, 121 and 148 TWh by 2020 according to low, reference and high scenarios respectively.
Dilaver and Hunt (2011b)	1960-2008	Structural Time Series Model	Residential Electricity Demand	Total final consumption expenditure elasticities are 0.38 in the short-run and 1.57 in the long-run. Price elasticities in the short- and long-run are -0.09 and -0.38, respectively.
Dilaver and Hunt (2011c)	1960-2008	Structural Time Series Model	Aggregate Electricity Demand	Income and price elasticities are 0.17 and -0.11, respectively. Aggregate electricity demand for Turkey will be between 259 and 368 TWh in 2020.
Turkekul and Unakitan (2011)	1970-2008	Cointegration and ECM	Agricultural Energy Demand	For the long-run diesel demand, price elasticity is -0.38 and income elasticity is 1.47. For the long-run electricity demand, price elasticity is -0.72 and income elasticity is 0.19.
Maden and Baykul (2012)	1970-2009	Cointegration Approach & ECM	Total Electricity Consumption	Income elasticities in the short-run and long-run are 0.168 and 0.928 respectively. Price elasticity is -1.440 in the short-term and -6.85 in the long-term.
Bilgili et al. (2012)	1990-2003	ANN, Linear Regression & Nonlinear Regression	Residential and Industrial Electric Energy Demand	Turkey's residential and industrial sector electricity consumptions would increase to 140.64 TWh and 124.85 TWh by 2015, respectively, according to ANN model with poor scenario.
Kıran et.al. (2012)	1979-2006	Artificial Bee Colony and Particle Swarm Optimization	Electricity Energy Demand	In 2025, electricity energy demand will be between 167 TWh and 435 TWh averagely.
Dahl (2012)	1990-2012	Static and Dynamic Demand Models	Gasoline and Diesel Demand	For gasoline demand, the average price and income elasticities are -0.19 and 1.10, respectively. For diesel demand, the average price and income elasticities are -0.13 and 2.27, respectively.
Melikoglu, (2013)	1987-2011	Logistic and Linear Equations	Natural Gas Demand	Natural gas demand for Turkey was forecasted between 2013 and 2023. For 2030, natural gas demand was estimated as 76.8 bcm and 83.8 bcm by using the linear and logistic model, respectively.
Goncu et al (2013)	2004-2011	Stochastic Temperature Model	Natural Gas Demand	Climatic conditions, especially temperature change is one of the main factors on natural gas demand. Due to the fact that Turkish natural gas price is controlled by the government, it did not fluctuate throughout the examined period and the power of natural gas price on consumption was reduced.
Solak and Beskaya (2013)	1970-2010	ARDL Bounds Testing Approach	Net Oil Imports Demand	The short- and long-run income elasticities are 1.11 and 0.67, respectively. The price elasticities in both short- and long-term were found to be negative and statistically insignificant (-0.03 and -0.11).
Bildirici and Bakirtas (2014)	1980-2011	ARDL Bounds Testing Approach	Natural, Coal and Oil Consumption	The income elasticity of natural gas demand is 0.6145 in the short-run and 2.578 in the long-run.

Arisoy and Ozturk (2014)	1960-2008	Time Varying Parameters Model based on Kalman Filter	Industrial and Residential Electricity Demand	Income elasticities of industrial and residential electricity demand are 0.979 and 0.995, respectively. Price elasticity of industrial energy demand is -0.014 and price elasticity of residential energy demand is -0.0223.
Erdogdu (2014)	2006-2010	Partial Adjustment Model and OLS	Gasoline, Diesel and LPG Demand	<u>*Gasoline Demand*</u> Short-run price elasticity: -0.213 Short-run income elasticity: 0.132 Long-run price elasticity: -0.481 Long-run income elasticity: 0.298 <u>*Diesel Demand*</u> Short-run price elasticity: 0.67 Short-run income elasticity: 0.71 Long-run price elasticity: 0.155 Long-run income elasticity: 1.64
Yaprakli and Kaplan (2015)	1970-2013	Multi-structural Breaks Analysis	Crude Oil Import Demand	The long-run price and income elasticities of import demand for crude oil are -0.25 and 0.18, respectively.
Boran (2015)	1987-2012	Grey Prediction with Rolling Mechanism Method	Natural Gas Consumption	Natural gas consumption will be 2.15 billion cubic feet in 2018.
Altinay and Yalta (2015)	2004-2012	Fixed-width Rolling Windows Framework with Maximum Entropy Resampling Method	Residential Natural Gas Demand	-The own-price elasticity is around zero. -The income elasticity is affected by both recession period and unusual weather changes negatively. -The elasticities of residential natural gas demand are fluctuating over the observed period. -The economic situation and weather changes affect the price and income elasticities.
Hasanov (2015)	2003-2014	Partial Adjustment Model, Distributed lag Model Autoregressive Distributed Lag Model and Error Correction Model	Gasoline and Diesel Demand	For diesel demand, the short- and long-run price elasticities of diesel demand are -0.021 and -0.278, respectively. The income elasticities are 0.182 in the short-run and 1.471 in the long-run. For gasoline demand, there is no long-run relationship among gasoline demand, income and gasoline price. In the short-run gasoline price and demand were correlated but income and demand were uncorrelated.
Yalta and Yalta (2016)	2003-2012	Fixed-width Rolling Windows Framework	Gasoline and Diesel Demand	<u>*Gasoline Demand*</u> SR price elasticity: -0.19 SR income elasticity: 0.12 LR price elasticity: -0.18 LR income elasticity: 0.1 <u>*Diesel Demand*</u> SR price elasticity: -0.28 SR income elasticity: 0.34 LR price elasticity: -0.14 LR income elasticity: 0.31

4.7. Summary

In this chapter, some selected studies in the energy demand modelling literature are reviewed. In this context, along with Turkish energy demand analyses, selected studies with regards to electricity, natural gas, gasoline and aggregate energy demand for other countries and regions are presented.

Since the first oil shock in the early 1970s, the energy issue has become even more important, and the number of studies in this area has gradually increased. The first studies that modelled and forecasted energy demand are Houthakker (1951), Fisher and Kaysen (1962), Wilson (1971), Halvorsen (1975) and Pindyck (1979). The common points of these analyses are that they all used econometric techniques and mainly focused on electricity demand. Then, besides economists; engineers, mathematicians, and other scientists have analysed not only just electricity but also the other types of energy.

When the studies in the literature are reviewed as a whole, it can be said that different results were obtained in studies examining energy demand. This is because of the variety of method used, country or region investigated, variables included, period analysed, etc. Some studies have used time series method, whereas some have employed panel and cross-sectional data methods. Most of the studies in the literature have analysed one sector such as; commercial, industrial, manufacturing, residential; while some others have investigated all the sectors. In addition, there are also aggregate energy demand studies in which the energy demand is derived from the demand for several energy services used in an economy. Main studies in the field of energy demand concentrate on electricity, natural gas, gasoline and aggregate energy analyses. Data types that used in the studies have differed such as the national or regional level. Furthermore, based on the availability of the data, micro-level data have been utilized as household, firm, sector and sub-sector level. The aims of the studies have determined the variation of methods that applied in the analyses.

Based on the economic theory, the energy demand generally depends on income and price. Most of the studies in the literature have analysed the price and income elasticities of energy demand. Since the elasticity estimates vary from one study to another, a common inference cannot be reached according to the results obtained. The reason is that besides the variation of the period and country analysed, several different methods were used for measuring the elasticities of energy demand. The majority of time-series energy demand studies have used cointegration analysis. As mentioned previously, after the paper of Engle and Granger (1987), the energy demand studies that use the cointegration techniques increased gradually. Ramanathan (1999), Bakirtas et al. (2000) and Alves and Bueno (2003) have used the Engle and Granger (1987) Two-Step method. In addition, Bentzen and Engsted (1993), Hondroyiannis (2004), Polemis (2006), Altinay (2007), Halicioglu (2007), Akinboade et al. (2008), Tatlidil et al. (2009), Athukorala and Wilson (2010), Payne et al. (2011), Turkekul and Unakitan (2011), Maden and Baykul (2012), Zaman et al. (2012) and Bernstein and Madlener (2011 and 2015) are some examples that employed cointegration analysis.

In time, several different methods have been utilized to analyse the energy demand. For example, Birol and Guerer (1993), Eltony (1996), Erdogdu (2007, 2010 and 2014), Bianco et al. (2010) and Hasanov (2015) have used partial adjustment model, while Dilaver and Hunt (2011a, 2011b and 2011c), Sa'ad (2011) and Adeyemi and Hunt (2014) have investigated energy demand by using structural time series model approaches. In recent years, the time-varying cointegration model (Park and Zhao, 2010 and Arisoy and Ozturk, 2014) have become popular in examining energy demand. In brief, a significant number of methods that are using different kinds of techniques have been employed by government agencies, private sector institutions, research establishments, and academicians for modelling and forecasting the energy demand.

Consequently, the results of the studies mentioned above are different from each other, and therefore, a general conclusion cannot be reached based on these findings. The price and income elasticities could change with respect to the model used. In addition to this, the time period, country and region, the type of energy, dependent and independent variables, data sets and other factors can be effective in terms of obtaining different elasticity estimates and conclusions. In this sense, several arguments have propounded by the scientists. For instance, Taylor and Kaysen (1962) stated that non-economic factors are as important as economic ones in terms of energy demand. On the other hand, Wilson (1971) argued that price and income are the main factors of energy demand. In terms of several branches of science, there is no single right that researchers agree on about this issue. In the literature of energy demand, the authors have brought several approaches, and in the light of these studies, the main aim of this thesis is to obtain reliable, significant and consistent estimates of price and income elasticities and to make a reasonable prediction for the future energy demand.

CHAPTER 5. METHODOLOGY AND DATA

5.1. Introduction

In this chapter, the methodological framework used in the analysis part will be given. First, the unit root tests will be presented and then the Engle-Granger (EG) Two-Step, Fully Modified Ordinary Least Squares (FMOLS), Johansen Cointegration, Autoregressive Distributed Lag (ARDL) Bounds Testing and Structural Time Series Modelling (STSM) methods will be explained, respectively. In addition, the methodologies of several diagnostic tests, namely, Jarque-Bera, White, Breusch-Godfrey and Ramset Reset tests will be given. Furthermore, the diagnostic tests for STSM method will also be presented. Then, the forecasting methods that used for predicting the future demand will be described. At the end of the chapter, the data that utilized in this study will be introduced.

5.2. Unit Root Tests

In econometric analysis, one of the most significant data is time series. Since these data sets include trend, when they are added into the regression without any conversion, the regression results may be spurious. In other words, the results of the econometric studies that using these kinds of data do not usually reflect the reality. For this reason, the stationarity of the variables is very important. The results of the analyses using such variables can be valid statistically only if the time series data are stationary. In general, the unit root tests are used for testing the stationarity of the time series. After the stationarity of a series is determined, the cointegration tests can be applied.

By using the stationarity tests, the series can be analysed whether they contain unit root or not. From this point of view, it can be said that the unit root tests are widely used to analyse the stationarity of the variables. In addition, the significance level of the regression analyses can be strengthened by implementing the unit root tests. The basic form of the unit root tests equation is as follows:

$$\boldsymbol{Y_t = \rho Y_{t-1} + u_t \qquad\qquad -1 \leq \rho \leq 1} \qquad\qquad \textbf{(5.1)}$$

where u_t is a white noise error term. In Equation (5.1), the regression model that created Y in t period with respect to $t\text{-}1$ period is expressed. In here, the unit root issue or non-stationarity stochastic process occurs if the coefficient of Y_{t-1} (ρ) is equal to 1. Therefore, one year lagged value of Y_t (Y_{t-1}) is modelled in the regression. The next step of the unit root test is determining whether ρ is statistically equal to 1 or not. If this coefficient is equal to 1, then the dependent variable (Y_t) is defined as non-stationary. This fact is valid for the general process of the unit root tests (Gujarati, 2003: 814).

Equation (5.1) can be formed as follows:

$$\boldsymbol{Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + u_t} \qquad \textbf{(5.2)}$$
$$\boldsymbol{= (\rho - 1)Y_{t-1} + u_t}$$

which can be written as;

$$\Delta \boldsymbol{Y_t = \delta Y_{t-1} + u_t} \qquad \textbf{(5.3)}$$

where $\boldsymbol{\delta} = (\rho - 1)$, Δ is the first difference operator and t is the trend variable.

Instead of analysing Equation (5.1), Equation (5.3) can be estimated. In here, the null hypothesis that $\delta = 0$ is tested. According to the test results, if δ is found as 0 or $\rho = 1$, then the unit root problem arises. In other words, the time series under consideration is said to be non-stationary. On the other hand, if $\delta < 0$, this means that the series (Y_t) is stationary (Gujarati, 2003; Verbeek, 2004).

Verbeek (2004) indicates that a time series which becomes stationary after the first differencing is defined as integrated in order one, and specified as *I(1)*. Similarly, if a time series is stationary after taking differences twice (the first differences of first-order differences), then this series is said to be stable in the second order [*I(2)*]. In general, if a series is differenced *d* times before it becomes stationary, then it is said to be integrated in order *d*. In parallel with these inferences, Engle and Granger (1987) identify the formal definition of integration and the properties for the higher order of integration.

In the next parts of the study, some unit root tests such as Augmented Dickey-Fuller, Phillips-Perron, Kwiatkowski-Phillips-Schmidt-Shin will be presented. In addition to these, the Zivot-Andrews unit root test that considers possible structural break in the series will be introduced.

5.2.1. Augmented Dickey Fuller Test

To test the stationarity of a time series, first of all, it should be determined whether ρ is equal to 1 in Equation (5.1) or δ is tested in Equation (5.3) by the following hypothesis;

$H_0: \delta = 0$ The series (Y_t) is non-stationary.

$H_1: \delta < 0$ The series (Y_t) is stationary.

Dickey and Fuller (1979) explained that the predicted *t* value of δ (the coefficient of Y_{t-1}) in Equation (5.3) follows the τ (tau) statistics, under the null hypothesis that δ = 0. They estimated the critical values of the *tau statistic* by using the Monte Carlo simulation method. The *tau test* is defined as the Dickey-Fuller test in econometrics literature (Enders, 2010).

Dickey and Fuller (1979) state that the Monte Carlo simulation method generates three equations as follows:

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\rho Y_{t-1}} + \boldsymbol{u_t} \quad \textbf{(5.4)}$$

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\beta_1} + \boldsymbol{\rho Y_{t-1}} + \boldsymbol{u_t} \quad \textbf{(5.5)}$$

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\beta_1} + \boldsymbol{\beta_2 t} + \boldsymbol{\rho Y_{t-1}} + \boldsymbol{u_t} \quad \textbf{(5.6)}$$

where *t* is the time variable. Y_t in Equation (5.4) is a random walk which means the following year's value equals the present year's value plus a stochastic error term. In the Equation (5.5), Y_t is a random walk with drift and in Equation (5.6) Y_t is a random walk with drift around a stochastic trend. In each of these cases, the null hypothesis is δ = 0, which means the series are non-stationary (there is a unit root). The alternative one is δ < 0, and this means Y_t is stationary.

The Dickey-Fuller test do not consider the autocorrelation of error terms. In other words, it assumes that the error terms are uncorrelated. This is one of the weaknesses of the Dickey-Fuller test. The error terms are correlated in the regression analyses and this characteristic cause the Dickey-Fuller test to be invalid (Verbeek, 2004). To overcome this issue, Dickey and Fuller have developed a new method, namely Augmented Dickey Fuller (ADF) test. They added the lagged value of the dependent variable in the model to manage the autocorrelation problem. As a result, the ADF test became popular in econometric analyses and being one of the most important unit root tests to determine the order of integration. The equation of the ADF tests is shown as below:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad \textbf{(5.7)}$$

where ε_t is a white noise error term, $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. Some sufficient terms should be added into the model to eliminate the correlation between the error terms in Equation (5.4). In the ADF test, the null hypothesis of $\delta = 0$ is tested as in the Dickey-Fuller test. If the null hypothesis is rejected, ΔY_t is said to be stationary. In addition, the ADF test uses the same asymptotic distribution as DF statistics (Enders, 2010: 215).

5.2.2. Phillips-Perron Test

Phillips and Perron (1988) unit root test is similar to the ADF test. The main difference between these two tests is how they deal with serial correlation and heteroscedasticity in the errors. In the ADF test, the lagged values are added to the model in order to adjust the autocorrelation problem. On the other hand, the weak dependency and heterogeneously distribution of the error terms are allowed in the Philips-Perron unit root test. Therefore, the autocorrelation problem does not arise.

The equation of the Phillips-Perron test is modelled as follows:

$$y_t = \hat{\alpha} y_{t-1} + \hat{u}_t \quad \textbf{(5.8)}$$

$$y_t = \hat{\mu} + \hat{\alpha} y_{t-1} + \hat{u}_t \quad \textbf{(5.9)}$$

$$y_t = \hat{\mu} + \hat{\beta}\left(t - \frac{1}{2}T\right) + \hat{\alpha} y_{t-1} + \hat{u}_t \quad \textbf{(5.10)}$$

where T is the number of observations and μ_t is the distribution of the error terms. Here, the assumptions of serial correlation among errors and homogeneity is not necessary.

The hypothesis of the Phillips-Perron unit root test is as below.

$H_0: \alpha = 0$ The series is non-stationary (There is a unit root in the series).

$H_1: \alpha < 0$ The series is stationary (There is no unit root in the series).

The null and alternative hypothesis are identical with the ADF test. In addition, the critical values for the Phillips-Perron test are the same as the ADF test.

5.2.3. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

In the KPSS test, the main aim is to transform the series into stationary by eliminating the deterministic trend from the observed series (Kwiatkowski et al., 1992). The fact that there is no unit root in the series omitted from trend shows the trend stationarity of the series.

Kwiatkowski et al. (1992) suggested the Lagrange Multiplier (LM) statistics for testing the null hypothesis of stationarity against the alternative hypothesis of non-stationarity. The unit root testing hypotheses of KPSS approach are different from the ADF and Phillips-Perron tests.

The test is starting with the model below.

$$\boldsymbol{Y_t = \xi_t + r_t + \varepsilon_t} \qquad \textbf{(5.11)}$$

$$\boldsymbol{r_t = r_{t-1} + u_t} \qquad \textbf{(5.12)}$$

where r_t is the random walk, t is the deterministic trend, ε_t and u_t are stationary residuals. The stationarity hypothesis (null hypothesis) assumes the variances of u_t are zero ($\sigma^2=0$). The hypotheses (H_0 and H_1) are established as follows:

$H_0: \sigma_u^2 = 0$ The series (Y_t) is stationary.

$H_1: \sigma_u^2 > 0$ The series (Yt) is non-stationary.

By defining e_t as the residuals from the regressions of Y_t, the cumulative sum of residuals can be estimated in Equation (5.13) as

$$\boldsymbol{S_t = \sum_{t=1}^{T} \varepsilon_t} \qquad \textbf{t=1,2,3,……T} \qquad \textbf{(5.13)}$$

The variances of ε_t is as follows:

$$\boldsymbol{\sigma_\varepsilon^2 = \lim_{T\to\infty} T^{-1}\, E\left(S_T^2\right)} \qquad \textbf{(5.14)}$$

Lagrange Multiplier Test is calculated as below:

$$\boldsymbol{LM = \sum_{t=1}^{T} \frac{S_t^2}{\sigma_\varepsilon^2}} \qquad \textbf{(5.15)}$$

From this formulation, the KPSS test statistics can be formulated as in Equation (5.16):

$$\hat{\eta} = T^{-2} \sum_{t=1}^{T} S_t^2 / s^2(l) \quad \textbf{(5.16)}$$

where $s^2(l)$ is the consistent estimator of σ_ε^2 since the residuals are correlated each other.

$$s^2(l) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{S=1}^{l} w(s,l) \sum_{t=s+1}^{T} e_t e_{t-1} \quad \textbf{(5.17)}$$

Kwiatkowski et al. (1992) calculated the critical values of $\hat{\eta}$ via the Monte Carlo Simulation method. If the estimated value of $\hat{\eta}$ by using LM test is greater than the critical value, the null hypothesis that Y_t is stationary can be rejected. In other words, Y_t is decided as non-stationary. On the other hand, if the value of $\hat{\eta}$ is smaller than the critical value, the null hypothesis cannot be rejected, and the series is determined as stationary.

5.2.4. Zivot-Andrews Test

The conventional unit root tests (ADF, PP, KPSS) do not include any possible structural break in the model. However, starting with Perron (1989), economists argued that the series in econometric models could have some potential breaks and when modelling these series without considering this phenomenon, the stationary test results may be misleading. In Perron's test, the structural break is determined as priori, which means the break period is added to the model exogenously.

On the other hand, Zivot and Andrews (1992) have criticized this exogeneity assumption of Perron's test in their paper. Different from Perron (1989), they developed a method that estimates the structural break endogenously in the dynamic structure of the model. Zivot and Andrews (1992) claimed that the test method they suggested has prevented the data loss and is, therefore, more appropriate than the Perron's test.

Zivot and Andrews (1992) followed the ADF test procedure identical to Perron's. They developed three models to test the null hypothesis of stationarity as follows:

$$\textit{Model A}: y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DU(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad \textbf{(5.18)}$$

$$\textit{Model B}: y_t = \mu + \beta t + \alpha y_{t-1} + \theta_2 DT(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad \textbf{(5.19)}$$

$$\textit{Model C}: y_t = \mu + \beta t + \alpha y_{t-1} + \theta_2 DT(\varphi) + \theta_1 DU(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \quad \textbf{(5.20)}$$

where *DU* is a dummy variable for a mean shift and *DT* is a dummy variable for a trend shift of any possible break date (TB). Model A (Equation 5.18) and Model B (Equation 5.19) enable structural change in the level and slope of the trend function, respectively. Model C (Equation 5.20), on the other hand, allows a structural change both in the level and the slope. The relationship between these dummy variables and TB can be written in a formal way as below;

$$\boldsymbol{DU_t(\varphi) = \begin{cases} 1 & if \quad t > TB \\ 0 & otherwise \end{cases}} \tag{5.21}$$

$$\boldsymbol{DT_t(\varphi) = \begin{cases} t - TB & if \quad t > TB \\ 0 & otherwise \end{cases}} \tag{5.22}$$

The null and alternative hypothesis of the Zivot-Andrews unit root test are;

$H_0: \alpha = 0$ The series is non-stationary with one structural break.

$H_1: \alpha < 0$ The series is stationary with one structural break.

and in this test, the whole series is analysing to find a potential break-date. Zivot-Andrews method uses different dummy variables for every possible breaking point. For this reason, *T-2* regressions are established by using the Ordinary Least Squares method and the date in which α has the minimum *t* statistics is chosen as the appropriate structural break point. After finding the break date, the estimated *t* statistics are checked from Zivot-Andrews critical values which are tabulated in Zivot and Andrews (1992). If the absolute value of this *t* statistics is greater than the Zivot-Andrews critical values, then the null hypothesis is rejected.

5.3. Engle-Granger Two-Step Method

As mentioned previously, adding a non-stationary time series into the econometric analyses might cause some problems. In other words, using the non-stationary time series in a regression can cause spurious results. In addition, the test statistics might be misleading because of this process. There has been a debate among researchers in changing the time series instead of converting them to stationary since the time series generally contain a time trend. However, as a result of the former approach, some long-run information can be excluded from the regression (Utkulu, 1997: 39).

Engle and Granger (1987) offer a solution to this problem. The cointegration analyses developed by Engle and Granger (1987) enable to include the non-stationary variables in the regression analyses. In addition, the results of the regression do not lead to spurious correlations.

The cointegration test developed by Engle and Granger (1987) uses a single equation model. They recommend a two-step procedure to analyse the cointegration relationship. In the first step, the long-run equation is estimated. The regression that used in Engle and Granger test is as follows:

$$\boldsymbol{y_t = \beta_0 + \beta_1 x_t + u_t} \tag{5.23}$$

The residuals from Equation (5.23) are tested for stationarity by using the ADF unit root test.

$$\boldsymbol{\hat{u}_t = y_t - \hat{\beta}_0 - \hat{\beta}_1 x_t} \tag{5.24}$$

where $\hat{\beta}_0$ and $\hat{\beta}_1$ are the OLS estimators of β's.

In addition, $\hat{u}_t$ follows an autoregressive process in the Equation (5.24).

$$\boldsymbol{\hat{u}_t = \hat{\delta} u_{t-1} + \hat{\varepsilon}_t} \tag{5.25}$$

where the error term $\hat{\varepsilon}_t$ ~ i.i.d. $(0,\sigma^2)$.

If $\hat{u}_t$ is found to be stationary, then it can be said that the series are cointegrated. The MacKinnon (1991) critical values are used for determining the cointegration relationship. Engle and Granger (1987) showed that this method introduces a consistent estimate between the variables in terms of long-term steady-state relation because of the super-consistency characteristic of the OLS estimator. However, the conventional diagnostic tests are not interpretable. Furthermore, the *t* ratios and standard errors of Equation (5.23) are biased and misleading. In short, the only important property of the first step is identifying the stationarity of the residuals and then discussing the cointegration relationship.

After specifying this relationship among variables, the second stage of the Engle-Granger two-step method can be proceeded. In the second step, an error correction model is built, and the residuals gained from the first step is added to this model as an explanatory variable such as:

$$\Delta y_t = \theta_0 + \sum_{j=1} \theta_j \Delta y_{t-j} + \sum_{h=0} \theta_h \Delta x_{t-h} + \rho \hat{u}_{t-1} + \epsilon_t \quad \textbf{(5.26)}$$

where $\hat{u}_{t-1}$ is the error correction term, ρ is the adjustment coefficient which is expected to be negative and between 0 and -2. This model identifies how *y* and *x* behave in the short-run consistent with a long-run cointegrating relationship. The *t* ratios and diagnostic tests are valid for the second step of the method.

Although the Engle-Granger Two-Step Method is simple, when the number of the variables used in the model are more than two, the result may be affected by which variable is taken as the dependent. However, this inference does not prevent using more than two variables in establishing the model.

5.4. Fully Modified Ordinary Least Squares (FMOLS) Method

Fully Modified Ordinary Least Squares (FMOLS) method is a semi-parametric approach suggested by Phillips and Hansen (1990) to estimate the cointegration relationship among *I(1)* variables. This method has some advantages in comparison with the Engle-Granger Two-Step Method. First, the Engle-Granger (EG) method has poor statistical properties, but FMOLS estimators give more consistent results than EG in terms of finite samples. Second, the inference problem of the EG method is overcome in FMOLS by introducing proper corrections to the model. Thus, the *t* statistics for the long-run parameters are valid and interpretable. In addition, the endogeneity condition and the serial correlation problem of the OLS estimator can be explained by the FMOLS method.

The FMOLS method allows for both deterministic and stochastic trends. This is also an advantage to analyse the unobservable trend of the series. Moreover, the structural breaks can be added to the model as dummy variables, parallel with the structural break cointegration tests. Considering all of these features, the FMOLS estimator can be defined as super-consistent, asymptotically unbiased and giving satisfying results even in the small samples (Phillips and Hansen, 1990).

The FMOLS method indicates a simple cointegration relationship as follows:

$$Y_t = \alpha \hat{X}_t + \beta_1 \hat{D}_{1t} + \hat{u}_{1t} \quad \textbf{(5.27)}$$

where the deterministic and stochastic trend variables are determined by X_t.

$$\boldsymbol{X_t = \widehat{\Gamma}_{21} D_{1t} + \widehat{\Gamma}_{22} D_{2t} + \hat{\epsilon}_t} \quad \textbf{(5.28)}$$

The difference of Equation (5.28) is

$$\Delta \boldsymbol{X_t = \widehat{\Gamma}_{21}} \Delta \boldsymbol{D_{1t} + \widehat{\Gamma}_{22}} \Delta \boldsymbol{D_{2t} + \hat{\varepsilon}_t} \quad \textbf{(5.29)}$$

where $\Delta\hat{\epsilon}_t = \hat{u}_{2t}$ and the residuals $\hat{u}_t = (\hat{u}_{1t}, \hat{u}_{2t}{}')'$ are assumed to be strictly stationary and have zero mean. The covariance matrices estimated using residuals are as follows:

$$\boldsymbol{\Sigma = E(u_t u_t') = \begin{bmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \Sigma_{22} \end{bmatrix}}$$

$$\boldsymbol{\Lambda = \sum_{k=0}^{\infty} E(u_t u_{t-k}{}') = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \Lambda_{22} \end{bmatrix}} \quad \textbf{(5.30)}$$

$$\boldsymbol{\Omega = \sum_{k=-\infty}^{\infty} E(u_t u_{t-k}{}') = \begin{bmatrix} \omega_{11} & \omega_{12} \\ \omega_{21} & \Omega_{22} \end{bmatrix}}$$

and

$$\boldsymbol{\Omega = \Sigma + \Lambda + \Lambda'} \quad \textbf{(5.31)}$$

As it is seen, the FMOLS estimator is obtained by the $\hat{u}_{1t}$ in Equation (5.27) and $\Delta\hat{\epsilon}_t = \hat{u}_{2t}$. The residuals $\hat{u}_t = (\hat{u}_{1t}, \hat{u}_{2t}{}')'$ are used to estimate the long-term covariance matrices ($\hat{\Omega}$ *and* $\hat{\Lambda}$).

By using FMOLS Y_t in Equation (5.27) is modified to Y_t^+ as follows:

$$\boldsymbol{Y_t^+ = Y_t - \widehat{\omega}_{12} \widehat{\Omega}_{22}^{-1} \widehat{u}_2} \quad \textbf{(5.32)}$$

Finally, the FMOLS estimator can be written as below

$$\boldsymbol{\widehat{\theta} = \begin{bmatrix} \widehat{\alpha} \\ \widehat{\beta} \end{bmatrix} = \left(\sum_{t=1}^{T} M_t M_t{}'\right)^{-1} \left(\sum_{t=1}^{T} M_t Y_t^+ - T \begin{bmatrix} \hat{\lambda}_{12}^{+}{}' \\ 0 \end{bmatrix}\right.} \quad \textbf{(5.33)}$$

where $M_t = (X_t{}' D_t{}')$ and $\hat{\lambda}_{12}^{+} = \hat{\lambda}_{12} - \widehat{\omega}_{12} \widehat{\Omega}_{22} \widehat{\Lambda}_{22}$ which is the estimated bias correction term. All in all, it can be said that the main determinant of finding the FMOLS estimator is computing the long-term covariance matrices $\hat{\Omega}$ and $\hat{\Lambda}$. The t statistics corresponding to FMOLS estimators converges asymptotically to the standard normal distribution (Phillips and Hansen, 1990).

5.5. Johansen Cointegration Method

Johansen (1988), and Johansen and Juselius (1990) have introduced and developed a maximum likelihood testing method on cointegrating vectors. This method analyses the cointegrating parameters for any set of variables with some linear restriction techniques. The Johansen cointegration approach accept all variables as endogenous, and thus the problem of normalizing the cointegrating vector on the variables cannot exist (Herzer et al., 2006). In addition, comparing with the Engle-Granger test, this method has also some advantages. For instance, Sephton and Larsen (1991) criticised the Engle and Granger method in terms of the lack of information about the asymptotic distribution and examining only the main cointegrating vector instead of analysing all possible ones.

At this point, Johansen (1988) suggested the maximum likelihood method to investigate cointegration relations among variables. Wu (1996) claimed that the Johansen approach is preferable to the Engle-Granger method since the normalization problem is solved in the Johansen test and more information about asymptotic behaviour can be found in this method.

In Johansen's method the non-stationarity of the time series is considered in a vector autoregression (VAR) process, as follows:

$$\Delta \boldsymbol{Y_t} = \boldsymbol{\mu} + \boldsymbol{\Pi_0} + \boldsymbol{\Pi_1} \Delta \boldsymbol{Y_{t-1}} + \ldots\ldots + \boldsymbol{\Pi_{p-1}} \Delta \boldsymbol{Y_{t-p+1}} + \boldsymbol{u_t} \qquad \textbf{(5.34)}$$

where Δ is the first difference term, Y_t is a px1 random vector in *I(1)* order, μ is the px1 vector of constant terms, Π is pxp coefficient matrix, and u_t is px1 vector of error term coefficients; independently and identically distributed (*iid*) with zero mean and constant variance.

Π contain the information about long-term relations between Y_t variables, and can be described in the following equation:

$$\boldsymbol{\Pi = \alpha x \beta'} \qquad \textbf{(5.35)}$$

where α and β are nxr matrices. β is the cointegrating matrix and α is the adjustment matrix. The Johansen test provides the direct estimations of cointegrating vectors. In addition, the rank (*r*) of cointegration can be analysed by this approach. The Johansen method uses two test statistics in determining the cointegration rank. The first one is defined as the trace statistic:

$$\lambda\, trace = -T \sum_{i=r+1}^{n} ln(1-\lambda_i) \qquad r = 0,1,2,3,......,n-1 \qquad (5.36)$$

where T is the number of total observations, n is the number of variables, λ_i is n-r smallest squared correlations between Y_{t-k} $(Y_{t-1}, Y_{t-2},......,Y_{t-p+1})$ and ΔY_t. The trace test examines the cointegration relationship between the variables under the null hypothesis in order to find the number of maximum cointegrating vectors.

The null hypothesis is tested against the alternative for each case. The critical values for evaluating the hypotheses were estimated by Johansen and Juselius (1990). According to their results, if the test statistic is greater than the critical value, the null hypothesis should be rejected.

The second test statistic is the maximum eigenvalue test:

$$\lambda\, max = -T\, ln(1-\lambda_{r+1}) \qquad (5.37)$$

In here, the null hypothesis of r cointegrating vectors is tested against the alternative hypothesis of $r+1$ cointegrating vectors. The hypotheses are:

H_0: r cointegrating vectors.

H_1: r + 1 cointegrating vectors.

where the null hypothesis of $r = 0$ is tested against the alternative $r = 1$, and if the null is rejected then the null of $r = 1$ is tested against $r = 2$. Johansen and Juselius (1990) state that the maximum eigenvalue test can give more consistent results than the trace test. In addition, determining an optimal lag length is very significant for the performance of cointegration tests (Hatemi-J and Irandoust, 2000). There are several techniques that can be utilized to choose the lag length. In this study, Schwarz and Hannah-Quinn information criteria are used to select the number of lags required in the cointegration test.

5.6. Autoregressive Distributed Lag (ARDL) Bounds Testing Method

The next methodological framework used in this study is the Autoregressive Distributed Lag (ARDL) Bounds Testing Method. Pesaran et al. (2001) introduced this model to the literature and ARDL Bounds Testing approach is widely used in the econometric analysis because of its several advantages over other cointegration techniques such as Engle-Granger Two-Step and Johansen Cointegration methods. First, the ARDL Bounds Testing method can be used with a mixture of *I(0)* and *I(1)* data. Second, contrary to the Johansen approach, this method can give more consistent results determining the cointegration relation in small sample size. Third, the short- and long-run relationships among variables can be tested simultaneously. Fourth, this method allows appropriate lag length for each variable, and thus the model can have a more dynamic structure. In addition, by using optimal lags, the ARDL model is free from serial correlation. Finally, the ARDL framework can distinguish between dependent and independent variables which enables to avoid the endogeneity problem.

There are three steps of the ARDL Bounds Testing method. Firstly, the cointegration relationship among variables is investigated. Secondly, the long-run and thirdly, the short-run relations among dependent and independent variables are analysed. The basic form of the two variable ARDL Bounds Testing procedure can be specified as:

$$\Delta lnY_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \Delta lnY_{t-i} + \sum_{j=0}^{m} \beta_{2j} \Delta lnX_{t-j} + \beta_3 lnY_{t-1} + \beta_4 lnX_{t-1} + \varepsilon_t \qquad \textbf{(5.38)}$$

where Δ is the first difference of the series, m is the lag length, Y and X are the dependent and independent variables, respectively. For estimating the model, the appropriate lag lengths of the variables should be chosen by using Akaike (AIC) or Schwartz-Bayesian (SBC) Information Criteria. The maximum lag length differs depending on the use of monthly, quarterly or annually series. The lowest lag length found from AIC or SBC, without autocorrelation problem, should be chosen to estimate the model. After the convenient model is selected, F statistics is estimated by utilizing the Wald test.[1] Firstly, the null hypothesis (H_0: $\beta_3=\beta_4=0$) is tested against the alternative (H_1: $\beta_3\neq\beta_4\neq0$) to decide the cointegration relationship. The estimated F statistics compare with the critical values tabulated by Pesaran et al. (2001). If the estimated F statistics is greater than the upper bound level, the null hypothesis is rejected, and the cointegration relation among variables can be decided. On the other hand, if the estimated F statistics is below the lower bound level, then the null hypothesis cannot be rejected, and this shows that there is no cointegration. Finally, if computed F statistics is between the lower and upper bound levels, the test result is decided as inconclusive (Pesaran et al., 2001: 299).

[1] The Wald Test is a test that determines whether the parameters of the explanatory variables in a model are significant.

After determining the cointegration relationship among variables, the equation that is used to examine the long-term relationship among the dependent variable and independent variables can be generated as follows:

$$\boldsymbol{lnY_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} lnY_{t-i} + \sum_{i=0}^{k} \beta_{2i} lnX_{t-i} + \varepsilon_t} \quad \textbf{(5.39)}$$

where *p* and *k* are the lag lengths of the variables. These lag lengths are determined independently in long-run analysis different from the Bounds Testing procedure above. The lag lengths of the variables are decided by using the AIC and/or SBC. Then the model is estimated with the appropriate lag length and the long-run coefficients are concluded whether significant or not by checking the F statistics.

After obtaining the long-run relation and estimating the coefficient of the independent variables, the short-run relationship among variables can be analysed via the Error Correction Model (ECM) as in Equation (5.40):

$$\boldsymbol{\Delta lnY_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta lnY_{t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta lnX_{t-i} + \lambda ECT_{t-1} + \varepsilon_t} \quad \textbf{(5.40)}$$

where λ represents the coefficient of the error correction term (ECT) in the model. ECT is the residuals gained from the long-run equation, and λ shows the system's power of the converging equilibrium. In addition, the short-run analysis of the ARDL Bounds Testing approach uses the first difference of the variables differently from the long-run model.

5.7. Structural Time Series Modelling (STSM) Method

Last but not the least econometric methodology that utilized in this study is Harvey's (1989) Structural Time Series Modelling (STSM) approach. The STSM method has different features compared to the conventional cointegration analyses discussed above. First of all, the order of integration of the variables does not matter. As a result of this characteristic, the series does not need to be checked by unit root tests. Second, the short- and long-term effects can be seen in one equation. This means that it is not necessary to construct equations for short- and long-run separately. Third, the structural changes and breaks of the series can be easily determined by using the STSM method. Fourth, the dynamic structure of this method allows indicating the unobservable stochastic trend.

The STSM method was first introduced by Harvey (1989) and then improved by Harvey and Shephard (1993), Harvey and Scott (1994), and Harvey (1997). The dependent variable is formulated in the regression of time trend and seasonal dummies in the primary form of the models (Harvey, 1989). This means that the model was a univariate time series model at the first stage and the parameters of the model are time-varying. Then a multivariate structural time series model was developed by adding observable explanatory variables to the univariate model (Harvey and Shephard, 1993). They tried to estimate the model in a state space format in an attempt to determine several unobserved components.

Harvey and Shephard (1993) discussed that the series used in economic analyses are mostly non-stationary and the expectation of stationarity by differencing these series is unreasonable. In addition, Harvey (1997) widely criticises the conventional cointegration techniques due to their insufficient statistical features in analysing the relationship among variables. In parallel with these inferences, the STSM approach, which do not interest in the stationarity of the time series, was suggested by the authors listed above in analysing the energy demand.

The STSM method can be formulated with an unobservable trend changing stochastically over time. Consider the following annual time series model:

$$\boldsymbol{Y_t = \mu_t + Z_t'\delta + \varepsilon_t} \tag{5.41}$$

where Y_t is the dependent variable, μ_t is the trend component and ε_t is the white noise disturbance term ($\varepsilon_t \sim NID\ (0,\ \sigma^2)$). Z_t is kx1 vector of explanatory variables and δ is kx1 vector of unknown parameters. As it is mentioned above, the trend is supposed to follow a stochastic process and can be defined as below:

$$\boldsymbol{\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t} \qquad \boldsymbol{\eta_t \sim NID\ (0, \sigma_\eta^2)} \tag{5.42}$$

$$\boldsymbol{\beta_t = \beta_{t-1} + \xi_t} \qquad \boldsymbol{\xi_t \sim NID\ (0, \sigma_\xi^2)} \tag{5.43}$$

where the mutually uncorrelated white noises disturbances μ_t and β_t are level and slope of the trend, correspondingly. Furthermore, η_t and ξ_t are the determinants of the change in the level and slope of the trend, respectively. The shape of the trend depends on the variances σ_η^2 and σ_ξ^2 which are called as hyperparameters. In STSM methodology, if these hyperparameters are both non-zero, then the trend is said to be stochastic. Otherwise, if both are zero, the model transforms into a conventional deterministic time trend regression.

Therefore, it can be said that depending on the values of the hyperparameters, the stochastic trend may vary (Table 5.1).

Table 5.1. Trend Classification

SLOPE	LEVEL		
	No Level Lvl = 0, $\sigma_\eta^2 = 0$	**Fixed Level** Lvl ≠ 0, $\sigma_\eta^2 = 0$	**Stochastic Level** Lvl ≠ 0, $\sigma_\eta^2 \neq 0$
No slope Slp = 0, $\sigma_\xi^2 = 0$	Conventional regression with no constant and no trend	Conventional regression with a constant and no trend	Local level model
Fixed Slope Slp ≠ 0, $\sigma_\xi^2 = 0$		Conventional regression with a constant and a trend	Local level model with drift
Stochastic Slope Slp ≠ 0, $\sigma_\xi^2 \neq 0$		Smooth trend model	Local trend model

Source: Hunt et al., 2003a

In this study, the STSM framework along with the Underlying Energy Demand Trend (UEDT) concept is used. UEDT is the unobservable trend that involves technical changes and other exogenous factors in energy demand such as preferences, tastes, economic structure, environmental issues, etc. Therefore, Hunt et al. (2000, 2003a and 2003b) argue that STSM approach has a proper structure to model UEDT. In this study, the main model that formulated with income, price, and UEDT can be formed as follows:

$$\boldsymbol{E_t = f(Y_t, P_t, UEDT_t)} \quad \textbf{(5.44)}$$

where;

E_t = Energy Demand,

Y_t = Income,

P_t = Price,

$UEDT_t$ = Underlying Energy Demand Trend.

The econometric form of Equation (5.44) can be rewritten as follows:

$$\boldsymbol{\alpha(L)e_t = \beta(L)y_t + \theta(L)p_t + UEDT_t + u_t} \quad \textbf{(5.45)}$$

where

$$\boldsymbol{\alpha(L) = \phi - \sum_i^p \phi_i L^i = 1} \quad \textbf{(5.46)}$$

α(L) is polynomial lag operator, $1 - \phi_1 L - \phi_2 L^2 - \phi_3 L^3 - \phi_4 L^4$ for i=4;

$$\boldsymbol{\beta}(\boldsymbol{L}) = \sum_{i=0}^{m} \boldsymbol{\varphi}_i \boldsymbol{L}^i \qquad \textbf{(5.47)}$$

β(L) is polynomial lag operator, $1 + \varphi_1 L + \varphi_2 L^2 + \varphi_3 L^3 + \varphi_4 L^4$ for i=4;

$$\boldsymbol{\theta}(\boldsymbol{L}) = \sum_{i=0}^{k} \boldsymbol{\lambda}_i \boldsymbol{L}^i \qquad \textbf{(5.48)}$$

θ(L) is polynomial lag operator, $1 + \lambda_1 L + \lambda_2 L^2 + \lambda_3 L^3 + \lambda_4 L^4$ for i=4;

e_t = the natural log of energy demand,

y_t = the natural log of income,

p_t = the natural log of price,

β(L)/α(L) = the long-run income elasticity of energy demand,

θ(L)/α(L) = the long-run price elasticity of energy demand,

$UEDT_t$ = the estimated value of the Underlying Energy Demand Trend at time t,

u_t = random white noise error term.

In Equation (5.45), the UEDT is equal to μ_t if there are no interventions to the model. On the other hand, if there are interventions, UEDT is the sum of μ_t, irregular interventions, level interventions, and slope interventions. These interventions give information about structural changes and breaks. In addition, the interventions are added to the model in order to provide the normality of the auxiliary residuals. Irregular interventions represent temporary effects on the trend. Level and slope interventions refer to permanent effects on the trend.

The STSM/UEDT method uses the Kalman filtering approach (Kalman, 1960) to estimate the dynamic equations in the state space form. The hyperparameters are estimated by using the smoothing algorithm of the Kalman filter. Auxiliary and equation residuals are estimated for model selection. Furthermore, Likelihood Ratio (LR) test is carried out to prove the difference between models which use deterministic and stochastic trend.

In brief, Equation (5.45) is estimated considering the level and slope components by eliminating the statistically insignificant variables and ensuring the model to pass the diagnostic tests. STAMP 8.20 (Koopman et al., 2009) is used as the software package to estimate the energy demand functions in this study.

5.8. Diagnostics Tests

The results of the cointegration models should contain some features to be trustable. Therefore, a number of diagnostics tests are developed to analyse the consistency of the parameters. In this study, the diagnostics tests such as Jarque-Bera, White, Breusch-Godfrey, Ramsey Reset tests are used to investigate the normality of the error terms, heteroscedasticity, autocorrelation and model verification, respectively.

5.8.1. Jarque-Bera Normality Test

Jarque-Bera (JB) is a test for analysing the normal distribution of the error terms. Normally distributed error term is one of the most important features of the Ordinary Least Squares (OLS) estimators. Even if the OLS estimators are the Best Linear Unbiased Estimator (BLUE), error terms have to be normally distributed for *F* and *t*-tests to become valid. Otherwise, the significance tests of the parameters are invalid.

The test of normality is done by comparing the statistics obtained from the JB test to the Chi-square table. The hypotheses are as follows:

H_0: Error terms are normally distributed.

H_1: Error terms are not normally distributed.

The Jarque-Bera Normality Test statistics is estimated as:

$$\boldsymbol{JB = n\left[\frac{\left(\frac{\mu_3}{\sigma^3}\right)^2}{6} + \frac{\left(\frac{\mu_4}{\sigma^4} - 3\right)^2}{24}\right]} \qquad \textbf{(5.49)}$$

where $\mu_2 = \frac{\sum \hat{e}_t^2}{n} = \sigma^2$, $\mu_3 = \frac{\sum \hat{e}_t^3}{n}$, $\mu_4 = \frac{\sum \hat{e}_t^4}{n}$, and n is the sample size.

The estimated JB statistic is compared to the Chi-square critical values with 2 degrees of freedom and α significance level. If the JB statistics is found to be lower than the critical value, then H_0 cannot be rejected and the normal distribution of the error terms is decided.

5.8.2. White Test

The White test is using in econometric models to analyse the heteroscedasticity of residuals (White, 1980). This test is used for determining whether the constant variance assumption is valid. Estimation of the model and determination of the residuals are necessary to conduct the test. The test statistics is estimated by an auxiliary regression. The first model with *m* independent variables is as follows:

$$\boldsymbol{Y_t = \alpha_0 + \theta_1 X_{i1} + \theta_2 X_{i2} + \cdots + \theta_m X_{im} + e_t} \tag{5.50}$$

The auxiliary model can be formulated from Equation (5.50) as below:

$$\boldsymbol{e_t^2 = \alpha_0 + \alpha_1 X_{i1} + \alpha_2 X_{i2} + \cdots + \alpha_m X_{im} + \beta_1 X_{i1}^2 + \beta_2 X_{i2}^2 + \cdots \beta_m X_{im}^2 + \gamma_1 X_{i1} X_{i2} + \gamma_2 X_{i2} X_{i3} + \cdots \gamma_m X_{im-1} X_{im} + \varepsilon_t} \tag{5.51}$$

The hypotheses of the White Test are;

$H_0: \theta_1 = \theta_2 = \cdots \theta_m = 0$ (There is no heteroscedasticity).

$H_1: \theta_1 \neq \theta_2 \neq \cdots \neq \theta_m \neq 0$ (There is heteroscedasticity).

The test statistics of the White Test are obtained by specificity value (R^2) of the auxiliary regression model times the sample size (n). That is nR^2. The test statistics have a Chi-squared distribution with degrees of freedom equals the number of the independent variables (excluding the constant term) in the auxiliary regression. If the estimated test statistic is lower than the critical value, then the null hypothesis of no heteroscedasticity cannot be rejected at the proper significance level.

5.8.3. Breusch-Godfrey (LM) Serial Correlation Test

In time series analysis, the serial correlation problem should be taken seriously. If the residuals in different time periods are correlated, then it can be said that the errors are serially correlated. Without the serial correlation is being identified and corrected, the regression results are misleading. This is because the serially correlated errors affect the residuals in previous periods.

Breusch and Godfrey (1981) are presented a Lagrange Multiplier (LM) test for detecting serial correlation among error terms of the regression. This test enables to analyse both first-order autocorrelation and higher order autocorrelation.

Consider the following regression model with *m* independent variables:

$$\boldsymbol{Y_t = \alpha_0 + \alpha_1 X_{i1} + \alpha_2 X_{i2} + \cdots + \alpha_m X_{im} + u_t} \tag{5.52}$$

where u_t's are the residuals, and they follow a stationary autoregressive [AR(k)] process as below.

$$\boldsymbol{u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \cdots + \rho_k u_{t-k} + \varepsilon_t} \quad \textbf{(5.53)}$$

In Equation (5.53), the error term ε_t is assumed to be normally distributed with mean zero and variance 1 ($\varepsilon_t \sim N(0, 1)$). Moreover, $\rho_1, \rho_2, \ldots, \rho_k$ demonstrate the order of the autocorrelation. The hypotheses of the serial correlation test are as follows;

$H_0: \rho_1 = \rho_2 = \cdots = \rho_k$ (There is no autocorrelation).

$H_1: \rho_1 \neq \rho_2 \neq \cdots \neq \rho_k$ (There is autocorrelation).

The Breusch-Godfrey LM test statistics is computed as the number of observation times R-squared ($(n)R^2_{\hat{u}}$)) where n is the sample size and R^2 is the specificity value of the Equation (5.53). If the estimated LM test statistic is lower than the Chi-square critical values with equal to maximum k degrees of freedom, the null hypothesis cannot be rejected, and it can be decided that there is no autocorrelation in the k^{th} degree.

5.8.4. Ramsey's Reset Test

The Ramsey's Regression Specification Error Test (RESET) is suggested by Ramsey (1969) which is mainly a specification test for the linear regression models. The RESET test measures the specification errors such as omitted variable, incorrect functional form, and the correlation between independent variables and error terms. This test is used to analyse whether non-linear combinations of the explanatory variables are convenient to explain the exogenous variable (Lago, 2009). The standard RESET test is implemented with a regression model in Equation (5.54) as follows:

$$\boldsymbol{Y_i = \varphi_0 + \varphi_1 X + \varphi_2 Z + \epsilon_t} \quad \textbf{(5.54)}$$

where X and Z are (Txk) and (Txm) matrices, respectively. From the model above, the $\hat{Y}_i$'s are obtained, and the new model is estimated as below:

$$\boldsymbol{Y_i = \gamma_0 + \gamma_1 X + \gamma_2 Z + \gamma_3 \hat{Y}_i^2 + \gamma_4 \hat{Y}_{i+1}^3 + \cdots \gamma_{k-1} \hat{Y}_i^k + \varepsilon_t} \quad \textbf{(5.55)}$$

where $\hat{Y}_i^2, \hat{Y}_{i+1}^3, \ldots \hat{Y}_{k-1}^k$ are additional explanatory variables.

Equation (5.54) and (5.55) are restricted and unrestricted models, respectively. Both of these models are estimated, and then the significance of the parameters of $\hat{Y}$'s on the restricted model are tested by the F statistics. The hypotheses are as follows:

$H_0: \gamma_0 = \gamma_1 = \cdots = \gamma_k = 0$ (There is no specification error).

$H_1: \gamma_0; \gamma_1; \ldots; \gamma_k \neq 0$ (There is specification error).

For the null hypothesis, an F test is applied as below:

$$\boldsymbol{F} = \frac{(\boldsymbol{RSS_R} - \boldsymbol{RSS_{UR}}) / (\boldsymbol{m})}{(\boldsymbol{RSS_{UR}}) / (\boldsymbol{n} - \boldsymbol{k})} \quad \textbf{(5.56)}$$

where RSS_R is the restricted residual sum of squares, obtained from running regression including all *Y*s without including *X*; RSS_{UR} is the unrestricted residual sum of squares (including *X*), *m* is the number of restrictions, *n* is the number of observations and *k* is the number of parameters in the unrestricted regression.

The estimated F statistic is compared to the F critical values with *m* and *n-k* degrees of freedom and α significance level ($F_{\alpha, m, n-k}$). If the estimated F statistic is lower than the F critical value, then the null hypothesis cannot be rejected. This means that the there is no specification error in the model.

5.8.5. Diagnostic Tests for STSM Method

Thomas (1993) indicates that a number of criteria such as data coherency, consistency with theory, parsimony, encompassing and parameter consistency should be checked for establishing a model. Koopman et al. (2009) state that in order to control whether the structural time series models are meeting these criteria, the estimated models should pass several diagnostic tests as follows:

- The standard error of estimate that defined as the evaluation of the variation of dependent variable values around the computed regression line can provide and insight for stability and consistency of the regression. The accuracy of estimations can be calculated by the standard error of estimate, and it can be formulated as:

$$\boldsymbol{SE} = \frac{\sum_{i=1}^{n} (\boldsymbol{Y} - \hat{\boldsymbol{Y}})}{\boldsymbol{N}} \quad \textbf{(5.57)}$$

where Y and $\hat{Y}$ are the actual and predicted values of the dependent variable, respectively, and *N* is the sample size.

- The Bowman-Shenton test is used for testing the normality of the series which is approximately distributed as χ^2. The Bowman-Shenton normality test utilises the skewness and kurtosis estimates of the regression as follows:

$$\boldsymbol{BS = n\left(\frac{(skewness)^2}{6} + \frac{(kurtosis)^2}{24}\right)} \qquad \textbf{(5.58)}$$

- Skewness and kurtosis are the measures of symmetry and peakedness of a distribution, respectively. They are both approximately distributed as χ^2. The skewness and kurtosis distributions can be defined as:

$$\boldsymbol{Skewness = \frac{\frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y})^3}{\sigma_y^3}} \qquad \textbf{(5.59)}$$

$$\boldsymbol{Kurtosis = \frac{\frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y})^4}{\sigma_y^4}} \qquad \textbf{(5.60)}$$

where σ_y is defined as the sample standard deviation ($\sigma_Y = \sqrt{\frac{\sum_{i=1}^{n}(Y-\bar{Y})^2}{n}}$).

- Heteroscedasticity test is a basic non-parametric two-sided $F_{(p,p)}$ test with (p, p) degrees of freedom. The test statistics *H(p)* can be described as below:

$$\boldsymbol{H(p) = \frac{\sum_{t=T-p+1}^{T} e_t^2}{\sum_{t=d+1}^{T=d+1+p} e_t^2}} \qquad \textbf{(5.61)}$$

where e_t represents the residuals, and p is the closest integer to the one-third of the number of observations.

- Autocorrelation is analysed using the Box-Ljung test, which is distributed as χ^2. The Box-Ljung test statistics is given by:

$$\boldsymbol{Q(p,q) = T(T+2)\sum_{T=1}^{p}\frac{r_T^2}{T-p}} \qquad \textbf{(5.62)}$$

where p is the number initial autocorrelations and q is the degrees of freedom. The serial correlation coefficients r with an appropriate lag length is approximately distributed as normal.

- Durbin-Watson (DW) test is used for identifying the autocorrelation in residuals from the regression analysis. DW test only investigates the first order autocorrelation which can be computed as:

$$\boldsymbol{DW} = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2} \quad \textbf{(5.63)}$$

where e_t are the residuals. DW is approximately distributed as *N(2, 4/T)*.

- R^2 and R_d^2 are the coefficient determination on the levels and first differences, respectively. R-squared is a measure of how well the dependent variable can be explained by the independent variable(s), and it can be formulated as follows;

$$\boldsymbol{R^2} = \frac{ESS}{TSS} = \frac{\sum_{t=1}^{T}(\hat{y}_i - \bar{y})^2}{\sum_{t=2}^{T}(y_i - \bar{y})^2} \quad \textbf{(5.64)}$$

$$\boldsymbol{R_d^2} = \frac{\sum_{t=1}^{T}(\hat{y}_i - \bar{y})^2}{\sum_{t=2}^{T}(\Delta y_i - \overline{\Delta y})^2} \quad \textbf{(5.65)}$$

where *ESS* is the explained sum of squares, and *TSS* is the total sum of squares. Δ in Equation (5.65) demonstrates the first difference of the dependent variable *y* ($\Delta y_t = y_t - y_{t-1}$).

- Prediction failure test is the test for analysing the power of the forecast for the model. This test re-estimates the regression by using the pre-sample period and predicts the last period of the model. The test statistic is estimated by;

$$\boldsymbol{pft} = \sum_{p=1}^{K} e_{T+p}^2 \quad \textbf{(5.66)}$$

where e_t are the standardized residuals, and the total number of observations are *t=T+1, T+2,……T+K*. *K* is the number of post-sample observations. The prediction failure test is approximately distributed as χ_K^2.

- The cumulative sum (CUSUM) of the recursive residuals (forecast errors) is used for testing the stability of the model which has the Student-t distribution. The Cusum test statistic can be written by;

$$CUSUM = \frac{\sum_{p=1}^{K} e_{T+p}}{\sqrt{K}} \tag{5.67}$$

where e_t are the standardized residuals and K is the number of post-sample observations.

5.9. Forecasting Methodology

In Chapter 6, after determining the energy demand models for the sub-sectors along with aggregate levels of electricity and natural gas, the forecast equations and scenarios are established. Forecast equations are maintained by substituted the error correction equations into the short-run dynamic equations for the conventional cointegrating approaches. And then these new equations are simplified and combined to reach the forecast equations. On the other hand, the STSM forecasting equations are used as it was with the trend increasing or decreasing by the estimated slope at the end of the estimation period.

In addition, three scenarios are applied sensitively to make the predictions of this study. These scenarios are named as low, reference and high. The scenario building approaches are widely used in the literature such as Erdogdu (2007), Dilaver and Hunt (2011a, 2011b, 2011c), Bilgili et al. (2012) and Kıran et al. (2012). According to the reference scenario, the optimal alterations of the economic indicators are used. On the other hand, for the low and high case scenarios, the lower and upper bound of the variations of economic variables are determined. As a result, three different energy demand predictions are obtained, and this enables more consistent forecasts for the future energy demand. The detailed information about the scenarios will be given in the empirical analysis chapter.

5.10 Data

The data that used in this thesis to analyse the energy demand relations for Turkey are annually observations. Two different sample sizes are identified for the electricity and natural gas demand. In terms of electricity demand estimation, the annual data for the period between 1978 and 2015 were used. For the natural gas demand estimation, on the other hand, the annual data from 1988 to 2015 were preferred because of data availability.

The variables used in industrial (E_d^I), residential (E_d^R) and aggregate (E_d^A) electricity demand analyses and the econometric representations of the models are presented as follows:

$E_d^I = f(IVA, IEP)$ $\quad$ $E_t^I = \alpha_0 + \alpha_1 IVA_t + \alpha_2 IEP_t + \varepsilon_t$

$E_d^R = f(HFCE, REP)$ $\quad$ $E_t^R = \beta_0 + \beta_1 HFCE_t + \beta_2 REP_t + \nu_t$

$E_d^A = f(GDP, AAEP, POP)$ $\quad$ $E_t^A = \gamma_0 + \gamma_1 GDP_t + \gamma_2 AAEP_t + \gamma_3 POP_t + \epsilon_t$

where;

E^I : Industrial Electricity Consumption,

E^R : Residential Electricity Consumption,

E^A : Aggregate Electricity Consumption,

IVA : Industrial Value Added,

IEP : Industrial Electricity Price,

HFCE : Household Final Consumption Expenditure,

REP : Residential Electricity Price,

GDP : Gross Domestic Product,

AAEP : Average Aggregate Electricity Price[2],

POP : Population.

E^I, E^R, and E^A are obtained from the International Energy Agency in kilowatt-hour (kWh) (IEA, 2015). *IVA*, *HFCE*, *GDP* in constant Turkish Liras (TL), and *POP* are retrieved from the World Bank database (World Bank, 2015). Nominal *IEP* and *REP* in TL/kWh are gained from IEA (IEA, 2015). The nominal average aggregate electricity price is estimated by using the weighted averages of nominal industrial and residential electricity prices. The nominal prices (industrial, residential and average aggregate electricity prices) are deflated by Consumer Price Index (2010=100) of Turkey available in World Development Indicators (World Bank, 2015).

[2] $AAEP_t = \left(IEP_t * \frac{E_t^I}{E_t^I + E_t^R}\right) + \left(REP_t * \frac{E_t^R}{E_t^I + E_t^R}\right)$

On the other hand, in terms of natural gas demand, the variables for determining industrial N_d^I, residential N_d^R and electricity generation sector N_d^{EG} and the econometric models are represented as below:

$$N_d^I = f(IVA, INP, IEP) \qquad N_t^I = \delta_0 + \delta_1 IVA_t + \delta_2 INP_t \pm \delta_3 IEP_t + u_t$$

$$N_d^R = f(HFCE, RNP, REP) \qquad N_t^R = \lambda_0 + \lambda_1 HFCE_t + \lambda_2 RNP_t \pm \lambda_3 REP_t + e_t$$

$$N_d^{EG} = f(IVA, EGNP, EGCP) \qquad N_t^{EG} = \phi_0 + \phi_1 IVA_t + \phi_2 EGNP_t \pm \phi_3 EGCP_t + \vartheta_t$$

where;

N^I : Industrial Natural Gas Consumption,

N^R : Residential Natural Gas Consumption,

N^{EG} : Electricity Generation Sector Natural Gas Consumption,

IVA : Industrial Value Added,

INP : Industrial Natural Gas Price,

IEP : Industrial Electricity Price,

HFCE : Household Final Consumption Expenditure,

RNP : Residential Natural Gas Price,

REP : Residential Electricity Price,

EGNP : Electricity Generation Sector Natural Gas Price,

EGCP : Electricity Generation Sector Coal Price.

N^I, N^R, and N^{EG} are obtained from the International Energy Agency in tonnes of oil equivalent (toe) (IEA, 2015). *IVA* and *HFCE*, in constant Turkish Liras (TL), are extracted from the World Bank database (World Bank, 2015). *INP*, *IEP*, *RNP*, *REP*, *EGNP*, and *EGCP* are all real prices[3] (2010=100) and collected from IEA (IEA, 2015).

The demand elasticities are investigated in this study to analyse primarily the impact of price and income, and then the other additional variables on energy consumptions. The

[3] The real prices are estimated by deflating the nominal prices with Turkish producer price index (2000=100) for industrial and electricity generation sectors and with consumer price index (2000=100) for the household sector.

econometric models are estimated by using Gretl (Version 1.9.92), Eviews 9 and STAMP 8.20 software packages.

5.11. Summary and Conclusion

In this chapter, the methodological framework and the data that used in the thesis are presented. First, the unit root tests that used for determining the stationarity of the series are explained. In conventional cointegration tests, the stationarity of the variables is a necessity. Therefore, unit root tests are applied for testing the stationarity, and then the cointegration models can be established. In this study, ADF, PP, and KPSS unit root tests are used to analyse whether the series contain a unit root. The first two tests (ADF and PP) investigates the non-stationarity of the series in the null hypotheses whereas the KPSS test seeks to measure the non-stationarity in the alternative hypothesis. Furthermore, the Zivot-Andrews test is also applied to consider possible structural breaks in the series. Different from the traditional unit root tests (ADF, PP, and KPSS), the Zivot-Andrews test estimates the structural breaks endogenously in its dynamic structure.

After determining the stationarity of the series, the cointegration tests can be performed. The Engle-Granger Two-Step Method, which uses a single equation model and two-step procedure to identify the cointegration relationship among variables, is the first test that utilized in this study. One of the weaknesses of this method is the lack of interpretation for diagnostic tests. In addition, the statistical properties of the Engle-Granger method are poor in terms of finite samples.

FMOLS and Johansen approaches suggest some solutions to the weaknesses of the EG method. In finite samples, the estimators of the FMOLS method give more consistent results than EG approach. Moreover, the diagnostic tests are valid and interpretable. On the other hand, the Johansen method enables to examine all possible cointegrating vectors while EG analysis only the main one. As it is seen that the FMOLS and Johansen methods have some superiorities over the EG test. Actually, one of the main aims of this study is to compare the cointegration tests mentioned here in terms of the mutual advantages over each other.

The ARDL Bounds Testing method has also several advantages over the EG and Johansen approaches. For the other cointegration tests, the series need to be integrated in the same order, whereas the ARDL method can use a mixture of $I(0)$ and $I(1)$ variables together. Moreover, in a small sample size, the ARDL Bounds Testing can give more consistent results than the Johansen test. In addition, the dynamic structure of the ARDL approach let to choose the optimal lag length for the variables, and so the past information of the series can be included in the model.

The last method used in this study is Harvey's (1989) STSM approach. In comparison with the above-mentioned cointegration tests, one of the most outstanding properties of STSM method is to estimate the unobservable stochastic trend. The STSM methodology enables to model the underlying energy demand trend (UEDT) and to observe the changes in demand tendency over time. Thus, the STSM method can be determined as an appropriate approach to estimate the stochastic UEDT (Hunt et al., 2000, 2003a and 2003b).

In addition to the methods that utilized to analyse the energy demand, the stabilities of these methods are also an important issue. Because of this reason, the models need to be checked by several diagnostic tests. The normality of the errors, heteroscedasticity, autocorrelation, and specification tests are introduced to examine the consistency of the parameters and the models themselves. Furthermore, the diagnostic tests for the STSM method are also presented to investigate the validity of the results that gained from this approach.

The methodological frameworks that described in this chapter are used to analyse Turkish electricity and natural gas demand in terms of sub-sectors and aggregate levels. For the electricity; industrial, residential and aggregate electricity demand functions are estimated. On the other hand, for the natural gas; industrial, residential and electricity generation sector natural gas demand equations are calculated. Furthermore, by using the information from the estimations of the cointegration methods and STSM approach, the future demands are forecasted with proper scenarios up to 2025. In chapter 6, the empirical analysis results of Turkey's energy demand are presented.

CHAPTER 6. EMPIRICAL ANALYSES OF ENERGY DEMAND IN TURKEY

6.1. Introduction

In this chapter, the empirical analyses of energy demand for Turkish electricity and natural gas sectors are introduced. For this purpose, the methodologic framework demonstrated in Chapter 5 is used. One of the aims of this part is analysing the relationship among prices, outputs and energy consumption for electricity (industrial, residential and aggregate) and natural gas (industrial, residential, electricity generation and aggregate) sectors. In this regard, the main headings are electricity demand and natural gas demand. After determining the elasticities, future demand prediction results are estimated separately for each sector of electricity and natural gas.

The main motivation of this chapter is to compare the performances of the conventional cointegration tests and the STSM approach in terms of computing the demand elasticities and forecasting future energy demand. The essential objective of following this procedure is to observe the differences and similarities of several approaches in estimating the elasticities of energy demand and forecasting possible future energy consumption of Turkey.

The structure of this chapter is as follows: In parallel with the methodology chapter, firstly the electricity demand functions for Turkish industrial, residential and aggregate level are given. Then the natural gas demand (industrial, residential and electricity generation sectors) equations for Turkey are presented. Forecast results for electricity and natural gas demands are examined in detail with respect to three scenarios (low, reference and high) at the end of each part.

6.2. Electricity Demand

Electricity is one of the most consumed energy types in Turkey. For this reason, the estimation of electricity demand is very significant for the Turkish energy sector. In this part of the study, several econometric techniques are used to estimate the industrial, residential and aggregate electricity demand elasticities for the period of 1978-2015.

First, the unit root test results are presented. Unit root tests are essential for conducting some of the conventional cointegration methods. Therefore, a variety of unit root tests (ADF, PP, KPSS, and ZA) are applied to the series. After then, the elasticity estimations obtained by EG Two-Step, FMOLS, Johansen, ARDL Bounds Testing and STSM approaches are given for each sector separately. At the end of the section, the scenarios and the forecast equations derived from elasticity estimations are constituted to predict the future elasticity demand for Turkey up to 2025.

6.2.1. Industrial Electricity Demand

6.2.1.1. Unit Root Tests Results

Stationarity is a very important and required specification in time series analyses. Therefore, before starting the modelling processes, stationarity of the series should be checked by unit root tests. The functional form and econometric specification for estimating the industrial electricity demand are generated as follows:

$$E_d^I = f(IVA, IEP) \qquad E_t^I = \alpha_0 + \alpha_1 IVA_t + \alpha_2 IEP_t + \varepsilon_t \qquad (6.1)$$

where E^I, *IVA*, and *IEP* represent industrial electricity consumption, industrial value added and industrial electricity price, respectively. At this stage, these three variables need to be checked whether they contain unit root or not. In line with this objective, ADF, PP, and KPSS unit root tests are used in this study to reveal the order of the integration for each variable. The unit root test results are given in Table 6.1.

Before testing stationarity with unit root tests, it is essential to determine the lag length. There is no general rule in selecting the maximum lag length, and therefore it is generally determined by researchers. In the literature, the lag length is specified as 12 or 24 in the studies that use monthly series, and as 4, 8, or 12 in the researches that use annual or seasonal series (Kadilar 2000: 54). Modified Akaike Information Criterion (AIC) is used in this study to select the appropriate lag length. The maximum lag length is decided as 9 and decreased to find the appropriate length for ADF. On the other hand, for PP and KPSS methods, the bandwidth is chosen by Newey-West selection criteria for the Bartlett Kernel model.

Table 6.1. The Unit Root Tests Results for Industrial Electricity Demand

	Variables	Level			1st Difference		
		ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Test Statistics (Constant)	***E^I***	-1.10	-1.37	0.74	-6.35*	-6.36*	0.17*
	IVA	-1.93	-2.44	0.68	-7.33*	-7.47*	0.25*
	IEP	-1.49	-1.42	0.51	-6.97*	-6.91*	0.21*
Critical Values (Constant)	***5%***	***-2.94***	***-2.94***	***0.46***	***-2.94***	***-2.94***	***0.46***
Test Statistics (Constant & Trend)	***E^I***	-1.91	-1.91	0.19	-6.55*	-7.51*	0.05*
	IVA	-2.50	-2.46	0.18	-7.32*	-8.25*	0.13*
	IEP	-2.99	-2.83	0.15	-7.21*	-7.17*	0.12*
Critical Values (Constant & Trend)	***5%***	***-3.53***	***-3.53***	***0.14***	***-3.53***	***-3.53***	***0.14***

Notes: *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively.

As it is seen from Table 6.1, all variables are stationary in their first differences. The test statistics for ADF and PP unit root tests were estimated as lower in the level and greater in the first differences than the critical values in absolute values. Therefore, the null hypotheses of non-stationarity can be rejected for these two unit root tests. On the other hand, the null hypothesis of stationarity cannot be rejected in KPSS unit root test since the estimated test statistics are lower (in absolute values) than the critical values at 5% significance level. In brief, all variables are said to be integrated of order one (I[1]).

In addition to the traditional stationarity tests, the Zivot-Andrews unit root test that considers a structural break in the series is also applied to the variables. Zivot and Andrews (1992) suggested structural break unit root tests for the models with the break in the constant, trend and also constant and trend. The estimated ZA test results for this study are presented in Table 6.2.

Table 6.2. Zivot-Andrews Unit Root Test Results for Industrial Electricity Demand

	Variables	Level			1st Difference		
		ZA	**Lag Length**	**Break Date**	**ZA**	**Lag Length**	**Break Date**
Test Statistics (Constant)	***E^I***	-4.03	0	1984	-6.20*	1	2003
	IVA	-4.62	0	1986	-7.95*	0	1999
	IEP	-3.85	0	2003	-8.23*	0	2008
Critical Value (Constant)	***5%***	***-4.80***					
Test Statistics (Constant & Trend)	***E^I***	-4.52	0	1987	-6.13*	1	1990
	IVA	-4.66	0	1986	-7.91*	0	1999
	IEP	-4.03	0	1986	-8.25*	0	2008
Critical Value (Constant & Trend)	***5%***	***-5.08***					

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 4 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)

3. The appropriate lag length was determined by Akaike Information Criteria.
4. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively.

According to the ZA unit root test results, the estimated critical values of E^I, *IVA*, and *IEP* are lower (in absolute terms) than the critical value in the levels. This shows that the null hypothesis of non-stationarity cannot be rejected at 5% significance level. Therefore, it can be said that the series are not stationary in their levels. After then the ZA test is applied again to the first differences of the series. The estimation results show that the series are determined as stationary in their first differences at 5% significance level. In this context, the ZA test results show consistency with the conventional unit root tests (ADF, PP, and KPSS) which does not consider structural breaks in the series.

6.2.1.2. EG Two-Step Method

The EG Two-Step method consists of two steps. In the first step, the long-run relationship is examined. The results of the long-run equation are given in Table 6.3. After then, in the second step, the short-run model is established by using the information from the long-run model.

Table 6.3. The Long-Run Results of EG Two-Step Method for Industrial Electricity Demand

Dependent Variable: E^I			
Sample: 1978-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	15.57	1.027078	15.16 [0.00]
IVA	0.36	0.044018	8.33 [0.00]
IEP	-0.01	0.042452	-0.13 [0.89]
T	0.04	0.001866	25.18 [0.00]

Notes: *1. p-values are in square brackets.*
2. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively. T is the trend variable.

The t-statistics and diagnostic tests for the long-run parameters are not valid in EG Two-Step method (for the details see Chapter 5). Therefore, the model is established without checking the stabilities of the parameters. In the first step of the EG Two-Step method, the long-run cointegrating vectors are given in Equation (6.2) as follows:

$$\boldsymbol{E_t^I = 15.57 + 0.36IVA_t - 0.01IEP_t + 0.04T} \quad \textbf{(6.2)}$$

For checking the cointegration, the residuals obtained from the long-run equation should be stationary. The ADF unit root test described in Chapter 5 is used to perform the test.

Table 6.4. Unit Root Test of Residuals for Industrial Electricity Demand

Variable		Constant		Constant and Trend		None	
		Level	*1st difference*	*Level*	*1st difference*	*Level*	*1st difference*
residuals	***Test Statistic***	-5.02*	-	-4.97*	-	-5.10*	-
	Critical Values (1%)	-3.62		-4.22		-2.62	

Note: *1. (*) Significant at 1% MacKinnon (1996) critical value.*

The residuals are stationary in their levels at 1% significance level of the ADF test statistics. Therefore, the validity of the cointegration relationship among variables can be accepted from the result of the unit root test for the residuals.

The second step of the model is conducted by using the information from the estimated long-run equation. The short-run results of the industrial electricity demand model are introduced in Table 6.5.

Table 6.5. The Short-Run Results of EG Two-Step Method for Industrial Electricity Demand

Dependent Variable: ΔE^I			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.05	0.006212	7.75 [0.00]
ΔIVA	0.28	0.065489	4.23 [0.00]
ΔIEP	-0.09	0.050696	-3.83 [0.00]
ECT(-1)	-0.80	0.190522	-4.22 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.035	Norm: χ^2 = 2.02 [0.36]	Het: F= 0.32 [0.96]	ARCH (1): F = 0.03 [0.85]
LM Serial Correlation: F = 0.91 [0.41]	Reset: F = 1.00 [0.37]	Wald: F = 13.50 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively.

Equation (6.3) represents the short-run equation of the industrial electricity demand for Turkey as follows:

$$\Delta E_t^I = 0.05 + 0.28\Delta IVA_t - 0.09\Delta IEP_t - 0.80ECT_{t-1} \quad \mathbf{(6.3)}$$

where *ECT* represents the error correction term and is formulated from the long-run equation as below:

$$ECT_t = E_t^I - 15.57 - 0.36IVA_t + 0.01IEP_t - 0.04T \quad (6.4)$$

The coefficient of the error correction term (-0.80) is negative as expected and statistically significant at 1% significance level. This shows that the 80% of any disequilibrium in the short-term is adjusted each year and the system can be balanced after 1.25 years.[4]

6.2.1.3. FMOLS Method

Before conducting the FMOLS estimation the lag length and the bandwidth should be determined. The maximum lag length is chosen as 3 for the industrial electricity demand model. The long-run results given in Table 6.6 shows that all variables included in the model are statistically significant.[5]

Table 6.6. The Long-Run Results of FMOLS Method for Industrial Electricity Demand

Dependent Variable: E^I			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-17.72	0.685925	25.83 [0.00]
IVA	0.26	0.033810	7.75 [0.00]
IEP	-0.04	0.026626	-1.75 [0.08]
T	0.05	0.001352	37.47 [0.00]

Notes: *1. p-values are in square brackets.*
2. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively. T is the trend variable.

The estimated long-run equation from the FMOLS method is given by:

$$E_t^I = -17.72 + 0.26IVA_t - 0.04IEP_t + 0.05T \quad (6.5)$$

where the error correction term is derived from this equation and used to estimate the short-term dynamic equation. The short-run results of the FMOLS approach is presented in Table 6.7.

[4] The formulation to estimate the adjustment period of the equilibrium is $[1/ECT_{(t-1)}]$. That is $[1/ECT_{(t-1)}]$ = [1/0.80] = 1.25.
[5] Constant, output and trend coefficients are statistically significant at 1% while only the price coefficient is significant at 10% level.

Table 6.7. The Short-Run Results of FMOLS Method for Industrial Electricity Demand

Dependent Variable: ΔE^I			
Sample: 1981-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.12	0.006934	17.89 [0.00]
ΔIVA	0.23	0.021661	10.71 [0.00]
ΔIEP	-0.06	0.015743	-4.28 [0.00]
D1999	-0.03	0.010814	-3.52 [0.00]
D2009	-0.07	0.010931	-6.69 [0.00]
ECT(-1)	-0.61	0.057161	-10.67 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.037	Norm: χ^2 = 3.22 [0.19]		

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively.

All of the short-run coefficients are statistically significant at 1% level with the required dummy variables. The short-run equation of the FMOLS method is calculated as follows:

$$\Delta E_t^I = 0.12 + 0.23\Delta IVA_t - 0.06\Delta IEP_t - 0.03D1999 - 0.07D2009 - 0.61ECT_{t-1} \quad (6.6)$$

where D1999 and D2009 are dummy variables for 1999 and 2009, respectively. The ECT represents the error correction term and is formulated from the long-run equation as below:

$$ECT_t = E_t^I + 17.72 - 0.26IVA_t + 0.04IEP_t - 0.05T \quad (6.7)$$

The coefficient of the error correction term indicates that almost 61% of any disequilibrium is adjusted each year.

6.2.1.4. Johansen Method

In the Johansen cointegration test, first, the maximum and appropriate lag length of the model should be identified. After then, the trace and maximum eigenvalue tests are used to specify the number of cointegrating vectors. The optimal model is selected as linear with intercept and trend by using Pantula[6] principle (Pantula, 1989). The results from Table 6.8 indicate that the null hypothesis of zero cointegration vector among variables is rejected at

[6] Pantula (1989) principle is suggested by Johansen (1992) to decide the most convenient model. By using Pantula principle all possible model specifications (no intercept-no trend, intercept-no trend, intercept-trend) are investigated and the results are obtained from the most restrictive one through to the least restrictive one.

5% significance level for both trace and maximum eigenvalue statistics since the test statistics are greater than the critical values. Therefore, it can be said that there is at most one cointegrating vector among variables.

Table 6.8. Johansen Cointegration Test for Industrial Electricity Demand

Unrestricted Cointegration Test	**Trace Statistic**			**Maximum Eigen Statistic**		
Number of Cointegrating Vectors	0	At most 1	At most 2	0	At most 1	At most 2
Critical Values (%5)	42.91	25.87	12.51	25.82	19.38	12.51
Test statistic	56.17*	23.98	8.02	32.19*	15.95	8.02
[probability]	[0.00]	[0.08]	[0.24]	[0.00]	[0.14]	[0.24]

Notes: *1. Maximum lag length is selected from VAR as 1.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

After specifying the cointegration relationship among E^I, *IVA*, and *IEP*, the long- and short-run demand elasticity equations can be calculated. First, the long-term industrial electricity demand is estimated in Equation (6.8) as follows:

$$\boldsymbol{E_t^I = 0.49IVA_t - 0.08IEP_t + 0.04T} \quad \textbf{(t=1978-2015)} \qquad \textbf{(6.8)}$$
$$\textbf{[0.04]} \qquad \textbf{[0.03]} \qquad \textbf{[0.00]}$$

All coefficients are statistically significant at 5% level. Therefore, the dynamic short-term equation can be estimated by using the Equation (6.8) to derive the error correction term. The preferred short-term model of the Johansen method is given as below:

$$\boldsymbol{\Delta E_t^I = -40.84 + 0.32\Delta IVA_t - 0.11\Delta IEP_t - 0.57ECT_{t-1}} \qquad \textbf{(6.9)}$$
$$\textbf{[0.01]} \qquad \textbf{[0.01]} \qquad \textbf{[0.04]} \qquad \textbf{[0.01]}$$

where $ECT_t = E_t^I - 0.49IVA_t + 0.08IEP_t - 0.04T$

Std. error of the regression: 0.044 LM Serial Correlation: F=0.94 [0.40]

Norm: JB=0.15 [0.92] Het: F= 1.75 [0.17] ARCH (1): F=0.20 [0.65]

Reset: F=3.47 [0.14] Wald: 7.71 [0.00].

The short-run dynamic equation passes all diagnostic tests. The coefficient of error correction term suggests that more than half of any disequilibrium is adjusted each year.

6.2.1.5. ARDL Bounds Testing Method

In terms of the ARDL Bounds Testing method, the cointegration analysis is required to test the long-run relationship among series. Therefore, first, the lag length of the series should be determined. In here, the maximum lag length is chosen as 4 since the number of observation is adequate and the annual data is used. The appropriate lag length is specified as (3,3,3) based on AIC with no autocorrelation issue (Table 6.9).

Table 6.9. Determination of the Lag Length (Industrial Electricity Demand)

Lag Length	AIC	Autocorrelation (LM)
(1,0,0)	-3.72	1.12 [0.33]
(1,1,1)	-3.64	3.19 [0.05]
(2,2,2)	-3.62	0.12 [0.88]
(3,3,3)*	-3.63	0.76 [0.47]
(4,4,4)	-3.55	1.45 [0.27]

Notes: *1. (*) indicates minimum AIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2^{nd} order (AR(2)) serial correlation.

After the optimal lag length is determined, Equation (5.38) from the methodology section is adapted to Equation (6.10) as follows:

$$\Delta E_t^I = \beta_0 + \beta_1 trend + \sum_{i=1}^{4} \beta_{2i} \Delta E_{t-i}^I + \sum_{i=0}^{4} \beta_{3i} \Delta IVA_{t-i} + \sum_{i=0}^{4} \beta_{4i} \Delta IEP_{t-i} + \beta_5 E_{t-1}^I + \beta_6 IVA_{t-1} + \beta_7 IEP_{t-1} + \varepsilon_t \quad \textbf{(6.10)}$$

where Δ indicates the first difference of the variables.

The estimation results for Equation (6.10) passes all diagnostic tests. The descriptive statistics of the solved model with appropriate lag length are presented in Table 6.10 as below. This table shows that the ARDL model is satisfied with respect to the conditions of autocorrelation, heteroscedasticity and normality. In addition, the R-square value is calculated high enough to meet the model selection criteria.

Table 6.10. Diagnostic Tests Statistics (Industrial Electricity Demand)

ARDL (3,3,3)	
R^2	0.72
Adjusted R^2	0.48
Autocorrelation (LM)	0.76 [0.47]
Heteroscedasticity (White)	1.04 [0.45]
Normality (Jarque-Bera)	1.78 [0.40]
F-stat	8.53

Note: *1. p-values of the tests are in square brackets.*

The F-statistic (8.53) is found to be greater than the upper bound critical values of both Pesaran et. al. (2001) and Narayan (2005) at 1%, 5%, and 10% significance levels (Table 6.11). Therefore, the null hypothesis of no cointegration among variables is rejected. This means that there is a cointegration relation between variables, and the variables move together in the long-run.

Table 6.11. Bounds Test Statistics for Industrial Electricity Demand

N=38, k=2	Pesaran		Narayan	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.99	5.85	5.98	6.97
5%	3.88	4.61	4.36	5.13
10%	3.38	4.02	3.66	4.37

Notes: *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with unrestricted intercept and restricted trend.

After identifying the cointegration relation among variables, the long-run equation can be estimated. First of all, the maximum and appropriate lag lengths are determined. The proper model, with the maximum lag of 3, is decided as ARDL (1,0,1). The long-term results and coefficients are represented in Table 6.12.

Table 6.12. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Industrial Electricity Demand

Dependent Variable: E^I		
Variables	**Coefficients**	**Probability Values**
E^I(-1)	0.26	0.11
IVA	0.24	0.00
IEP	-0.06	0.26
IEP(-1)	0.12	0.03
C	-59.22	0.00
T	0.03	0.00
Long-Term Coefficients		
IVA	0.32*	0.00
IEP	0.08	0.23
C	-12.42*	0.00
T	0.04*	0.00
Diagnostic Statistics		
R^2: 0.99	DW: 1.77	
Adjusted R^2: 0.99	F stat: 2415.8 (0.00)	
Autocorrelation (LM): 0.68 (0.51)	χ^2_{White}: 1.42 (0.24)	
χ^2_{Norm}: 1.84 (0.39)	χ^2_{Ramsey}: 1.89 (0.17)	

Notes: *1. E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively. T is the trend variable.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

The statistically significant long-term coefficients of the industrial electricity demand are presented in Equation (6.11).

$$\boldsymbol{E_t^I = -12.42 + 0.32 IVA_t + 0.04T} \qquad \textbf{(6.11)}$$

In the next stage of the ARDL Bounds Testing approach, the short-term equation is estimated by using the information from the long-term model. The results of the dynamic short-term model are given in Table 6.13.

Table 6.13. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Industrial Electricity Demand

Dependent Variable: ΔE^I		
Variables	**Coefficients**	**Probability Values**
C	-12.30*	0.00
Δ*IVA*	0.24*	0.00
Δ*IEP*	-0.05	0.22
ECT(-1)	-0.72*	0.00
Diagnostic Statistics		
Std. error of regression: 0.035	ARCH (1): F=0.03 [0.85]	
Autocorrelation (LM): 0.88 (0.76)	χ^2_{White}: 1.22 (0.18)	
χ^2_{Norm}: 1.94 (0.42)	χ^2_{Ramsey}: 2.89 (0.07)	

Notes: 1. *E^I, IVA and IEP are natural logs of the industrial electricity consumption, real industrial value added and real industrial electricity price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

The short-term dynamic equation of ARDL model is given by

$$\boldsymbol{\Delta E_t^I = -12.30 + 0.24 \Delta IVA_t - 0.72 ECT_{t-1}} \qquad \textbf{(6.12)}$$

where the error correction term of this equation is $ECT_t = E_t^I + 12.42 - 0.32IVA_t - 0.08IEP_t - 0.04T$ and the coefficient of this term can be interpreted as 72% of any disequilibrium is adjusted in each year.

Furthermore, the price variable of industrial electricity is found to be insignificant in both short- and long-term equations, thus they are omitted from the models. Other variables are statistically significant at 5% level.

6.2.1.6. STSM Method

Different from the conventional cointegration approaches, the short- and long-term elasticities of the demand can be estimated via one equation in the STSM method. The estimation results and diagnostic tests are presented in Table 6.14.

Table 6.14. The Results of STSM Method for Industrial Electricity Demand

Dependent Variable: E^I				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
IVA	0.12082	0.04641	2.60330	[0.01]
IEP	-0.08704	0.03881	-2.24296	[0.03]
Level Break 1984	0.09725	0.02711	3.58709	[0.00]
Irregular 1991	-0.07763	0.01987	-3.62090	[0.00]
Irregular 2009	-0.07378	0.02038	4.16327	[0.00]
Level and Slope Components of $UEDT_{2015}$				
Level	22.0423 [0.00]			
Slope	0.04933 [0.00]			

Residuals		**Auxiliary Residuals**	***Irregular***	***Level***	***Slope***
Std. Error	0.0290	*Std. Error*	1.2639	1.1693	0.9099
Normality	0.4109	*Normality*	0.1958	0.9417	0.0000
Skewness	0.5805	*Skewness*	0.2740	0.7374	0.0000
Kurtosis	0.6171	*Kurtosis*	0.1508	0.9295	0.0000
H(10)	0.8981				
R(1)	-0.0253	**LR Test**			
R(6)	0.0325	*Test (a)* 101.215 (0.00)			
DW	2.0205	*Test (b)* 4.159 (0.00)			
Q(6,4)	1.9188				

Predictive Test 2008-2015		**Goodness of Fit**	
Failure	0.4046	R^2	0.99839
Cusum t(7)	1.7790	R_d^2	0.67935
		P.E.V.	0.00084
		P.E.V./ (M.D.)^2	0.85167

Hyperparameters	
Irregular	0.0086605
Level	0.0237038
Slope	0.0008805

Notes: *1. Model estimation is made in STAMP 8.20.*

2. There are one level intervention dummy variable for the year 1984, and two irregular dummy variables for the years 1991 and 2009 in the model.

3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.

4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2), and the Coefficient Determination (R^2 and R_d^2).

5. H(10) is the heteroscedasticity statistic.

6. R(1) and R(6) are the serial correlation coefficients at the 1st and 6th lag, respectively

7. DW is the Durbin-Watson statistic.

8. Q(6,4) is the Box-Ljung Q-statistics based on the first 6 residuals autocorrelations and distributed as $\chi 2$ (4).

9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.
10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and fixed slope hyperparameter and Test (b) after imposing a fixed level and zero slope; both are distributed as $\chi 2(2)$ and probabilities are given in parenthesis.
11. The hyperparameters determine the shape of the UEDT.

The estimated equation for the Turkish industrial electricity demand is given by

$$\boldsymbol{E_t^I = 0.12IVA_t - 0.08IEP_t + UEDT_t} \quad \textbf{(6.13)}$$

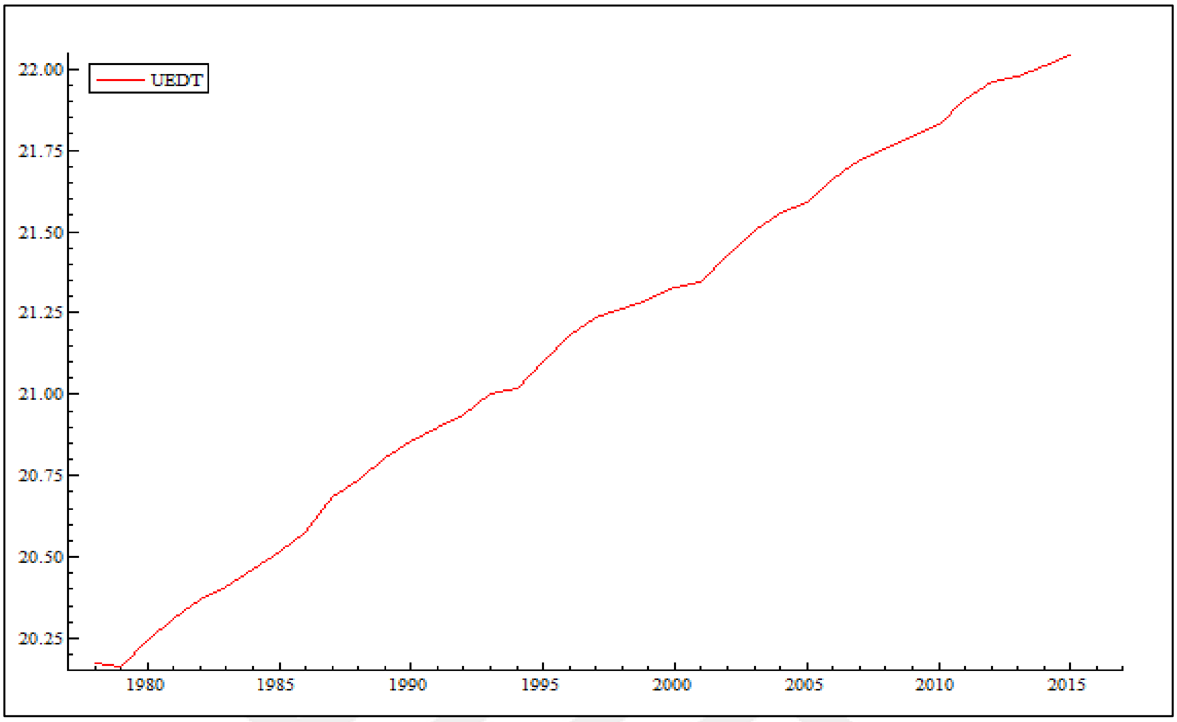
where UEDT is 22.04239 with a slope of 0.04933 at the end of the period. The slope value shows that the annual increase is about 5% for the observed period.

The model passes all the diagnostic tests as shown in Table 6.14. Furthermore, the results of the additional normality tests for auxiliary residuals are statistically significant. On the other hand, this model required a level intervention dummy and two irregular dummies.

As mentioned in the methodology chapter, the intervention dummy variables need to be added to the model for providing the normality of the auxiliary residuals. Therefore, three interventions are included in the model for the years 1984, 1991 and 2009. The level intervention for 1984 may represent the conditions of Turkey after the military coup, the irregular intervention for 1991 may present economic crises following the Gulf war and the irregular intervention for 2009 may reflect the global economic crises.

The estimated stochastic trend (UEDT) is illustrated in Figure 6.1. It is seen from the graph that the shape of the trend is upward which can be demonstrated as the increase in energy use over the estimation period.

Figure 6.1. UEDT (μ_t) for Turkish Industrial Electricity Consumption (1978-2015)



6.2.1.7. Comparison of Elasticity Estimates for Industrial Electricity Demand

Table 6.15 presents the estimated price and income elasticities of the Turkish industrial electricity demand by using various econometric approaches. The price elasticity estimates range between -0.11 and -0.01. On the other hand, the income elasticities vary between 0.12 and 0.49.

Table 6.15. Summary of Estimated Industrial Electricity Demand Elasticities

	INCOME		PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	0.28	0.36	-0.09	-0.01
FMOLS	0.23	0.26	-0.06	-0.04
Johansen	0.32	0.49	-0.11	-0.08
ARDL Bounds Test	0.24	0.32	-	-
STSM-UEDT	0.12		-0.08	

The lowest price elasticity is estimated by Johansen approach as -0.11 while the highest price elasticity (-0.01) is found by the Engle-Granger Two-Step method. In terms of the income elasticities, the maximum value (0.49) is estimated via the Johansen test, and the minimum value (0.12) is calculated by the STSM method.

The stochastic trend -instead of deterministic one- is added to the model in the STSM/UEDH approach. This may be the main reason why the income elasticity is found to be the lowest in the STSM method.

In brief, the results indicate that the estimated price elasticities of the Turkish industrial electricity demand are very low and that of the income elasticities are smaller than 1. In addition, the gap between the values of short- and long-run elasticities are not very large in terms of both price and income. These results imply that since the electricity usage in Turkey's industrial sector is a necessity, consumers are not changing their consumption behaviour easily with respect to the income and price movements.

6.2.2. Residential Electricity Demand

6.2.2.1. Unit Root Tests Results

Residential electricity demand function and its econometric model are presented as follows:

$$\boldsymbol{E_d^R = f(HFCE, REP)} \qquad \boldsymbol{E_t^R = \beta_0 + \beta_1 HFCE_t + \beta_2 REP_t + v_t} \qquad \textbf{(6.14)}$$

where E^R, *HFCE*, and *REP* are residential electricity consumption, household final consumption expenditure, and residential electricity price, respectively. The ADF, PP, and KPSS unit root tests are used to examine the stationarity of these variables. The results of the unit root tests are given in Table 6.16.

Table 6.16. The Unit Root Tests Results for Residential Electricity Demand

	Variables	**Level**			**1st Difference**		
		ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
	$\boldsymbol{E^R}$	-2.60	-2.12	0.72	-3.43*	-3.42*	0.41*
Test Statistics (Constant)	***HFCE***	-1.16	-1.32	0.73	-8.25*	-9.01*	0.13*
	REP	-2.67	-2.28	0.23*	-6.27*	-6.33*	-
Critical Values (Constant)	***5%***	***-2.94***	***-2.94***	***0.46***	***-2.94***	***-2.94***	***0.46***
	$\boldsymbol{E^R}$	0.50	0.14	0.18	-6.55*	-3.96*	0.10*
Test Statistics (Constant & Trend)	***HFCE***	-2.80	-2.73	0.19	-7.32*	-11.38*	0.08*
	REP	-2.51	-2.33	0.09*	-7.21*	-6.60*	-
Critical Values (Constant & Trend)	***5%***	***-3.54***	***-3.53***	***0.14***	***-3.54***	***-3.53***	***0.14***

***Notes*:** *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

The ADF and PP unit root test results indicate that E^R, *HFCE*, and *REP* are stationary in their first differences and integrated of order one, *I(1)*. However, according to the KPSS test results, the consumption and output variables are estimated as stationary in the first difference whereas the price variable is found to be stationary in the level.

Furthermore, the Zivot-Andrews unit root test is also considered to analyse the stationarity of the variables with structural break.

Table 6.17. Zivot-Andrews Unit Root Test Results for Residential Electricity Demand

	Variables	Level			1st Difference		
		ZA	Lag Length	Break Date	ZA	Lag Length	Break Date
Test Statistics (Constant)	***E^R***	-1.80	1	2009	-5.24*	0	1985
	HFCE	-4.49	0	1987	-5.56*	4	1987
	REP	-4.69	2	1985	-4.85*	0	1991
Critical Value (Constant)	***5%***			***-4.80***			
Test Statistics (Constant & Trend)	***E^R***	-3.43	1	1996	-5.13*	0	1985
	HFCE	-5.01	0	1987	-5.68*	4	1992
	REP	-5.03	2	1991	-5.73*	0	2001
Critical Value (Constant & Trend)	***5%***			***-5.08***			

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 4 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)
3. The appropriate lag length was determined by Akaike Information Criteria.
4. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

As it is seen from the Table 6.17, the null hypotheses of unit root are rejected, and the variables are stationary in the first differences. These results show parallelism with the findings of the ADF and PP unit root tests.

6.2.2.2. EG Two-Step Method

In the first step of the EG Two-Step method, the long-run equation is estimated. The results of this estimation are given in Table 6.18.

Table 6.18. The Long-Run Results of EG Two-Step Method for Residential Electricity Demand

Dependent Variable: E^R
Sample: 1978-2015

Variables	Coefficient	Std. Error	t-statistic [prob]
C	-27.67	0.709766	-24.89 [0.00]
HFCE	1.89	0.035869	52.78 [0.00]
REP	-0.18	0.068608	-2.64 [0.01]

Notes: *1. p-values are in square brackets.*
2. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

The long-term equation is given by

$$E_t^R = -27.67 + 1.89HFCE_t - 0.18REP_t \quad (6.15)$$

where the trend variable (T) is omitted from the model because when it is added the price variable became positive, and this situation is not consistent with the economic theory.

Next, the stationarity of the residuals is checked to decide the cointegration relation among variables. The ADF test results are shown in Table 6.19.

Table 6.19. Unit Root Test of Residuals for Residential Electricity Demand

Variable		Constant		Constant and Trend		None	
		Level	***1st difference***	***Level***	***1st difference***	***Level***	***1st difference***
residuals	***Test Statistic***	-6.04*	-	-5.95*	-	-6.13*	-
	Critical Values (1%)	-3.62		-4.22		-2.62	

Note: *1. (*) Significant at 1% MacKinnon (1996) critical value.*

According to the unit root test results, the null hypothesis of non-stationarity can be rejected, and the residuals are said to be stationary in their levels. This means that there is a cointegration relationship among variables.

After determining the cointegration, the second step of the model can be proceeded. In Table 6.20, the detailed estimation results of the short-run equation are introduced.

Table 6.20. The Short-Run Results of EG Two-Step Method for Residential Electricity Demand

Dependent Variable: ΔE^R			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.05	0.007701	7.78 [0.00]
ΔHFCE	0.33	0.106665	3.14 [0.00]
D1986	0.08	0.038123	2.12 [0.04]
D1991	0.08	0.038704	2.24 [0.03]
D2013	-0.09	0.037454	-2.37 [0.02]
ECT(-1)	-0.25	0.090049	-2.80 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.036	Norm: χ^2 = 1.64 [0.43]	Het: F= 1.64 [0.17]	ARCH (1): F = 0.72 [0.40]
LM Serial Correlation: F = 2.18 [0.13]	Reset: F = 4.22 [0.12]	Wald: F = 5.26 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

The short-run dynamic equation with three dummy variables is presented in Equation (6.16) as follows:

$$\Delta E_t^R = 0.05 + 0.33\Delta HFCE_t + 0.08D1986 + 0.08D1991 - 0.09D2013 - 0.25ECT_{t-1} \quad \textbf{(6.16)}$$

where the error correction term (*ECT*) is estimated as in Equation (6.17).

$$ECT_t = E_t^R + 27.67 - 1.89HFCE_t + 0.18REP_t \quad \textbf{(6.17)}$$

The model passes all diagnostic tests. Moreover, the dummy variables for the years 1986, 1991 and 2013 are added to the model because of eliminating the serial correlation problem (for the details see Chapter 5). In addition, the price variable is found statistically insignificant and therefore excluded from the model. The statistically significant coefficient of error correction term states that quarter of any disequilibrium is adjusted each year and the model would be stable in 4 years[7].

6.2.2.3. FMOLS Method

The FMOLS model is established with the maximum lag length of 3 and Newey-West automatic bandwidth selection. The long-term results of FMOLS method are given in Table 6.21.

Table 6.21. The Long-Run Results of FMOLS Method for Residential Electricity Demand

Dependent Variable: E^R			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-29.60	0.626064	-26.51 [0.00]
HFCE	1.84	0.032889	55.88 [0.00]
REP	-0.15	0.037771	4.07 [0.00]

Notes: *1. p-values are in square brackets.*
2. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

According to these results, all parameters are statistically significant, except the trend variable. Therefore, the deterministic trend variable is omitted from the model. The long-run equation is presented in Equation (6.18) as below:

[7] (1/0.25=4).

$$E_t^R = -29.60 + 1.84HFCE_t - 0.15REP_t \quad (6.18)$$

where this equation is used to compute the error correction term. After estimating the *ECT*, short-run dynamic equation can be calculated. The preferred short-run dynamic equation results for the FMOLS method is given in Table 6.22.

Table 6.22. The Short-Run Results of FMOLS Method for Residential Electricity Demand

Dependent Variable: ΔE^R			
Sample: 1981-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.19	0.018090	10.57 [0.00]
Δ*HFCE*	0.30	0.045354	6.72 [0.00]
Δ*REP*	-0.21	0.071356	-2.97 [0.00]
D1991	0.08	0.016286	5.34 [0.00]
D1996	0.09	0.016582	5.61 [0.00]
ECT(-1)	-0.26	0.041040	-6.41 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.029	Norm: χ^2 = 0.57 [0.74]		

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.

This model also passes the diagnostic tests with two dummies for the years 1991 and 1996. The coefficients are statistically significant, and the equation form of the short-run model is described as follows:

$$\Delta E_t^R = 0.19 + 0.30\Delta HFCE_t - 0.21\Delta REP_t - 0.08D1991 - 0.09D1996 - 0.26ECT_{t-1} \quad (6.19)$$

where $ECT_t = E_t^R + 29.60 - 1.84HFCE_t + 0.15REP_t$, and the coefficient on the error correction term shows that almost 26% of any disequilibrium is adjusted in each year.

6.2.2.4. Johansen Method

In estimating the residential electricity demand by using the Johannsen approach, the trace and maximum eigen value tests are applied initially to determine the number of cointegrating equations. The appropriate model is found to be linear with an intercept but no trend. The results of the Johansen test are summarized in Table 6.23.

Table 6.23. Johansen Cointegration Test for Residential Electricity Demand

Unrestricted Cointegration Test	**Trace Statistic**			**Maximum Eigen Statistic**		
Number of Cointegrating Vectors	0	At most 1	At most 2	0	At most 1	At most 2
Critical Values (%5)	35.19	20.26	9.16	22.29	15.89	9.16
Test statistic	41.17*	18.08	7.62	23.08*	10.46	7.62
[probability]	[0.01]	[0.09]	[0.09]	[0.03]	[0.29]	[0.09]

Notes: *1. Maximum lag length is selected from VAR as 1.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

Both trace and maximum eigenvalue statistics show that there is only one cointegrating vector among E^R, *HFCE*, and *REP*.

Given the cointegration relation among variables, the long-run model can be estimated. The long-run cointegrating equation is shown below:

$$\boldsymbol{E_t^R = 2.01HFCE_t - 0.36REP_t} \qquad \textbf{(t=1980-2015)} \qquad \textbf{(6.20)}$$
[0.04] [0.02]

where the trend variable was omitted from the equation since it was statistically insignificant. As it is seen from the probability values in square brackets, the output and price variables are statistically significant at 5% level.

Equation (6.20) is used to obtain the error correction term, and this term is utilized to estimate the dynamic short-term equation. The preferred short-run equation for the Johansen method is given by

$$\boldsymbol{\Delta E_t^R = -6.80 + 0.21\Delta HFCE_t - 0.15ECT_{t-1}} \qquad \textbf{(6.21)}$$
[0.00] [0.02] [0.00]

where $ECT_t = E_t^R - 2.01HFCE_t + 0.36REP_t$

Std. error of the regression: 0.036 LM Serial Correlation: F=0.84 [0.43]

Norm: JB=1.35 [0.50] Het: F= 1.05 [0.38] ARCH (1): F=0.75 [0.39]

Reset: F=0.95 [0.39] Wald: 42.43 [0.00].

The price variable is not included in the short-run equation since the coefficient on ΔREP is not statistically significant. On the other hand, remaining variables are statistically significant at 5% level. Furthermore, the short-term equation passes the diagnostic tests listed above.

6.2.2.5. ARDL Bounds Testing Method

The ARDL model with maximum five lag lengths is used to estimate Turkey's residential electricity demand. In Table 6.24, the lag order is selected as (5,5,5) by AIC with no autocorrelation.

Table 6.24. Determination of the Lag Length (Residential Electricity Demand)

Lag Length	AIC	Autocorrelation (LM)
(1,0,0)	-3.49	0.06 [0.93]
(1,1,1)	-3.70	0.14 [0.86]
(2,2,2)	-3.68	0.96 [0.40]
(3,3,3)	-3.63	0.80 [0.47]
(4,4,4)	-4.62	3.61 [0.08]
(5,5,5)*	-5.43	2.79 [0.20]

Notes: *1. (*) indicates minimum AIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2nd order (AR(2)) serial correlation.

The preferred model for computing the ARDL Bounds Testing method is shown as below:

$$\Delta E_t^R = \beta_0 + \sum_{i=1}^{5} \beta_{1i} \Delta E_{t-i}^R + \sum_{i=0}^{5} \beta_{2i} \Delta HFCE_{t-i} + \sum_{i=0}^{5} \beta_{3i} \Delta REP_{t-i} + \beta_4 E_{t-1}^R + \beta_5 HFCE_{t-1} + \beta_6 REP_{t-1} + \varepsilon_t \quad \textbf{(6.22)}$$

where E^R, HFCE, and *REP* represent the residential electricity consumption, household final consumption expenditure, and residential electricity price, respectively. Equation (6.22) passes the diagnostic tests which are given in Table 6.25.

Table 6.25. Diagnostic Tests Statistics (Residential Electricity Demand)

ARDL (5,5,5)	
R^2	0.97
Adjusted R^2	0.87
Autocorrelation (LM)	2.79 [0.20]
Heteroscedasticity (White)	3.06 [0.11]
Normality (Jarque-Bera)	0.42 [0.80]
F-stat	10.44

Note: *1. p-values of the tests are in square brackets.*

The value of the F-statistic is found to be 10.44, which is greater than the upper bound critical values shown in Table 6.26. This means that there is a cointegration relation among variables and the long-run equation can be estimated.

Table 6.26. Bounds Test Statistics for Residential Electricity Demand

N=38, k=2	Pesaran		Narayan	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.13	5.00	4.77	5.85
5%	3.10	3.87	3.43	4.26
10%	2.63	3.35	2.83	3.58

Notes: *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with restricted intercept and no trend.

The optimal long-term model with maximum 5-year lag is determined as ARDL (2,4,0) and presented in Table 6.27.

Table 6.27. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Residential Electricity Demand

Dependent Variable: E^R		
Variables	**Coefficients**	**Probability Values**
E^R(-1)	1.22	0.00
E^R(-2)	-0.36	0.09
HFCE	0.15	0.20
HFCE(-1)	0.15	0.16
HFCE(-2)	-0.24	0.03
HFCE(-3)	-0.05	0.63
HFCE(-4)	0.22	0.03
REP	-0.05	0.26
C	-2.05	0.42
Long-Term Coefficients		
HFCE	1.63*	0.00
REP	-0.35	0.51
C	-34.63*	0.00
Diagnostic Statistics		
R^2: 0.99	DW: 1.77	
Adjusted R^2: 0.99	F stat: 2414.7 (0.00)	
Autocorrelation (LM): 0.08 (0.92)	χ^2_{White}: 0.50 (0.84)	
χ^2_{Norm}: 1.16 (0.55)	χ^2_{Ramsey}: 1.56 (0.45)	

Notes: *1. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

The long-term equation for the residential electricity demand is given by:

$$\boldsymbol{E_t^R = -34.63 + 1.63HFCE_t} \quad \textbf{(6.23)}$$

where the price and trend variables were omitted from the Equation (6.23) since they were not statistically significant.

On the other hand, the short-run equation results of the model are shown in Table 6.28. In here, due to the dynamic form of the model, the error correction representation includes the information from the long-term equation.

Table 6.28. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Residential Electricity Demand

Dependent Variable: ΔE^R		
Variables	**Coefficients**	**Probability Values**
Δ***HFCE***	0.16*	0.07
Δ***REP***	-0.03	0.37
ECT(-1)	-0.14**	0.00
Diagnostic Statistics		
Std. error of the regression: 0.034	ARCH (1): F=0.02 [0.88]	
Autocorrelation (LM): 0.15 (0.85)	χ^2_{White}: 1.22 (0.18)	
χ^2_{Norm}: 1.95 (0.78)	χ^2_{Ramsey}: 3.36 (0.18)	

Notes**:** *1. E^R, HFCE and REP are natural logs of the residential electricity consumption, real household final consumption expenditure and real residential electricity price, respectively.*
2. (*) and (**) indicate 5% and 10% significance levels, respectively.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

The dynamic short-run equation is presented as below:

$$\boldsymbol{\Delta E_t^R = 0.16\Delta HFCE_t - 0.14ECT_{t-1}} \qquad \textbf{(6.24)}$$

where $ECT_t = E_t^R + 34.63 - 1.63HFCE_t$, and the coefficient of *ECT* shows the speed of adjustment for the model. The estimated coefficient of the error correction term (-0.14) is low, and this shows that the model is balanced slowly. In addition, the *HFCE* variable is statistically significant at 10% level whereas the *REP* variable is excluded from the equation because of insignificancy.

6.2.2.6. STSM Method

The STSM method provides flexibility to estimate both short- and long-term elasticities in one equation. The detailed estimations for the coefficients and level-slope values with the diagnostic test results are given in Table 6.29.

Table 6.29. The Results of STSM Method for Residential Electricity Demand

Dependent Variable: E^R				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
E^R(-1)	0.43042	0.11785	3.65221	[0.00]
HFCE(-1)	0.22057	0.07229	3.05115	[0.00]
REP	-0.07323	0.03206	-2.28408	[0.02]
Level Break 1991	0.10338	0.03411	3.03088	[0.03]
Irregular 2008	0.05118	0.02277	2.24815	[0.00]

Level and Slope Components of $UEDT_{2015}$	
Level	8.44215 [0. 01070]
Slope	0.02925 [0. 00922]

Residuals		**Auxiliary Residuals**			
			Irregular	***Level***	***Slope***
Std. Error	0.0289	*Std. Error*	0.8655	0.9597	0.7834
Normality	0.8101	*Normality*	0.7007	0.6654	0.1237
Skewness	0.7303	*Skewness*	0.8445	0.8788	0.0410
Kurtosis	0.5824	*Kurtosis*	0.4120	0.3737	0.9442
H(10)	0.9659				
R(1)	0.1275	**LR Test**			
R(6)	0.1645	*Test (a)* 12.809 (0.00)			
DW	1.6230	*Test (b)* 2.057 (0.00)			
Q(6,4)	5.7757				

Predictive Test 2008-2015		**Goodness of Fit**	
Failure	0.4211	R^2	0.9991
Cusum t(7)	1.7852	R_d^2	0.6991
		P.E.V.	0.0008
		P.E.V./ (M.D.)^2	1.1711

Hyperparameters	
Irregular	0.0000877
Level	0.0010243
Slope	0.0000014

Notes: *1. Model estimation is made in STAMP 8.20.*

2. There are one level intervention dummy variable for the year 1991, and one irregular dummy variable for the year 2008 in the model.

3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.

4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2), and the Coefficient Determination (R^2 and R_d^2).

5. H(10) is the heteroscedasticity statistic.

6. R(1) and R(6) are the serial correlation coefficients at the 1st and 6th lag, respectively

7. DW is the Durbin-Watson statistic.

8. Q(6,4) is the Box-Ljung Q-statistics based on the first 6 residuals autocorrelations and distributed as $\chi 2$ (4).

9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.

10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and fixed slope hyperparameter and Test (b) after imposing a fixed level and zero slope; both are distributed as $\chi 2(2)$ and probabilities are given in parenthesis.

11. The hyperparameters determine the shape of the UEDT.

The estimated equation for the Turkish residential electricity demand is as follows:

$$\boldsymbol{E_t^R = 0.43E_{t-1}^R + 0.22HFCE_{t-1} - 0.07REP_t + UEDT_t} \qquad \textbf{(6.25)}$$

where UEDT of the equation is 8.44215 with a slope of 0.02925 at the end of the period. The nature of the trend can be defined as local level with drift, which means that the level and slope are identified stochastically.

As mentioned previously, the short- and long-run demand elasticities can be calculated by one equation. Equation (6.25) shows the short-run elasticities. On the other hand, the long-run elasticities of residential electricity demand can be estimated by using the short-term coefficients as follows:

$$\boldsymbol{\alpha(L) = 1 - E_{t-1}^R = 1 - 0.43042 = 0.569}$$

$$\boldsymbol{\beta(L) = 0.22057}$$

$$\boldsymbol{\theta(L) = -0.07323}$$

$$\frac{\boldsymbol{\beta(L)}}{\boldsymbol{\alpha(L)}} = \frac{\boldsymbol{0.2205}}{\boldsymbol{0.569}} = \boldsymbol{0.39}\ (\boldsymbol{long\ term\ income\ elasticity})$$

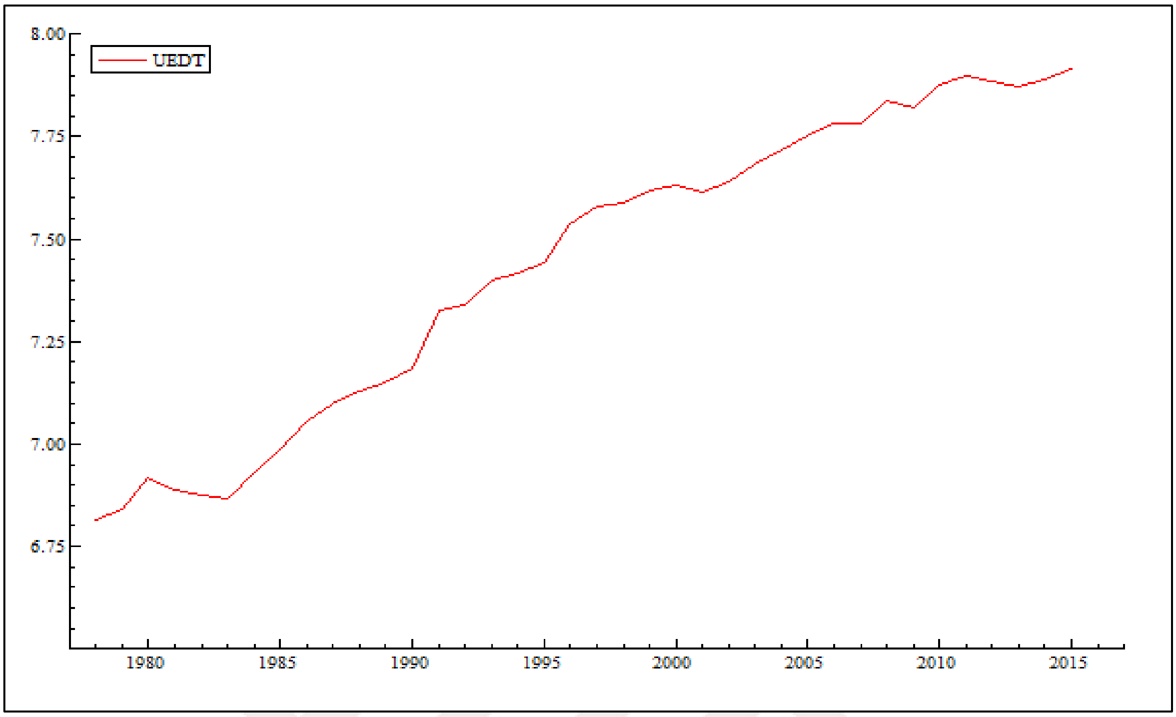
$$\frac{\boldsymbol{\theta(L)}}{\boldsymbol{\alpha(L)}} = \frac{\boldsymbol{-0.0732}}{\boldsymbol{0.569}} = \boldsymbol{-0.13}\ (\boldsymbol{long\ term\ price\ elasticity})$$

where *α(L)*, *β(L)*, and *θ(L)* are polynomial lag operators. In other words, they are the long-term coefficient estimators for electricity consumption, output and price, respectively. The division of short-term output and price coefficients to $[1 - E_{t-1}^R]$ gives the long-term income and price elasticities, correspondingly.

The model passes all diagnostic tests with a level and irregular intervention dummies for 1991 and 2008. The level intervention dummy for 1991 may represent economic crises following the Gulf war, and the irregular dummy for 2008 may present the global economic crises.

In Figure 6.2, the estimated UEDT is illustrated. Although the stochastic trend shows a floating structure in time, it is said to be increasing in general.

Figure 6.2. UEDT (μ_t) for Turkish Residential Electricity Consumption (1978-2015)



6.2.2.7. Comparison of Elasticity Estimates for Residential Electricity Demand

The estimation results of price and income elasticities for the residential electricity demand are summarized in Table 6.30. In the short-term, the price elasticities are estimated by only two methods, namely FMOLS (-0.21) and STSM (-0.07). On the other hand, the income elasticities range from 0.16 to 0.33 in the short-term.

Table 6.30. Summary of Estimated Residential Electricity Demand Elasticities

	INCOME		PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	0.33	1.89	-	-0.18
FMOLS	0.30	1.83	-0.21	-0.15
Johansen	0.21	2.01	-	-0.36
ARDL Bounds Test	0.16	1.63	-	-
STSM-UEDT	0.22	0.39	-0.07	-0.13

In terms of the long-term estimations, the lowest income elasticity is estimated by the STSM approach as 0.39, whereas the results obtained from EG Two-Step, FMOLS, Johansen, and ARDL Bounds Testing methods are close to each other.

In addition, the price elasticities in the long-term are also found convergent except the Johansen test result. The minimum and maximum price elasticities are calculated to be -0.13 and -0.36 by the STSM and Johansen methods in absolute values, respectively.

Consequently, the price and income elasticities of residential electricity demand are estimated greater than the industrial electricity demand in the long-term. This means that households are more sensitive to the income and price changes rather than the consumers in the industrial sector. The price elasticities for both short- and long-term are close to zero. Therefore, the price variations are said not to be very effective on consumer's decisions.

6.2.3. Aggregate Electricity Demand

6.2.3.1. Unit Root Tests Results

The appropriate variables and the model of aggregate electricity demand for this study are shown by

$$E_d^A = f(GDP, AAEP, POP) \quad E_t^A = \gamma_0 + \gamma_1 GDP_t + \gamma_2 AAEP_t + \gamma_3 POP_t + \epsilon_t \quad (6.26)$$

where E^A is aggregate electricity consumption, *GDP* is gross domestic product, *AAEP*[8] is average aggregate electricity price and *POP* is population.

The order of integration of the variables mentioned above is determined by unit root tests. The ADF, PP, and KPSS unit root test outputs are introduced in Table 6.31.

Table 6.31. The Unit Root Tests Results for Aggregate Electricity Demand

	Variables	**Level**			**1st Difference**		
		ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Test Statistics (Constant)	E^A	-1.65	-1.65	0.73	-5.29*	-5.27*	0.35*
	GDP	-0.73	-0.79	0.74	-7.99*	-11.05*	0.17*
	AAEP	-1.94	-1.88	0.68	-7.22*	-8.64*	0.20*
	POP	1.18	-2.29	0.74	-2.99*	-3.58*	0.42*
Critical Values (Constant)	***5%***	***-2.94***	***-2.94***	***0.46***	***-2.94***	***-2.94***	***0.46***
Test Statistics (Constant & Trend)	E^A	-0.24	-0.24	0.20	-5.76*	-5.78*	0.10*
	GDP	-3.48	-3.49	0.17	-7.87*	-10.96*	0.13*
	AAEP	-3.46	-3.43	0.16	-7.20*	-8.73*	0.12*
	POP	-2.79	-3.48	0.18	-3.86*	-3.64*	0.13*
Critical Values (Constant & Trend)	***5%***	***-3.54***	***-3.54***	***0.14***	***-3.54***	***-3.54***	***0.14***

***Notes*:** *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. E^A, GDP, AAEP and POP are natural logs of the aggregate electricity consumption, real gross domestic product, real average aggregate electricity price and population, respectively.

[8] The estimation method of average price is introduced in the Methodology and Data chapter.

The results show that all variables are stationary in their first differences. In other words, the variables are integrated of order one, *I(1)* and consequently the cointegration relationship can be examined.

In addition, the Zivot and Andrews structural break unit root test is also applied to the series, and the results are presented in Table 6.32.

Table 6.32. Zivot-Andrews Unit Root Test Results for Aggregate Electricity Demand

	Variables	**Level**			**1st Difference**		
		ZA	**Lag Length**	**Break Date**	**ZA**	**Lag Length**	**Break Date**
Test Statistics (Constant)	E^A	-2.12	0	2009	-6.59*	0	1984
	GDP	-4.42	0	1985	-4.88*	4	1997
	AAEP	-4.47	2	2004	-7.89*	0	2008
	POP	-4.66	4	2003	-5.38*	3	2007
Critical Value (Constant)	***5%***			***-4.80***			
Test Statistics (Constant & Trend)	E^A	-3.50	0	1997	-6.43*	0	1984
	GDP	-4.79	0	1998	-5.19*	3	1991
	AAEP	-4.77	2	2005	-7.98*	0	2008
	POP	-4.15	4	2006	-5.34*	3	2007
Critical Value (Constant & Trend)	***5%***			***-5.08***			

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 4 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)
3. The appropriate lag length was determined by Akaike Information Criteria.
4. E^A, GDP, AAEP and POP are natural logs of the aggregate electricity consumption, real gross domestic product, real average aggregate electricity price and population, respectively.

E^A, *GDP*, *AAEP*, and *POP* are not stationary in the level according to the results of the Zivot-Andrews test. In the first difference, all these variables become stationary. That is to say, the results of the conventional and Zivot-Andrews unit root tests are similar with regards to the order of integration characteristic.

6.2.3.2. EG Two-Step Method

After checking the stationarity of the series, the demand models can be established. Using the same order of integration of the variables is a requirement for the conventional cointegration methods, like Engle-Granger Two-Step. Therefore, the results of the unit root tests are highly important for this approach. The long-term estimation results for aggregate electricity demand by using the EG Two-Step method are shown in Table 6.33.

Table 6.33. The Long-Run Results of EG Two-Step Method for Aggregate Electricity Demand

Dependent Variable: E^A			
Sample: 1978-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-44.12	2.798309	-15.76 [0.00]
GDP	0.37	0.153803	2.45 [0.01]
AAEP	-0.17	0.073323	-2.35 [0.02]
POP	3.32	0.335258	9.91 [0.00]

Notes: *1. p-values are in square brackets.*
2. E^A, GDP, AAEP and POP are natural logs of the aggregate electricity consumption, real gross domestic product, real average aggregate electricity price and population, respectively.

The t-ratios of the long-term estimation are uninterpretable (for the details see Chapter 5). Therefore, there is no information in terms of the stabilities of the coefficients. The preferred long-term aggregate electricity demand equation of the EG Two-Step method is given by

$$\boldsymbol{E_t^A = -44.12 + 0.37GDP_t - 0.17AAEP_t + 3.32POP} \qquad \textbf{(6.27)}$$

where E^A, *GDP*, *AAEP*, and *POP* represent the aggregate electricity consumption, gross domestic product, average aggregate electricity price, and population, correspondingly.

The results of diagnostic tests for Equation (6.27) are not reliable. The only important issue in here is the stationarity of the residuals for analysing the cointegration relationship among variables. The unit root test for the residuals is conducted by ADF, and the results are presented in Table 6.34 as follows.

Table 6.34. Unit Root Test of Residuals for Aggregate Electricity Demand

Variable		**Constant**		**Constant and Trend**		**None**	
		Level	***1st difference***	***Level***	***1st difference***	***Level***	***1st difference***
residuals	***Test Statistic***	-3.75*	-	-4.72*	-	-3.82*	-
	Critical Values (1%)	-3.62		-4.22		-2.62	

Note: *1. (*) Significant at 1% MacKinnon (1996) critical value.*

According to the ADF test results, the stationarity property of the residuals is provided in the level. This means that the variables are cointegrated in the long-run and the short-run equation can be estimated.

In the second step of the process, the information from the long-term equation is used to set up the short-term model. In Table 6.35, the results of the short-run equation and diagnostic tests are given.

Table 6.35. The Short-Run Results of EG Two-Step Method for Aggregate Electricity Demand

Dependent Variable: ΔE^A			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.05	0.005067	11.19 [0.00]
Δ*GDP*	0.28	0.067313	4.24 [0.00]
ECT(-1)	-0.25	0.110871	-2.27 [0.02]
Diagnostic Tests			
Std. error of the regression: 0.026	Norm: χ^2 = 0.97 [0.61]	Het: F= 2.44 [0.11]	ARCH (1): F = 0.10 [0.74]
LM Serial Correlation: F = 0.08 [0.91]	Reset: F = 3.10 [0.16]	Wald: F = 9.85 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^A, GDP, AAEP and POP are natural logs of the aggregate electricity consumption, real gross domestic product, real average aggregate electricity price and population respectively.

The short-term estimated equation is specified in Equation (6.28) as follows:

$$\boldsymbol{\Delta E_t^A = 0.05 + 0.28\Delta GDP_t - 0.25ECT_{t-1}} \qquad \textbf{(6.28)}$$

where $ECT_t = E_t^A + 44.12 - 0.37GDP_t + 0.017AAEP_t - 3.32POP_t$, and the coefficient of ECT is quite low. In addition, the price and population variables are removed from the equation since they are not statistically different from zero.

6.2.3.3. FMOLS Method

The FMOLS model for the aggregate electricity demand is estimated with a maximum 3-year lag. The appropriate bandwidth and lag length are selected by Newey-West automatic selection method. The estimated long-term coefficients and significance test results are summarized in Table 6.36.

Table 6.36. The Long-Run Results of FMOLS Method for Aggregate Electricity Demand

Dependent Variable: E^A			
Sample: 1979-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-17.70	0.775362	22.83 [0.00]
GDP	0.24	0.037690	6.48 [0.00]
AAEP	-0.10	0.019945	-5.24 [0.00]
T	0.05	0.001387	42.35 [0.00]

Notes: *1. p-values are in square brackets.*
2. E^A, GDP and AAEP are natural logs of the aggregate electricity consumption, real gross domestic product and real average aggregate electricity price, respectively. T is the trend variable.

The outputs from the above table indicates that *GDP*, *AAEP*, and *trend* variables are statistically significant at the 1% level. *POP* variable, on the other hand, is omitted from the model since the sign of the coefficient is found to be negative and this result is not consistent with the economic theory[9]. The preferred long-term equation is given by

$$E_t^A = -17.70 + 0.24GDP_t - 0.10AAEP_t + 0.05T \qquad (6.29)$$

where there is no role of the population variable in estimating the aggregate electricity demand as mentioned above.

The results of short-run dynamic model obtained by the information from the long-run equation are shown in Table 6.37.

Table 6.37. The Short-Run Results of FMOLS Method for Aggregate Electricity Demand

Dependent Variable: ΔE^A			
Sample: 1981-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.05	0.001157	50.95 [0.00]
ΔGDP	0.24	0.016516	15.09 [0.00]
ΔAAEP	-0.07	0.009437	-7.38 [0.00]
ECT(-1)	-0.68	0.050019	-13.63 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.022	Norm: χ^2 = 1.19 [0.55]		

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. E^A, GDP and AAEP are natural logs of the aggregate electricity consumption, real gross domestic product and real average aggregate electricity price, respectively.

[9] The negative sign of the population parameter denotes that if the population increase then energy consumption decreases. This result is not significant and not reflect the reality consistent with the economic structure.

The short-term model passes the diagnostic tests. In Equation (6.30), the estimated equation of the short-run dynamic model is presented:

$$\Delta E_t^A = 0.05 + 0.24\Delta GDP_t - 0.07\Delta AAEP_t - 0.68ECT_{t-1} \qquad (6.30)$$

where the coefficients are statistically significant, and the error correction term is formulated by

$$ECT_t = E_t^A + 17.70 - 0.24GDP_t + 0.10AAEP_t - 0.05T \qquad (6.31)$$

The coefficient on *ECT* is estimated as -0.68. In other words, 68% of any disequilibrium of the last period's impact is adjusted within the next period, and the model is balanced approximately after 1.5 period.

6.2.3.4. Johansen Method

The number of cointegrating vectors are determined by trace and maximum eigen value statistics. The specification of the model is determined as linear with an intercept and trend. Under these circumstances, the cointegration test results are introduced in Table 6.38.

Table 6.38. Johansen Cointegration Test for Aggregate Electricity Demand

Unrestricted Cointegration Test	**Trace Statistic**			**Maximum Eigen Statistic**		
Number of Cointegrating Vectors	0	At most 1	At most 2	0	At most 1	At most 2
Critical Values (%5)	42.91	25.87	12.51	25.82	19.38	12.51
Test statistic	54.67*	25.21	9.98	29.15*	15.52	9.98
[probability]	[0.00]	[0.06]	[0.12]	[0.01]	[0.16]	[0.12]

Notes: *1. Maximum lag length is selected from VAR as 1.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

According to the trace and maximum eigen statistics, there is one cointegrating vector among variables.

After determining the cointegration, the long-run estimation can proceed as follows:

$$E_t^A = \underset{[0.04]}{0.48}GDP_t + \underset{[0.03]}{2.79}POP_t \qquad \text{(t=1980-2015)} \qquad (6.32)$$

where the price and trend variables are not added to the model since they are not statistically significant. On the other side, *GDP* and *POP* are statistically significant at the 5% level.

Secondly, the short-run dynamic equation is estimated by using the inputs obtained from the long-run model as shown in Equation (6.33) below:

$$\Delta \boldsymbol{E_t^A} = -\mathbf{6.22} + \mathbf{0.42}\Delta \boldsymbol{GDP_t} - \mathbf{0.06}\boldsymbol{AAEP_t} - \mathbf{0.05}\boldsymbol{D}\mathbf{1985} - \mathbf{0.09}\boldsymbol{D}\mathbf{1998}$$

[0.00] [0.00] [0.09] [0.02] [0.00]

$$- \mathbf{0.14}\boldsymbol{ECT_{t-1}} \qquad \textbf{(6.33)}$$

[0.00]

where $ECT_t = E_t^A - 0.48GDP_t - 2.79POP_t$

Std. error of the regression: 0.021 LM Serial Correlation: F=0.00 [0.99]

Norm: JB=1.22 [0.54] Het: F= 0.61 [0.69] ARCH (1): F=0.40 [0.53]

Reset: F=1.11 [0.57] Wald: 20.60 [0.00].

The population variable is omitted from the short-run dynamic equation. In addition, the price variable is included in the model contrary to the long-run. The coefficient of *AAEP* is statistically significant at the 10% level. The diagnostic test results demonstrate that the short-run equation is released from the autocorrelation, heteroscedasticity, normality, and model verification problems.

6.2.3.5. ARDL Bounds Testing Method

Given the sample size of this study, the maximum lag length is determined as 5 for estimating the aggregate electricity demand. For the cointegration model, the appropriate lag length is accepted as (5,5,5,5) based on AIC with no autocorrelation problem (Table 6.39).

Table 6.39. Determination of the Lag Length (Aggregate Electricity Demand)

Lag Length	AIC	Autocorrelation (LM)
(1,0,0,0)	-4.30	2.11 [0.14]
(1,1,1,1)	-4.31	3.09 [0.06]
(2,2,2,2)	-4.40	2.28 [0.13]
(3,3,3,3)	-4.47	3.08 [0.08]
(4,4,4,4)	-4.44	1.85 [0.23]
(5,5,5,5)*	-5.37	2.49 [0.40]

Notes: *1. (*) indicates minimum AIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2nd order (AR(2)) serial correlation.

The main model with the preferred variables is shown in Equation (6.34) as below:

$$\Delta \boldsymbol{E_t^A} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 trend} + \sum_{i=1}^{5} \boldsymbol{\beta_{2i}} \Delta \boldsymbol{E_{t-i}^A} + \sum_{i=0}^{5} \boldsymbol{\beta_{3i}} \Delta \boldsymbol{GDP_{t-i}} + \sum_{i=0}^{5} \boldsymbol{\beta_{4i}} \Delta \boldsymbol{AAEP_{t-i}} + \sum_{i=0}^{5} \boldsymbol{\beta_{5i}} \Delta \boldsymbol{POP_{t-i}} + \boldsymbol{\beta_6 E_{t-1}^A} + \boldsymbol{\beta_7 GDP_{t-1}} + \boldsymbol{\beta_8 AAEP_{t-1}} + \boldsymbol{\beta_9 POP_{t-1}} + \boldsymbol{\varepsilon_t} \qquad \textbf{(6.34)}$$

where E^A is aggregate electricity consumption, *GDP* is gross domestic product, *AAEP* is average aggregate electricity price, and *POP* is population. The diagnostic test results of this equation are summarized in Table 6.40.

Table 6.40. Diagnostic Tests Statistics (Aggregate Electricity Demand)

ARDL (5,5,5,5)	
R^2	0.96
Adjusted R^2	0.59
Autocorrelation (LM)	2.49 [0.40]
Heteroscedasticity (White)	0.35 [0.94]
Normality (Jarque-Bera)	0.47 [0.78]
F-stat	8.84

Note: *1. p-values of the tests are in square brackets.*

Equation (6.34) passes the diagnostic tests with the fitted lag length. The R^2 value demonstrates that the independent variables (*GDP*, *AAEP*, and *POP*) explain over 96% of the dependent variable (E^A). In addition, the null hypotheses of no autocorrelation, no heteroscedasticity, and normal distribution cannot be rejected for the Breusch-Godfrey LM, White, and Jarque-Bera normality tests, respectively. Furthermore, the F-statistic which guiding the decision of cointegration relation is estimated as 8.84 and it is greater than *I(1)* values given in Table 6.41.

Table 6.41. Bounds Test Statistics for Aggregate Electricity Demand

N=38, k=3	**Pesaran**		**Narayan**	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.30	5.23	5.25	6.52
5%	3.38	4.23	3.85	4.78
10%	2.97	3.74	3.26	4.09

***Notes*:** *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with unrestricted intercept and restricted trend.

The results of the bounds test show that there is a cointegration relationship among variables, and the model is established as ARDL (1,0,0,3). The long-run cointegrating equation results are presented in Table 6.42.

Table 6.42. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Aggregate Electricity Demand

Dependent Variable: E^A		
Variables	**Coefficients**	**Probability Values**
E^A(-1)	0.12	0.36
GDP	0.31	0.62
AAEP	-0.02	0.00
POP	-49.75	0.02
POP(-1)	145.54	0.01
POP(-2)	-167.06	0.00
POP(-3)	72.38	0.01
C	-2.57	0.65
T	0.02	0.03
Long-Term Coefficients		
GDP	0.36*	0.00
AAEP	-0.02	0.62
POP	1.26	0.12
C	-5.32*	0.00
T	-0.02*	0.02
Diagnostic Statistics		
R^2: 0.99	DW: 1.87	
Adjusted R^2: 0.99	F stat: 5256.3 (0.00)	
Autocorrelation (LM): 0.59 (0.55)	χ^2_{White}: 0.50 (0.82)	
χ^2_{Norm}: 3.39 (0.18)	χ^2_{Ramsey}: 0.42 (0.66)	

Notes: *1. E^A, GDP, AAEP and POP are natural logs of the aggregate electricity consumption, real gross domestic product, real average aggregate electricity price and population, respectively. T is the trend variable.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

From the results of the above table, the long-run equation of the ARDL Bounds Testing method can be written as follows:

$$\boldsymbol{E_t^A = -5.32 + 0.36GDP_t - 0.02T} \quad \textbf{(6.35)}$$

where *AAEP* and *POP* variables are excluded from Equation (6.35) since they are not found as statistically significant.

Next, the short-run dynamic equation is estimated by the error correction model, and the results are reported in Table 6.43.

Table 6.43. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Aggregate Electricity Demand

Dependent Variable: ΔE^A		
Variables	**Coefficients**	**Probability Values**
Δ***C***	-4.84*	0.00
Δ***GDP***	0.32*	0.00
Δ***AAEP***	-0.04	0.18
Δ***POP***	-5.18	0.32
ECT(-1)	-0.80*	0.00
Diagnostic Statistics		
Std. error of the regression: 0.020	ARCH (1): F=0.02 [0.88]	
Autocorrelation (LM): 0.75 (0.45)	χ^2_{White}: 0.62 (0.69)	
χ^2_{Norm}: 3.45 (0.14)	χ^2_{Ramsey}: 0.74 (0.70)	

***Notes*:** *1. E^A, GDP and AAEP are natural logs of the aggregate electricity consumption, real gross domestic product and real average aggregate electricity price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

The estimated short-run equation with the proper variables are given by

$$\Delta \boldsymbol{E_t^A} = -\mathbf{4.84} + \mathbf{0.32}\Delta \boldsymbol{GDP_t} - \mathbf{0.80}\boldsymbol{ECT_{t-1}} \qquad \textbf{(6.36)}$$

where the price and population are not statistically different from zero at the 10% level, and therefore omitted from the short-run dynamic equation. In addition, $ECT_t = E_t^A + 5.32 - 0.36GDP_t + 0.02T$, and the estimated coefficient of the ECT is found considerably high. This shows that the speed of adjustment of the model is also high, and the model will quickly be balanced.

6.2.3.6. STSM Method

The detailed estimation results for the preferred specification of Turkey's aggregate electricity demand equation is presented below. Furthermore, the diagnostic, predictive and likelihood ratio test's results are also summarized in Table 6.44.

Table 6.44. The Results of STSM Method for Aggregate Electricity Demand

Dependent Variable: E^A				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
GDP	0.41376	0.07149	5.78784	[0.00]
AAEP	-0.07052	0.03152	-2.23729	[0.03]
Irregular 1979	-0.05543	0.01575	-3.51812	[0.00]
Irregular 1984	0.04273	0.01411	3.02837	[0.00]
Level Break 1998	-0.10671	0.02638	-4.04462	[0.00]

Level and Slope Components of $UEDT_{2015}$	
Level	16.1188 [0.00000]
Slope	0.02969 [0.00901]

Residuals		Auxiliary Residuals	*Irregular*	*Level*	*Slope*
Std. Error	0.9649	*Std. Error*	0.9664	0.9397	0.9451
Normality	0.9524	*Normality*	0.6639	0.9994	0.5378
Skewness	0.9250	*Skewness*	0.5150	0.9892	0.2775
Kurtosis	0.7658	*Kurtosis*	0.5296	0.9740	0.5348
H(10)	1.0558				
R(1)	0.0629	**LR Test**			
R(6)	-0.0683	*Test (a)* 71.36 (0.00)			
DW	2.4807	*Test (b)* 90.54 (0.00)			
Q(6,4)	5.9529				

Predictive Test 2008-2015		Goodness of Fit	
Failure	0.1579	R^2	0.9995
Cusum t(7)	1.8644	R_d^2	0.7367
		P.E.V.	0.0003
		P.E.V./ (M.D.)^2	1.0854

Hyperparameters	
Irregular	0.000041831
Level	0.000242134
Slope	0.000031762

Notes: *1. Model estimation is made in STAMP 8.20.*

2. There are one level intervention dummy variable for the year 1998 and two irregular dummy variables for the years 1979 and 1984 in the model.

3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.

4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2*), and the Coefficient Determination (*R^2 *and* R_d^2*).*

5. H(10) is the heteroscedasticity statistic.

6. R(1) and R(6) are the serial correlation coefficients at the 1st and 6th lag, respectively

7. DW is the Durbin-Watson statistic.

8. Q(6,4) is the Box-Ljung Q-statistics based on the first 6 residuals autocorrelations and distributed as $\chi 2$ *(4).*

9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.

10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and fixed slope hyperparameter and Test (b) after imposing a fixed level and zero slope; both are distributed as $\chi 2(2)$ *and probabilities are given in parenthesis.*

11. The hyperparameters determine the shape of the UEDT.

Turkish aggregate electricity demand equation is given by

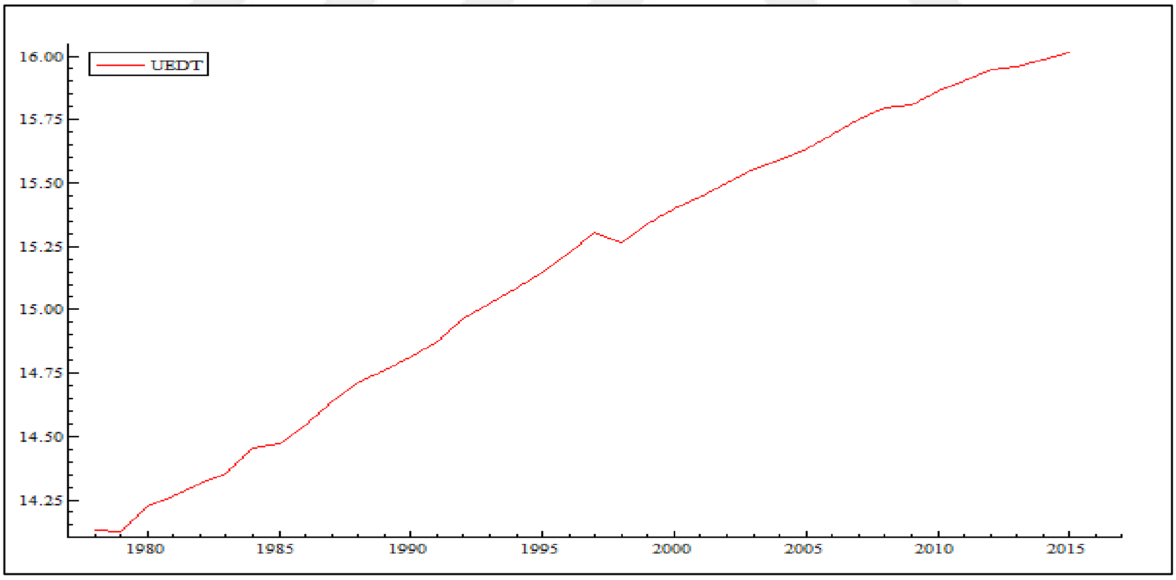
$$E_t^A = 0.41GDP_t - 0.07AAEP_t + UEDT_t \quad (6.37)$$

where UEDT for the aggregate demand is 16.1188 with a slope of 0.02969 at the end of the period.

The model passes the diagnostic tests with one level (1998) and two irregular (1979 and 1984) intervention dummy variables. The irregular dummies for 1979 and 1984 may reflect the economic and social conditions before and after the military coup, correspondingly. The level intervention dummy variable for 1998 may represent the effects of the economic crises in Asia countries and Russia to the Turkish economy.

The tendency of the UEDT is shown in Figure 6.3. The upward shape of the graph demonstrates that the aggregate electricity consumption is increasing over the estimation period with a break in 1998.

Figure 6.3. UEDT (μ_t) for Turkish Aggregate Electricity Consumption (1978-2015)



6.2.3.7. Comparison of Elasticity Estimates for Aggregate Electricity Demand

The elasticity estimates of aggregate electricity demand for the short- and long-term are listed in Table 6.45. Income elasticities in the short-term vary between 0.24 and 0.42 whereas in the long-term they vary between 0.24 and 0.48. The maximum values for the income elasticities are estimated by the Johansen method both in the short- and long-run. Moreover, the minimum values in terms of income elasticities are calculated by the FMOLS method.

Table 6.45. Summary of Estimated Aggregate Electricity Demand Elasticities

	INCOME		PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	0.28	0.37	-	-0.17
FMOLS	0.24	0.24	-0.07	-0.10
Johansen	0.42	0.48	-0.06	-
ARDL Bounds Test	0.32	0.36	-	-
STSM-UEDT	0.41		-0.07	

From the stand point of the price elasticities, the lowest one is estimated by the Johansen method. However, the computed price elasticities are close to each other especially in the short-term. In the case of long-term, the highest estimation is estimated by the Engle-Granger Two-Step method in absolute value.

To sum up, the aggregate electricity demand elasticities are greater than the industrial income and price elasticities but smaller than the residential ones. Specifically, due to the electricity market structure in Turkey, the price elasticities for aggregate electricity demand are near zero, similar to the above sectors. The prices are under the control of the government and, therefore they are not more effective on consumers' choices. In addition, electricity is a necessary good and people need to utilise from it whatever the price is.

6.3. Forecast Scenarios and Results for Electricity Demand

In this part of the study, the forecast scenarios and assumptions are produced to predict the future electricity demand for the industrial, residential and aggregate levels separately. In Chapter 5, the forecast procedure and techniques for obtaining the forecast equations are introduced in detail. The forecast period is up to 2025 and the long and short-run elasticity estimates are used to predict the future electricity demands. First, the scenario assumptions will be given. Then the forecast equations and results will be presented in the below.

6.3.1. Forecast Scenarios

The forecast scenarios are grouped into three categories as low, reference and high. First, the reference scenarios are constituted, and then the low and high scenarios are generated in regard to the reference scenarios. When creating the scenarios, the real industry value added, real household final consumption expenditure, real GDP, real energy prices, and population growth assumptions are required to derive the forecast equations. The detailed specifications of the three scenario assumptions are described as follows.

- *In the reference scenario*, the real industrial, residential and average aggregate electricity prices will increase by 1.00% annually between 2016 and 2025. The real industrial value added will be expected to increase by 4.50% for 2015, 2016 and 2017. Then, it will continue to rise 0.50% biyearly. Furthermore, the real *HFCE* growth is 3.40% in 2015 and assumed to be 3.50% in 2016. From 2017 to 2019, the real *HFCE* will be 4%, following four years (up to 2023) it will be 5.00%, and then it will be 5.50% last two years of the forecast period. On the other hand, the real *GDP* growth is supposed to be 4.00%, 2.10% and 2.70% for the years 2015, 2016 and 2017, respectively. Between 2018 and 2023 the economic growth of Turkey will range from 3.50% to 5.00% and at the end of the examined period it will be 5.50% for the reference scenarios. Finally, the population growth rate of Turkey will gradually decrease from 1.34% to 1.20% between 2015 and 2025. All of the above-mentioned assumptions are listed in Table 6.46.

Table 6.46. Reference Scenario Assumptions for the Electricity Demand

	INDUSTRIAL			***RESIDENTIAL***			***AGGREGATE***		
t	***IVA Growth***	***Price Growth***	***Trend Growth***	***HFCE Growth***	***Price Growth***	***Trend Growth***	***GDP Growth***	***Price Growth***	***Population Growth***
2015	4.50%	-0.01%	0.05%	3.40%	-1.00%	0.05%	4.00%	-0.98%	1.34%
2016	4.50%	1.00%	0.05%	3.50%	1.00%	0.05%	2.10%	1.00%	1.35%
2017	4.50%	1.00%	0.05%	4.00%	1.00%	0.05%	2.70%	1.00%	1.36%
2018	5.00%	1.00%	0.05%	4.00%	1.00%	0.05%	3.50%	1.00%	1.30%
2019	5.00%	1.00%	0.05%	4.00%	1.00%	0.05%	3.70%	1.00%	1.29%
2020	5.50%	1.00%	0.05%	5.00%	1.00%	0.05%	4.00%	1.00%	1.28%
2021	5.50%	1.00%	0.05%	5.00%	1.00%	0.05%	4.50%	1.00%	1.27%
2022	6.00%	1.00%	0.05%	5.00%	1.00%	0.05%	4.50%	1.00%	1.26%
2023	6.00%	1.00%	0.05%	5.00%	1.00%	0.05%	5.00%	1.00%	1.25%
2024	6.50%	1.00%	0.05%	5.50%	1.00%	0.05%	5.50%	1.00%	1.24%
2025	6.50%	1.00%	0.05%	5.50%	1.00%	0.05%	5.50%	1.00%	1.20%

Notes: *1. The actual values are used for 2015.*
2. IVA, HFCE and GDP represent the real industrial value added, household final consumption expenditure and gross domestic product, respectively.

- *In the low scenario*, the real prices are assumed to increase by 1.00% more than the reference scenario per year for the industrial, residential, and aggregate sectors over the period 2016-2025. The real *IVA* and *HFCE* are both supposed to decrease by 2.00% less than reference case for the industrial and residential sectors, respectively. The real *GDP*, on the other hand, is planned to diminish by 0.50% for the aggregate level. In addition, it is assumed that the population growth will shrink by 0.10% per year over the prediction period.

- *In the high scenario*, it is assumed that the real prices will increase gradually by 0.50% each year. Conversely to the low scenario, the real *IVA* and *HFCE* growth rates are supposed to rise by 2.00% more per year during the period. Moreover, the real *GDP* growth rates are expected to increase by 0.50% more than the reference case per annum from 2016 to 2025. Finally, the population growth rates are assumed to increase by 0.20% more than the reference scenario for each year.

The *GDP* growth rates prediction assumptions up to 2019 are obtained from the World Bank (World Bank, 2017). The rest of the years are generated by taking into consideration the Main Macroeconomic Indicators of Turkey. The *IVA* and *HFCE* growth rates assumptions between 2016 and 2025 are derived by utilising the 10th Development Plan (Ministry of Development, 2013). In addition, the population growth rate predictions are estimated from the population forecasts (TurkStat, 2013).

6.3.2. Forecast Equations and Results

The estimated equations for the industrial electricity demand forecasts based on the procedure described in the methodology chapter are summarized in in Table 6.47.

Table 6.47. Forecast Equations for the Industrial Electricity Demand

	Constant	e_{t-1}	y_t	y_{t-1}	p_t	p_{t-1}	t_{t-1}	*Slope of* μ_t
EG TWO-STEP	-12.50	0.20	0.28	0.01	-0.09	0.08	0.032	
FMOLS	-10.68	0.39	0.23	-0.07	-0.067	0.036	0.030	
JOHANSEN	-40.84	0.42	0.32	-0.04	-0.11	0.06	0.02	
ARDL	-17.51	0.27	0.24	0.007			0.035	
STSM	22.04		0.12		-0.08			0.04933

Note: *1. e, y, p* and *t* represent the industrial electricity consumption, industrial value added, industrial electricity price and trend, respectively.

By using these equations and the scenario assumptions, the industrial electricity consumption forecast results up to 2025 are given in Table 6.48. According to these results, in 2025, the Turkish industrial electricity consumption will be between 109760 GWh and 143464 GWh, 116447 GWh and 150548 GWh, and 122872 GWh and 163805 GWh in the low, reference, and high scenarios, respectively. The highest demands are estimated by the STSM method whereas the lowest ones are forecasted by the FMOLS approach.

Table 6.48. Industrial Electricity Demand Forecast Results for Turkey over the period between 2016 and 2025 (GWh)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**	**95866**
2015*	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**	**98758**
2016	99893	100554	101083	100184	100566	100849	100484	101145	101644	100139	100599	101059	94412	94743	95033
2017	100829	102225	103451	101032	101998	102820	101636	103169	104469	101102	102162	103228	99133	99858	100592
2018	101872	104033	106017	101875	103481	104905	1028262	105305	107493	102077	103786	105515	104057	105247	106599
2019	102950	105901	108681	102718	104988	107044	104040	107505	110636	103058	105443	107869	109128	110860	113034
2020	104189	107957	111572	103696	106649	109362	105445	109936	114062	104171	107254	110409	114409	116769	119996
2021	105479	110089	114578	104704	108358	111752	106910	112465	117638	105326	109128	113042	119838	122920	127464
2022	106939	112425	117832	105857	110234	114339	108583	115249	121534	106629	111174	115883	125485	129391	135553
2023	108457	114850	121220	107044	112164	117009	110325	118147	1256060	107980	113293	118832	131280	136120	144242
2024	110155	117495	124884	108382	114274	119893	112289	121326	130035	109488	115597	122008	137299	143196	153667
2025	111917	120241	128700	109760	116447	122872	114332	124639	134673	111050	117985	125307	143464	150548	163805

Note: *(*) indicates the real values.*

The estimated residential electricity demand forecast equations are listed in Table 6.49.

Table 6.49. Forecast Equations for the Residential Electricity Demand

	Constant	e_{t-1}	y_t	y_{t-1}	p_t	p_{t-1}	t_t	*Slope of* μ_t
EG TWO-STEP	-6.93	0.75	0.33	0.14		-0.045		
FMOLS	-7.50	0.74	0.30	0.17	-0.21	0.17	-0.005	
JOHANSEN	-6.80	0.85	0.21	0.09	-0.05		-0.003	
ARDL	-6.40	0.85	0.16	0.06				
STSM	8.44	0.43		0.22	-0.073			0.02925

Note: *1. e, y, p* and *t* represent the residential electricity consumption, household final consumption expenditure, residential electricity price and trend, respectively.

Based on the estimated forecast equations and scenarios, the future residential electricity consumption results are shown in Table 6.50. These results indicate that Turkey's residential electricity demand in 2025 will be between 67609 GWh and 90861 GWh in the low scenario, between 90929 GWh and 104775 GWh in the reference scenario, and between 95983 GWh and 124331 GWh in the high scenario.

Table 6.50. Residential Electricity Demand Forecast Results for Turkey over the period between 2016 and 2025 (GWh)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**	**46194**
2015*	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**	**48285**
2016	50462	50781	51099	50141	50532	50771	50521	50723	50926	50693	50847	51002	50929	50965	50947
2017	52612	53695	54754	51807	53186	54091	52795	53518	54206	53401	53926	54453	53713	54029	54208
2018	54791	57045	59252	53380	56262	58231	55138	56699	58169	56432	57550	58681	56707	57444	57945
2019	57013	60816	64591	54886	59735	63169	57555	60278	62852	59794	61743	63737	59892	61152	62062
2020	59475	65207	71010	56512	63776	69100	60172	64400	68439	63596	66638	69790	63269	65134	66528
2021	62244	70306	78661	58342	68476	76171	63046	69148	75072	67895	72325	76984	66981	69535	71488
2022	65301	76117	87630	60350	73831	84442	66180	74561	82861	72716	78869	85448	70976	74307	76898
2023	68632	82666	98032	62517	79849	94001	69579	80687	91938	78089	86349	95343	75240	79440	82755
2024	72344	90122	110177	64926	86673	105104	73324	87666	102559	84113	94929	106935	79774	84944	89074
2025	76474	98596	124331	67609	94409	117991	77457	95611	114974	90861	104755	120492	84675	90929	95983

Note: *(*) indicates the real values.*

Finally, the estimated forecast equations for the aggregate electricity demand are introduced in Table 6.51.

Table 6.51. Forecast Equations for the Aggregate Electricity Demand

	Constant	e_{t-1}	y_t	y_{t-1}	p_t	p_{t-1}	pop_{t-1}	t_{t-1}	*Slope of* μ_t
EG TWO-STEP	-10.26	0.75	0.28	-0.19		-0.043	-0.81		
FMOLS	-11.97	0.32	0.25	-0.41	-0.069	-0.001		0.039	
JOHANSEN	-5.22	0.86	0.42	-0.35	-0.06		0.39		
ARDL	-9.09	0.20	0.32	0.61				0.02	
STSM	16.11		0.41		-0.07				0.02969

Note: *1. e, y, p, pop* and *t* represent the aggregate electricity consumption, gross domestic product, average aggregate electricity price, population and trend, respectively.

Given the above equations and assumptions, the forecast results of the aggregate electricity demand for Turkey between 2016 and 2025 are presented in Table 6.52. In 2025, Turkey's aggregate electricity demand is expected to be between 307029 GWh and 347127 GWh, between 317143 GWh and 362511 GWh, and between 332072 GWh and 393625 GWh according to the low, reference, and high case scenarios, respectively. Similar to the industrial sector, the highest prediction was made by the STSM method.

Table 6.52. Aggregate Electricity Demand Forecast Results for Turkey over the period between 2016 and 2025 (GWh)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**	**205478**
2015*	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**	**213569**
2016	221626	221925	222224	221082	221202	221542	220532	221108	221493	221582	221924	222266	245702	246447	247156
2017	230649	231568	232526	226712	227453	228723	228766	230174	231101	226995	228448	229904	254580	256199	257982
2018	240829	242656	244597	232791	234352	236797	238538	241040	242675	233357	236140	238943	264394	267034	270306
2019	251728	254729	257961	240014	242501	246269	249307	253175	255694	241354	245597	249893	274558	278382	283615
2020	263427	267858	272679	248161	251659	256878	261212	266737	270329	250452	256281	262215	285200	290385	298111
2021	276109	282223	288936	257432	262027	268833	274537	282034	286910	260924	268486	276226	296578	303326	314157
2022	289460	297509	306420	267858	273648	282194	288819	298621	305005	272844	282312	292056	308132	316653	331264
2023	303887	314135	325571	279311	286403	296857	304690	317175	325326	285957	297521	309487	320484	331020	350201
2024	319482	332211	346525	292377	300904	313476	322295	337886	348096	301165	315074	329545	333690	346512	371167
2025	335903	351398	368954	307029	317143	332072	341126	360264	372845	318410	334946	352246	347127	362511	393625

Note: *(*) indicates the real values.*

6.4. Natural Gas Demand

Turkey is dependent on the external suppliers, especially in terms of fossil fuels. This dependency is about 75%. In the context of natural gas, this dependency rate is approximately 99%, and natural gas is widely used in many fields in Turkey such as industrial, residential and electricity generation sectors. Therefore, the elasticity estimations for natural gas demand and prediction of possible consumption are very significant for Turkey in terms of both policy making and future planning.

In this part of the study, the price and income elasticity estimates of the above-mentioned sectors are estimated by utilizing the same five approaches (EG Two-Step, FMOLS, Johansen, ARDL Bounds Testing and STSM) as in electricity demand modelling cases. After estimating the elasticities, the prediction equations will be generated from these elasticity models, and then possible future natural gas demand results will be given. The annual data covering the period of 1988-2015 are used to make the necessary calculations.

The procedure of the estimations are as follows: Firstly, the unit root test results are given. Secondly, the estimated elasticities for each sector are presented. Lastly, the scenario assumptions and the future natural gas demand prediction results for Turkey are shared in detail.

6.4.1. Industrial Natural Gas Demand

6.4.1.1. Unit Root Tests Results

As in the cointegration analyses for electricity sectors, unit root tests are also applied to the natural gas series. First, the industrial natural gas demand equations are tested with ADF, PP and KPSS unit root tests. In addition, the ZA structural break unit root test is conducted to the variables. The industrial natural gas demand function and preferred equation are given by

$$\boldsymbol{N_d^I = f(IVA, INP, IEP) \;\; N_t^I = \delta_0 + \delta_1 IVA_t + \delta_2 INP_t \pm \delta_3 IEP_t + u_t} \quad \textbf{(6.38)}$$

where N^I, *IVA*, *INP*, and *IEP* represent industrial natural gas consumption, industrial value added, industrial natural gas price, and industrial electricity price, respectively. The unit root test results with respect to ADF, PP, and KPSS tests are summarized in Table 6.53.

Table 6.53. The Unit Root Tests Results for Industrial Natural Gas Demand

	Variables	Level			1st Difference		
		ADF	PP	KPSS	ADF	PP	KPSS
Test Statistics (Constant)	***N^I***	-0.78	-2.20	0.68	-6.61*	-14.6*	0.25*
	IVA	-1.38	-1.37	0.61	-5.37*	-5.40*	0.05*
	INP	-1.43	-1.35	0.56	-4.94*	-6.37*	0.12*
	IEP	-2.10	-2.24	0.51	-4.73*	-4.73*	0.06*
Critical Values (Constant)	***5%***	***-2.98***	***-2.98***	***0.46***	***-2.98***	***-2.98***	***0.46***
Test Statistics (Constant & Trend)	***N^I***	-2.35	-3.05	0.19	-6.25*	-13.5*	0.11*
	IVA	-2.87	-2.87	0.15	-5.26*	-5.28*	0.06*
	INP	-3.16	-3.16	0.16	-4.83*	-9.48*	0.11*
	IEP	-2.17	-2.17	0.19	-4.66*	-4.65*	0.04*
Critical Values (Constant & Trend)	***5%***	***-3.59***	***-3.59***	***0.14***	***-3.59***	***-3.59***	***0.14***

Notes: *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively.

The maximum lag length is determined as 6 for the ADF unit root test. On the other hand, the Bartlett-Kernel model is used to select the appropriate bandwidth for PP and KPSS tests. The results indicate that all variables are *I(1)*. In other words, they are stationary at the first difference for both constant and constant and trend models at the 5% significance levels.

Furthermore, the Zivot-Andrews structural break unit root test results for the series are presented in Table 6.54.

Table 6.54. Zivot-Andrews Unit Root Test Results for Industrial Natural Gas Demand

	Variables	Level			1st Difference		
		ZA	Lag Length	Break Date	ZA	Lag Length	Break Date
Test Statistics (Constant)	***N^I***	-3.66	3	2000	-5.97*	1	1993
	IVA	-4.23	0	2001	-6.34*	0	1999
	INP	-4.54	0	1993	-4.84*	2	1993
	IEP	-4.57	0	2004	-5.58*	0	2008
Critical Value (Constant)	***5%***	***-4.80***					
Test Statistics (Constant & Trend)	***N^I***	-3.81	3	2001	-7.35*	1	2002
	IVA	-4.23	0	2001	-6.54*	0	1999
	INP	-4.91	0	2003	-5.57*	1	1997
	IEP	-4.30	0	2004	-5.57*	0	2008
Critical Value (Constant & Trend)	***5%***	***-5.08***					

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 3 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)
3. The appropriate lag length was determined by Akaike Information Criteria.
4. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively.

According to these results, N^I, *IVA*, *INP*, and *IEP* are stationary in their first differences. All in all, the ZA unit root test results show parallelism with the conventional ones, which means the outcomes of these approaches are similar.

6.4.1.2. EG Two-Step Method

In analysing the industrial natural gas demand by using the Engle-Granger Two-Step method, the long-run elasticity estimates are calculated initially, and then the short-run equation can be established by using the results from the long-run relationship. This procedure is used for all conventional cointegration models because of observing the effects of the short terms on the long terms. The estimation results of the long-run model for the EG-Two-Step method are given in Table 6.55.

Table 6.55. The Long-Run Results of EG Two-Step Method for Industrial Natural Gas Demand

Dependent Variable: N^I			
Sample: 1988-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	1.86	6.741424	0.27 [0.78]
IVA	0.79	0.443177	1.78 [0.08]
INP	-0.80	0.288763	-2.77 [0.01]
IEP	0.64	0.351057	1.84 [0.07]
T	0.13	0.012944	10.14 [0.00]

Notes: *1. p-values are in square brackets.*
2. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively. T is the trend variable.

As it is seen from the table above, the t-statistics and the probability values of some variables are not significant. However, due to the invalidity of the t-statistics and diagnostics test, these values are not interpretable for the long-term. The only important expectation in the first step of the EG Two-Step method is to define the cointegration relationship among the variables. The preferred estimated equation for the first step is presented as follows:

$$\boldsymbol{N_t^I = 1.86 + 0.79IVA_t - 0.80INP_t + 0.64IEP_t + 0.13T} \qquad \textbf{(6.39)}$$

where *INP* and *IEP* are industrial natural gas and electricity prices, respectively, and they are both included in the model to examine the effects of cross-price elasticities of the natural gas demand in the industrial sector.

Before continuing to the second step, it is necessary to identify the stationarity of the residuals obtained from the long-run equation. The unit root test results of the residuals are summarized in Table 6.56.

Table 6.56. Unit Root Test of Residuals for Industrial Natural Gas Demand

Variable		**Constant**		**Constant and Trend**		**None**	
		Level	***1st difference***	***Level***	***1st difference***	***Level***	***1st difference***
residuals	***Test Statistic***	-4.04*	-	-4.08*	-	-4.07*	-
	Critical Values (5%)	-2.97		-3.58		-1.95	

Note: *1. (*) Significant at 5% MacKinnon (1996) critical value.*

The ADF unit root test results indicate that residuals are level-stationary, which means the cointegration relation among variables is valid.

After specifying the cointegration, the second step of the method can proceed. Estimated variables for the short-term and the diagnostic tests are introduced in Table 6.57.

Table 6.57. The Short-Run Results of EG Two-Step Method for Industrial Natural Gas Demand

Dependent Variable: ΔN^I			
Sample: 1989-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.16	0.023959	6.92 [0.00]
ΔIVA	1.59	0.451736	3.53 [0.00]
ΔINP	-0.71	0.200092	-3.55 [0.00]
ΔIEP	1.02	0.336757	3.03 [0.00]
D1998	-0.66	0.191001	-3.47 [0.00]
D2008	-0.29	0.123162	-2.35 [0.02]
ECT(-1)	-0.43	0.157283	-2.76 [0.01]
Diagnostic Tests			
Std. error of the regression: 0.11	Norm: χ^2 = 0.26 [0.87]	Het: F= 2.53 [0.07]	ARCH (1): F = 0.54 [0.56]
LM Serial Correlation: F = 0.25 [0.77]	Reset: F = 0.09 [0.75]	Wald: F = 9.33 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively.

The generated short-term equation of the industrial natural gas demand with two dummy variables is given by

$$\Delta N_t^I = 0.16 + 1.59\Delta IVA_t - 0.71\Delta INP_t + 1.02\Delta IEP_t - 0.66D98 - 0.29D08 - 0.43ECT_{t-1} \quad \textbf{(6.40)}$$

where all coefficients are statistically significant, and the error correction term (*ECT*) can be formulated as below:

$$ECT_t = N_t^I - 1.86 - 0.79IVA_t + 0.80INP_t - 0.64IEP_t - 0.13T \quad \textbf{(6.41)}$$

The long-run model is used to estimate Equation (6.41). The coefficient of the *ECT* shows that approximately 43% of any disequilibrium can be adjusted each year, and the model can be balanced shortly before 2.5 years.

6.4.1.3. FMOLS Method

The maximum lag length is chosen as 3 to estimate the industrial natural gas demand equations by using the FMOLS method. In addition, the Newey-West automatic selection approach is used to determine the bandwidth. The appropriate model and long-term results are presented in Table 6.58.

Table 6.58. The Long-Run Results of FMOLS Method for Industrial Natural Gas Demand

Dependent Variable: N^I			
Sample: 1989-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	1.82	0.740517	2.46 [0.02]
IVA	0.89	0.044152	20.28 [0.00]
INP	-0.94	0.022620	-41.96 [0.00]
IEP	0.49	0.035906	13.72 [0.00]
T	0.12	0.000990	126.9 [0.00]

Notes: *1. p-values are in square brackets.*
2. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively. T is the trend variable.

According to the results of the above table, the long-run equation is as follows:

$$N_t^I = 1.82 + 0.89IVA_t - 0.94INP_t + 0.49IEP_t + 0.12T \quad \textbf{(6.42)}$$

where *T* represents the linear deterministic trend. All coefficients are statistically significant. Therefore, the cointegration relations are demonstrated, and the short-run equation can be estimated. In Table 6.59, the short-term outcomes are shown.

Table 6.59. The Short-Run Results of FMOLS Method for Industrial Natural Gas Demand

Dependent Variable: ΔN^I			
Sample: 1991-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.17	0.008664	20.04 [0.00]
ΔIVA	1.03	0.074103	13.90 [0.00]
ΔINP	-0.64	0.028607	-22.66 [0.00]
ΔIEP	0.47	0.048415	9.86 [0.00]
D1998	-0.49	0.030673	-15.97 [0.00]
ECT(-1)	-0.46	0.035209	-13.11 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.11	Norm: χ^2 = 0.92 [0.62]	Wald: F = 246.35 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively.

A dummy variable is included in the model for the year 1998, and the coefficients in the short-run equation are statistically significant at 1% significance level. The preferred short-term model for the FMOLS method can be formed as below:

$$\boldsymbol{\Delta N_t^I = 0.17 + 1.03\Delta IVA_t - 0.64INP_t + 0.47\Delta IEP_t - 0.49D1998 - 0.46ECT_{t-1}} \quad \textbf{(6.43)}$$

where $ECT_t = N_t^I - 1.82 - 0.89IVA_t + 0.94INP_t - 0.49IEP_t - 0.12T$, and the coefficient of the *ECT* equals -0.46.

6.4.1.4. Johansen Method

The trace and maximum eigen value statistics are used in the Johansen method to determine the number of cointegrating vectors. The results of the linear with the intercept and trend model are summarized in Table 6.60.

Table 6.60. Johansen Cointegration Test for Industrial Natural Gas Demand

Unrestricted Cointegration Test	**Trace Statistic**				**Maximum Eigen Statistic**			
Number of Cointegrating Vectors	0	At most 1	At most 2	At most 3	0	At most 1	At most 2	At most 3
Critical Values (%5)	63.87	42.91	25.87	12.51	32.11	25.82	19.38	12.51
Test statistic [probability]	66.45* [0.02]	41.28 [0.07]	23.03 [0.10]	9.82 [0.13]	25.17 [0.27]	18.25 [0.35]	13.20 [0.31]	9.82 [0.13]

Notes: *1. Maximum lag length is selected from VAR as 1.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

While the trace statistics specifies that there is only one cointegrating vector among variables, the maximum eigen statistics indicate that there is no cointegration relationship. Given the results of the trace test, long-run model is estimated as follows:

$$\boldsymbol{N_t^I = 1.11IVA_t - 0.23INP_t + 0.69IEP_t + 0.10T} \quad \textbf{(t=1990-2015)} \quad \textbf{(6.44)}$$

[0.03] [0.02] [0.02] [0.00]

where the *IVA*, *INP*, *IEP*, and *trend* variables are found to be statistically significant at the 5% level.

Furthermore, the dynamic short-run equation is estimated by

$$\boldsymbol{\Delta N_t^I = -124.82 + 2.04\Delta IVA_t - 0.48INP_t + 0.94IEP_t - 0.78D98}$$

[0.00] [0.00] [0.00] [0.02] [0.00]

$$\boldsymbol{- 0.56ECT_{t-1}} \quad \textbf{(6.45)}$$

[0.00]

where $ECT_t = N_t^I - 1.11IVA_t + 0.23INP_t - 0.69IEP_t - 0.10T$

Std. error of the regression: 0.11 LM Serial Correlation: F=0.25 [0.77]

Norm: JB=2.45 [0.29] Het: F= 0.92 [0.48] ARCH (1): F=0.00 [0.95]

Reset: F=1.48 [0.25] Wald: 9.46 [0.00].

All coefficients of the dynamic short-run equation for the Johansen cointegration method are statistically significant at 5% level. In addition, the diagnostic tests are passed. The coefficient of error correction term shows that more than half of any disequilibrium is adjusted each period, and the model will reach the balance shorter than 2 years.

6.4.1.5. ARDL Bounds Testing Method

In the ARDL Bounds Testing approach, it is necessary to determine the maximum lag length to decide the appropriate model. The maximum lag length for the industrial natural gas demand equation is specified as two since annual data is used and the number of observation is limited. In Table 6.61, the preferred lag length is identified as (2,2,2,2) based on the Schwarz Bayesian Information Criteria (SBIC) with no autocorrelation problem.

Table 6.61. Determination of the Lag Length (Industrial Natural Gas Demand)

Lag Length	SBIC	Autocorrelation (LM)
(1,0,0,0)	-0.52	7.70 [0.00]
(1,1,1,1)	-0.38	7.60 [0.00]
(2,2,2,2)*	-0.42	0.85 [0.47]

Notes: *1. (*) indicates minimum SBIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2nd order (AR(2)) serial correlation.

Equation (6.46) shows the convenient specification of the ARDL Bounds Testing method by using the optimal lag length determined above.

$$\Delta N_t^I = \beta_0 + \beta_1 trend + \sum_{i=1}^{2} \beta_{2i} \Delta N_{t-i}^I + \sum_{i=0}^{2} \beta_{3i} \Delta IVA_{t-i} + \sum_{i=0}^{2} \beta_{4i} \Delta INP_{t-i} + \sum_{i=0}^{2} \beta_{5i} \Delta IEP_{t-i} + \beta_6 N_{t-1}^I + \beta_7 IVA_{t-1} + \beta_8 INP_{t-1} + \beta_9 IEP_{t-1} + \varepsilon_t \quad \mathbf{(6.46)}$$

The descriptive statistics of Equation (6.46) are listed in Table 6.62. As it is seen, the equation passes the diagnostic tests, and now the existence of the cointegration relation can be analysed to estimate the long and short-run models.

Table 6.62. Diagnostic Tests Statistics (Industrial Natural Gas Demand)

	ARDL (2,2,2,2)
R^2	0.77
Adjusted R^2	0.31
Autocorrelation (LM)	0.85 [0.47]
Heteroscedasticity (White)	0.61 [0.80]
Normality (Jarque-Bera)	0.13 [0.93]
F-stat	5.50

Note: *1. p-values of the tests are in square brackets.*

Based on the F-statistic found, the null hypothesis of no cointegration can be rejected at least at 5% significance level for both test statistics. The F statistic (5.50) is smaller only than the upper and lower bounds of Narayan's (2005) 1% critical values (Table 6.63). As a result, the cointegration relationship among variables can be decided.

Table 6.63. Bounds Test Statistics for Industrial Natural Gas Demand

N=27, k=3	**Pesaran**		**Narayan**	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.30	5.23	5.66	6.98
5%	3.38	4.23	4.04	5.09
10%	2.97	3.74	3.37	4.27

Notes: *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with unrestricted intercept and restricted trend.

In terms of the long-run equation, the appropriate model is determined as ARDL (1,0,0,0) with the maximum lag length of 2. The results of long-term equation are given in Table 6.64.

Table 6.64. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Industrial Natural Gas Demand

Dependent Variable: N^I		
Variables	**Coefficients**	**Probability Values**
N^I(-1)	0.43	0.00
IVA	0.04	0.90
INP	-0.43	0.04
IEP	0.16	0.51
C	12.45	0.09
T	0.07	0.00
Long-Term Coefficients		
IVA	1.07*	0.00
INP	-0.76*	0.05
IEP	0.28*	0.04
C	7.96*	0.00
T	0.13*	0.00
Diagnostic Statistics		
R^2: 0.98	DW: 1.47	
Adjusted R^2: 0.98	F stat: 5256.3 (0.00)	
Autocorrelation (LM): 1.30 (0.29)	χ^2_{White}: 1.36 (0.27)	
χ^2_{Norm}: 0.59 (0.74)	χ^2_{Ramsey}: 0.95 (0.43)	

Notes: *1. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively. T is the trend variable.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

All variables are found to be statistically significant in the long-run, and the equation can be written as follows:

$$N_t^I = 7.96 + 1.07IVA_t - 0.76INP_t + 0.28IEP_t + 0.13T \qquad (6.47)$$

Given the information from Equation (6.47), the short-run equation of the ARDL Bounds Testing method can be estimated. The dynamic short-run equation results with the lagged variable are introduced in Table 6.65.

Table 6.65. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Industrial Natural Gas Demand

Dependent Variable: ΔN^I		
Variables	**Coefficients**	**Probability Values**
C	7.60*	0.00
Δ***IVA***	1.27*	0.01
Δ***INP***	-0.53*	0.01
Δ***IEP***	0.23	0.46
ECT(-1)	-0.53*	0.00
Diagnostic Statistics		
Std. error of the regression: 0.021	ARCH (1): F=0.43 [0.55]	
Autocorrelation (LM): 1.01 (0.56)	χ^2_{White}: 1.27 (0.20)	
χ^2_{Norm}: 0.94 (0.62)	χ^2_{Ramsey}: 1.89 (0.27)	

Notes: *1. N^I, IVA, INP and IEP are natural logs of the industrial natural gas consumption, real industrial value added, real industrial natural gas price and real industrial electricity price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

According to these results, the short-run equation of the ARDL model can be rearranged as follows:

$$\Delta N_t^I = 7.60 + 1.27\Delta IVA_t - 0.53INP_t - 0.53ECT_{t-1} \quad \textbf{(6.48)}$$

where the industrial electricity price (*IEP*) variable is not significant and omitted from the equation. Other variables are statistically significant at 5% significance level.

The error correction term of the model can be formulated as

$$ECT_t = N_t^I - 7.96 - 1.07IVA_t + 0.76INP_t - 0.28IEP_t - 0.13T \quad \textbf{(6.49)}$$

where the coefficient is found to be -0.53. The sign and value of *ECT* is parallel with the theoretical framework. The coefficient of *ECT* can be interpreted as 53% of any instability in the system is stabilized each year.

6.4.1.6. STSM Method

For the STSM approach, the appropriate model is established as local trend in which the level and slope are determined stochastically. This is one of the main differences between conventional cointegration analyses and the STSM method. The estimation results and the descriptive statistics of Turkey's industrial natural gas demand are presented in Table 6.66.

Table 6.66. The Results of STSM Method for Industrial Natural Gas Demand

Dependent Variable: N^I				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
IVA	1.41693	0.30146	4.70014	[0.00]
INP	-0.55820	0.12918	-4.32098	[0.00]
IEP	0.74447	0.21605	3.44585	[0.00]
Level Break 1998	-0.77532	0.12909	-6.00586	[0.00]
Irregular 2003	0.15859	0.05011	3.16518	[0.00]
Irregular 2008	-0.26469	0.05324	-4.97141	[0.00]
Level and Slope Components of $UEDT_{2015}$				
Level	-4.83939 [0.03458]			
Slope	0.10272 [0.00515]			

Residuals		**Auxiliary Residuals**			
			Irregular	***Level***	***Slope***
Std. Error	0.9063	*Std. Error*	0.9539	0.9403	0.7148
Normality	0.5695	*Normality*	0.7025	0.6152	0.9465
Skewness	0.9933	*Skewness*	0.5550	0.7835	0.8188
Kurtosis	0.2887	*Kurtosis*	0.5498	0.3438	0.8105
H(6)	0.6964				
R(1)	-0.1736	**LR Test**			
R(5)	-0.3053	*Test (a)* 14.5667 (0.00)			
DW	2.1672	*Test (b)* 68.8082 (0.00)			
Q(5,3)	3.8875				
Predictive Test 2008-2015		**Goodness of Fit**			
Failure	0.2587	R^2	0.9950		
Cusum t(7)	1.9162	R_d^2	0.8421		
		P.E.V.	0.0040		
		P.E.V./ (M.D.)^2	0.9950		
Hyperparameters					
Irregular	0.000000				
Level	0.049115				
Slope	0.013206				

Notes: *1. Model estimation is made in STAMP 8.20.*

2. There are one level intervention dummy variable for the year 1998, and two irregular dummy variables for the years 2003 and 2008 in the model.

3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.

4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2), and the Coefficient Determination (R^2 and R_d^2).

5. H(6) is the heteroscedasticity statistic.

6. R(1) and R(5) are the serial correlation coefficients at the 1st and 5th lag, respectively

7. DW is the Durbin-Watson statistic.

8. Q(5,3) is the Box-Ljung Q-statistics based on the first 6 residuals autocorrelations and distributed as $\chi2$ (3).

9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.

10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and fixed slope hyperparameter and Test (b) after imposing a fixed level and zero slope; both are distributed as $\chi2(2)$ and probabilities are given in parenthesis.

11. The hyperparameters determine the shape of the UEDT.

Turkish industrial natural gas demand equation is given by

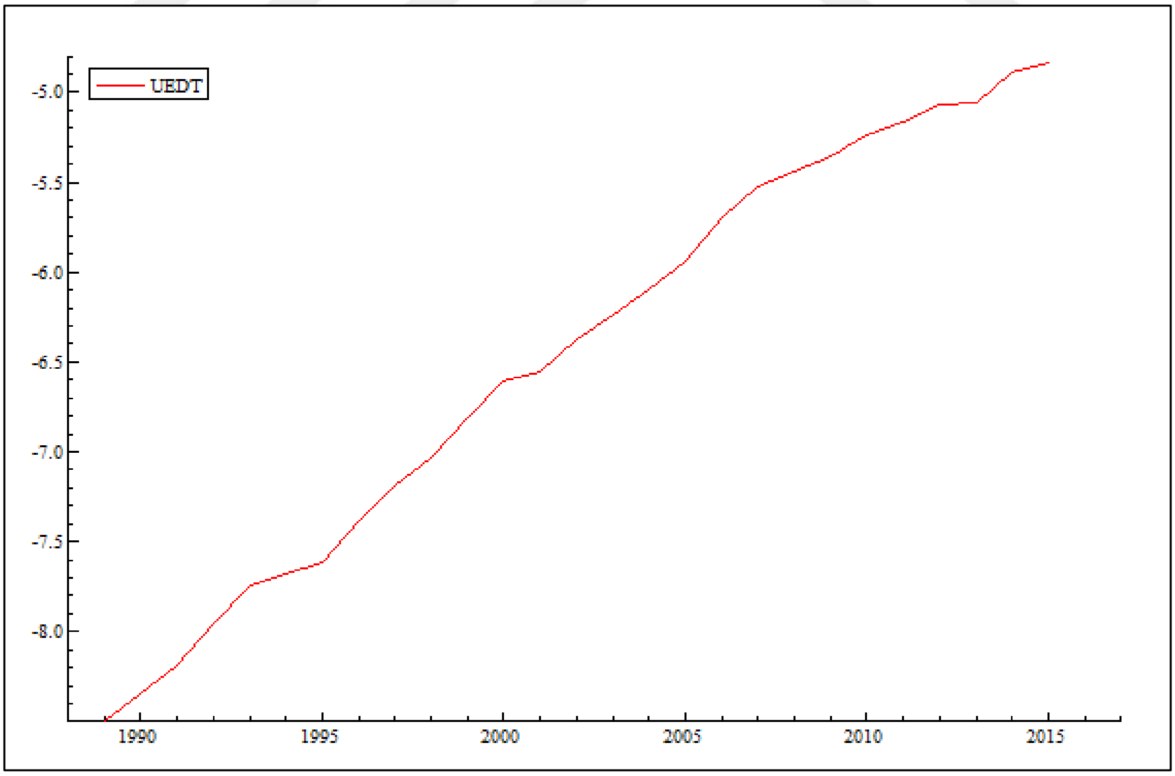
$$N_t^I = 1.41IVA_t - 0.55INP_t + 0.74IEP_t + UEDT_t \quad (6.50)$$

where UEDT for the industrial natural gas demand is -4.83939 with a slope of 0.10272 at the end of the period.

The diagnostic tests are passed with the inclusion of three dummy variables. The level dummy variable for the year 1998 may reflect the economic conditions in Turkey after the economic crises in Asia countries and Russia. On the other hand, the irregular dummies for the years 2003 and 2008 may represent the rapid natural gas consumption growth in Turkey's industrial sector after 2001 crisis and the effects of 2008 global economic crisis on Turkish economy.

The shape of the UEDT is illustrated in Figure 6.4. The estimated stochastic trend shows an upward tendency between 1988 and 2015. This can be interpreted as the usage of the natural gas in the industrial sector of Turkey increases over the estimation period.

Figure 6.4. UEDT (μt) for Turkish Industrial Natural Gas Consumption (1988-2015)



6.4.1.7. Comparison of Elasticity Estimates for Industrial Natural Gas Demand

In table 6.67, the income, own-price and cross-price elasticities of industrial natural gas demand are summarized.

Table 6.67. Summary of Estimated Industrial Natural Gas Demand Elasticities

	INCOME		OWN-PRICE		CROSS-PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	1.59	0.79	-0.71	-0.80	1.02	0.64
FMOLS	1.03	0.89	-0.64	-0.94	0.47	0.49
Johansen	2.04	1.11	-0.48	-0.23	0.94	0.69
ARDL Bounds Test	1.27	1.07	-0.53	-0.76	-	0.28
STSM-UEDT	1.41		-0.55		0.74	

The results indicate that the income elasticities in the long-run are smaller than that of the short-run. Also, the cross-price elasticities are found to be positive as expected, and in the short-run they are calculated as greater than the long-run, except for the estimation of the FMOLS method.

The estimations of the long-term own-price elasticities are in the range between -0.94 and -0.23. The minimum values are estimated by the Engle-Granger Two-Step and FMOLS methods in the short and long terms, respectively. On the other hand, the maximum own-price elasticity estimates are calculated by the Johansen approach for both the short- and long-run.

In terms of the income elasticities, the greatest values for both short and long terms are found by the Johansen method, as in the own-price elasticity estimates. The lowest income elasticity is estimated by the FMOLS method (1.03) in the short-run and by the Engle-Granger Two-Step method (0.79) in the long-run.

As a result, the electricity prices are more effective than the natural gas prices in the industrial natural gas demand especially in the short-run. The reason is that the magnitude of the cross-price elasticity estimates is more than that of the own-price. Furthermore, the estimated income elasticities are usually greater than one. This means, when the income increases by 1 percent, the natural gas demand increases by more than 1 percent.

The positive cross-price elasticities indicate that electricity and natural gas are substitute goods for the industrial sector (for the details see Chapter 5). On the other hand, the own-price elasticities are found as inelastic which means the degree of the effectiveness of price changes on natural gas demand is small. In other words, when the price rises by 1 percent, the consumption decreases by less than 1 percent.

6.4.2. Residential Natural Gas Demand

6.4.2.1. Unit Root Tests Results

In the second stage of analysing the sectoral natural gas demands in Turkey, the residential sector is examined. The demand function and econometric model of residential natural gas are introduced as below:

$$N_d^R = f(HFCE, RNP, REP) \quad N_t^R = \lambda_0 + \lambda_1 HFCE_t + \lambda_2 RNP_t \pm \lambda_3 REP_t + e_t \quad (6.51)$$

where N^R, *HFCE*, *RNP*, and *REP* represent residential natural gas consumption, household final consumption expenditure, residential natural gas price, and residential electricity price, respectively.

In terms of the unit root tests, first, the conventional (ADF, PP, and KPSS) and then the Zivot-Andrews approaches are applied to the series. The results for the conventional ones are presented in Table 6.68.

Table 6.68. The Unit Root Tests Results for Residential Natural Gas Demand

	Variables	Level			1st Difference		
		ADF	PP	KPSS	ADF	PP	KPSS
Test Statistics (Constant)	N^R	-4.78*	11.84*	0.59	-	-	0.61
	HFCE	-1.19	-1.41	0.67	-5.90*	-5.98*	0.10*
	RNP	-3.62*	-3.72*	0.16*	-	-	-
	REP	-3.33*	-3.33*	0.14*	-	-	-
Critical Values (Constant)	***5%***	***-2.98***	***-2.98***	***0.46***	***-2.98***	***-2.98***	***0.46***
Test Statistics (Constant & Trend)	N^R	-2.43	-2.58	0.17	-4.25*	-4.22*	0.12*
	HFCE	-3.55	-3.55	0.15	-5.84*	-5.92*	0.04*
	RNP	-3.41	-3.54	0.15	-5.16*	-7.61*	0.11*
	REP	-3.06	-3.07	0.19	-4.95*	-4.95*	0.09*
Critical Values (Constant & Trend)	***5%***	***-3.59***	***-3.59***	***0.14***	***-3.59***	***-3.59***	***0.14***

***Notes*:** *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.

In ADF, the maximum lag length is determined as 6 by using the Schwert (1989) formulation and the appropriate lag length for each variable is determined by Modified AIC. Furthermore, the Bartlett Kernel model with Newey West bandwidth selection criteria is used to decide the proper patterns for PP and KPSS tests.

In model 1 (constant), only the *HFCE* variable is estimated as stationary in the first difference for all unit root tests. On the other hand, all variables are stationary in the first difference in model 2 (constant and trend). Because of the null hypothesis of non-stationarity hypotheses are rejected at the 5% level, and the series are found to be integrated of order one in model 2, the cointegration procedure can be conducted with the constant and trend model.

Following the conventional tests mentioned above, the Zivot-Andrews method is also implemented to see whether the results are different with the consideration of any possible structural break. The outcomes of the ZA unit root test are summarized in Table 6.69.

Table 6.69. Zivot-Andrews Unit Root Test Results for Residential Natural Gas Demand

	Variables	**Level**			**1st Difference**		
		ZA	**Lag Length**	**Break Date**	**ZA**	**Lag Length**	**Break Date**
Test Statistics (Constant)	N^R	-2.57	0	2008	-5.31*	0	1993
	HFCE	-4.77	0	1998	-6.16*	0	2003
	RNP	-4.11	1	2008	-5.23*	1	2005
	REP	-3.72	0	2003	-5.92*	0	2008
Critical Value (Constant)	***5%***	***-4.80***					
Test Statistics (Constant & Trend)	N^R	-3.86	0	1995	-5.42*	0	1993
	HFCE	-4.62	0	1998	-6.00*	0	2003
	RNP	-5.01	1	2007	-5.12*	1	2005
	REP	-3.46	0	1992	-6.14*	0	1993
Critical Value (Constant & Trend)	***5%***	***-5.08***					

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 3 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)
3. The appropriate lag length was determined by Akaike Information Criteria.
4. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.

Model A (constant) and Model C (constant and trend) that described in the methodology chapter are subjected to the Zivot-Andrews structural break unit root test. The results indicate that the series are stationary in their first differences for both models at the 5% significance level. The outputs of Model C in here and Model 2 in conventional tests show similarity in terms of the series integration levels. As a result, the cointegration analyses can be proceeded for the residential natural gas demand to examine the relationship among variables.

6.4.2.2. EG Two-Step Method

In terms of the Engle-Granger Two-Step method, first, the long-run elasticity estimates of Turkey's residential natural gas demand are found. The estimation results are given in Table 6.70.

Table 6.70. The Long-Run Results of EG Two-Step Method for Residential Natural Gas Demand

Dependent Variable: N^R			
Sample: 1988-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-79.08	36.70041	-2.15 [0.04]
HFCE	5.51	2.167452	2.54 [0.01]
RNP	-1.37	1.065949	-1.28 [0.21]
REP	3.16	0.726636	4.35 [0.00]
T	-0.03	0.084497	-0.35 [0.72]

Notes: *1. p-values are in square brackets.*
2. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively. T is the trend variable.

The long-run equation of the residential natural gas demand is shown by

$$N_t^R = -79.08 + 5.51HFCE_t - 1.37RNP_t + 3.16REP_t - 0.03T \qquad (6.52)$$

where the residential electricity price (*REP*) is added to the model to analyse the cross-price effect on demand.

In Table 6.71, the stationarity of the residuals is examined using the ADF unit root test.

Table 6.71. Unit Root Test of Residuals for Residential Natural Gas Demand

Variable		**Constant**		**Constant and Trend**		**None**	
		Level	***1st difference***	***Level***	***1st difference***	***Level***	***1st difference***
residuals	***Test Statistic***	-3.54*	-	-3.68*	-	-3.59*	-
	Critical Values (5%)	-2.97		-3.58		-1.95	

Note: *1. (*) Significant at 5% MacKinnon (1996) critical value.*

The results indicate that there is a cointegration relation among series, and the short-run dynamic equation can be estimated as the second step of the method.

The detailed estimation results and diagnostic tests for the short-term equation are introduced in Table 6.72.

Table 6.72. The Short-Run Results of EG Two-Step Method for Residential Natural Gas Demand

Dependent Variable: ΔN^R			
Sample: 1989-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.09	0.043282	2.08 [0.04]
Δ*HFCE*	1.68	0.572592	2.94 [0.00]
Δ*REP*	0.78	0.343905	2.27 [0.03]
D1991	0.92	0.200403	4.61 [0.00]
D1995	0.70	0.188898	3.72 [0.00]
ECT(-1)	-0.15	0.069697	-2.27 [0.03]
Diagnostic Tests			
Std. error of the regression: 0.017	Norm: χ^2 = 1.68 [0.42]	Het: F= 0.79 [0.56]	ARCH (1): F = 0.08 [0.77]
LM Serial Correlation: F = 1.38 [0.27]	Reset: F = 1.17 [0.33]	Wald: F = 4.76 [0.01]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.

The short-run equation with two dummies is given by

$$\Delta N_t^R = 0.09 + 1.68\Delta HFCE_t + 0.78REP_t + 0.92D1991 + 0.70D1995 - 0.15ECT_{t-1} \quad \textbf{(6.53)}$$

where the residential natural gas price is omitted from the model because it is not statistically different from zero and the error correction term (*ECT*) is estimated as $ECT_t = N_t^R + 79.08 - 5.51HFCE_t + 1.37RNP_t - 3.16REP_t + 0.03T$. Moreover, the coefficient of the *ECT* is negative as expected.

The short-run equation passes the diagnostic tests listed above with the inclusion of two dummy variables. In addition, the statistically significant *ECT* means that 15% of any disequilibrium is adjusted in each year, and the model would be balanced after 6.66 (1/0.15=6.66) period.

6.4.2.3. FMOLS Method

In establishing the residential natural gas demand model by the FMOLS method, first, the maximum lag length should be decided, and then the bandwidth selection should be made. The AIC is utilized to find the optimal lag length with the maximum of 3. Furthermore, Bartlett Kernel model with Newey-West automatic bandwidth selection approach is used, and the proper lag length is determined as 2. In the light of this information, the long-term results of the FMOLS method is presented in Table 6.73.

Table 6.73. The Long-Run Results of FMOLS Method for Residential Natural Gas Demand

Dependent Variable: N^R			
Sample: 1989-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-55.09	5.626595	-9.79 [0.00]
HFCE	4.63	0.253158	18.30 [0.00]
RNP	-3.59	0.788129	-4.56 [0.00]
REP	3.08	0.533315	5.79 [0.00]

Notes: *1. p-values are in square brackets.*
2. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.

In Equation (6.54), the preferred long-term equation is given by

$$\boldsymbol{N_t^R = -55.09 + 4.63HFCE_t - 3.59RNP_t + 3.08REP_t} \quad \textbf{(6.54)}$$

where the trend variable is excluded from the model since it is not statistically different from zero. On the other hand, output, own-price and cross-price variables are found to be statistically significant. Therefore, the *ECT* can be computed from the equation above, and then the short-term model can be estimated. The results of the short-run dynamic equation are shown in Table 6.74.

Table 6.74. The Short-Run Results of FMOLS Method for Residential Natural Gas Demand

Dependent Variable: ΔN^R			
Sample: 1991-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.06	0.027748	2.21 [0.03]
ΔHFCE	3.40	0.431350	7.90 [0.00]
ΔREP	2.32	0.239074	9.74 [0.00]
D1995	0.88	0.128547	6.87 [0.00]
ECT(-1)	-0.45	0.052590	-8.67 [0.00]

Diagnostic Tests		
Std. error of the regression: 0.25	Norm: χ^2 = 2.37 [0.30]	Wald: F = 50.77 [0.00]

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.

The short-term results indicate that the diagnostic tests are passed, and all coefficients are significant. *RNP*, on the other hand, was omitted from the short-run equation since it is not statistically significant. The appropriate form of the equation with one dummy variable for 1995 is given by

$$\Delta N_t^I = \mathbf{0.06 + 3.40\Delta HFCE_t + 2.32\Delta REP_t + 0.88D1995 - 0.45ECT_{t-1}} \quad \textbf{(6.55)}$$

where $ECT_t = N_t^R + 55.09 - 4.63HFCE_t + 3.59RNP_t - 3.08REP_t$, and the coefficient on the error correction term is negative, and between -2 and 0 as expected. It also shows that the 45% of any disequilibrium is adjusted in each year.

6.4.2.4. Johansen Method

After specifying the maximum and proper lag lengths, the Johansen approach for testing the cointegration relationship can be conducted. To determine this relationship, the trace and maximum eigen statistics are used. The most convenient model is decided by the Pantula principle as linear with the intercept but no trend. The outcomes of the Johansen test are given in Table 6.75.

Table 6.75. Johansen Cointegration Test for Residential Natural Gas Demand

Unrestricted Cointegration Test	**Trace Statistic**				**Maximum Eigen Statistic**			
Number of Cointegrating Vectors	0	At most 1	At most 2	At most 3	0	At most 1	At most 2	At most 3
Critical Values (%5)	47.85	29.79	15.49	3.84	32.11	25.82	19.38	12.51
Test statistic [probability]	75.94* [0.00]	38.39* [0.00]	12.75 [0.12]	1.64 [0.20]	37.54* [0.00]	25.64* [0.01]	11.11 [0.14]	1.64 [0.20]

Notes: *1. Maximum lag length is selected from VAR as 1.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

According to the Johansen cointegration tests results, trace and maximum eigenvalue statistics indicate that there are at most two cointegrating vectors among variables at the 5% significance level, which shows that the long-run equation can be estimated.

The estimated long-term equation is given by

$$\boldsymbol{N_t^R = 3.45HFCE_t - 5.02RNP_t + 1.19REP_t} \quad \textbf{(t=1990-2015)} \qquad \textbf{(6.56)}$$
$$\textbf{[0.03]} \qquad \textbf{[0.04]} \qquad \textbf{[0.02]}$$

where N^R, *HFCE, RNP*, and *REP* are logs of residential natural gas consumption, real household final consumption expenditure, real residential natural gas price, and real residential electricity price, respectively. The trend variable is not found to be statistically significant thus, it was omitted from the equation. Output and price variables, on the other hand, are statistically significant at the 5% level.

In the second level of the Johansen method, the long-run equation is utilized to obtain the error correction term, and then this term is included in the short-term equation. The short-run dynamic model can be formed as follows:

$$\boldsymbol{\Delta N_t^R = 3.63 + 0.79\Delta HFCE_t - 0.46\Delta RNP_{t-2} + 0.83\Delta REP_{t-3} - 0.38D2004}$$
$$\textbf{[0.00]} \qquad \textbf{[0.09]} \qquad \textbf{[0.00]} \qquad \textbf{[0.02]} \qquad \textbf{[0.00]}$$
$$\boldsymbol{- 0.46D2009 - 0.09ECT_{t-1}} \qquad \textbf{(6.57)}$$
$$\textbf{[0.00]} \qquad \textbf{[0.00]}$$

where $ECT_t = N_t^R - 3.45HFCE_t + 5.02RNP_t - 1.19REP_t$

Std. error of the regression: 0.11 LM Serial Correlation: F=0.27 [0.76]

Norm: JB=0.59 [0.74] Het: F= 0.62 [0.71] ARCH (1): F=0.16 [0.69]

Reset: F=2.46 [0.11] Wald: 7.57 [0.00].

All variables in the short-run equation are found to be statistically significant at the 5% significance level, except *HFCE*.[10] In addition, the own- and cross-price (*RNP* and *REP*) variables are not statistically different from zero in the level. Therefore, the past values of these variables are used to estimate the equation. Furthermore, the diagnostic tests are passed with two additional dummy variables for the years 2004 and 2009. Last but not the least, the coefficient of the error correction term (*ECT*) is found as -0.09. This means that the instabilities in model would be balanced very slowly.

[10] The household final consumption expenditure (HFCE) variable is significant at the 10% level.

6.4.2.5. ARDL Bounds Testing Method

In analysing the cointegration relationship by using the ARDL Bounds Testing method, the maximum and proper lag lengths should be determined initially. The optimal lag length is chosen as (3,3,3,3) by SBIC, and the results are summarized in Table 6.76.

Table 6.76. Determination of the Lag Length (Residential Natural Gas Demand)

Lag Length	SBIC	Autocorrelation (LM)
(1,0,0,0)	0.86	18.94 [0.00]
(1,1,1,1)	0.52	2.23 [0.15]
(2,2,2,2)	-0.35	0.67 [0.54]
(3,3,3,3)*	-1.02	11.87 [0.20]

Notes: *1. (*) indicates minimum SBIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2nd order (AR(2)) serial correlation.

The preferred model with the appropriate lag length is given by

$$\Delta N_t^R = \beta_0 + \beta_1 trend + \sum_{i=1}^{3} \beta_{2i} \Delta N_{t-i}^R + \sum_{i=0}^{3} \beta_{3i} \Delta HFCE_{t-i} + \sum_{i=0}^{3} \beta_{4i} \Delta RNP_{t-i} + \sum_{i=0}^{3} \beta_{5i} \Delta REP_{t-i} + \beta_6 N_{t-1}^R + \beta_7 HFCE_{t-1} + \beta_8 RNP_{t-1} + \beta_9 REP_{t-1} + \varepsilon_t \quad (6.58)$$

where this equation passes the diagnostic tests presented in Table 6.77.

Table 6.77. Diagnostic Tests Statistics (Residential Natural Gas Demand)

ARDL (3,3,3,3)	
R^2	0.97
Adjusted R^2	0.80
Autocorrelation (LM)	11.87 [0.20]
Heteroscedasticity (White)	1.24 [0.49]
Normality (Jarque-Bera)	1.32 [0.51]
F-stat	7.80

Note: *1. p-values of the tests are in square brackets.*

According to the estimated F-statistics value, the cointegration relation among variables is decided since 7.80 is greater than the upper bounds (*I(1)*) for both critical values which are listed in Table 6.78.

Table 6.78. Bounds Test Statistics for Residential Natural Gas Demand

N=27, k=3	**Pesaran**		**Narayan**	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.30	5.23	5.66	6.98
5%	3.38	4.23	4.04	5.09
10%	2.97	3.74	3.37	4.27

Notes: *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with unrestricted intercept and restricted trend.

After the determination of cointegration relation, long-run model can be established as ARDL (1,3,1,3). The results of the long-term model are shown in Table 6.79.

Table 6.79. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Residential Natural Gas Demand

Dependent Variable: N^R		
Variables	**Coefficients**	**Probability Values**
N^R(-1)	0.34	0.00
HFCE	1.23	0.08
HFCE(-1)	-0.61	0.30
HFCE(-2)	0.50	0.37
HFCE(-3)	2.35	0.00
RNP	-0.03	0.92
RNP(-1)	-0.47	0.19
REP	-0.79	0.03
REP(-1)	0.19	0.58
REP(-2)	-0.17	0.61
REP(-3)	1.15	0.00
C	-38.44	0.03
T	-0.05	0.15
Long-Term Coefficients		
HFCE	5.29*	0.00
RNP	-0.76	0.24
REP	0.57	0.32
C	-42.74*	0.05
T	-0.08*	0.04
Diagnostic Statistics		
R^2: 0.99	DW: 2.14	
Adjusted R^2: 0.99	F stat: 219.99 (0.00)	
Autocorrelation (LM): 0.88 (0.44)	χ^2_{White}: 0.98 (0.51)	
χ^2_{Norm}: 1.33 (0.51)	χ^2_{Ramsey}: 0.93 (0.46)	

Notes: *1. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively. T is the trend variable.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

The long-term equation with statistically significant variables is set up as

$$N_t^R = -42.74 + 5.29HFCE_t - 0.08T \qquad \textbf{(6.59)}$$

where the own- and cross-price parameters are excluded from the model since they are not statistically different from zero.

In the next stage of the ARDL approach, the dynamic short-run model is generated by using the information from the long run equation. The results of the short-term equation can be viewed in Table 6.80.

Table 6.80. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Residential Natural Gas Demand

Dependent Variable: ΔN^R		
Variables	**Coefficients**	**Probability Values**
C	42.80*	0.00
Δ*HFCE*	1.23*	0.00
Δ*RNP*	-0.03	0.89
Δ*REP*	-0.79*	0.00
ECT(-1)	-0.65*	0.00
Diagnostic Statistics		
Std. error of the regression: 0.017	ARCH (1): F=0.05 [0.80]	
Autocorrelation (LM): 0.72 (0.38)	χ^2_{White}: 1.22 (0.42)	
χ^2_{Norm}: 1.95 (0.78)	χ^2_{Ramsey}: 4.36 (0.11)	

Notes: *1. N^R, HFCE, RNP and REP are natural logs of the residential natural gas consumption, real household final consumption expenditure and real residential natural gas price and real residential electricity price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

The dynamic short-run equation is given by

$$\Delta N_t^R = 42.80 + 1.23\Delta HFCE_t - 0.79REP_t - 0.65ECT_{t-1} \qquad \textbf{(6.60)}$$

where Equation (6.60) also passes the diagnostic tests listed above. The natural gas price variable is not found to be statistically significant while the household expenditure and residential electricity price variables are estimated as convenient to be included in the short-term equation.

In addition, the error correction term is estimated as follows:

$$ECT_t = N_t^R + 42.74 - 5.29HFCE_t + 0.08T \qquad \textbf{(6.61)}$$

where the coefficient of the *ECT* is statistically significant, and it demonstrates that the 65% of any disequilibrium is adjusted in each year, and the model would be balanced shorter than 2 years.

6.4.2.6. STSM Method

As it is mentioned in the methodology chapter, both short- and long-run calculations can be made with one equation in the STSM method. This flexibility of the STSM approach enables not to construct two separate equations for analysing short- and long-term. In addition, the trend classification is determined as local level, which means only stochastic level (no slope) component is included in the model. In Table 6.81, the estimation results and diagnostic tests are listed in detail.

Table 6.81. The Results of STSM Method for Residential Natural Gas Demand

Dependent Variable: N^R				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
N^R(-1)	0.54139	0.05751	9.41427	[0.00]
HFCE(-2)	1.16130	0.30702	3.78247	[0.00]
RNP(-1)	-0.55730	0.24431	-2.28116	[0.03]
REP(-2)	0.78851	0.22467	3.50968	[0.00]
Level Break 1991	0.80476	0.16062	5.01031	[0.00]
Irregular 1994	-0.45951	0.13508	-3.40173	[0.00]
Level and Slope Components of $UEDT_{2015}$				
Level	-12.93933 [0.01022]			
Slope	-			

Residuals			**Auxiliary Residuals**		
			Irregular	***Level***	***Slope***
Std. Error	0.8962	*Std. Error*	0.9549	0.9494	-
Normality	0.7803	*Normality*	0.7062	0.7014	-
Skewness	0.9825	*Skewness*	0.8214	0.6297	-
Kurtosis	0.4814	*Kurtosis*	0.4220	0.4899	-
H(6)	1.5364				
R(1)	0.1392	**LR Test**			
R(5)	0.2594	*Test (a)* 9.675 (0.00)			
DW	1.6815				
Q(5,4)	6.8943				
Predictive Test 2008-2015		**Goodness of Fit**			
Failure	0.4065	R^2	0.9946		
Cusum t(7)	1.8180	R_d^2	0.9030		
		P.E.V.	0.0130		
		P.E.V./ (M.D.)^2	1.1863		
Hyperparameters					
Irregular	0.0135245				
Level	0.0008635				
Slope	-				

Notes: *1. Model estimation is made in STAMP 8.20.*
2. There are one level intervention dummy variable for the year 1991, and one irregular dummy variable for the year 1994 in the model.
3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.

4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2), and the Coefficient Determination (R^2 and R_d^2).
5. H(6) is the heteroscedasticity statistic.
6. R(1) and R(5) are the serial correlation coefficients at the 1st and 5th lag, respectively
7. DW is the Durbin-Watson statistic.
8. Q(5,4) is the Box-Ljung Q-statistics based on the first 5 residuals autocorrelations and distributed as $\chi 2$ (4).
9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.
10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and fixed slope hyperparameter which is distributed as $\chi 2(2)$. Probabilities are given in parenthesis.
11. The hyperparameters determine the shape of the UEDT.

The preferred equation of Turkey's residential natural gas demand by using the STSM model is shown as follows:

$$\boldsymbol{N_t^R = 0.54N_{t-1}^R + 1.16HFCE_{t-2} - 0.55RNP_{t-1} + 0.78REP_{t-2} + UEDT_t} \quad \textbf{(6.62)}$$

where UEDT of the equation is -12.93933 with no slope at the end of the period.

Equation (6.62) demonstrates the short-term equation. As shown in the methodology chapter, the long-term elasticities can be estimated as follows.

$$\boldsymbol{\alpha(L) = 1 - N_{t-1}^R = 1 - 0.54139 = 0.4586}$$

$$\boldsymbol{\beta(L) = 1.1613}$$

$$\boldsymbol{\theta(L) = -0.5573}$$

$$\boldsymbol{\gamma(L) = 0.7885}$$

$$\boldsymbol{\frac{\beta(L)}{\alpha(L)} = \frac{1.1613}{0.4586} = 2.53\ (long\ term\ income\ elasticity)}$$

$$\boldsymbol{\frac{\theta(L)}{\alpha(L)} = \frac{-0.5573}{0.4586} = -1.21\ (long\ term\ own - price\ elasticity)}$$

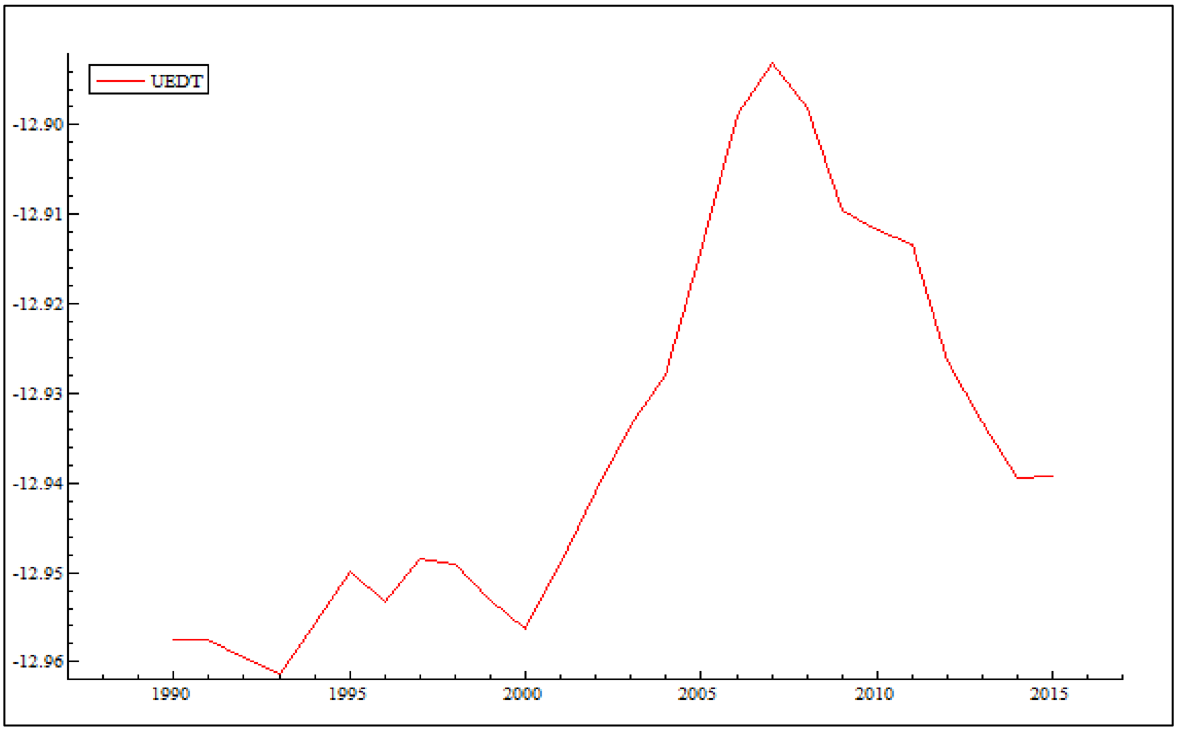
$$\boldsymbol{\frac{\gamma(L)}{\alpha(L)} = \frac{0.7885}{0.4586} = 1.71\ (long\ term\ cross - price\ elasticity)}$$

where *α(L)*, *β(L)*, *θ(L)*, and *γ(L)* are polynomial lag operators. These operators are utilized to estimate the elasticities of the long-term. In addition to the output and own-price elasticities, the cross-price elasticity is also calculated in the same way.

The residential natural gas demand model passes the diagnostic tests. A level and irregular dummy variable are required to sustain the normality of residuals and to achieve optimal results. The level dummy variable for the year 1991 may reflect the regional economic crises in Asia countries and Russia. The irregular dummy variable for the year 1994 may represent the economic crises in Turkey.

Furthermore, the shape of the predicted UEDT is illustrated in Figure 6.5. Since there is no slope component in the trend, the estimated UEDT rises and diminishes over the period. The trend shows a fluctuating process in the first half of the estimation period, and then it increases up to 2008, after then it decreases progressively till 2015.

Figure 6.5. UEDT (μ_t) for Turkish Residential Natural Gas Consumption (1988-2015)



6.4.2.7. Comparison of Elasticity Estimates for Residential Natural Gas Demand

The aggregated elasticity estimates of Turkish residential natural gas demand are listed in Table 6.82.

Table 6.82. Summary of Estimated Residential Natural Gas Demand Elasticities

	INCOME		OWN-PRICE		CROSS-PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	1.68	5.51	-	-1.37	0.78	3.16
FMOLS	3.40	4.63	-	-3.59	2.32	3.38
Johansen	0.79	3.45	-0.46	-5.02	0.83	1.19
ARDL Bounds Test	1.23	5.29	-	-	-0.79	-
STSM-UEDT	1.16	2.53	-0.55	-1.21	0.78	1.71

In addition to the income and own-price, the cross-price elasticity estimates are also shown in the above table. The income elasticities are in the range between 0.79 and 3.40 in the short-term, and 2.53 and 5.51 in the long-term. The lowest income elasticities are estimated by the Johansen and STSM approaches for the short- and long-run, respectively.

The own-price elasticities in the short-term are not estimated by the majority of the methods. Only the Johansen and STSM approaches enable to find the short-term elasticities. In the long-run, the lowest own-price elasticity is estimated by the STSM whereas the biggest one is calculated by the Johansen method (in absolute value).

On the other hand, the cross-price elasticities are found as positive except for the one estimated by the ARDL Bounds Testing method in the short-term. As well as the other two elasticity estimates (income and own-price), the cross-price elasticities vary according to the methods used.

The results, as a whole, demonstrate that the elasticity estimates in residential natural gas demand are relatively higher than other sectors. This means that households are more sensitive to the price and income changes than other consumers. In addition, the elasticities are larger in the long-term than in the short-term. The own- and cross-price elasticities are elastic, especially in the long terms, which means the change in natural gas demand is greater than the change in prices. Therefore, it can be said that planning the long-run demand attitudes are critical for the consumer in the residential sector.

6.4.3. Electricity Generation Sector Natural Gas Demand

6.4.3.1. Unit Root Tests Results

The functional form and econometric representation of the electricity generation sector natural gas demand is given by

$$N_d^{EG} = f(IVA, EGNP, EGCP) \quad N_t^{EG} = \phi_0 + \phi_1 IVA_t + \phi_2 EGNP_t \pm \phi_3 EGCP_t + \vartheta_t \quad \textbf{(6.63)}$$

where N^{EG}, *IVA*, *EGNP*, and *EGCP* represent electricity generation sector natural gas consumption, industrial value added, electricity generation sector natural gas price, and electricity generation sector coal price, respectively.

The conventional unit root tests (ADF, PP, and KPSS) results are presented in Table 6.83.

Table 6.83. The Unit Root Tests Results for Electricity Generation Sector Natural Gas Demand

	Variables	Level			1st Difference		
		ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
Test Statistics (Constant)	N^{EG}	-0.72	-0.70	0.63	-2.32	-3.85*	0.17*
	IVA	-1.38	-1.37	0.61	-5.37*	-5.40*	0.06*
	EGNP	-2.54	-3.23*	0.60	-4.94*	-	0.05*
	EGCP	-4.04*	-4.11*	0.50	-	-	0.45*
Critical Values (Constant)	***5%***	***-2.98***	***-2.98***	***0.46***	***-2.98***	***-2.98***	***0.46***
Test Statistics (Constant & Trend)	N^{EG}	-0.73	-1.30	0.18	-3.80*	-3.82*	0.11*
	IVA	-2.87	-2.87	0.15	-5.26*	-5.28*	0.06*
	EGNP	-3.00	-2.84	0.17	-5.05*	-10.1*	0.05*
	EGCP	-3.38	-3.39	0.15	-4.67*	-4.67*	0.11*
Critical Values (Constant & Trend)	***5%***	***-3.59***	***-3.59***	***0.14***	***-3.59***	***-3.59***	***0.14***

Notes: *1. (*) Significant at 5% MacKinnon (1996) critical value for ADF and PP tests.*
2. (*) Significant at 5% Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1) critical value for KPSS test.
3. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.

The maximum lag length is chosen as 6 in the ADF test, and the proper lag length selection is made by Modified AIC. Moreover, in PP and KPSS unit root tests, Newey-West bandwidth selection property of Bartlett Kernel model is used to determine the suitable bandwidths and lags.

In terms of model with the constant, *EGNP* is found to be stationary in the PP test in the level. In addition, the null hypotheses of non-stationarity cannot be rejected for the *EGCP* variable in the level in both ADF and PP unit root tests. On the other hand, all variables are determined as stationary in their first differences in the KPSS test. Furthermore, for the model with constant and trend, N^{EG}, *IVA*, *EGNP*, and *EGEP* series are first difference stationary, and the cointegration procedures can be proceeded by this model.

In addition to the ADF, PP, and KPSS unit root tests, the Zivot-Andrews approach is also used to analyse the unit roots in the series with structural break for the electricity generation sector natural gas demand models. The ZA unit root test results are listed in Table 6.84.

Table 6.84. Zivot-Andrews Unit Root Test Results for Electricity Generation Sector Natural Gas Demand

	Variables	Level			1st Difference		
		ZA	Lag Length	Break Date	ZA	Lag Length	Break Date
Test Statistics (Constant)	***N^{EG}***	-2.83	2	1999	-6.97*	0	1994
	IVA	-4.23	0	2001	-6.34*	0	1999
	EGNP	-3.62	2	1993	-6.51*	1	1998
	EGCP	-4.28	0	1992	-6.08*	0	1992
Critical Value (Constant)	***5%***			***-4.80***			
Test Statistics (Constant & Trend)	***N^{EG}***	-3.51	2	2005	-6.79*	0	1994
	IVA	-4.23	0	2001	-6.54*	0	1999
	EGNP	-4.24	2	1997	-6.46*	1	2010
	EGCP	-3.70	0	1993	-6.95*	0	1997
Critical Value (Constant & Trend)	***5%***			***-5.08***			

Notes: *1. (*) Significant at 5% Zivot and Andrews (1992) critical value.*
2. Max lag length is determined as 3 by using Schwert (1989). ($p_{max} = [4*(T/100)^{1/4}]$)
3. The appropriate lag length was determined by Akaike Information Criteria.
4. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.

The results show that all variables are stationary with a structural break at the 5% significance level for both models (Model A and Model C). ZA test outputs are in line with that of the conventional unit root tests. This means that the cointegration models can be established, and the relationship among variables can be analysed for the electricity generation sector.

6.4.3.2. EG Two-Step Method

In the Engle-Granger Two-Step method, the first step is to estimate the long-run model. The estimated coefficients of the long-run equation are presented in Table 6.85.

Table 6.85. The Long-Run Results of EG Two-Step Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: N^{EG}
Sample: 1988-2015

Variables	Coefficient	Std. Error	t-statistic [prob]
C	-25.88	7.962548	-3.25 [0.00]
IVA	2.55	0.627754	4.06 [0.00]
EGNP	1.57	0.441858	3.55 [0.00]
EGCP	-0.60	0.383087	-1.58 [0.12]

Notes: *1. p-values are in square brackets.*
2. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.

The electricity generation sector natural gas demand equation is given by

$$N_t^{EG} = -25.88 + 2.55IVA_t + 1.57EGNP_t - 0.60EGCP_t \quad \textbf{(6.64)}$$

where the trend variable is omitted from the long-run equation because when it is added, the output and price elasticities were not coincided with the economic theory.

Since the diagnostic tests are not valid for the Engle-Granger Two-Step method in the long-run, the cointegration relationship can be determined by analysing the stationarity of the residuals. The ADF unit root test results for the residuals are listed in Table 6.86.

Table 6.86. Unit Root Test of Residuals for Electricity Generation Sector Natural Gas Demand

Variable		Constant		Constant and Trend		None	
		Level	*1st difference*	*Level*	*1st difference*	*Level*	*1st difference*
residuals	***Test Statistic***	-2.61	-5.37*	-2.95	-5.26*	-2.66*	-
	Critical Values (5%)	-2.97		-3.58		-1.95	

Note: *1. (*) Significant at 5% MacKinnon (1996) critical value.*

The ADF test results indicate that only the model without the constant and trend provides the cointegration properties. Therefore, the null hypothesis of a unit root can be rejected, and the residuals can be decided as stationary.

In the second step of the Engle-Granger method, the short-run dynamic equation is estimated. The estimated coefficients and diagnostic test results are shown in Table 6.87.

Table 6.87. The Short-Run Results of EG Two-Step Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: ΔN^{EG}
Sample: 1989-2015

Variables	Coefficient	Std. Error	t-statistic [prob]
C	0.08	0.012462	6.80 [0.00]
Δ*IVA*	0.47	0.218491	2.17 [0.04]
Δ*EGCP*	-0.24	0.080701	-3.08 [0.00]
D1998	-0.22	0.101551	-2.21 [0.03]
D2005	0.21	0.065664	3.33 [0.00]
ECT(-1)	-0.22	0.044793	-5.05 [0.00]

Diagnostic Tests			
Std. error of the regression: 0.05	Norm: χ^2 = 0.40 [0.81]	Het: F= 0.87 [0.51]	ARCH (1): F = 0.38 [0.54]
LM Serial Correlation: F = 0.74 [0.48]	Reset: F = 0.75 [0.48]	Wald: F = 6.45 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.

The estimated short-run equation is represented as follows:

$$\Delta N_t^{EG} = 0.08 + 0.47\Delta IVA_t - 0.24EGCP_t - 0.22D1998 + 0.21D2005 - 0.22ECT_{t-1} \quad \textbf{(6.65)}$$

where the natural gas price variable (*EGNP*) is found to be statistically insignificant, and therefore it is excluded from the short-run equation. Furthermore, the short-run dynamic equation passes all diagnostic tests listed above.

In addition, the coefficient of the error correction term is found as -0.22 by using the formula shown as below:

$$ECT_t = N_t^{EG} + 25.88 - 2.55IVA_t + 1.57EGNP_t + 0.60EGCP_t \quad \textbf{(6.66)}$$

where the coefficient (-0.22) confirms that 22% of any disequilibrium is adjusted in each year, and the system would be balanced after approximately 4.5 years.

6.4.3.3. FMOLS Method

By using the AIC, the appropriate lag length is decided to estimate the electricity generation sector natural gas demand equations in the context of the FMOLS method. The long-term demand estimation results with 2-year lag are represented in Table 6.88.

Table 6.88. The Long-Run Results of FMOLS Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: N^{EG}			
Sample: 1989-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	-20.69	2.072811	-9.98 [0.00]
IVA	2.05	0.161460	12.69 [0.00]
EGNP	1.95	0.105653	18.47 [0.00]
EGCP	-0.49	0.111695	-4.42 [0.00]

Notes: *1. p-values are in square brackets.*

2. N^{EG}, *IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.*

The long-run equation can be formed as follows:

$$\boldsymbol{N_t^{EG} = -20.69 + 2.05IVA_t + 1.95EGNP_t - 0.49EGCP_t} \quad \textbf{(6.67)}$$

Where the trend variable is omitted from the equation. Also, the *IVA*, *EGNP,* and *EGCP* variables are found to be statistically significant at the 1% level. Equation (6.67) is used to obtain the *ECT*, and then the short-run dynamic model can be estimated. The short-term results and diagnostic tests are summarized in Table 6.89.

Table 6.89. The Short-Run Results of FMOLS Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: ΔN^{EG}			
Sample: 1990-2015			
Variables	**Coefficient**	**Std. Error**	**t-statistic [prob]**
C	0.08	0.003278	24.67 [0.00]
Δ*IVA*	0.15	0.032683	4.63 [0.00]
Δ*EGNP*	0.23	0.023417	10.20 [0.00]
Δ*EGCP*	-0.20	0.023181	-8.70 [0.00]
ECT(-1)	-0.19	0.012965	-14.97 [0.00]
Diagnostic Tests			
Std. error of the regression: 0.25	Norm: χ^2 = 2.37 [0.30]	Wald: F = 50.77 [0.00]	

Notes: *1. Δ shows the first difference of the variable.*
2. p-values of the tests are in square brackets.
3. N^{EG}, *IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.*

All coefficients are statistically significant in the short-term without adding any intervention dummy variable. Furthermore, the diagnostic tests refer that errors are distributed normally, and the explanatory variables are significant in explaining the dependent variable. The preferred short-run equation is shown by

$$\boldsymbol{\Delta N_t^{EG} = 0.08 + 0.15\Delta IVA_t + 0.23\Delta EGNP_t - 0.20EGCP_t - 0.19ECT_{t-1}} \quad \textbf{(6.68)}$$

where $ECT_t = N_t^{EG} + 20.69 - 2.05IVA_t - 1.95EGNP_t + 0.49EGCP_t$, and the coefficient is calculated as -0.19. This means that nearly one fifth of any disequilibrium can be adjusted each year and the model would be stable in five years.

6.4.3.4. Johansen Method

In the Johansen method, two test statistics are used, namely trace and maximum eigenvalue, for analysing the number of cointegrating vectors. First, the maximum and optimal lag length is determined, and then the model is decided by the Pantula principle as no intercept and trend. The Johansen cointegration test results are expressed in Table 6.90.

Table 6.90. Johansen Cointegration Test for Electricity Generation Sector Natural Gas Demand

Unrestricted Cointegration Test	**Trace Statistic**				**Maximum Eigen Statistic**			
Number of Cointegrating Vectors	0	At most 1	At most 2	At most 3	0	At most 1	At most 2	At most 3
Critical Values (%5)	40.17	24.27	12.32	4.12	24.15	17.79	11.22	4.12
Test statistic [probability]	54.63* [0.00]	25.27* [0.03]	12.43* [0.04]	0.30 [0.64]	29.36* [0.00]	12.83 [0.23]	11.20 [0.07]	0.30 [0.64]

Notes: *1. Maximum lag length is selected from VAR as 2.*
2. Schwarz and Hannah-Quinn information criteria indicates the optimal lag length as 1.
3. p-values of the tests are in square brackets.

The results show that there are 3 cointegrating equations in terms of trace statistics and 1 cointegrating vector in terms of maximum eigen statistics at the 5% significance level. Eventually, the cointegration relationship among series is identified and the long-run equation can be estimated as follows:

$$\mathbf{N_t^{EG} = 0.37IVA_t + 3.38EGNP_t - 0.98EGCP_t} \quad \textbf{(t=1990-2015)} \qquad \textbf{(6.69)}$$
$$\textbf{[0.01]} \qquad \textbf{[0.00]} \qquad \textbf{[0.02]}$$

where N^{EG}, *IVA*, *EGNP*, and *EGCP* are natural logs of electricity generation sector natural gas consumption, real industrial value added, real electricity generation sector natural gas price, and real electricity generation sector coal price, respectively. All coefficients are found to be statistically significant at the 5% significance level, except the trend variable.

In the second stage, the short-run dynamic equation is estimated with the inclusion of the *ECT* in the model as below:

$$\mathbf{\Delta N_t^{EG} = 0.04 + 0.39\Delta IVA_{t-1} - 0.36\Delta EGCP_t - 0.10ECT_{t-1}} \qquad \textbf{(6.70)}$$
$$\textbf{[0.02]} \qquad \textbf{[0.00]} \qquad \textbf{[0.00]} \qquad \textbf{[0.02]}$$

where $ECT_t = N_t^{EG} - 0.37IVA_t - 3.38EGNP_t + 0.98EGCP_t$

Std. error of the regression: 0.06 LM Serial Correlation: F=0.05 [0.95]

Norm: JB=1.19 [0.54] Het: F= 0.27 [0.84] ARCH (1): F=1.27 [0.27]

Reset: F=0.43 [0.65] Wald: 12.16 [0.00].

The probability values of t-statistics and the diagnostic tests demonstrate that output and cross-price variables are statistically significant, and the model overcomes the autocorrelation and heteroscedasticity problems. In addition, there is no specification error in the model according to the Ramsey Reset test. Moreover, although the estimated coefficient of the *ECT* is low, it is significant and has a negative sign as expected.

6.4.3.5. ARDL Bounds Testing Method

The decision process of cointegration relation for the electricity generation sector natural gas demand equations in the ARDL Bounds Testing method is shown below. First, the maximum lag length is determined as 3 in keeping with the data, and then the appropriate ARDL model is specified as (3,3,3,3) by using the SBIC without autocorrelation problem (Table 6.91).

Table 6.91. Determination of the Lag Length (Electricity Generation Sector Natural Gas Demand)

Lag Length	SBIC	Autocorrelation (LM)
(1,0,0,0)	-2.20	0.32 [0.72]
(1,1,1,1)	-1.98	1.33 [0.30]
(2,2,2,2)	-2.06	6.83 [0.02]
(3,3,3,3)*	-3.45	14.27 [0.18]

Notes: *1. (*) indicates minimum SBIC value without autocorrelation problem.*
2. p-values of the tests are in square brackets.
3. The Breusch-Godfrey test is performed for maximum 2nd order (AR(2)) serial correlation.

The ARDL model to decide the cointegration relation is given by

$$\Delta N_t^{EG} = \beta_0 + \beta_1 trend + \sum_{i=1}^{3}\beta_{2i}\,\Delta N_{t-i}^{EG} + \sum_{i=0}^{3}\beta_{3i}\,\Delta IVA_{t-i} + \sum_{i=0}^{3}\beta_{4i}\,\Delta EGNP_{t-i} + \sum_{i=0}^{3}\beta_{5i}\,\Delta EGCP_{t-i} + \beta_6 N_{t-1}^{EG} + \beta_7 IVA_{t-1} + \beta_8 EGNP_{t-1} + \beta_9 EGCP_{t-1} + \varepsilon_t \quad \textbf{(6.71)}$$

where the constant and trend variables are added to this equation, and the diagnostic test results are listed in Table 6.92.

Table 6.92. Diagnostic Tests Statistics (Electricity Generation Sector Natural Gas Demand)

ARDL (3,3,3,3)	
R^2	0.98
Adjusted R^2	0.89
Autocorrelation (LM)	14.27 [0.18]
Heteroscedasticity (White)	0.19 [0.99]
Normality (Jarque-Bera)	0.54 [0.75]
F-stat	8.14

Note: *1. p-values of the tests are in square brackets.*

The estimated F-statistic of the Equation (6.71) refers that there is a cointegration relationship among variables, because 8.14 is greater than the Pesaran's and Narayan's *I(1)* critical values shown in Table 6.93.

Table 6.93. Bounds Test Statistics for Electricity Generation Sector Natural Gas Demand

N=27, k=3	**Pesaran**		**Narayan**	
Significance	*I(0)*	*I(1)*	*I(0)*	*I(1)*
1%	4.30	5.23	5.66	6.98
5%	3.38	4.23	4.04	5.09
10%	2.97	3.74	3.37	4.27

Notes**:** *1. N and k indicate the number of observation and independent variables in the model, respectively.*
2. I(0) and I(1) represent the lower and upper bounds, respectively.
3. The critical values are obtained from Pesaran et al. (2001) and Narayan (2005).
4. The critical values are for the model with unrestricted intercept and restricted trend.

The long-run ARDL model is decided as (2,3,3,2) with the maximum lags of 3. According to the results presented in Table 6.94, the optimal long-term equation is given by

$$\boldsymbol{N_t^{EG} = -4.73 - 1.71EGCP_t + 0.15T} \quad \textbf{(6.72)}$$

where *IVA* and *EGNP* are omitted from the equation. Moreover, the only statistically significant variable is *EGCP*. In addition, the deterministic trend variable is added to the model.

Table 6.94. The Long-Run Results and Coefficients of ARDL Bounds Testing Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: N^{EG}		
Variables	**Coefficients**	**Probability Values**
N^{EG}(-1)	0.58	0.06
N^{EG}(-2)	0.74	0.02
IVA	-0.19	0.22
IVA(-1)	0.37	0.04
IVA(-2)	0.05	0.78
IVA(-3)	-0.38	0.07
EGNP	-0.01	0.93
EGNP(-1)	0.03	0.79
EGNP(-2)	0.21	0.15
EGNP(-3)	-0.21	0.10
EGCP	-0.15	0.29
EGCP(-1)	0.48	0.00
EGCP(-2)	0.24	0.14
C	-3.65	0.03
T	-0.05	0.01
Long-Term Coefficients		
IVA	0.45	0.57
EGNP	-0.05	0.94
EGCP	-1.71*	0.00
C	-4.73*	0.03
T	0.15*	0.00
Diagnostic Statistics		
R^2: 0.99	DW: 2.59	
Adjusted R^2: 0.99	F stat: 468.89 (0.00)	
Autocorrelation (LM): 2.97 (0.11)	χ^2_{White}: 0.76 (0.68)	
χ^2_{Norm}: 1.72 (0.42)	χ^2_{Ramsey}: 0.88 (0.45)	

Notes: *1. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively. T is the trend variable.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob. values are in the parenthesis.

After estimating the long-run equation, the dynamic short-run equation can be calculated as the second stage of the ARDL method. The estimated coefficients and diagnostic statistics are summarized in Table 6.95.

Table 6.95. The Short-Run Results and Coefficients of ARDL Bounds Testing Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: ΔN^{EG}		
Variables	**Coefficients**	**Probability Values**
C	-4.78*	0.00
Δ***IVA***	0.32*	0.00
Δ***EGNP***	0.21*	0.00
Δ***EGCP***	-0.15*	0.00
ECT(-1)	-0.33*	0.00
Diagnostic Statistics		
Std. error of the regression: 0.011	ARCH (1): F=0.10 [0.70]	
Autocorrelation (LM): 2.72 (0.15)	χ^2_{White}: 1.45 (0.30)	
χ^2_{Norm}: 1.90 (0.71)	χ^2_{Ramsey}: 0.96 (0.40)	

Notes: *1. N^{EG}, IVA, EGNP and EGCP are natural logs of the electricity generation sector natural gas consumption, real industrial value added and real electricity generation sector natural gas price and real electricity generation sector coal price, respectively.*
2. (*) indicates 5% significance level.
3. Autocorrelation (LM), χ^2_{White}, χ^2_{Norm}, χ^2_{Ramsey} represents Breusch-Godfrey Serial Correlation Test, White Heteroscedasticity Test, Jarque-Bera Normality Test and Ramsey RESET test, respectively.
4. The prob values are in the parenthesis.

The short-run equation is shown as follows:

$$\Delta N_t^{EG} = -4.78 + 0.32\Delta IVA_t + 0.21 EGNP_t - 0.15 EGCP_t - 0.33 ECT_{t-1} \quad \textbf{(6.73)}$$

where all variables in the model are found to be statistically significant at the 1% significance level. In addition, the diagnostic tests are passed by the dynamic short-run equation.

Furthermore, the error correction term is formulated as below:

$$ECT_t = N_t^{EG} + 4.73 + 1.71 EGCP_t - 0.15T \quad \textbf{(6.74)}$$

where the coefficient is estimated as -0.33, which is statistically significant and has the right sign. It shows that almost one third of any disequilibrium is adjusted annually, and the model would reach the balance in 3 years.

6.4.3.6. STSM Method

In examining the Turkish electricity generation sector natural gas demand model by the STSM method, the independent variables are specified as one year lagged, and the stochastic level with no slope component is determined as the trend specification (local level model). The results and diagnostic checks are demonstrated in Table 6.96.

Table 6.96. The Results of STSM Method for Electricity Generation Sector Natural Gas Demand

Dependent Variable: N^{EG}				
Variables	**Coefficient**	**Standard Errors**	**T-value**	**Prob**
N^{EG}(-1)	0.82864	0.05740	14.43580	[0.00]
IVA(-1)	0.38807	0.13417	2.89226	[0.00]
EGNP(-1)	0.21289	0.08134	2.61721	[0.01]
Irregular 2005	0.19206	0.06555	2.92988	[0.00]
Level and Slope Components of $UEDT_{2015}$				
Level	-3.87716 [0.04258]			
Slope	-			

Residuals		**Auxiliary Residuals**			
			Irregular	***Level***	***Slope***
Std. Error	0.8485	*Std. Error*	0.9971	0.9946	-
Normality	0.7383	*Normality*	0.7476	0.8492	-
Skewness	0.7419	*Skewness*	0.8346	0.9645	-
Kurtosis	0.4802	*Kurtosis*	0.4631	0.5687	-
H(7)	1.1694				
R(1)	0.0243	**LR Test**			
R(5)	-0.1868	*Test (a)* 9.808 (0.00)			
DW	1.9067				
Q(5,4)	11.938				
Predictive Test 2008-2015		**Goodness of Fit**			
Failure	0.4133	R^2	0.9952		
Cusum t(7)	1.8586	R_d^2	0.6117		
		P.E.V.	0.0039		
		P.E.V./ (M.D.)^2	1.2373		
Hyperparameters					
Irregular	0.00309686				
Level	0.00060698				
Slope	-				

Notes: *1. Model estimation is made in STAMP 8.20.*
2. There is one irregular intervention dummy variable for the year 2005 in the model.
3. Error normality statistics of Bowman-Shenton Normality Test, Skewness and Kurtosis tests are all approximately distributed as χ^2.
4. The goodness of fit of the model is shown by Prediction Error Variance (P.E.V.), Prediction Error Mean Deviation (P.E.V./ (M.D.)^2), and the Coefficient Determination (R^2 and R_d^2).
5. H(7) is the heteroscedasticity statistic.
6. R(1) and R(5) are the serial correlation coefficients at the 1st and 5th lag, respectively
7. DW is the Durbin-Watson statistic.
8. Q(5,4) is the Box-Ljung Q-statistics based on the first 5 residuals autocorrelations and distributed as $\chi 2$ (4).
9. Predictive test is made by STAMP and re-estimate the model up to 2007 and forecasting the period between 2008 and 2015. Failure is an estimated failure statistic and Cusum is a stability statistic of the model.
10. LR Test(a) represent likelihood ratio tests on the same specification after imposing a fixed level and no slope hyperparameter which is distributed as $\chi 2(2)$. Probabilities are given in parenthesis.
11. The hyperparameters determine the shape of the UEDT.

According to the results of the above table, the electricity generation sector short-term natural gas demand equation is given by

$$\boldsymbol{N_t^{EG} = 0.82N_{t-1}^{EG} + 0.38IVA_{t-1} + 0.21EGNP_{t-1} + UEDT_t} \qquad \textbf{(6.75)}$$

where UEDT of the equation is -3.87716 with no slope at the end of the period. In addition, the cross-price variable (*EGCP*) is found as insignificant, and therefore omitted from the equation.

As it is indicated in the methodology chapter, in STSM method, the long-run elasticities can be estimated by using the short-run elasticities. The formulations and long-term elasticities are shown by

$$\boldsymbol{\alpha(L) = 1 - N_{t-1}^{EG} = 1 - 0.82864 = 0.17136}$$

$$\boldsymbol{\beta(L) = 0.38807}$$

$$\boldsymbol{\theta(L) = 0.21289}$$

$$\boldsymbol{\frac{\beta(L)}{\alpha(L)} = \frac{0.38807}{0.17136} = 2.26\ (long\ term\ income\ elasticity)}$$

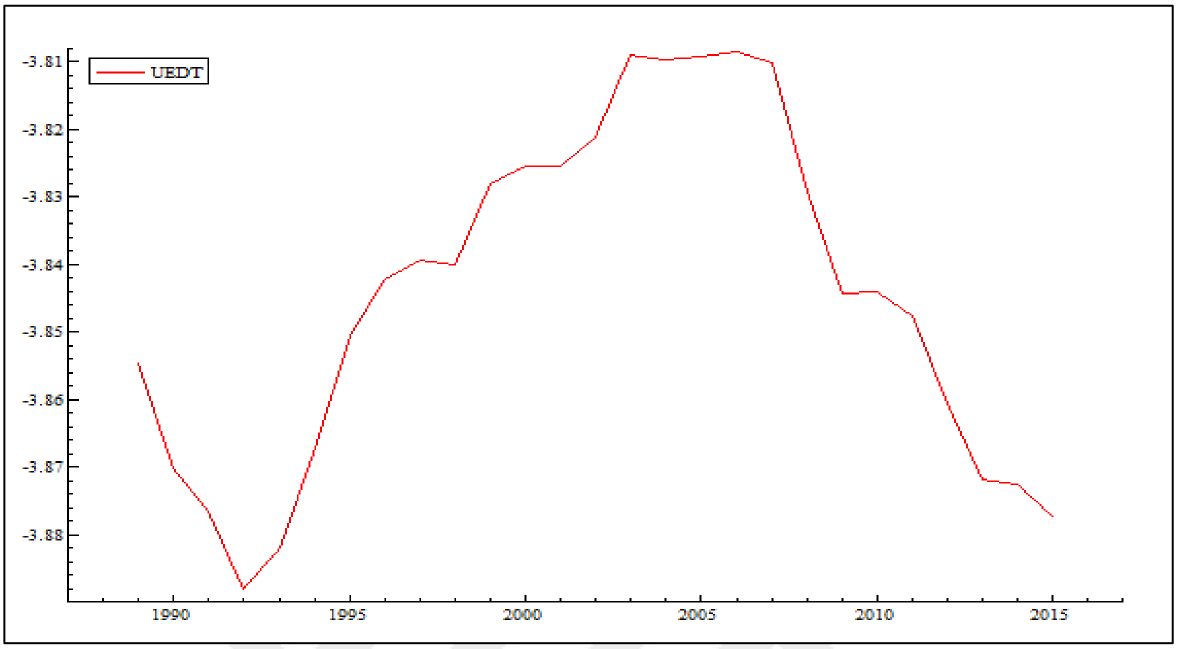
$$\boldsymbol{\frac{\theta(L)}{\alpha(L)} = \frac{0.21289}{0.17136} = 1.24\ (long\ term\ own-price\ elasticity)}$$

where *α(L)*, *β(L)* and *θ(L)* represent the polynomial lag operators.

The model passed all the diagnostic checks. Furthermore, the additional normality tests for auxiliary residuals are also consistent with one irregular intervention dummy variable for the year 2005. This dummy variable may reflect the increase of electricity generation of Turkey as a result of the high growth rates at that period.

Moreover, the change in the UEDT for the estimation period is shown in Figure 6.6. Turkey's natural gas consumption in the electricity generation sector hit the bottom in 1992 due to the reflections of the Gulf War to the Turkish economy. After then, the natural gas consumption of the said sector increased up to 2005, and reached its peak in this period. Thereafter, the natural gas consumption trend gradually decreased until the end of the investigated period.

Figure 6.6. UEDT (μ_t) for Turkish Electricity Generation Sector Natural Gas Consumption (1988-2015)



6.4.3.7. Comparison of Elasticity Estimates for Electricity Generation Sector Natural Gas Demand

The elasticity estimates of the methods used for analysing the electricity generation sector natural gas demand are summarized in Table 6.97. In this context, the income, own-price and cross-price elasticities are listed as follows.

Table 6.97. Summary of Estimated Electricity Generation Natural Gas Demand Elasticities

	INCOME		OWN-PRICE		CROSS-PRICE	
METHOD	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***	***Short-Term***	***Long-Term***
Engle-Granger Two-Step	0.47	2.55	-	1.57	-0.24	-0.60
FMOLS	0.15	2.05	0.23	1.95	-0.20	-0.49
Johansen	0.39	0.37	-	3.38	-0.36	-0.98
ARDL Bounds Test	0.32	-	0.21	-	-0.15	-1.71
STSM-UEDT	0.38	2.26	0.21	1.24	-	-

One of the remarkable result is the positive own-price elasticity estimates for the electricity generation sector in both short- and long-term. This result seems contrary to the economic theory. In general terms, economic theory states that there is an inverse relation between price and demand, and price affects demand negatively.

The situation in Turkey, especially in the electricity generation sector, is quite different from the above-mentioned norm. The electricity selling price of electricity generation sector that use natural gas does not depend on the natural gas cost. In this sector "cost-pass-through" principle is used which means any increase in price is directly reflected in final tariffs. In the sense of this logical inference, when prices increase in this sector, the consumption of natural gas would also increase, ceteris paribus.

In this context, the estimation results of the own-price elasticities in electricity generation sector can be understood as a supply relationship rather than demand. In short, natural gas demand in electricity generation sector do not respond to price changes in Turkey, and therefore, the elasticity estimates are not consistent with the economic theory.

On the other hand, the cross-price elasticities are estimated as negative. In the short-run, these elasticities are found to be close to each other. In the long-run, the smallest elasticity estimate is estimated by the ARDL approach, while the greatest one is calculated by the FMOLS method. The negative cross-price elasticities indicate that the natural gas and coal are complementary goods in the electricity generation sector. This means that when the price of coal increases, the quantity of demanded natural gas diminishes.

Furthermore, the income elasticity estimates of the electricity generation sector range between 0.15 (FMOLS) and 0.47 (EG Two-Step) in the short-term, and vary between 0.37 (Johansen) and 2.55 (EG Two-Step) in the long-term. The income elasticities are smaller than 1 in the short-run, which demonstrate that the changes in income does not affect the natural gas demand extremely in the short-term. However, contrary to the short-run, the income elasticity estimates for the long-run are greater than 1 except the one that estimated by the Johansen approach. In other words, according to the economic theory, the natural gas can be said to be a luxury good for Turkey's electricity generation sector in the long-run.

6.4.4. Aggregate Natural Gas Demand

The functional form and the econometric specification used in analysing the aggregate natural gas demand elasticities are as follows:

$$N_d^{EG} = f(GDP, AANP, AAEP) \qquad N_t^A = \theta_0 + \theta_1 GDP_t + \theta_2 AANP_t \pm \theta_3 AAEP_t + \omega_t \quad \textbf{(6.76)}$$

where *GDP*, *AANP*, and *AAEP* represent the real gross domestic product, real average aggregate natural gas price, and real average aggregate electricity price, respectively. The own-price is symbolized by *AANP* and the cross-price is identified by *AAEP*.

The weighted average of aggregate natural gas prices is estimated as below:

$$AANP_t = \left(INP_t * \frac{N_t^I}{N_t^I + N_t^R + N_t^{EG}}\right) + \left(RNP_t * \frac{N_t^R}{N_t^I + N_t^R + N_t^{EG}}\right) + \left(EGNP_t * \frac{N_t^{EG}}{N_t^I + N_t^R + N_t^{EG}}\right) \quad \textbf{(6.77)}$$

where *INP*, *RNP*, and *EGNP* are industrial, residential, and electricity generation sector natural gas prices, respectively. Furthermore, N^I, N^R, and N^{EG} are industrial, residential, and electricity generation sector natural gas consumption, correspondingly.

Moreover, the weighted average formulation of the aggregate electricity prices is given by

$$AAEP_t = \left(IEP_t * \frac{E_t^I}{E_t^I + E_t^R}\right) + \left(REP_t * \frac{E_t^R}{E_t^I + E_t^R}\right) \quad \textbf{(6.78)}$$

where *IEP* and *REP* are industrial and residential electricity prices. In addition, E^I and E^R are industrial and residential electricity consumption, respectively.

After obtaining these data and transforming them from nominal to real, the elasticity estimates can be made. The same procedure as in all the above elasticity estimations was applied in terms of the aggregate natural gas demand. However, the cointegration relationship among variables cannot be found. In addition, the results from the STSM method were not satisfactory with regards to economic and econometric theories. The coefficient was not estimated as statistically significant, and the diagnostic tests cannot be passed.

As a result, the elasticity estimation outcomes of the aggregate natural gas demand are not given in this part of the study. On the other hand, the predictions are made by using the information of the sub-sectors, and the results are presented in the next pages of this chapter.

6.5. Forecast Scenarios and Results for Natural Gas Demand

In this part of the study, the scenarios and assumptions for the future natural gas demand in industrial, residential and electricity generation sector are introduced. In addition, the aggregate natural gas demand forecasts are obtained from the total of the above-mentioned sub-sectors and additional sectors (business sector, government, and others). This procedure is explained in detail in the following section.

The prediction period for the natural gas demand is from 2016 to 2025 as in the electricity demand. Furthermore, the estimated elasticities are utilized to forecast the future natural gas demands for each of the sectors. Initially, the scenarios are introduced, and then reconstituted forecast equations plus prediction results are given in the below.

6.5.1. Forecast Scenarios

As in the electricity demand predictions, the three scenario assumptions are used, namely low, reference, and high, to forecast the future natural gas demand for the industrial, residential, and electricity generation sector. The high and low case scenarios are constituted from the reference scenarios. First of all, the assumptions for real industry value-added, real household final consumption expenditure, and real energy prices (natural gas, electricity and coal) are made for the reference scenario, and then these assumptions are adapted to the low and high scenarios. The explanations of these three scenarios are introduced as follows.

- *In the reference scenario*, the real *IVA* will be supposed to increase by 4.50% for the first three years of the forecast period. Then it will proceed to rise by 0.50% biyearly. In addition, the real *HFCE* is assumed to increase by 0.10% from 2015 to 2016. For the next three years (2017-2019), the real *HFCE* is supposed to be 4.00%, and then it is decided to be 5.00% up to 2023. Last two years of the estimation period, it is arranged as 5.00% and 5.50%, respectively. Furthermore, the natural gas prices of industrial, residential and electricity generation sector are presumed to increase by 1.00% more from the previous years. That being said, the electricity prices of industrial and residential sectors and the coal prices of the electricity generation sector are assumed to have the same tendency as the natural gas prices. The reference case assumptions are summarized in Table 6.98.

Table 6.98. Reference Scenario Assumptions for the Natural Gas Demand

	INDUSTRIAL			*RESIDENTIAL*			*ELECTRICITY GENERATION*		
t	***IVA Growth***	***Natural Gas Price Growth***	***Electricity Price Growth***	***HFCE Growth***	***Natural Gas Price Growth***	***Electricity Price Growth***	***IVA Growth***	***Natural Gas Price Growth***	***Coal Price Growth***
2015	4.50%	-4.79%	5.01%	3.40%	-0.62%	0.20%	4.50%	-0.63%	-16.32%
2016	4.50%	1.00%	1.00%	3.50%	1.00%	1.00%	4.50%	1.00%	1.00%
2017	4.50%	1.00%	1.00%	4.00%	1.00%	1.00%	4.50%	1.00%	1.00%
2018	5.00%	1.00%	1.00%	4.00%	1.00%	1.00%	5.00%	1.00%	1.00%
2019	5.00%	1.00%	1.00%	4.00%	1.00%	1.00%	5.00%	1.00%	1.00%
2020	5.50%	1.00%	1.00%	5.00%	1.00%	1.00%	5.50%	1.00%	1.00%
2021	5.50%	1.00%	1.00%	5.00%	1.00%	1.00%	5.50%	1.00%	1.00%
2022	6.00%	1.00%	1.00%	5.00%	1.00%	1.00%	6.00%	1.00%	1.00%
2023	6.00%	1.00%	1.00%	5.00%	1.00%	1.00%	6.00%	1.00%	1.00%
2024	6.50%	1.00%	1.00%	5.50%	1.00%	1.00%	6.50%	1.00%	1.00%
2025	6.50%	1.00%	1.00%	5.50%	1.00%	1.00%	6.50%	1.00%	1.00%

Notes: *1. The actual values are used for 2015.*
2. IVA and HFCE represent the real industrial value added and household final consumption expenditure, respectively.

- *In the low scenario*, the real *IVA* and *HFCE* growth are 2.00% less than the reference scenario for each year. For instance, the *IVA* and *HFCE* growth are going to be 3.50% and 3.00% in 2020, respectively. Moreover, the annual growth rates of the natural gas, electricity, and coal prices are supposed to be 2.00% for all the sectors.

- *In the high scenario*, contrary to the low case scenario, the real *IVA* and *HFCE* growth rates are assumed to be 2.00% more than that of the reference scenario assumptions for each year. On the other hand, the rises in the prices (natural gas, electricity, and coal) are supposed to be 0.50% more annually than the reference scenario.

For the real natural gas, electricity, and coal prices, the actual data of 2015 are used, and the assumptions are made for the rest of the years by considering the structure of the natural gas market in Turkey. In addition, the assumptions for the real *IVA* and *HFCE* growth rates are obtained from the 10th Development Plan (Ministry of Development, 2013).

6.5.2. Forecast Equations and Results

After determining the scenario assumptions, the forecast equations obtained from the elasticity estimations and the prediction results can be given. First, the equations and then the forecast results for each sector are presented. The derived equations for the industrial natural gas demand forecasts are shown in Table 6.99.

Table 6.99. Forecast Equations for the Industrial Natural Gas Demand

	Constant	g_{t-1}	y_t	y_{t-1}	p_t	p_{t-1}	pe_t	pe_{t-1}	t_t	t_{t-1}	*Slope of* μ_t
EG TWO-STEP	0.97	0.56	1.59	-1.24	-0.71	-0.09	1.02	-0.74		0.05	
FMOLS	1.01	0.54	1.03	-0.62	-0.65	0.11	0.48	-0.26	0.002	0.06	
JOHANSEN	-124.8	0.44	2.04	-1.42	-0.48	0.35	0.95	-0.56		0.06	
ARDL	11.82	0.47	1.27	-0.70	-0.53	0.13		0.14		0.07	
STSM	-4.83		1.41		-0.55		0.74				0.10272

Note: *1. g, y, p, pe* and *t* represent the industrial natural gas consumption, industrial value added, industrial natural gas price, industrial electricity price and trend, respectively.

The prediction results based on the scenario assumptions and the forecast equations are given in Table 6.100. These results indicate that the lowest demand forecasts for 2025 are estimated by the Engle-Granger Two-Step method with respect to all scenarios. On the other hand, the highest forecast estimations for 2025 are made by the STSM method as 23.43 bcm, 29.98 bcm, and 39.14 bcm according to the low, reference, and high case scenarios, respectively.

Table 6.100. Industrial Natural Gas Demand Forecast Results for Turkey over the period between 2016 and 2025 (bcm)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**	**12.38**
2015*	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**	**13.97**
2016	14.72	14.78	14.90	14.78	14.91	15.02	14.48	14.58	14.79	14.87	15.10	15.23	14.51	14.88	15.29
2017	15.14	15.41	15.67	15.29	15.69	15.95	15.01	15.31	15.83	15.46	16.03	16.38	15.08	15.85	16.73
2018	15.48	16.07	16.49	15.72	16.45	16.92	15.72	16.28	17.18	15.99	16.97	17.61	15.77	17.00	18.43
2019	15.68	16.65	17.25	16.05	17.16	17.88	16.42	17.27	18.64	16.43	17.87	18.86	16.50	18.23	20.30
2020	15.91	17.33	18.12	16.42	17.95	18.95	17.30	18.49	20.41	16.95	18.90	20.30	17.38	19.68	22.50
2021	16.08	17.97	18.97	16.75	18.75	20.06	18.17	19.75	22.29	17.45	19.95	21.81	18.30	21.24	24.95
2022	16.33	18.73	19.96	17.15	19.65	21.31	19.25	21.27	24.54	18.06	21.17	23.56	19.40	23.08	27.83
2023	16.53	19.47	20.96	17.54	20.59	22.63	20.33	22.83	26.95	18.68	22.45	25.43	20.57	25.07	31.05
2024	16.84	20.37	22.13	18.02	21.66	24.13	21.65	24.71	29.83	19.42	23.94	27.60	21.95	27.42	34.86
2025	17.10	21.25	23.31	18.51	22.78	25.73	22.99	26.67	32.92	20.19	25.52	29.94	23.43	29.98	39.14

Note: *(*) indicates the real values.*

The forecast equations of the residential natural gas demand are listed in Table 6.101.

Table 6.101. Forecast Equations for the Residential Natural Gas Demand

	Constant	g_{t-1}	y_t	y_{t-1}	y_{t-2}	p_t	p_{t-1}	pe_t	pe_{t-1}	pe_{t-2}	t_{t-1}	$Slope\ of\ \mu_t$
EG TWO-STEP	-12.56	0.84	1.68	-0.80			-0.20	0.78	-0.28		-0.004	
FMOLS	-25.27	0.54	3.30	-1.27			-1.65	2.32	0.90			
JOHANSEN	-3.63	0.90	0.79	-0.44		-0.46	-0.04	0.84	-0.72			
ARDL	-70.58	0.35	1.23	2.20			-0.50	-0.79	1.16		-0.05	
STSM	-12.93	0.54			1.16		-0.55			0.78		-

Note: *1. g, y, p, pe* and *t* represent the industrial natural gas consumption, industrial value added, industrial natural gas price, industrial electricity price and trend, respectively.

The forecast results according to these equations and related scenario assumptions are presented in Table 6.102. These results show that in 2025, the natural gas demand of the residential sector will be between 15.15 bcm and 17.68 bcm, between 18.84 bcm and 25.76 bcm, and between 28.75 bcm, and 33.08 bcm according to the low, reference, and high scenarios, respectively. The top values are estimated by the STSM approach as well as the industrial natural gas demand forecasts.

Table 6.102. Residential Natural Gas Demand Forecast Results for Turkey over the period between 2016 and 2025 (bcm)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**	**9.30**
2015*	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**	**11.00**
2016	12.40	12.58	12.88	11.93	12.20	12.75	12.63	12.75	12.95	11.84	11.76	11.55	12.11	12.34	12.49
2017	13.57	13.99	14.74	12.48	13.01	14.20	14.10	14.48	14.98	11.98	12.22	12.24	12.86	13.50	13.95
2018	14.43	15.15	16.49	12.72	13.49	15.37	15.32	16.12	17.04	11.98	12.70	13.16	13.39	14.57	15.42
2019	14.96	16.02	18.09	12.77	13.77	16.39	16.21	17.61	19.07	11.94	13.21	14.21	13.79	15.62	16.97
2020	15.42	16.88	19.83	13.16	14.41	17.88	16.89	19.04	21.19	12.02	13.90	15.55	14.28	16.85	18.81
2021	15.71	17.58	21.54	13.57	15.09	19.52	17.27	20.32	23.30	12.41	14.99	17.44	14.83	18.25	20.95
2022	15.84	18.15	23.24	14.01	15.80	21.32	17.35	21.43	25.37	12.93	16.30	19.71	15.43	19.80	23.37
2023	15.82	18.58	24.91	14.47	16.56	23.29	17.15	22.36	27.38	13.51	17.78	22.35	16.07	21.51	26.11
2024	15.82	19.06	26.79	15.20	17.64	25.84	16.78	23.19	29.42	14.21	19.52	25.50	16.83	23.50	29.35
2025	15.77	19.50	28.76	16.00	18.84	28.75	16.23	23.86	31.43	15.15	21.70	29.45	17.68	25.76	33.08

Note: *(*) indicates the real values.*

Lastly, the forecast equations for the electricity generation sector that obtained from short- and long-term elasticity estimates are given in Table 6.103.

Table 6.103. Forecast Equations for the Electricity Generation Sector Natural Gas Demand

	Constant	g_{t-1}	y_t	y_{t-1}	p_t	p_{t-1}	pc_t	pc_{t-1}	$Slope\ of\ \mu_t$
EG TWO-STEP	-5.60	0.78	0.47	0.09		0.34	-0.24	0.10	
FMOLS	-3.85	0.81	0.15	0.24	0.23	0.05	-0.20	0.11	
JOHANSEN	0.045	0.90	0.39	-0.35		0.34	-0.36	0.26	
ARDL	-3.19	0.67	0.32	-0.17	0.21	-0.22	-0.15	-0.41	
STSM	-3.87	0.82		0.38		0.21			-

Note: *1. g, y, p* and *pc* represent the electricity generation sector natural gas consumption, industrial value added, electricity generation sector natural gas price and electricity generation sector electricity price, respectively.

The estimated results of the future natural gas demand for the Turkish electricity generation sector are shown in Table 6.104. These results suggest that the electricity generation sector natural gas demand in 2025 will be between 22.09 bcm and 27.19 bcm in terms of the low case scenario, between 26.95 bcm and 33.48 bcm in terms of the reference case scenario, and between 34.38 bcm and 40.60 bcm in terms of the high case scenario in Turkey. Furthermore, once again, the maximum values are estimated by the STSM method for the three scenarios.

Table 6.104. Electricity Generation Sector Natural Gas Demand Forecast Results for Turkey over the period between 2016 and 2025 (bcm)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**	**23.44**
2015*	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**	**19.01**
2016	16.20	16.48	17.30	17.09	17.23	17.21	15.48	15.66	15.73	18.34	18.42	18.67	16.68	16.72	16.70
2017	14.77	15.38	16.76	16.05	16.40	16.52	13.52	13.86	14.09	18.09	18.43	19.04	15.52	15.71	15.81
2018	14.19	15.19	17.06	15.62	16.25	16.60	12.56	13.07	13.52	18.15	18.85	19.91	15.15	15.57	15.87
2019	14.18	15.65	18.02	15.64	16.62	17.30	12.27	12.98	13.73	18.38	19.55	21.15	15.35	16.08	16.69
2020	14.62	16.68	19.61	16.04	17.43	18.57	12.54	13.50	14.64	18.78	20.49	22.75	16.01	17.16	18.19
2021	15.46	18.26	21.85	16.77	18.69	20.43	13.31	14.59	16.28	19.27	21.61	24.64	17.17	18.86	20.47
2022	16.68	20.42	24.83	17.82	20.40	22.93	14.62	16.33	18.79	19.87	22.93	26.86	18.81	21.23	23.64
2023	18.31	23.25	28.66	19.22	22.61	26.17	16.51	18.81	22.37	20.53	24.40	29.38	20.98	24.35	27.86
2024	20.39	26.87	33.55	20.97	25.39	30.29	19.16	22.26	27.40	21.28	26.06	32.26	23.73	28.35	33.39
2025	22.98	31.43	39.72	23.14	28.83	35.51	22.72	26.95	34.38	22.09	27.87	35.48	27.19	33.48	40.60

Note: *(*) indicates the real values.*

In addition to the sub-sectors, the aggregate natural gas demand predictions are also estimated. Since the elasticity estimates cannot be calculated, the future aggregate demand for natural gas is forecasted from the information and shares of the sub-sectors on total natural gas consumption.

In terms of aggregate natural gas demand forecasts, the sub-sectors' (industrial, residential, and electricity generation sector) demand predictions are added together. Total consumption of these sub-sectors is calculated as 92.33% of aggregate natural gas consumption on average between 2011 and 2016 (EMRA, 2016). Therefore, this percentage will be valid for the forecast period (2016-2025) of aggregate natural gas demand.

The rest of the aggregate natural gas demand will be added to each year forecasts. This percentage is again on average of 7.67% and consist of the business sector, government office, and others. The shares of the natural gas consumption according to the sectors are summarized in Table 6.105.

Table 6.105. Shares of Sectoral Natural Gas Consumption (2011-2016, %)

	Electricity Generation Sector	**Industrial**	**Residential**	**Service Sector (Business and Government Office)**	**Others**	**Total**
2011	48.00%	26.00%	19.90%	5.26%	0.84%	100%
2012	47.82%	25.23%	19.56%	6.02%	1.37%	100%
2013	45.85%	25.11%	20.87%	6.61%	1.66%	100%
2014	48.12%	25.40%	19.10%	5.82%	1.56%	100%
2015	39.61%	29.10%	22.92%	6.02%	2.36%	100%
2016	36.06%	30.38%	25.05%	6.13%	2.38%	100%

Source: EMRA, 2016

The aggregate natural gas demand forecast results for each of the methods are listed in Table 6.106. According to these results, in 2025, the aggregate natural gas demand based on the assumptions mentioned above will be as follows: In the low scenario, the demand is supposed to vary between 65.51 bcm and 80.13 bcm. In the reference scenario, the demand is expected to range between 82.64 bcm and 104.67 bcm. In the high scenario, the demand is forecasted to change between 105.56 bcm and 132.35 bcm.

The highest estimation results are gained from the STSM method whereas the lowest ones are obtained from Engle-Granger Two-Step method for the low case scenario and the FMOLS approach for the reference and high case scenarios.

Table 6.106. Aggregate Natural Gas Demand Forecast Results for Turkey over the period between 2016 and 2025 (bcm)

	ENGLE-GRANGER TWO-STEP			FMOLS			JOHANSEN			ARDL BOUNDS TESTING			STSM		
Years	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**	**Low**	**Reference**	**High**
2014*	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**	**48.72**
2015*	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**	**48.00**
2016	50.82	51.42	52.87	51.37	52.02	52.76	49.95	50.43	50.99	52.85	53.12	53.31	50.79	51.54	52.18
2017	51.02	52.54	55.34	51.41	52.91	54.75	50.01	51.21	52.67	53.41	54.76	55.90	50.98	52.86	54.53
2018	51.74	54.44	58.70	51.68	54.18	57.35	51.14	53.33	56.00	54.10	56.91	59.44	51.98	55.29	58.33
2019	52.57	56.69	62.60	52.16	55.78	60.50	52.67	56.14	60.34	54.84	59.39	63.62	53.53	58.56	63.29
2020	53.91	59.69	67.52	53.50	58.41	64.99	54.82	59.87	65.97	56.01	62.50	68.74	55.92	62.97	69.80
2021	55.42	63.12	73.14	55.23	61.62	70.39	57.19	64.12	72.57	57.64	66.34	74.94	59.01	68.44	77.85
2022	57.30	67.22	79.80	57.46	65.53	76.90	60.08	69.24	80.59	59.66	70.86	82.27	62.93	75.20	87.80
2023	59.43	71.91	87.43	60.10	70.11	84.56	63.34	75.08	89.97	61.84	75.82	90.52	67.59	83.20	99.74
2024	62.23	77.77	96.73	63.57	75.89	94.16	67.56	82.31	101.65	64.43	81.56	100.14	73.33	92.99	114.48
2025	65.51	84.67	107.67	67.62	82.64	105.56	72.65	90.89	115.82	67.36	88.08	111.29	80.13	104.67	132.35

Note: *(*) indicates the real values.*

6.6. Summary and Conclusion

In this chapter, the elasticity estimates of the electricity and natural gas demands are given in terms of the sub-sectors. For the electricity, the industrial, residential and aggregate demand elasticities are analysed. Furthermore, for the natural gas, demand elasticities of the industrial, residential and electricity generation sector are estimated. In line with this purpose, five different econometric methods are used, namely Engle-Granger Two-Step, Johansen Cointegration, Fully Modified Ordinary Least Squares, ARDL Bounds Testing and Structural Time Series Modelling.

One of the main motivation of this chapter is to quantify Turkish electricity and natural gas demand elasticities for different sectors. By carrying out this procedure, different approaches are used to identify and compare the performances of these methods in terms of estimating the elasticities and also predicting the future demand for the sub-sectors plus aggregate levels. Moreover, it is aimed to contribute the policymakers and actors in the Turkish energy market for developing future policies and investment opportunities. Therefore, the price and income elasticity estimations and forecast results in this research not only should be classified as numbers but also, they will assist the public and private sectors in making the policy analysis.

As mentioned above, first, Turkish industrial, residential and aggregate electricity demand equations are estimated in this chapter. After then, the industrial, residential and electricity generation sector natural gas demand functions are estimated by using five different econometric techniques. The results of these estimations can be summarised as follows:

Industrial electricity demand: The estimated industrial value added (output) elasticities are found between 0.12 and 0.32 in the short-term and between 0.12 and 0.49 in the long-term. Additionally, the price elasticities range between -0.06 and -0.11 in the short-run whereas they change between -0.01 and -0.08 in the long-run.

The income and price elasticities that found by Dilaver and Hunt (2011a) are consistent with the results of this study. They found the income elasticity as 0.15 and the price elasticity as -0.16. On the other hand, Arisoy and Ozturk (2014) estimated income elasticity as 0.97, and which is greater than this study’s estimations.

In terms of the industrial electricity demand prediction, the results indicate that the electricity consumption of this sector will be between 103696 and 119996 GWh in 2020 and between 109760 and 163805 GWh in 2025 based on the scenario assumptions (Table 6.48). Dilaver and Hunt (2011a) state that the demand would be 121000 GWh in 2020 and this result is higher than the high case prediction of this study.

Residential electricity demand: Based on different methods used in this research, the household final consumption expenditure elasticities vary between 0.16 and 0.33 in the short-term and between 0.39 and 2.01 in the long-term. In addition, the price elasticities range from -0.07 to -0.21 in the short-run and from -0.13 to -0.36 in the long-run.

As far as known, there are three previous studies that analyse the Turkish residential sector in terms of income and price elasticities. The first one was done by Halicioglu (2007), and he found the income elasticity as 0.44 and 0.70 in the short- and long-run, respectively. Moreover, the price elasticities are estimated as -0.33 in the short-term and -0.52 in the long-term. Although the short-term income elasticity computed by Halicioglu (2007) is higher than that of this study, the long-term income elasticities of this research are estimated far greater than Halicioglu's result (except the STSM method). On the other hand, the price elasticities of this study are smaller than that of Halicioglu (2007) in the short and long terms.

Secondly, Dilaver and Hunt (2011b) estimated the short- and long-run income elasticities to be 0.38 and 1.57, respectively. These results are consistent with the estimated income elasticities in here (except the STSM method). In addition, the price elasticities of this study are estimated similarly to the aforesaid study's elasticities, which are -0.09 in the short- and -0.38 in the long-term.

Thirdly, Arisoy and Ozturk (2014) calculated the price and income elasticities as -0.02 and 0.99, respectively. The price elasticities of this study are found greater than that of Arisoy and Ozturk (2014) in absolute values. Moreover, the long-term income elasticities obtained by Engle-Granger Two-Step, FMOLS, Johansen and ARDL Bounds Testing methods are estimated greater than Arisoy and Ozturk's study.

Dilaver and Hunt (2011b), the previous study focusing on predicting Turkish residential electricity demand, estimated that the demand would be 48000 GWh, 64000 GWh and 80000 GWh in 2020 according to the low, reference, and high case scenarios, correspondingly. In this study, on the other hand, the predictions of the low case scenario are between 56512 GWh and 63596 GWh, of the reference case scenario are between 63776 GWh and 66638 GWh, and of the high case scenario are between 66528 GWh and 71010 GWh for 2020 (Table 6.50). The forecast results of this study are greater than the predictions of Dilaver and Hunt (2011b) in terms of low case scenarios whereas for the reference case the results show similarity in both studies. In the high case scenario, Dilaver and Hunt (2011b) found greater demand predictions than this study.

In addition, according to the forecast result of this study for the year 2025, the lowest electricity demand would be 67609 GWh, and the highest residential electricity demand would be 124331 GWh in the Turkish residential sector.

Aggregate electricity demand: For the aggregate electricity demand, the income elasticities vary between 0.24 and 0.42 in the short-term and between 0.24 and 0.48 in the long-term. Furthermore, the price elasticities of aggregate electricity demand are in the range between -0.06 and -0.07 in the short-run and between -0.07 and -0.17 in the long-run.

The estimated income elasticities are greater than that of Tatlidil et al. (2009) and Dilaver and Hunt (2011c) whereas they are smaller than that of Bakirtas et al. (2000), which are 3.13 in the long-term and 0.69 in the short-term. The long-run income elasticity estimates show parallelism with those obtained by Erdogdu (2007).

In terms of the price elasticities, Bakirtas et al. (2000) and Tatlidil et al. (2009) cannot estimate statistically significant results for both the short- and long-run. Moreover, Maden and Baykul (2012) found extraordinary values, which are -1.44 in the short- and -6.85 in the long-term. On the other hand, the results estimated in this study are close to those obtained by Erdogdu (2007) and Dilaver and Hunt (2011c).

The prediction results of this study for the aggregate electricity demand for 2025 are between 307029 GWh and 347127 GWh, between 317143 GWh and 362511 GWh, and between 332072 GWh and 393625 GWh based on the low, reference, and high case scenarios, correspondingly (Table 6.52). These results are smaller by comparison with the official predictions made by TEİAŞ (2015b). Additionally, Kiran et al. (2012) forecasted the aggregate electricity demand for 2025 as 167000 GWh, 230000 GWh, and 435000 GWh according to scenario 1, 2, and 3, respectively. When comparing the results of this study with

Kiran et al. (2012), it can be said that only the highest value that forecasted by Kiran et al. (2012) is greater than this study's predictions. Lastly, the estimated forecast values by using reference and high case scenarios in here are smaller than that of Dilaver and Hunt (2011c) for the year 2020.

Industrial natural gas demand: The income (output) elasticities for the industrial natural gas demand are estimated in the range between 1.03 and 2.04 in the short-term, and between 0.79 and 1.41 in the long-term. Moreover, the own-price elasticities vary between -0.48 and -0.71 in the short-run, and between -0.23 and -0.94 in the long-run.

As far as known, there are no previous studies considering the cross-prices in analysing the industrial natural gas demand elasticities for Turkey. Therefore, this study makes a significant contribution to the energy demand literature of Turkey in terms of examining the effects of the additional product in the industrial sector. The electricity prices are included in the models to represent the cross-prices. The results indicate that cross-price elasticities are found to be positive and vary between 0.47 and 1.02 in the short- and between 0.28 and 0.74 in the long-term.

The only previous research investigating the Turkish industrial natural gas demand was done by Erdogdu (2010). He used quarterly series and found the income elasticity as 0.47 in the short-run and as 4.73 in the long-run. Furthermore, Erdogdu (2010) estimated the short-run elasticity to be -0.78 and the long-run elasticity to be -7.81. According to these results, the estimated income elasticities of this study are found to be greater than Erdogdu (2010) in the short-run and smaller than aforesaid study in the long-run. In addition, although the short-run price elasticity estimates are similar to the Erdogdu's results, there is a big difference in terms of the long-run price elasticities between this study and Erdogdu (2010).

The future industrial natural gas demands are also forecasted in this study. The results show that in 2025, the natural gas demand in this sector would be between 17.10 bcm and 23.43 bcm, between 21.25 bcm and 29.98 bcm and between 23.31 bcm and 39.14 bcm, according to the low, reference and high scenarios, correspondingly (Table 6.100).

Residential natural gas demand: The income elasticities are found between 0.79 and 3.40 in the short- and between 2.53 and 5.51 in the long-term. On the other hand, the estimated own-price elasticities vary between -0.46 and -0.55 in the short-run and between -1.21 and -5.02

in the long-run. Furthermore, the cross-price elasticity estimates range between -0.79 and 2.32 in the short- and 1.19 and 3.38 in the long-term.

In comparison with the previous study, the income elasticities estimated in here are smaller (except the short-term estimation of the FMOLS method) than Erdogdu (2010) in both short- and long-term. On the other hand, Erdogdu (2010) found the short-term price elasticity as -7.82 and the long-run price elasticity as -31.90, which are far smaller than the results of this study.

When examining Turkey's residential natural gas demand predictions, it is forecasted that the natural gas demand would range between 15.15 bcm and 17.68 bcm in the low case scenario, between 18.84 bcm and 25.76 in the reference case scenario and between 28.75 bcm and 33.08 bcm in the high case scenario in 2025 (Table 102). Because of the fact that there is no remarkable study about predicting the future residential natural gas demand for Turkey, the comparison of the results cannot be made.

Electricity generation sector natural gas demand: The income elasticity estimates for the electricity generation sector change between 0.15 and 0.47 in the short- and between 0.37 and 2.55 in the long-term. Additionally, the own-price elasticities are found as positive which vary between 0.21 and 0.23 in the short-run and range between 1.24 and 3.38 in the long-run. Moreover, the cross-price elasticities are estimated between -0.15 and -0.36 in the short- and between -0.49 and -1.71 in the long-term.

Again, comparing with the study of Erdogdu (2010), the income elasticity, which is found as 5.11, is greater than this study's estimation in the long-run while the short-run income elasticity estimates of this study and Erdogdu (2010) are similar. In addition, the estimated price elasticities are greater than those found by Erdogdu (2010) in the short-term.

The forecast results of the electricity generation sector suggest that in 2025, the natural gas demand would vary between 22.09 bcm and 27.19 bcm, between 26.95 bcm and 33.48 bcm and between 34.38 bcm and 40.60 bcm according to the low, reference and high case scenarios, respectively, in Turkey (Table 104).

Aggregate natural gas demand: The same methods used to estimate the elasticities for industrial, residential and electricity generation sector are applied to establish the aggregate natural gas demand model. However, due to the cointegration relation among variables cannot be found and the coefficients of the models cannot be estimated statistically significant, the elasticity estimation results are not introduced in this part of the study.

On the other hand, information from the sub-sectors and share of these sectors on total natural gas consumption are utilized to make the predictions of Turkey's future aggregate natural gas demand. As a result of these forecasts, the Turkish aggregate natural gas demand in 2025 would be expected to be between 65.51 bcm and 80.13 bcm, between 82.64 bcm and 104.67 bcm and between 105.56 bcm and 132.35 bcm based on the low, reference and high scenarios, respectively (Table 6.106).

The selected previous aggregate natural gas demand prediction studies in the literature are Erdogdu (2010), Melikoglu (2013) and Boran (2015). Erdogdu (2010) found that the natural gas demand would be 76.2 bcm in 2025 which is in the range of the low case scenario estimations of this study. Furthermore, Melikoglu (2013) used two different models, and he estimated that the aggregate natural gas would be 65.7 bcm and 77.4 bcm by linear and logistic model, respectively, for the year 2025. The results are again similar to the low case predictions of this study. Lastly, Boran (2015) estimated that Turkey's aggregate natural gas demand would be 60.96 bcm in 2018. As a whole, the forecast results of this study for the year 2018 are smaller than that of Boran's (2015) estimation; however, the high case scenario predictions of this study converge the aforesaid research's outcomes.

In addition to all these studies in the literature, there are also some other forecasts made by official institutions for predicting the Turkish aggregate natural gas demand. The results of these predictions are summarized in Table 6.107.

Table 6.107. Official Aggregate Natural Gas Demand Predictions of Turkey

Institution	Prediction Period	Focus of the Study	Prediction Results		
EMRA[11]	2017	Natural Gas Demand	46 bcm in 2017		
MENR[12]	2020	Natural Gas Demand	82 bcm in 2020		
BOTAS[13]	2015-2030	Natural Gas Demand	*2020*	*2025*	*2030*
			65.9 bcm	70.5 bcm	76.4 bcm

[11] Energy Market Regulatory Authority (EMRA), *National Natural Gas Consumption Prediction for 2017*, Retrieved on 4 June 2017 from http://www.epdk.org.tr/tr/duyurular/1924
[12] Ministry of Energy and Natural Resources (MENR), *2002 Yılı Faaliyet Raporu*, Ankara.
[13] Petroleum Pipeline Cooperation (BOTAS), *Natural Gas Demand and Supply Projections*, Retrieved on 4 June 2017 from http://www.botas.gov.tr/

According to these results, EMRA predicted smaller natural gas demand than all scenario estimations of this study for 2017. On the other hand, the aggregate natural gas demand forecast of MENR is greater than this study's predictions for 2020. Furthermore, the estimation of BOTAS is similar for 2020 but in general smaller than this study's forecasts for 2025.

Consequently, this part of the study covers the elasticity estimations for electricity and natural gas demand with regards to the sub-sectors. The estimated elasticities are then used for making predictions for all sectors and aggregate levels up to 2025. The results obtained in this chapter are expected to be significant for policymakers and actors to analyse the Turkish energy sector and have a general idea about the framework of electricity and natural gas demand in Turkey. Therefore, the outcomes of this study should be taken seriously in terms of implementing the future energy policies in Turkey about energy dependence, energy security, consumption habits, etc.

CHAPTER 7. SUMMARY AND CONCLUSIONS

7.1. Introduction

This thesis has analysed Turkey's electricity and natural gas demand models by using five econometric methods which are Engle-Granger Two-Step, Fully Modified Ordinary Least Squares, Johansen Cointegration, Auto Regressive Distributed Lag Bounds Testing, and Structural Time Series Modelling, respectively. In addition to aggregate demands, the results for sectoral electricity (industrial and residential) and natural gas (industrial, residential and electricity generation sector) demand were presented in this study. Furthermore, the estimated demand elasticities were used to forecast possible future energy demand for all sectors up to 2025.

Chapter 1 introduces the significant role of energy usage in daily life and the importance of energy demand studies for nations, policymakers, and market participants. In this chapter, the research questions and objectives of the thesis are also given. Chapter 2 examines the theoretical framework of energy demand modelling. In this context, the factors that affect the energy demand are discussed, and the main characteristics of energy demand models are explained. Chapter 3 provides an overview of Turkey's electricity and natural gas demand on aggregate levels and sectoral basis. Chapter 4 reviews the empirical literature on energy demand modelling and forecasting both in some selected countries and in Turkey. Chapter 5 presents the methodologies and data used in this thesis. Chapter 6 shares the results of elasticity estimates and demand forecasts for Turkey. Finally, this chapter summarises and concludes the thesis. In the next section, answers to the research questions are given. The chapter ends up with a brief conclusion and recommendation part.

The main reason for using all the above-mentioned methods together is to compare the performances of them in terms of estimating the elasticities and also forecasting the future energy demand. In this way, the strengths and weaknesses of different methods that are used can be revealed. First four approaches (EG Two-Step, FMOLS, Johansen and ARDL Bounds Testing) are classified as conventional cointegration methods. On the other hand, the STSM method is different from these conventional techniques in terms of estimating the unobservable components of energy demand rather than income and price. The STSM/UEDT approach enables to be included the stochastic trend into the model, and so the impact of important factors such as economic structure, consumers' preferences, and environmental issues can be captured in a non-deterministic way. This allows determining the major structural changes in the energy demand trend.

In the light of the information mentioned above, the decision can be made about the performances of the methods used in this study by considering the answers of the research questions which are listed in the next section.

7.2. Answers to the Research Questions

Based on the research questions given in Chapter 1, the appropriate answers for the elasticity estimations are presented as below:

Question 1: What are the short-term price and income elasticities of electricity demand for Turkey?

For the Industrial Sector: The short-term price elasticities of industrial electricity demand vary between -0.11 and -0.06. On the other hand, the short-run income elasticities range from 0.12 to 0.32. Both the price and income elasticities of electricity demand are smaller than 1 for Turkish industrial sector. This means that consumers in this sector have not changed their behaviour very much in the short-term in response to the price and income variations.

For the Residential Sector: The short-run price elasticities for Turkish residential electricity demand is only found by the FMOLS and STSM/UEDT methods as -0.21 and -0.07, respectively. In addition, the income elasticities are estimated between 0.16 and 0.33. As a result, the price and income elasticities of residential sector electricity demand are inelastic in the short-term.

For the Aggregate Demand: The price elasticities for the aggregate electricity demand have been estimated as -0.07 (FMOLS and STSM/UEDT) and -0.06 (Johansen) in the short-run. In other words, the estimated price elasticities are close to each other in the short-term. In the case of income elasticities, the estimations range between 0.24 and 0.41. The income elasticities of aggregate electricity demand are, in general, greater than that of both industrial and residential sector. However, they have been calculated smaller than 1 again, and thus, it can be said that the price and income changes have not notably affected the aggregate electricity consumption in the short-term.

Question 2: What are the long-term price and income elasticities of electricity demand for Turkey?

For the Industrial Sector: In the long-term, the price elasticities for Turkey's industrial sector change between -0.08 and -0.01. In terms of income elasticities, conventional cointegration methods have estimated bigger values (between 0.26 and 0.49) than the STSM/UEDT approach (0.12) for the long-run. As is in the short-term, the price and income elasticities for the Turkish industrial sector have been found as smaller than 1 in the long-term. This means that price and income changes have not overly affected the electricity consumption habits in Turkey's industrial sector.

For the Residential Sector: The price elasticities for the residential electricity demand vary between -0.36 and -0.13 in the long-term. Except for the Johansen method (-0.36), the price elasticities are close to each other for Turkish residential sector in the long-run. On the other hand, while the income elasticities found by conventional cointegration approaches (between 1.63 and 2.01) are convergent, the result of the STSM/UEDT method (0.39) is quite smaller than that of the cointegration methods. As it is seen, the results are greater than 1, especially in terms of income elasticities. In other words, the income elasticities are elastic (except the STSM/UEDT method's result). In addition, the price and income elasticities of residential electricity demand have been calculated greater than the industrial sector in the long-term. This means that consumers in the residential sector can be more sensitive to the price and income variations than that of the industrial sector.

For the Aggregate Demand: Finally, the price elasticities of aggregate electricity demand for Turkey range between -0.17 and -0.07 in the long-run. While the Johansen and ARDL Bounds Testing methods are failed to estimate the long-term price elasticities, Engle-Granger Two-Step, FMOLS and STSM/UEDT approaches have found the elasticities as -0.17, -0.10, and -0.7, respectively. In terms of the long-term income elasticities, the values are in the range between 0.24 and 0.48. As a result, the estimated price and income elasticities for the aggregate electricity demand have been determined as greater than the industrial sectors' but smaller than the residential sectors' in the long-run.

Question 3: What are the short-term price and income elasticities of natural gas demand for Turkey?

For the Industrial Sector: The short-term own-price elasticities for industrial natural gas demand vary between -0.71 and -0.48. On the other hand, the cross-price (electricity price) elasticities for this sector were estimated between 0.47 and 1.02. Furthermore, the income elasticities are in the range between 1.03 and 2.04 in the short-run. These results show that while the own- and cross-price elasticities are found as inelastic, the income elasticities are classified as elastic since they are greater than 1 in the short-term. That is to say, changes in the income are more effective than the price variations for the Turkish industrial sector in the short-run. In addition, positive cross-price elasticities present that natural gas and electricity are substitute goods for the Turkish industrial sector.

For the Residential Sector: For the short-term, own-price elasticities of Turkish residential natural gas demand were properly estimated by only two methods, namely Johansen (-0.46) and STSM/UEDT (-0.55). In contrast to the own-price elasticities, the cross-price elasticities were estimated by all methods used. However, contrary to the expectations, the value found by the ARDL Bounds Testing approach were calculated as negative (-0.79). Apart from this, the cross-price (electricity price) elasticities range from 0.78 to 2.32 in the short-term. The short-run income elasticities, on the other hand, were computed in the range between 0.79 and 3.40. Consequently, the outcomes indicate that in the short-term, there was no significant difference between the residential and other sectors in terms of natural gas demand elasticities.

For the Electricity Generation Sector: The own-price elasticities of the electricity generation sector's natural gas demand were found as positive and between the values of 0.21-0.23. This situation can be specified unusual as being in contrast to the economic theory (for the details see Chapter 6). On the other hand, the cross-price (coal price) elasticities were estimated as negative contrary to the expectations and varied between -0.36 and -0.15 in the short-run. In addition, the short-term income elasticities of electricity generation sector natural gas demand found to be lower than that of the industrial and residential sectors and have ranged between 0.15 and 0.47. As a result, in the short-run, the smallest income elasticities belong to the electricity generation sector among the sectors that use natural gas.

For the Aggregate Demand: In terms of aggregate natural gas demand, the appropriate elasticity estimates could not be found for the short-term (for the details see Chapter 6).

Question 4: What are the long-term price and income elasticities of natural gas demand for Turkey?

For the Industrial Sector: According to the own-price elasticity results for the long-term industrial natural gas demand, the minimum and maximum values were estimated as -0.94 and -0.23 by FMOLS and Johansen method, respectively. In addition to this, the cross-price elasticities range between 0.28 and 0.74 in the long-run. In terms of the income elasticities of industrial natural gas demand, the estimations vary from 0.79 to 1.41. The results show that own- and cross-price elasticities are inelastic which indicates that the price variations in natural gas and electricity have a small effect on natural gas consumption. On the other hand, the long-term income elasticities in this sector were found close to or greater than 1. All in all, the short-term income, own-price and cross-price elasticities were estimated more than that of in the long-term.

For the Residential Sector: The long-term price elasticities for residential natural gas demand are in the range between -5.02 and -1.21. Moreover, long-run cross-price elasticity estimates have changed from 1.19 to 3.38. Additionally, long-term income elasticities were estimated between 2.53 and 5.51. One remarkable fact of these results is that all elasticity estimations were found greater than 1. In other words, own-price, cross-price, and income elasticities were computed as elastic which means that one-unit change in households' income level or prices of electricity and natural gas have caused increases or decreases to the residential natural gas consumption more than one-unit. Furthermore, the price and income elasticities in the residential sector were estimated higher than the other sectors, especially for the long-term. This indicates that natural gas demand of the consumers in the residential sector is found more responsive to the price and income changes than that of the industrial and electricity generation sector.

For the Electricity Generation Sector: In terms of the electricity generation sector, the own-price elasticities of natural gas demand range between 1.24 and 3.38 in the long-run. As is in the short-run, the long-run own-price elasticities were also estimated as positive. This situation can be explained by the usage of "cost-pass-through" principle in Turkey's electricity generation sector (for the details see Chapter 6). On the other hand, the cross-price elasticities were found as negative and varied between -1.71 and -0.49 in the long-term. In addition, the long-term income elasticities for the electricity generation sector are in the range between 0.37 and 2.55. As a result, while the long-term own-price elasticities of the electricity generation sector were found greater than that of the short-term, the cross-price elasticity outcomes show a tendency in contrast with the situation in own-price elasticities. In terms of income, the long-run elasticities were estimated greater than the short-run elasticities except for the Johansen method's estimation result.

For the Aggregate Demand: As is the case in short-term, conventional cointegration approaches and STSM/UEDT method were unable to calculate statistically significant elasticity estimates for the long-term aggregate natural gas demand (for the details see Chapter 6).

Question 5: Do the price and income elasticities vary across the methods that used in short- and long-term?

According to the results obtained from elasticity estimations, the answer to this question is 'yes' in the simplest form. In other words, price and income elasticities have shown different tendencies between the periods (short and long) with respect to the methods used in this study.

For instance, while the short-term price elasticities (in absolute values) of industrial electricity demand are greater than the long-term elasticity values, income elasticities in the long-run are greater than the short-run values. On the other hand, the long-term residential electricity demand's price elasticities are greater than that of the short-run elasticity estimations. In addition, the long-run income elasticities for residential electricity demand are found bigger than the short-run elasticities. Furthermore, the long-run price (in absolute terms) and income elasticities of aggregate electricity demand are estimated greater than the short-run elasticities.

In addition, the speed of adjustment estimates of this study verify the difference between short- and long-term elasticities. In general, the long-run elasticities are found to be greater than the short-run ones. This means that any disequilibrium in the short-term will be adjusted and the model will reach the balance in the long-term. This fact is explained as the speed of adjustment factor in the thesis.

In the context of natural gas demand elasticities, different from the electricity elasticity estimations, the cross-prices are added to the models. The results for the industrial natural gas demand own-price elasticities indicate that long-term elasticities are greater than short-term elasticities, except for the Johansen method's outcomes. The long-term cross-price and income elasticities for the industrial sector, on the other hand, are smaller than the short-term counterparts. In terms of residential and electricity generation sectors' natural gas demand elasticities, the estimation results show that all of the elasticities (own-price, cross-price, and income) are found greater in the long-run than in the short-run. Finally, since there are no appropriate and significant elasticity estimations, comments on price and income variations cannot be made in terms of aggregate natural gas demand.

The estimated elasticities for electricity and natural gas demand by different methods are discussed below:

For the industrial electricity demand: While the short-run price elasticities are close to each other, the Engle-Granger Two-Step method has estimated smaller value than the other methods for the long-run. The short- and long-term income elasticities show close estimates except for the STSM/UEDT method's result.

For the residential electricity demand: The smallest estimates in terms of the price elasticities belong to STSM/UEDT method. The average short-term income elasticity based on the methods that used is 0.24. In this sense, the ARDL Bounds Testing method's result (0.16) is far away from the average value. On the other hand, while the estimation results of conventional cointegration methods for the long-term income elasticities have approximate values, the STSM/UEDT approach's value (0.39) is quite small.

For the aggregate electricity demand: Price elasticities found by the FMOLS and STSM/UEDT methods are smaller than the elasticities obtained by other methods. In terms of income elasticities, the Johansen method's estimation results (0.24) are the same in both the short- and long-term. In addition, these values are the smallest ones among the others.

From this point of view, it is possible to deduce that price elasticities (in absolute terms) found by the STSM/UEDT method for electricity sectors are relatively small compared to other methods.

On the other hand, the estimation results for natural gas demand elasticities are presented as follows:

For the industrial natural gas demand: Own-price elasticities found by the Johansen method are the smallest ones in both the short- and long-run. In addition, Engle-Granger Two-Step (for the short-term) and FMOLS method (for the long-term) have found relatively greater price elasticities than the others. In terms of cross-price elasticities, the values estimated by the Engle-Granger Two-Step, Johansen and STSM/UETD methods approximate. On the other hand, while the smallest income elasticity is computed by the FMOLS approach in the short-run, the Engle-Granger Two-Step method has found the minimum value in the long-run.

For the residential natural gas demand: According to the own-price elasticity results, while the maximum estimate is found by the STSM/UEDT approach, the Johansen method has computed the minimum value for the short-term. On the other hand, the smallest and greatest own-price elasticity estimations have been obtained by STSM/UEDT and Johansen approaches, respectively for the long-term. In addition to this, the greatest cross-price elasticities have been estimated by the FMOLS method for both short- and long-term. Moreover, while negative cross-price elasticity estimate is found by the ARDL Bounds Testing method (-0.79) for the short-run in contrast with the other methods, the minimum cross-price elasticity value has been calculated by the Johansen approach as 1.19 except the one found by the ARDL Bounds Testing method. The short-term income elasticity estimates of the Engle-Granger Two-Step, ARDL Bounds Testing, and STSM/UEDT methods are close to each other. Furthermore, the smallest long-run income elasticity was estimated by the STSM/UEDT method (2.53) which is almost half of the values that obtained by the Engle-Granger Two-Step, FMOLS and ARDL Bounds Testing approaches.

For the electricity generation sector natural gas demand: Given the own-price elasticity estimates for electricity generation sector, the one that computed by the STSM/UEDT method is the smallest for both short- and long-term. In addition, the Johansen method's long-run own-price elasticity (3.38) is quite more than the other estimation results. In terms of cross-price elasticities, the ARDL Bounds Testing method's result is the smallest one in the short-term but greatest in the long-term. Finally, the short-run income elasticities show close estimates except for the one that calculated by the FMOLS method. On the other hand, for the long-term income elasticities, while the result of the Johansen method has the minimum value with 0.37, the maximum estimate belongs to the Engle-Granger Two-Step method by 2.55.

All in all, the long-term price (except the one in industrial electricity demand) and income (except the one in industrial natural gas demand) elasticities are greater than that of the short-term in a general manner. This means that in the long-term, consumers in electricity and natural gas markets give more reaction to the price and income changes than in the short-term.

Question 6: Are there any advantages of using the STSM/UEDT concept rather than the conventional cointegration techniques?

As discussed in the previous chapters, energy is a derived demand which is not demanded for its own sake. In this sense, there are various exogenous factors that affect the energy demand. Therefore, without taking into consideration of these effects, the estimation results may be spurious. Estimation of the exogenous variables, such as technical progress, consumer tastes, and economic structure is quite difficult in a linear framework. However, the flexible structure of the STSM/UEDT concept enables to measure the effects of these exogenous variables (for the details see Chapter 5). In addition, through the estimated UEDTs, the unobserved energy demand trend can be seen by holding income and price constant. Consequently, this situation provides an advantage to analyse the exogenous factors that affect the energy demand behaviour.

Question 7: What is the main difference of using stochastic trend instead of deterministic one in terms of estimating elasticities of energy demand?

In statistical and econometric theory, stochastic trend models are favoured to the deterministic ones since including the unobserved components in the estimations. In terms of estimating Turkish electricity and natural gas demand models, using a stochastic trend has caused the parameters to be more statistically significant than the models that used a deterministic trend (for the details see Chapter 6).

Question 8: What is the best method and the most convenient specification for estimating Turkey's energy demand models?

In terms of conventional cointegration models that used in this study, each method has a number of advantages over the others. For instance, the FMOLS method gives more consistent estimation results than the Engle-Granger Two-Step approach in terms of finite samples. In addition, the inference problem of the Engle-Granger Two-Step method is solved in the FMOLS method by introducing appropriate corrections to the models (for the details see Chapter 5). Furthermore, the Johansen cointegration method is superior to the above techniques since it enables to analyse all possible cointegration vectors instead of only the main cointegrating vector. Moreover, the ARDL Bounds Testing method has significant advantages than the Engle-Granger Two-Step and Johansen approaches. For example, the order of integration is not important in the ARDL Bounds Testing method when estimating the model (the variables might be *I(0)* or *I(1)*, but not *I(2)*). In addition, the dynamic structure of the ARDL Bounds Testing method allows to select an optimal lag length for each variable and to analyse the short- and long-run relations at once. Consequently, as indicated above, the conventional cointegration methods show differences from each other in terms of statistical properties.

On the other hand, comparing with the above-mentioned methods, the STSM/UEDT approach also has different properties. These properties are discussed in Chapter 5 in detail. To sum up them, the series used in the STSM/UEDT method does not need to be checked by unit root tests since the order of integration for the variables are not important. Furthermore, the short- and long-run relationships can be investigated by one equation. In addition to this, the dynamic structure of this method enables to determine the structural breaks of the series. Lastly, rather than deterministic trend, the unobservable stochastic trend can be seen by this method.

In brief, by only evaluating the statistical properties of the methods used in this thesis, it can be said that the STSM/UEDT approach has some significant advantages over the traditional cointegration methods. Therefore, it can be preferred to the cointegration methods for estimating the energy demand models. In addition, the results of the empirical analyses of this study support this argument. Especially the income elasticities for industrial and residential electricity demand found by the STSM/UEDT method are smaller than that of other methods. This means that adding a stochastic trend to the model as a determinant of technical progress might yield more reliable and unbiased estimations for the elasticities. Furthermore, the STSM/UEDT method's own-price elasticity estimations for the natural gas demand, in general, are lower (in absolute terms) than the conventional cointegration approaches' results. In other words, the real effects of price on natural gas consumption can be said to be overestimated by the conventional cointegration methods.

That being said, the STSM/UEDT is the best method among others used in this thesis and the most convenient specification for estimating the energy demand models of Turkey both theoretically and empirically. The methodological framework and the analyses results of this study are such as to support the above-mentioned argument.

In addition to the elasticity estimation questions, the proper answers for the prediction questions are as follows:

Question 9: What are the prediction results of Turkey's future sectoral and aggregate electricity demand?[14]

For the Industrial Sector: It is forecasted that Turkey's industrial electricity demand will be between 109760-143464 GWh, 116447-150548 GWh, and 122872-163308 GWh in 2025 according to the low, reference and high scenarios, respectively. For all scenarios, while the lowest predictions are made by the FMOLS method, the STSM/UEDT approach has obtained the highest values.

For the Residential Sector: Turkish residential electricity demand for the year of 2025 is estimated to be between 67609-90861 GWh in the low scenario, between 90929-104775 GWh in the reference scenario, and between 95983-124331 GWh in the high scenario. In the low scenario, the lowest and highest predictions were made by the FMOLS and ARDL Bounds Testing method, respectively. In the reference scenario, while the minimum estimation was obtained by the STSM/UEDT method, the maximum value has estimated by the ARDL Bounds Testing approach. In high scenario, the smallest forecast was estimated

[14] Only a short summary of the prediction results for Turkey's electricity demands are given in this part of the study. The comparisons of these results with the outcomes of past studies and authorized institution were made in the "Summary and Conclusion" part of Chapter 6.

by the STSM/UEDT method, and the greatest forecast was obtained by the Engle-Granger Two-Step method.

For the Aggregate Electricity Demand: In 2025, Turkey's aggregate electricity demand is forecasted to be between 307029-347127 GWh, 317143-362511 GWh, and 332072-393365 GWh based on the low, reference, and high scenarios, respectively. Similar to the industrial electricity demand forecast, the FMOLS and STSM/UEDT methods have found the minimum and maximum prediction results, correspondingly.

Question 10: What are the prediction results of Turkey's future sectoral and aggregate natural gas demand?[15]

For the Industrial Sector: The forecast results for the industrial sector show that in 2025, the natural gas demand will be between 17.10-23.43 bcm, 21.25-29.98 bcm and 23.31-39.14 bcm with respect to the low, reference and high scenarios, respectively. For all scenario cases, while the lowest estimation results are obtained from the Engle-Granger Two-Step method, the STSM/UEDT approach's predictions are the highest ones.

For the Residential Sector: According to the prediction results for the Turkish residential sector natural gas demand for 2025, in terms of the low case scenario, the minimum and maximum estimates were made by the ARDL Bounds Testing method (15.15 bcm) and the STSM/UEDT approach (17.68 bcm), respectively. On the other hand, based on the reference and high scenarios, the lowest forecasts were estimated by the FMOLS method (18.84 bcm for the reference scenario and 28.75 bcm for the high scenario), while the highest values were forecasted by the STSM/UEDT method (25.76 bcm for the reference scenario and 33.08 bcm for the high scenario).

For the Electricity Generation Sector: The possible future natural gas demand for the electricity generation sector for 2025 will be between 22.09 bcm and 27.19 bcm, between 26.95 bcm and 33.48 bcm, and between 34.38 bcm and 40.60 bcm according to the low, reference and high scenarios, respectively. While the greatest prediction results were obtained by the STSM/UEDT approach, the ARDL Bounds Testing method has found the

[15] As is in the electricity demand, the comparisons of prediction results for natural gas demands were made in Chapter 6.

smallest estimation in the low case scenario, and additionally, for the reference and high scenarios the lowest values were estimated by the Johansen method.

<u>For the Aggregate Natural Gas Demand:</u> The aggregate natural gas demand in 2025 is estimated to be between 65.51-80.13 bcm in the low scenario, between 82.64-104.67 bcm in the reference scenario, and between 105.56-132.35 bcm in the high scenario. In the aggregate level, the STSM/UEDT method's prediction results for each scenario have the maximum values, as are in the sectoral natural gas demand forecasts. On the other hand, the minimum value for the low scenario was estimated by the Engle-Granger Two-Step method. Furthermore, the lowest forecasts for both reference and high scenarios were made by the FMOLS approach.

Question 11: Do the prediction results differ based on the methods that used?

In this study, three different scenarios were used, namely low, reference and high for forecasting the future energy demand of Turkey (for the details see Chapter 5 and 6). Since the assumptions of these scenarios and the elasticity estimates of the several methods are different from each other, prediction results of the methods used have also differed.

As indicated in the previous research questions (Question 9 and 10), in terms of the sectoral and aggregate energy demand the maximum and minimum prediction results are changed based on the methods. However, one of the most notable results in terms of electricity and natural gas demand forecasts is that the projections made by the STSM/UEDT method have the greatest values for all sectors and all scenarios (except for the prediction of residential electricity demand). This means that, in general, without introducing the technical progress, consumer preferences, and economic structure to the model, the forecast results were found smaller. Therefore, it can be said that the STSM/UEDT method's forecast calculations give more reliable and consistent results.

7.3. Conclusion and Recommendations

Energy is a very significant factor for modern economies in today's world. Therefore, for nations, estimating how much energy that needs to be consumed is as important as energy itself. After the first oil shock in 1973, studies measuring the energy demand have gained popularity since countries have wanted to know the quantity of energy that they need. Since then, experts in the market have been studying on modelling and forecasting the demand for energy to provide the security of energy supply on behalf of the consumers. The reason is that the actors in the energy markets know that the energy resources are unsustainable. Since energy scarcity and security are two major issues that developing economies faced, the appropriate and correct energy demand modelling procedures become significant.

In Turkey, this procedure is by far important because of the fact that Turkey's energy dependence to external resources is almost 75 percent. In addition, Turkey's energy expenditures are considerably high as a result of this extreme external dependence rate. For this reason, modelling and forecasting accurate energy demand for Turkey is as crucial as decreasing this high energy dependence by using domestic sources.

In this study, the two energy types (electricity and natural gas) used in Turkey are analysed. The main reason for choosing electricity and natural gas as a research subject is that almost half of Turkey's total final energy consumption is met from them (for the details see Figure 3.3 in Chapter 3). Therefore, these energy types constitute an important part of Turkey's energy demand portfolio. In addition, as a developing country, Turkey's economy is highly dependent on energy, and thus, the understanding of energy consumption behaviour and possible future energy demand trends are vital for both consumers and authorities. For this reason, it is aimed to obtain the estimation of reliable results for the energy demand in this thesis.

One of the most significant objectives of this study is to compare the performances of different econometric techniques in estimating the demand elasticities and forecasting future energy demand for Turkey. Considering the econometric methods that used in here, the STSM/UEDT approach has come into prominence in the point of methodology and application. This method provides some advantages not only for the calculation of elasticities but also for the prediction of demand. In addition, due to the usage of a stochastic trend in STSM/UEDT approach instead of the deterministic one, several components that cannot be estimated by the conventional cointegration methods can be included in the model. Furthermore, the estimated UEDT line guides in terms of predicting the future energy demand.

All in all, the conventional cointegration methods and the STSM/UEDT approach are compared in this study. Consequently, it is concluded that with regards to modelling and forecasting Turkey's energy demand, the STSM/UEDT method has given statistically more significant results in comparison with the other methods used in this research.

By considering all the results of this study, the elasticity estimates and the prediction outcomes can be summarized as follows:

- The price elasticities for electricity demand are in general estimated close to zero for the industrial, residential and aggregate level. This means that the price changes are not very effective on electricity demand for these sectors. In terms of income, the estimates show that all elasticities are found between 0 and 0.5 except the long-run residential income elasticities. Therefore, it can be said that residential customers are more sensitive to the income changes than the other sectors in the long-run.

- For the natural gas demand, on the other hand, while the industrial price elasticities are smaller than 1 for both short- and long-term, especially the long-term residential price elasticities were estimated greater than 1 in absolute value. These results indicate that price changes are more effective in the residential sector than in the industrial. Beside this, contrary to the economic theory, unexpected results are obtained for the price elasticities of electricity generation sector. The price elasticities were found as positive which means the price and demand increases or decreases move in the same direction. This situation can be explained by the cost-pass-through principle for the electricity generation sector (for the details see Chapter 6). In addition, the elasticities of the residential sector regarding to the income are greater than the other sectors. In other words, as is the case with the price elasticities, the households were observed as more sensitive to the income changes than the other sectors.

- When considering the forecast results of this study, average forecasts of the reference case scenario for the industrial, residential and aggregate electricity demand are expected to be 125972 GWh, 96860 GWh, and 345252 GWh, respectively, in 2025. In addition, the average natural gas demands for the reference case in 2025 are estimated to be 25.24 bcm, 21.93 bcm, 29.71 bcm, and 90.19 bcm in terms of industrial, residential, electricity generation sector, and aggregate level, respectively. These results show some similarities and differences when compared to previous research. For instance, the aggregate electricity demand prediction made by TEİAŞ (2015b) is greater than this study. Moreover, while Kiran et al. (2012) found smaller estimations than this thesis, Dilaver and Hunt (2011c) obtained higher prediction results than this study for the year of 2020. On the other hand, Erdogdu (2010) and Melikoglu (2013) achieved similar results with this study for the aggregate natural gas demand. However, the predictions of Boran (2015) are greater than that of this research for 2018. According to the results of official institutions, for 2020, while the estimations in here are found as greater than EMRA's and MENR's, the prediction of BOTAS is similar to this study. Moreover, BOTAS's forecast for the year 2025 is smaller than the estimation results of this thesis (for the details see Chapter 6 and Table 6.107).

Given the results of this study, the following inferences can be taken into consideration by the authorities for improving and developing the energy market in Turkey.

- In general, the price and income elasticities of natural gas demand are higher than the electricity demand elasticities. This result indicates that electricity and natural gas consumers respond differently to the price and income changes. While the electricity consumers do not easily change their consumption behaviour by the increases and decreases in their income or the price of electricity, natural gas consumers are more sensitive to the income and price variations than the electricity sector. Therefore, when making policy about the energy market, consumer trends should be considered.

- In terms of electricity demand, while the difference between the short- and long-run income elasticities are not very much for the industrial sector, there is a marked difference between the periods in the residential sector. In the light of these results, policymakers can have a position. For instance, long-term price-fixing contract system may be applied. In this way, especially in the residential sector, the big differences between short- and long-term elasticities can be reduced.

- For the natural gas demand, the own-price elasticities of the industrial sector are close to each other in the short- and long-run. This shows that the consumers in the industrial sector do not change their consumption behaviour among the periods. On the other hand, in terms of the residential and electricity generation sector, price elasticities in the long-term are much more than those in the short-term. Therefore, when making policies for the long-run, the structure of these two sectors can be taken into consideration.

- The price elasticities of natural gas demand in the electricity generation sector were found as positive and considerably high, especially in the long-term. This is because of the natural gas used in this sector are mainly imported from the external suppliers and the price is determined by the average of import prices. Therefore, the high dependency rate on natural gas in this sector should be decreased gradually. In this respect, the usage of domestic coal, nuclear power, and renewable energy resources need to be prioritized in electricity generation.

- One significant outcome of this study is about the residential sector's elasticities. The price and income elasticities of households are greater than the other sectors both in electricity and natural gas demand. This means that households are more sensitive to price and income changes than the other sectors. In terms of electricity and natural gas used in residentials, some applied price regulations such as price floor and price ceiling may be improved to provide an efficient price control mechanism.

- In this thesis, along with the own price, the cross-price elasticities were examined for the natural gas. As a result of these analyses, the natural gas and electricity were found to be substitute goods for the industrial and residential sectors. On the other hand, the natural gas and coal were classified as complementary goods for the electricity generation sector. These inferences might be true theoretically since positive or negative cross-price elasticities show the categorization of these commodities in economic sense. However, there are some technical barriers in front of these substitution and complementary effects in terms of energy economics. Firstly, the usage areas of these commodities differ. For instance, people use natural gas for heating and electricity for lighting in the residential sector. Secondly, these commodities are necessary goods. In other words, individuals and/or institutions have to use these resources in order to achieve the energy. Therefore, even if the empirical results of this study classify the natural gas, electricity and coal as substitute or complementary, these analyses cannot be said to be a substitutability or complementarity in real terms considering from the microeconomics perspective.

- According to the prediction results of this study, in 2025, the expected average aggregate electricity and natural gas demands will be about 350000 GWh and 100 bcm, respectively. Therefore, the installed power capacity and natural gas infrastructure need to be improved in parallel with the increase in the demand. In this context, the existing nuclear power and renewable energy investments should be increasingly continued. In addition, the exploration and drilling activities require to proceed. Turkey has a substantial amount of shale gas reserves especially in the South-eastern Anatolia and Thrace regions. The potential of these two regions in terms of shale gas is approximately 650 bcm which can meet the increasing demand for natural gas in the next 10-15 years (EIA, 2013). However, Turkey is faced with some technological barriers in terms of drilling equipment. To achieve economic benefit from these resources the required technological progress should be provided, and wide-ranging investment incentives should be implemented.

- Turkey is importing almost all of its natural gas need from external suppliers, and this situation brings along some political and economic risks. To overcome these risks and to ensure the security of energy supply, source-country diversification should be increased. According to the results of this study, the natural gas demand will increase approximately to 100 bcm in the next 10 years. This quantity is almost double of current consumption. In this sense, it is very significant to be added new ones to the projects like TANAP and TurkStream for continuous and sustainable energy supply. Also, these projects would play an important role in Turkey's target of being an energy centre. On the other hand, to decrease Turkey's high energy dependency on external energy resources, production and consumption by domestic energy resources should be promoted. In this way, both energy expenditures will be reduced, and energy supply security will be provided.

- To meet the high electricity and natural gas demand in the future, it is necessary to develop effective policies based on the usage of energy resources as efficiently. The "National Energy Efficiency Action Plan" shows that the Ministry of Energy and Natural Resources is aimed to save almost 8.4 billion dollars in energy expenditures up to 2023 (MENR, 2017b). This quantity is approximately 20% of Turkey's ten years average energy expenditure (for the details see Chapter 3). For this reason, in Turkey, the efficient usage of energy is vitally important in terms of the policies that developed for satisfying the energy demands. In addition, based on the results of this study, the energy prices are not very effective on consumption. Therefore, to overcome the high energy expenditures, some non-price mechanisms should be implemented such as energy efficiency.

Along with all these inferences, Turkey should determine the priority energy resources to compete with the world in terms of energy. In this respect, the potential of renewable energy sources such as wind, solar, geothermal, biomass, and hydro should be utilized as soon as possible. In addition, the geostrategic location of Turkey provides a significant advantage to the country in terms of being an energy trade centre. Therefore, it is crucial for Turkey to develop the domestic energy infrastructure as well as to take an active role in international energy transfer projects. As a result of these efforts, Turkey will make progress in the fields of ensuring the security of energy supply, decreasing the energy expenditures, producing energy in domestic sources and being effective in global energy markets.

Finally, this thesis is believed to contribute the energy demand literature since it compares the different econometric approaches in modelling Turkey's electricity and natural gas demand equations. However, there are still research fields to improve the literature. The future researches could analyse further sub-sectors such as manufacturing, agriculture, and transportation to understand Turkey's energy demand structure better and deeper. The general framework can be formed more comprehensively by performing the modelling and forecasting analyses of these sectors. In addition, monthly or quarterly data can be used instead of annual data to perceive the differences between them. Then, the results obtained from monthly or quarterly data sets can be compared to the estimations made by using annual data. Furthermore, adding the cross-prices to the demand models, as are in the natural gas analyses of this study, would be helpful to observe the real effects of the variables on energy demand.

Consequently, as it is mentioned above, this thesis is expected to fill a gap in the energy demand literature. Therefore, the results, inferences, and projections obtained by this study should be of particular importance for researchers, academicians, and policymakers to guide long-term energy plans and to help in understanding the future energy demand trends.

REFERENCES

Adacay, F. R. (2014). Türkiye İçin Enerji ve Kalkınmada Perspektifler. [Perspectives in Energy and Development for Turkey]. *Aksaray Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *6*(2), 87-103.

Adeyemi, O. I., & Hunt, L. C. (2014). Accounting for Asymmetric Price Responses and Underlying Energy Demand Trends in OECD Industrial Energy Demand. *Energy Economics*, *45*, 435-444.

Agnolucci, P. (2009). The Energy Demand in the British and German Industrial Sectors: Heterogeneity and Common Factors. *Energy Economics*, *31*(1), 175-187.

Akay, D., & Atak, M. (2007). Grey Prediction with Rolling Mechanism for Electricity Demand Forecasting of Turkey. *Energy*, *32*(9), 1670-1675.

Akinboade, O. A., Ziramba, E., & Kumo, W. L. (2008). The Demand for Gasoline in South Africa: An Empirical Analysis Using Co-Integration Techniques. *Energy Economics*, *30*(6), 3222-3229.

Altinay, G., & Karagol, E. (2005). Electricity Consumption and Economic Growth: Evidence from Turkey. *Energy Economics*, *27*(6), 849-856.

Altinay, G. (2007). Short-Run and Long-Run Elasticities of Import Demand for Crude Oil in Turkey. *Energy Policy*, *35*(11), 5829-5835.

Altinay, G., & Yalta, A. T. (2015). Estimating the Evolution of Elasticities of Natural Gas Demand: The Case of Istanbul, Turkey. *Empirical Economics*, *51*(1), 201-220.

Alves, D. C., & da Silveira Bueno, R. D. L. (2003). Short-Run, Long-Run and Cross Elasticities of Gasoline Demand in Brazil. *Energy Economics*, *25*(2), 191-199.

Arisoy, I., & Ozturk, I. (2014). Estimating Industrial and Residential Electricity Demand in Turkey: A Time Varying Parameter Approach. *Energy*, *66*, 959-964.

Asche, F., Nilsen, O. B., & Tveterås, R. (2008). Natural Gas Demand in the European Household Sector. *The Energy Journal*, *29*(3), 27-46.

Athukorala, P. W., & Wilson, C. (2010). Estimating Short and Long-Term Residential Demand for Electricity: New Evidence from Sri Lanka. *Energy Economics*, *32*, S34-S40.

Bakırtas, T., Karbuz, S., & Bildirici, M. (2000). An Econometric Analysis of Electricity Demand in Turkey. *METU Studies in Development*, *27*(1-2), 23-34.

Balestra, P., & Nerlove, M. (1966). Pooling Cross Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas. *Econometrica, 34*(3), 585-612.

Baltagi, B. H., & Griffin, J. M. (1983). Gasoline Demand in the OECD: An Application of Pooling and Testing Procedures. *European Economic Review*, *22*(2), 117-137.

Beenstock M., Goldin E., & Nabot D. (1999). The Demand for Electricity in Israel. *Energy Economics*, *21*(2), 168-183.

Bentzen, J., & Engsted, T. (1993). Short- and Long-Run Elasticities in Energy Demand: A Cointegration Approach. *Energy Economics*, *15*(1), 9-16.

Bernstein, R., & Madlener, R. (2011). Residential Natural Gas Demand Elasticities in OECD Countries: An ARDL Bounds Testing Approach. FCN Working Paper no. 15/2011.

Bernstein, R., & Madlener, R. (2015). Short- and Long-Run Electricity Demand Elasticities at the Subsectoral Level: A Cointegration Analysis for German Manufacturing Industries. *Energy Economics*, *48*, 178-187.

Bhattacharyya, S. C. (1996). Applied General Equilibrium Models for Energy Studies: A Survey. *Energy Economics*, *18*(3), 145-164.

Bhattacharyya S. C., & Timilsina G. R. (2009). Energy Demand Models for Policy Formulation: A Comparative Study of Energy Demand Models. *The World Bank Policy Research Working Paper Series*. No: 4866.

Bhattarai M. (2004). *Irrigation Kuznets Curve Governance and Dynamics of Irrigation Development: A Global Cross-Country Analysis from 1972–1991*, International Water Management Institute, Colombo, Sri Lanka.

Bianco, V., Manca, O., Nardini, S., & Minea, A. A. (2010). Analysis and Forecasting of Nonresidential Electricity Consumption in Romania. *Applied Energy*, *87*(11), 3584-3590.

Bianco, V., Scarpa, F., & Tagliafico, L. A. (2014). Scenario Analysis of Nonresidential Natural Gas Consumption in Italy. *Applied Energy*, *113*, 392-403.

Bildirici, M. E., & Bakirtas, T. (2014). The Relationship Among Oil, Natural Gas and Coal Consumption and Economic Growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) Countries. *Energy*, *65*, 134-144.

Bilgili, M., Sahin, B., Yasar, A., & Simsek, E. (2012). Electric Energy Demands of Turkey in Residential and Industrial Sectors. *Renewable and Sustainable Energy Reviews*, *16*(1), 404-414.

Birol, F., & Guerer, N. (1993). Modelling the Transport Sector Fuel Demand for Developing Economies. *Energy Policy*, *21*(12), 1163-1172.

Bohi, D. R., & Zimmerman, M. B. (1984). An Update on Econometric Studies of Energy Demand Behavior. *Annual Review of Energy*, *9*(1), 105-154.

Bohi, D. R. (2013). *Analyzing Demand Behavior: A Study of Energy Elasticities*. Routledge, London, UK.

Boran, F. E. (2015). Forecasting Natural Gas Consumption in Turkey Using Grey Prediction. *Energy Sources, Part B: Economics, Planning, and Policy*, *10*(2), 208-213.

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

Breusch, T.S., & L.G. Godfrey (1981). A Review of Recent Work on Testing for Autocorrelation in Dynamic Simultaneous Models. In D.A. Currie, R. Nobay and D. Peels, (Eds.), *Macroeconomic Analysis, Essays in Macroeconomics and Economics, Croom*, Helm, London, 63-100.

Capistrano, A. D., & Kiker, C. F. (1995). Macro-Scale Economic Influences on Tropical Forest Depletion. *Ecological Economics*, *14*(1), 21-29.

Chang, D., & Serletis, A. (2014). The Demand for Gasoline: Evidence from Household Survey Data. *Journal of Applied Econometrics*, *29*(2), 291-313.

Dahl, C. A. (2012). Measuring Global Gasoline and Diesel Price and Income Elasticities. *Energy Policy*, *41*, 2-13.

Dahl, C., & Sterner, T. (1991). Analysing Gasoline Demand Elasticities: A Survey. *Energy Economics*, *13*(3), 203-210.

Demirbas, A. (2001). Energy Balance, Energy Sources, Energy Policy, Future Developments and Energy Investments in Turkey. *Energy Conversion and Management*, *42*(10), 1239-1258.

Dickey, D. A., & Fuller W. A. (1979). Distributions of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74, 427-431.

Dilaver, Z., & Hunt, L. C. (2011a). Industrial Electricity Demand for Turkey: A Structural Time Series Analysis. *Energy Economics*, *33*(3), 426-436.

Dilaver, Z., & Hunt, L. C. (2011b). Modelling and Forecasting Turkish Residential Electricity Demand. *Energy Policy*, *39*(6), 3117-3127.

Dilaver, Z., & Hunt, L. C. (2011c). Turkish Aggregate Electricity Demand: An Outlook to 2020. *Energy*, *36*(11), 6686-6696.

Ediger, V. S., & Akar, S. (2007). ARIMA Forecasting of Primary Energy Demand by Fuel in Turkey. *Energy Policy*, *35*(3), 1701-1708.

Ediger, V. S., & Tatlidil, H. (2002). Forecasting the Primary Energy Demand in Turkey and Analysis of Cyclic Patterns. *Energy Conversion and Management*, *43*(4), 473-487.

Egelioglu, F., Mohamad, A. A., & Guven, H. (2001). Economic Variables and Electricity Consumption in Northern Cyprus. *Energy*, *26*(4), 355-362.

Eltony, M. N. (1996). Demand for Natural Gas in Kuwait: An Empirical Analysis Using Two Econometric Models. *International Journal of Energy Research, 20*(11), 957-963.

Enders, W. (2010). *Applied Econometrics Time Series*, 3rd ed. Hoboken: Wiley.

Energy Market Regulatory Authority (EMRA), (2012). Turkish Natural Gas Market Report 2011. Available online at http://www.epdk.org.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu.

Energy Market Regulatory Authority (EMRA), (2016). Turkish Natural Gas Market Report 2015. Available online at http://www.epdk.org.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu.

Energy Market Regulatory Authority (EMRA), (2017). Turkish Natural Gas Market Report 2016. Available online at http://www.epdk.org.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu.

Energy Market Regulatory Authority (EMRA), (2018). Turkish Natural Gas Market Report 2017. Available online at http://www.epdk.org.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu.

Engle, R., & Granger C. (1987). Cointegration and Error Correction Representation: Estimation and Testing. *Econometrica, 55*, 251-276.

Enz, C. A., Canina, L., & Lomanno, M. (2009). Competitive Pricing Decisions in Uncertain Times. *Cornell Hospitality Quarterly, 50*(3), 325-341.

Erbaykal, E. (2008). Disaggregate Energy Consumption and Economic Growth: Evidence from Turkey. *International Research Journal of Finance and Economics, 20*(20), 172-179.

Ercan, Y., Durmaz, A., & Sivrioglu, M. (1988). EFOM-12C Enerji Arz Modelinin Türkiye'ye Uygulanması [Application of the Energy Supply Model EFOM-I2C for Turkey]. Project Report, Gazi University, Ankara.

Erdal, G., Erdal, H., & Esengün, K. (2008). The Causality Between Energy Consumption and Economic Growth in Turkey. *Energy Policy, 36*(10), 3838-3842.

Erdogdu, E. (2007). Electricity Demand Analysis Using Cointegration and ARIMA Modelling: A Case Study of Turkey. *Energy Policy*, *35*(2), 1129-1146.

Erdogdu, E. (2010). Natural Gas Demand in Turkey. *Applied Energy*, *87*(1), 211-219.

Erdogdu, E. (2014). Motor Fuel Prices in Turkey. *Energy Policy*, *69*, 143-153.

Espey, M. (1998). Gasoline Demand Revisited: An International Meta-Analysis of Elasticities. *Energy Economics*, *20*(3), 273-295.

Estrada, J., & Fugleberg, O. (1989). Price Elasticities of Natural Gas Demand in France and West Germany. *The Energy Journal*, *10*(3), 77-90.

European Environmental Agency, (2015). Final Energy Consumption by Sector and Fuel. Retrieved on 15 March 2015 from https://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-9/assessment-1.

Fiebig, D. G., Seale, J., & Theil, H. (1987). The Demand for Energy: Evidence from a Cross-Country Demand System. *Energy Economics*, *9*(3), 149-153.

Filippini, M., & Hunt, L. C. (2011). Energy Demand and Energy Efficiency in the OECD Countries: A Stochastic Demand Frontier Approach. *Energy Journal*, *32*(2), 59-80.

Filippini, M., & Hunt, L. C. (2012). US Residential Energy Demand and Energy Efficiency: A Stochastic Demand Frontier Approach. *Energy Economics*, *34*(5), 1484-1491.

Fisher, F. M., & Kaysen, C. (1962*). A Study in Econometrics: The Demand for Electricity in the United States*. North-Holland.

Gately, D., Adelman, M. A., & Griffin, J. M. (1986). Lessons from the 1986 Oil Price Collapse. *Brookings Papers on Economic Activity*, *1986*(2), 237-284.

Goncu, A., Karahan, M., & Kuzubas, T. (2013). Forecasting Daily Residential Natural Gas Consumption: A Dynamic Temperature Modelling Approach. *Bogazici University, Department of Economics Working Paper*. No: 2013/11. Retrieved from http://www.econ.boun.edu.tr/content/wp/EC2013_11.pdf.

Griffin, J.M. (1979). *Energy Conservation in the OECD: 1980 to 2000*. United States: Ballinger Publishing Company, Cambridge, UK.

Gujarati, D. N. (2003). *Basic Econometrics*, 4^{th} ed. New York: McGraw-Hill.

Halicioglu, F. (2007). Residential Electricity Demand Dynamics in Turkey. *Energy Economics*, *29*(2), 199-210.

Halvorsen, R. (1975). Residential Demand for Electric Energy. *The Review of Economics and Statistics*, *57*(1), 12–18.

Haque, M. O. (2006). *Income Elasticity and Economic Development: Methods and Applications* (Vol. 42). Springer, Dordrecht, The Netherlands.

Harvey, A. C. (1989). *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge University Press, Cambridge, UK.

Harvey, A. C., & Shephard N. (1993). Structural Time Series Models. In: Maddala G. S., Rao C. R. and Vinod H. D. (Eds), *Handbook of Statistics*, Vol. 11, North Holland: Amsterdam, 261-302.

Harvey, A. C., & Scott A. (1994). Seasonality in Dynamic Regression Models. *Economic Journal*, *104*, 1324-1345.

Harvey, A. C. (1997). Trends, Cycles and Auto Regressions. *Economic Journal*, *107*, 192-201.

Hasanov, M. (2015). The Demand for Transport Fuels in Turkey. *Energy Economics*, *51*, 125-134.

Hatemi-J, A., & Irandoust, M. (2000). Time-Series Evidence for Balassa's Export-Led Growth Hypothesis. *Journal of International Trade and Economic Development*, *9* (3), 355-365.

Herzer, D., Lehmann F. N., & Siliverstovs B. (2006). Export-Led Growth in Chile: Assessing the Role of Export Composition in Productivity Growth. *The Developing Economies*, *44* (3), 306-328.

Hondroyiannis, G. (2004). Estimating Residential Demand for Electricity in Greece. *Energy Economics*, *26*(3), 319-334.

Houthakker, H. S. (1951). Some Calculations on Electricity Consumption in Great Britain. *Journal of the Royal Statistical Society. Series A (General)*, *114*(3), 359-371.

Houthakker, H. S., Verleger, P. K., & Sheehan, D. P. (1974). Dynamic Demand Analyses for Gasoline and Residential Electricity. *American Journal of Agricultural Economics*, *56*(2), 412-418.

Houthakker, H. S., & Taylor, L. D. (1970). *Consumer Demand in the United States, 1929-1970: Analyses and Projection*, 2nd ed. Harvard University Press.

Hughes, J. E., Knittel, C. R., & Sperling, D. (2008). Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand. *The Energy Journal*, *29*(1), 113-134.

Hunt, L. C., Judge, G., & Ninomiya, Y. (2000). Modelling Technical Progress: An Application of the Stochastic Trend Model to UK Energy Demand. *Surrey Energy Economics Discussion Paper SEEDS*, No. 99.

Hunt, L. C., Judge, G., & Ninomiya, Y. (2003a). Modelling Underlying Energy Demand Trends, *Surrey Energy Economics Discussion Paper, No. 105*, 1-40. Surrey Energy Economics Centre (SEEC), Department of Economics, University of Surrey, Guildford, UK.

Hunt, L.C., Judge, G., & Ninomiya, Y. (2003b). Underlying Trends and Seasonality in UK Energy Demand: A Sectoral Analysis. *Energy Economics*, 25(1), 93-118.

Hunt, L. C., & Witt, R. (1995). An Analysis of UK Energy Demand Using Multivariate Cointegration. Surrey Energy Economics Discussion Paper Series (SEEDS) No. 86, Department of Economics, University of Surrey, Guildford, UK.

IEA: International Energy Agency. (2004). *Energy Statistics Manual.* Paris, France.

IEA: International Energy Agency. (2015). International Energy Agency Data Services, IEA, France.

IEA: International Energy Agency. (2017a). World Energy Balances, International Energy Agency, France.

IEA: International Energy Agency. (2017b). Electricity Information, International Energy Agency, France.

IEA: International Energy Agency. (2017c). Natural Gas Information, International Energy Agency, France.

Jobert, T., & Karanfil, F. (2007). Sectoral Energy Consumption by Source and Economic Growth in Turkey. *Energy Policy*, *35*(11), 5447-5456.

Johansen, S. (1992). Determination of Cointegration Rank in the Presence of a Linear Trend. *Oxford Bulletin of Economics and Statistics*, *54*(3), 383-397.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, *12*, 231-254.

Johansen, S., & Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, *52*, 169-211.

Jones, C. T. (1994). Accounting for Technical Progress in Aggregate Energy Demand. *Energy Economics*, *16*(4), 245-252.

Joskow, P. L., & Baughman, M. L. (1976). The Future of the US Nuclear Energy Industry. *The Bell Journal of Economics*, 3-32.

Kadilar, C. (2000). *Uygulamalı Çok Değişkenli Zaman Serileri Analizi*. [Applied Multivariate Time Series Analysis]. Ankara: Büro Basımevi.

Kalman, R. E. (1960). A New Approach to Linear Filtering and Prediction Problems. *Journal of Basic Engineering*; *82*, 35-45.

Karanfil, F. (2008). Energy Consumption and Economic Growth Revisited: Does the Size of Unrecorded Economy Matter?. *Energy Policy*, *36*(8), 3029-3035.

Karimu, A., & Brännlund, R. (2013). Functional Form and Aggregate Energy Demand Elasticities: A Nonparametric Panel Approach for 17 OECD Countries. *Energy Economics*, *36*, 19-27.

Kıran, M. S., Özceylan, E., Gündüz, M., & Paksoy, T. (2012). Swarm Intelligence Approaches to Estimate Electricity Energy Demand in Turkey. *Knowledge-Based Systems*, *36*, 93-103.

Kleijweg, A., Huigen, R., van Leeuwen, G., & Zeelenberg, K. (1990). Firm Size and the Demand for Energy in Dutch Manufacturing, 1978–1986. *Small Business Economics*, *2*(3), 171-181.

Koopman S.J., Harvey A.C., Doornik J.A., & Shephard N. (2009). STAMP 8.2: Structural Time Series Analyser, Modeler, and Predictor. Timberlake Consultants, London.

Kraft, J., & Kraft, A. (1978). Relationship between Energy and GNP. *Journal of Energy and Development*, *3*(2), 401-403.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root: How Sure are We that Economic Time Series Have A Unit Root?. *Journal of Econometrics*, *54*(1-3), 159-178.

Lago, C. (2009). The Influence of Match Location, Quality of Opposition, and Match Status on Possession Strategies in Professional Association Football. *Journal of Sports Sciences*, *27*(13), 1463-1469.

Lise, W., & Van Montfort, K. (2007). Energy Consumption and GDP in Turkey: Is There a Co-Integration Relationship?. *Energy Economics*, *29*(6), 1166-1178.

MacKinnon, J. J. (1991). Critical Values for Cointegration Tests in Long-Run Economic Relationships, In. R. F. Engle and C. W. Granger (Eds), *Readings in Cointegration*, Oxford University Press, Oxford, 267-76.

Maddala, G. S., Trost, R. P., Li, H., & Joutz, F. (1997). Estimation of Short-Run and Long-Run Elasticities of Energy Demand from Panel Data Using Shrinkage Estimators. *Journal of Business & Economic Statistics*, *15*(1), 90-100.

Maden, S., & Baykul, A. (2012). Co-integration Analyses of Price and Income Elasticities of Electricity Power Consumption in Turkey. *European Journal of Social Sciences*, *30*(4), 523-534.

Mankiw, N. G. (2012). *Principles of Economics*. 6th Edition. South-Western Cengage Learning, Mason, USA.

Mansfield, E. (1997). *Applied Microeconomics*. 2nd Edition. New York: W.W. Norton Company.

McEachern, W. A. (2011). *Economics: A Contemporary Introduction*. 9th Edition. South-Western Cengage Learning, Mason, USA.

McMahon, T. (2017). Historical Crude Oil Prices, Inflation Data, Retrieved on 4 April 2018 from https://inflationdata.com/Inflation/Inflation_Rate/Historical_Oil_Prices_Table.asp.

McVeigh J. C. & Mordue, J.G. (1999). *Energy Demand and Planning.* The Watt Committee on Energy, UK.

Medlock, K.B. (2009). "Energy Demand Theory" in *International Handbook on the Economics of Energy*, Evans J and Hunt LC (Eds), Edward Elgar Publishing, UK, 89-111.

Mehta, J. S., Narasimham, G. V., & Swamy, P. A. (1978). Estimation of a Dynamic Demand Function for Gasoline with Different Schemes of Parameter Variation. *Journal of Econometrics*, *7*(3), 263-279.

Melikoglu, M. (2013). Vision 2023: Forecasting Turkey's Natural Gas Demand between 2013 and 2030. *Renewable and Sustainable Energy Reviews*, *22*, 393-400.

Ministry of Development, (2013). 10th Development Plan, (in Turkish translated by author). Retrieved on 16 April 2017 from http://www.kalkinma.gov.tr/Pages/KalkinmaPlanlari.aspx.

Ministry of Energy and Natural Resources (MENR). Energy Balance Sheets (in Turkish translated by author). Retrieved on 12 March 2018 from http://www.eigm.gov.tr/tr-TR/Denge-Tablolari/Denge-Tablolari.

Ministry of Energy and Natural Resources (MENR), (2014). 2015-2019 Strategic Plan (in Turkish translated by author). Retrieved on 12 March 2018 from www.enerji.gov.tr/tr-TR/Stratejik-Plan.

Ministry of Energy and Natural Resources (MENR), (2017a). Energy Investments in 2017 (in Turkish translated by author). Retrieved on 14 March 2018 from http://www.eigm.gov.tr/tr-TR/Sayfalar/Enerji-Yatirimlari.

Ministry of Energy and Natural Resources (MENR), (2017b). National Energy Efficiency Action Plan 2017-2023 (in Turkish translated by author). Retrieved on 10 June 2018 from http://www.resmigazete.gov.tr/eskiler/2018/01/20180102M1-1-1.pdf.

Narayan, P. K. (2005). The Saving and Investment Nexus for China: Evidence from Cointegration Tests. *Applied Economics*, *37*(17), 1979-1990.

Øvergaard, S. (2008). Definition of Primary and Secondary Energy. Retrieved on 16 May 2017 from https://unstats.un.org/unsd/envaccounting/londongroup/meeting13/LG13_12a.pdf.

Pantula, S. G. (1989). Testing for Unit Roots in Time Series Data. *Econometric Theory*, *5*(2), 256-271.

Park, S. Y., & Zhao, G. (2010). An Estimation of US Gasoline Demand: A Smooth Time-Varying Cointegration Approach. *Energy Economics*, *32*(1), 110-120.

Payne, J. E., Loomis, D., & Wilson, R. (2011). Residential Natural Gas Demand in Illinois: Evidence from the ARDL Bounds Testing Approach. *Journal of Regional Analysis & Policy*, *41*(2), 138.

Perron, P. (1989). The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis. *Econometrica*, *57*(6), 1361-1401.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds Testing Approaches to the Analysis of Level Relationship. *Journal of Applied Econometrics*, *16*(3), 289-326.

Petroleum Pipeline Corporation (BOTAŞ), (2008). Natural Gas Demand and Supply Projections. Available online at http://www.botas.gov.tr/.

Phillips, P.C., & Hansen, B.E. (1990). Statistical Inference in Instrumental Variables Regression with I(1) Processes. *The Review of Economic Studies*, *57*, 99-125.

Phillips, P. C., & Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika*, *75*(2), 335-346.

Pindyck, R. S. (1979). Interfuel Substitution and the Industrial Demand for Energy: An International Comparison. *The Review of Economics and Statistics*, 169-179.

Polemis, M. L. (2006). Empirical Assessment of the Determinants of Road Energy Demand in Greece. *Energy Economics*, *28*(3), 385-403.

Prosser, R. D. (1985). Demand Elasticities in OECD: Dynamical Aspects. *Energy Economics*, *7*(1), 9-12.

Ramanathan, R. (1999). Short-and Long-Run Elasticities of Gasoline Demand in India: An Empirical Analysis Using Cointegration Techniques. *Energy Economics*, *21*(4), 321-330.

Ramsey, J. B. (1969). Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis. *Journal of the Royal Statistical Society. Series B (Methodological)*, 350-371.

Ryan, D., & Plourde, A. (2009). “Empirical Modelling of Energy Demand” in *International Handbook on the Economics of Energy*, Evans J and Hunt LC (Eds), Edward Elgar Publishing, UK, 112-143.

Sa’ad, S. (2011). Underlying Energy Demand Trends in South Korean and Indonesian Aggregate Whole Economy and Residential Sectors. *Energy Policy*, *39*(1), 40-46.

Schwert, G. W. (1989). Tests for Unit Roots: A Monte Carlo Investigation. *Journal of Business & Economic Statistics*, *7*(2), 147-159.

Sene, S. O. (2012). Estimating the Demand for Gasoline in Developing Countries: Senegal. *Energy Economics*, *34*(1), 189-194.

Sephton, P. S., & Larsen, H. K. (1991). Tests of Exchange Market Efficiency: Fragile Evidence from Cointegration Tests. *Journal of International Money and Finance*, *10*, 561-570.

Solak, A. O., & Beskaya, A. (2013). Türkiye’nin Net Petrol İthalatının Fiyat ve Gelir Esneklikleri: ARDL Modelleme Yaklaşımı ile Eşbütünleşme Analizi. [Price and Income Elasticities of Net Oil Imports in Turkey: An ARDL Modelling Approach to Cointegration Analysis]. *Uluslararası Yönetim İktisat ve İşletme Dergisi*, *9*(18), 19-29.

Soytas, U., & Sari, R. (2007). The Relationship between Energy and Production: Evidence from Turkish Manufacturing Industry. *Energy Economics*, *29*(6), 1151-1165.

Taban, S., & Aktar, İ. (2008). An Empirical Examination of the Export Led-Growth Hypothesis in Turkey. *Journal of Yasar University*, *3*(11), 1535-1551.

Tatlidil, H., Cemrek, F., & Sen, H. (2009). Cointegration Relationship among Electricity Consumption, GDP, and Electricity Price Variables in Turkey. *Sosyal ve Ekonomik Araştırmalar Dergisi*, *17*, 439-451.

Thomas, R. (1993). *Introductory Econometrics: Theory and Applications,* 2nd Edition, Longman, London.

Toptas, M. (2015). Turkey's Energy Demand, Production and Policies. *International Journal of Energy Economics and Policy*, *5*(2), 631-638.

Turkekul, B., & Unakitan, G. (2011). A Co-Integration Analysis of the Price and Income Elasticities of Energy Demand in Turkish Agriculture. *Energy Policy*, *39*(5), 2416-2423.

Turkish Electricity Transmission Company (TEIAS), (2014). Annual Report 2014. Available online at https://www.teias.gov.tr/tr/faaliyet-raporu.

Turkish Electricity Transmission Company (TEIAS), (2015a). Annual Report 2015. Available online at https://www.teias.gov.tr/tr/faaliyet-raporu.

Turkish Electricity Transmission Company (TEIAS), (2015b). Turkish Electric Energy Five-Year Generation Capacity Projections 2015-2019, (in Turkish translated by author). Retrieved on 30 May 2017 from https://www.epdk.org.tr/.

Turkish Electricity Transmission Company (TEIAS), (2017a). Installed Power – 2017 (in Turkish translated by author). Retrieved on 14 March 2018 from https://www.teias.gov.tr/sites/default/files/2018-01/Kguc2017.pdf.

Turkish Electricity Transmission Company (TEIAS), (2017b). Turkish Electric Energy Five-Year Generation Capacity Projections 2017-2021, (in Turkish translated by author). Retrieved on 15 March 2018 from http://www.epdk.org.tr/Detay/Icerik/3-0-66/elektrikuretim-kapasite-projeksiyonlari#.

Turkish Electricity Transmission Company (TEIAS), (2018). Electricity Statistics (in Turkish translated by author). Retrieved on 25 March 2018 from https://www.teias.gov.tr/tr/elektrik-istatistikleri.

Turkish Statistical Institute (TurkStat). Foreign Trade Statistics (in Turkish translated by author). Retrieved on 13 March 2018 from http://www.tuik.gov.tr/PreTablo.do?alt_id=1046.

Turkish Statistical Institute (TurkStat). Energy Statistics (in Turkish translated by author). Retrieved on 15 March 2018 from http://www.tuik.gov.tr/PreTablo.do?alt_id=1029.

Turkish Statistical Institute (TurkStat). (2013). Population Projections, (in Turkish translated by author). Retrieved on 6 May 2017 from http://www.tuik.gov.tr/PreTablo.do?alt_id=1027#.

Uddin, M. F., & Sano, K. (2012). Coordination and Optimization: The Integrated Supply Chain Analysis with Non-Linear Price-Sensitive Demand. *An International Journal of Optimization and Control*, *2*(1), 83-94.

UNFCCC (1998). Kyoto Protocol to the United Nations Framework Convention on Climate Change, Retrieved on 4 April 2018 from http://unfccc.int/2860.php.

UNFCCC (2015). Paris Agreement, Retrieved on 9 April 2018 from http://unfccc.int/paris_agreement/items/9485.php.

US-EIA: US Energy Information Administration. (2013). EIA/ARI World Shale Gas and Shale Oil Resource Assessment Technically Recoverable Shale Gas and Shale Oil Resources: An Assessment of 137 Shale Formations in 41 Countries outside the United States. Retrieved on 21 March 2018 from https://www.eia.gov/analysis/studies/worldshalegas/.

Utkulu, U. (1997). How to Estimate Long-Run Relationships in Econometrics: An Overview of Recent Developments. *Dokuz Eylül Üniversitesi İİBF Dergisi*, *12*(2), 39-48.

Verbeek, M. (2004). *A Guide to Modern Econometrics*. 2nd ed. New York: John Wiley and Sons.

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica*, *48*(4), 817-838.

Wilson, J. W. (1971). Residential Demand for Electricity. *Quarterly Review of Economics and Business*, *11*(1), 7-22.

Wirl, F., & Szirucsek, E. (1990). Energy Modelling - A Survey of Related Topics. *OPEC Review*, *14*(3), 361-378.

WMO: World Meteorological Organization. (2017). Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Using Global Observations Through 2016. Retrieved on 9 April 2017 from https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-surge-new-record.

World Bank, (2015). World Development Indicators. Retrieved on 3 March 2016 from http://databank.worldbank.org/data/reports.aspx?source=2&country=TUR.

World Bank, (2017). *Global Economic Prospects*, Washington, USA.

Wu, J. L. (1996). The Empirical Investigation of Long-Run Purchasing Power Parity: The Case of Taiwan Exchange Rates. *International Economic Journal*, *10*(4), 59-69.

Yalta, A. T., & Yalta, A. Y. (2016). The Dynamics of Fuel Demand and Illegal Fuel Activity in Turkey. *Energy Economics*, *54*, 144-158.

Yaprakli, S., & Kaplan, F. (2015). Re-Examining of the Turkish Crude Oil Import Demand with Multi-Structural Breaks Analysis in the Long-Run Period. *International Journal of Energy Economics and Policy*, *5*(2), 402-407.

Yumurtaci, Z., & Asmaz, E. (2004). Electric Energy Demand of Turkey for the Year 2050. *Energy Sources*, *26*(12), 1157-1164.

Zaman, K., Khan, M. M., Ahmad, M., & Rustam, R. (2012). Determinants of Electricity Consumption Function in Pakistan: Old Wine in a New Bottle. *Energy Policy*, *50,* 623-634.

Zivot, E., & Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business and Economic Statistics*, *10*(3), 251-270.

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Book Chapters

Erdal Tanas Karagöl, **İsmail Kavaz**. (2017). Enerji Üssü Olma Yolunda Türkiye, *AK Parti'nin 15 Yılı: Ekonomi,* İstanbul, SETA Yayınları, s. 181-200.

Erdal Tanas Karagöl, **İsmail Kavaz**, Büşra Zeynep Özdemir, Salihe Kaya. (2017). 2017'de Enerji, *2017'de Türkiye*, SETA Yayınları, s. 239-257

Conference Presentations

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İsmail Kavaz, "Türkiye İçin Sanayi Sektörü Elektrik Talebi Analizi", 5th Anadolu International Conference in Economics (EconAnadolu 2017), 11-13 Mayıs 2017, Eskişehir-Türkiye.

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İsmail Kavaz, Erdal Tanas Karagöl, "Sanayi Sektörü Doğal Gaz Talebi: Türkiye Örneği", International Congress on Politic, Economic and Social Studies (ICPESS 2017), 9-11 Kasım 2017, Ankara-Türkiye.

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Soyadı : KAVAZ
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TEZİN ADI (İngilizce): Modelling and Forecasting the Energy Demand for Turkey

TEZİN ADI (Türkçe): Türkiye için Enerji Talebi Modellemesi ve Tahmini

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