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ARAŞTIRMA MAKALESİ

RELATIONSHIP BETWEEN RESIDENTAL ENERGY CONSUMPTION AND SELECTED MACROECONOMIC FACTORS IN TÜRKIYE[1]

Mahmut POLAT[1] I İlkay GÜLER[2]

[1] Uzman, T.C..Çevre ve Şehircilik Bakanlığı, Tapu Kadastro Genel Müdürlüğü, Ankara/Türkiye
ORCID: 0009-0005-7428-3140
Mail: mahmutpolat080@gmail.com

[2] Dr. Öğr. Üyesi., Ankara Hacı Bayram Üniversitesi, Ankara/Türkiye
ORCID: 0000-0003-1289-6652
Mail: ilkay.guler@hbv.edu.tr

Corresponding Author:
İlkay Güler
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Abstract

The aim of the study is to examine the relationship between economic growth, energy imports and exchange rate affecting natural gas and electricity consumption in residences 1990-2022. It was determined that natural gas and electricity consumption in residences were not stationary, but independent variables were stationary and a regression model was created for the data of these factors. Then, ARDL analysis was applied. In terms of electricity consumption in residences, it was determined that there was a weak relationship with economic growth in the short term and a strong relationship in the long term, but there was no relationship between it and energy imports. When it comes to exchange rates, it was determined that there is a stronger relationship in the long term than in the short term. When the results were evaluated in terms of natural gas used in residences, it was determined that there was no relationship with economic growth. There was a negative relationship with the exchange rate compared to three years ago, and a positive relationship compared to two years ago. It was determined that the increase in energy imports reduces residential energy consumption in the short term and increases it in the long term.

Key Words: *Economic growth, energy economics, energy imports, exchange rate, residential energy consumption*

Öz

Çalışmanın amacı, 1990-2022 döneminde konutlarda doğalgaz ve elektrik tüketimini etkileyen ekonomik büyüme, enerji ithalatı ve döviz kuru arasındaki ilişkiyi incelemektir. Konutlarda doğalgaz tüketimi ve konutlarda elektrik tüketiminin durağan olmadığı ancak bağımsız değişkenlerin durağan olduğu belirlenmiş ve bu faktörlere ait veriler için kendi aralarında bir regresyon modeli oluşturulmuştur. Ardından ARDL analizi uygulanmıştır. Konutlarda elektrik tüketimi açısından incelendiğinde, ekonomik büyüme ile arasında kısa dönemde zayıf, uzun dönemde ise kuvvetli bir ilişki olduğu, enerji ithalatı ile arasında ilişki bulunmadığı saptanmıştır. Söz konusu döviz kuru olduğunda ise, uzun dönemde kısa döneme göre kuvvetli bir ilişki olduğu tespit edilmiştir. Sonuçlar, konutlarda kullanılan doğal gaz açısından değerlendirildiğinde ise, ekonomik büyüme ile arasında ilişkiye ulaşılamamıştır. Döviz kuru ile arasında, üç yıl öncesine göre negative yönlü, iki yıl öncesine göre ise pozitif ilişkinin varlığı görülmüştür. Enerji ithalatında ortaya çıkan artışın kısa dönemde konutlarda enerji tüketimini azaltırken uzun dönemde arttırdığı belirlenmiştir.

Anahtar Kelimeler: *Ekonomik büyüme, enerji ekonomisi, enerji ithalatı, döviz kuru, konutlarda enerji tüketimi*

[1] This study is derived from Mahmut Polat's master's thesis titled "Relationship between energy consumption in residences and economic growth, energy imports, exchange rates: The example of Türkiye".

Introduction

The need for energy, which is the basic input of all sectors, is increasing day by day due to reasons such as population growth, economic growth, urbanization, migration and technological innovations. For the continuity of economic growth, it is necessary to continue production, and to continue production, it is necessary to use energy. The change in Türkiye is shown in Figure 1 in terms of energy consumption between 1980 and 2020 (EPDK, 2023; Republic of Türkiye Ministry of Energy and Natural Resources, 2022).

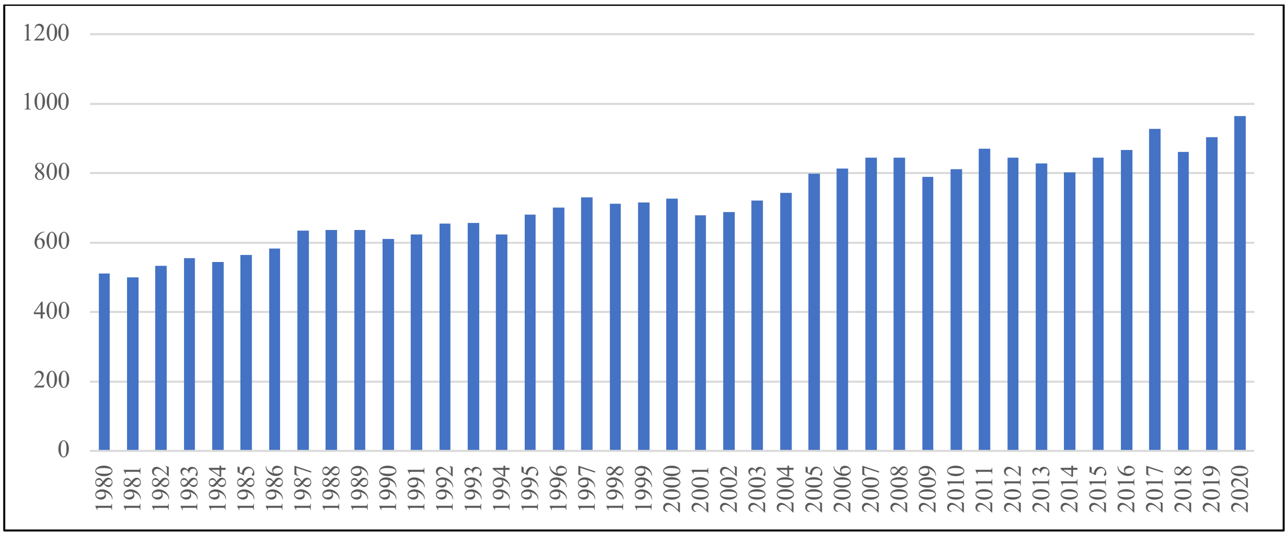

Figure 1. Energy Consumption

As seen in Figure 1, although it shows a fluctuating trend, energy consumption has increased in Türkiye from 1980 to 2020. The distribution of sectors in terms of energy consumption is shown in Figure 2. (EPİAŞ, 2023).

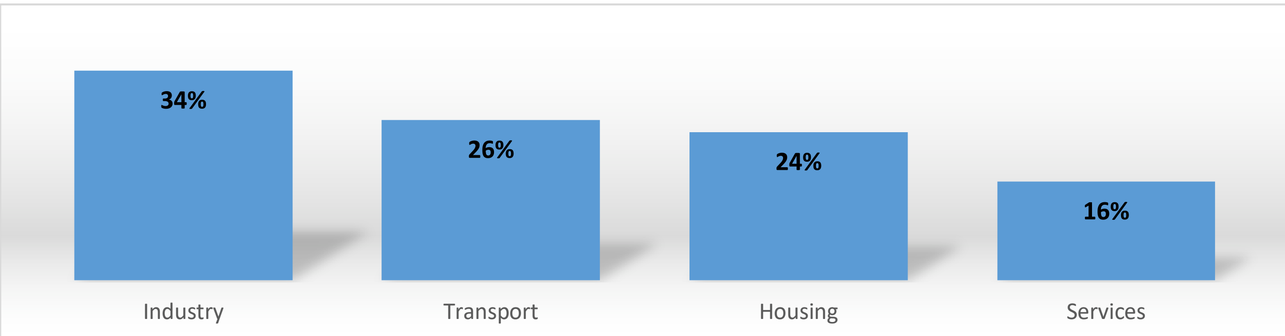

Figure 2. Distribution of Energy Consumption by Sectors

As seen in Figure 2, one quarter of energy consumption in Türkiye occurs in residences. Natural gas consumption in residences is shown in Figure 3. (EPDK, 2023; EPİAŞ, 2023).

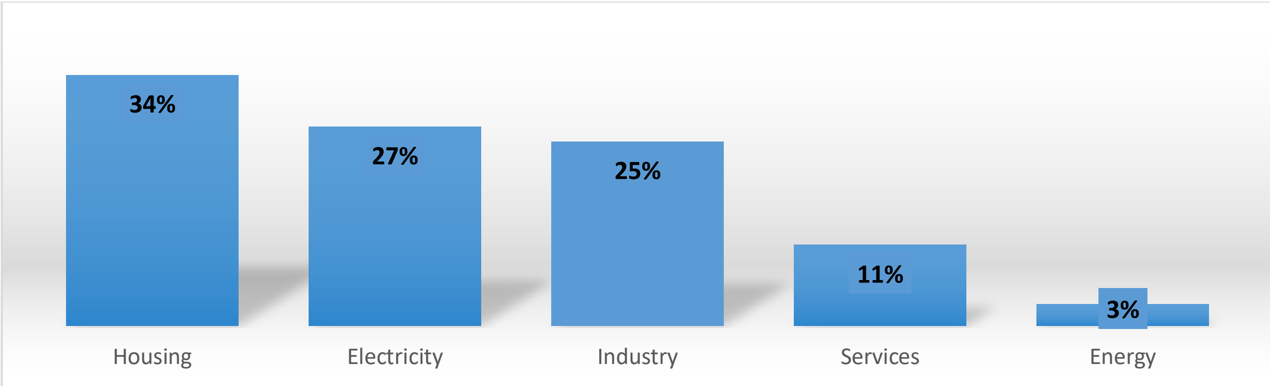

Figure 3. Natural Gas Consumption

When the distribution of natural gas consumption by sectors is examined, it is seen that the largest share belongs to the housing sector. The sectoral distribution of electricity consumption in residences is shown in Figure 4 (GAZBİR, 2023).

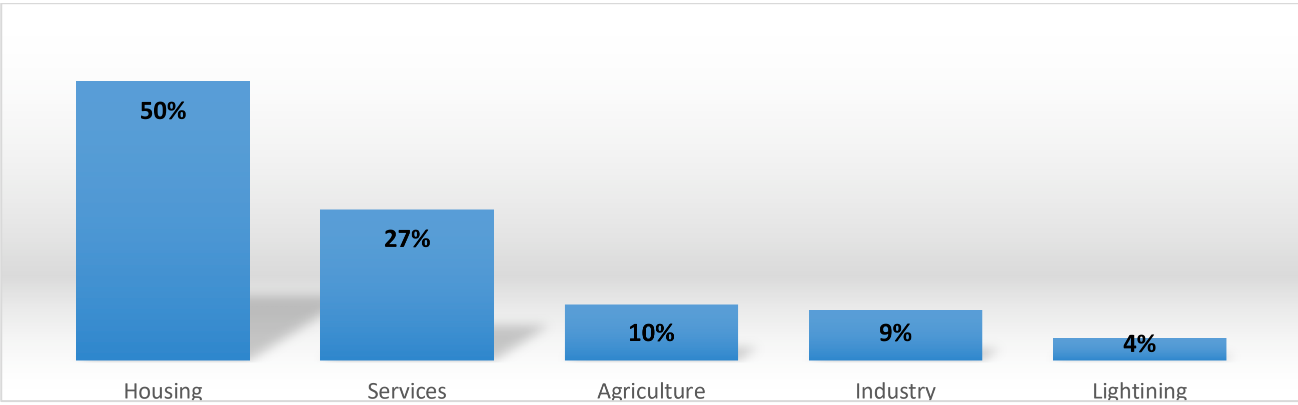

Figure 4. Electricity Consumption

The largest share in electricity consumption, as in natural gas consumption, belongs to residences. Therefore, energy consumption in residences consists the motivation of the study.

There are many factors that affect energy consumption in residences (Güler,2024). In this study, the impact of macroeconomic factors is investigated. Three macroeconomic factors were chosen as independent variables. The first of these is economic growth, consistent with the literature. Because economic growth increases the demand for housing, this increase triggers an increase in energy demand. Figure 5 shows economic growth and housing sales numbers in Türkiye.

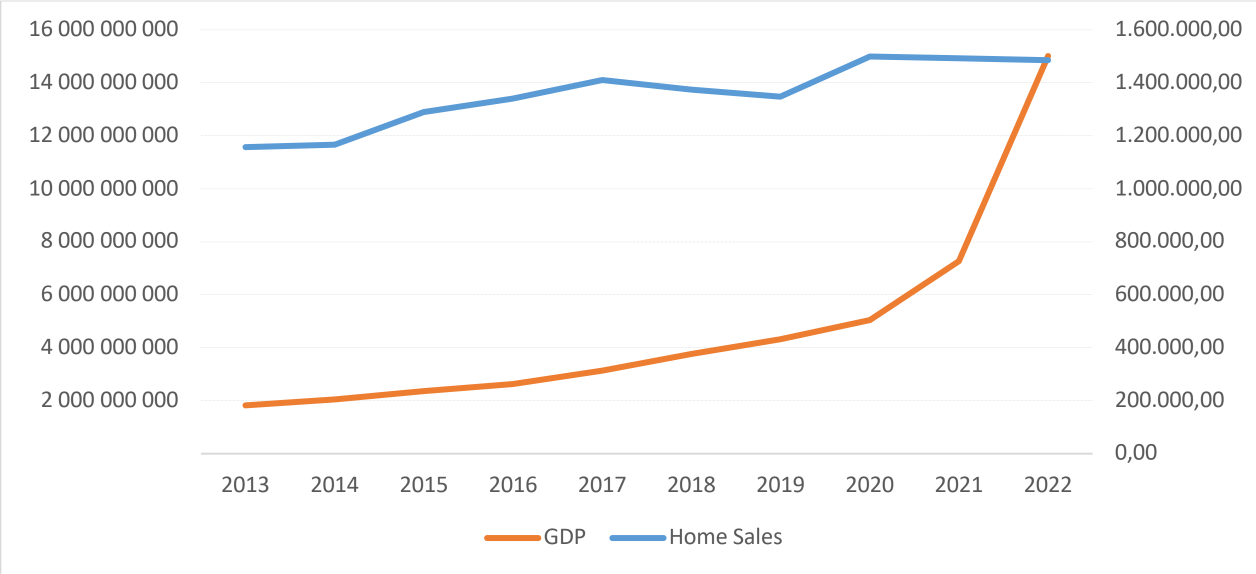

Figure 5. Economic Growth and the Number of Housing Sales

In this study, the relationship between residential energy consumption and exchange rate, energy imports and gross national product (GDP) is investigated. Since Türkiye is dependent on foreign energy sources, energy imports are seen as an important independent variable. Due to this situation, the increase in the exchange rate is reflected in energy prices and is expected to reduce energy consumption. It is also thought that when economic growth occurs, there will be an increase in energy consumption. However, in this study, energy consumption in residences is not considered as the only dependent variable, but is examined separately as natural gas consumption and electricity consumption. In this context, especially when it comes to natural gas, it is expected that it will have a negative relationship with the increase in the exchange rate, since almost all of it is imported.

In the study, energy consumption in residences is analyzed through two separate dependent variables, which are natural gas consumption and electricity consumption, thus more detailed results are obtained. Hereby, it is aimed that the results obtained will be a guide in the future in determining policies for energy sources used in residences and to eliminate the gap in the literature.

In this article, it is aimed to analyse the relationship between natural gas and electricity used in residences and economic growth, energy imports and exchange rate. The following sections of the study include the literature, data, method, analytical findings and conclusion, respectively (TÜİK, 2023; MB, 2023).

Literature

Studies examining the relationship between the energy used in residences and selected macroeconomic factors are based on the relationship between the energy used in all sectors and economic growth. Studies on this subject have been carried out in different countries in different time periods. The literature was examined in two stages. While the first stage includes studies on the relationship between energy consumption and economic growth, the second stage includes studies on the relationship between energy consumption in residences and macroeconomic factors.

Table 1.

Literature summary

Energy consumption and economic growth				
Author, Year	Time Period	Country	Method	Result
Stern (2000)	1947-1990	USA	VAR, Granger Causality Analysis	No relationship
Yang (2000)	1954-1997	Taiwan	Granger Causality Analysis	Economic growth ⇔ Energy consumption
Hondroyiannis, Lolos & Papapetrou, (2002)	1969-1996	Greece	Vector Error Correction Model	Energy consumption → Economic growth
Lise & Montfort (2007)	1970-2003	Türkiye	Co-integration analysis and Vector Error Correction Model	Economic growth → Energy consumption
Sancak et al. (2011)	1984-2008	Türkiye	ADF, co-integration, VECM analyses	Oil prices ↑ Current account deficit ↑
Odhiambo, 2009	1971-2006	Tanzania	Granger Causality Analysis	Energy consumption → Economic growth
Saidi, Rahman & Amamri, (2016)	1990-2014	53 countries	Granger Causality Analysis	Energy consumption ↑ Economic growth↑
Koç (2020)	2010-2016	132 countries	Panel data	Energy consumption in all sectors separately ↑ Economic growth ↑
Ray, Aditya & Kumar Pal, 2023)	1980-2019	10 Asian economies	EGLS Method	$CO2$ emission → Energy consumption Population → $CO2$ emission Financial development ⇔ Economic growth
Energy consumption in residences and macroeconomic factors				
Author, Year	Time Period	Country	Method	Result
Kar & Kınık (2008)	1975-2005	Türkiye	VECM, Granger-causality and Johansen co-integration testi	Electricity consumption ⇔ Economic performance
Bowden & Payne (2009)	1949-2006	USA	Toda Yamamoto- Granger-causality	Energy consumption of housing, industry and services sectors ⇔ Economic growth
Şahbaz & Yanar (2013)	1970 and 2010	Türkiye	Toda ve Yamamoto	There is no causal relationship.
Ojonugw & Obi (2016)	1990-2013	Nigeria	ECM	Energy consumption of housing, industry and services sectors → Economic growth
Narayan & Doytch (2017)	1971-2011	89 countries	GMM	Energy consumption in residences → Economic growth
Usta & Berber (2017)	1970-2012	Türkiye	Todo-Yamamoto causality analysis	There is no causal relationship.
Bouznit, Pablo-Romero, & Sánchez-Braza, (2018)	1970-2013	Algeria	ARDL	Energy consumption in residences → Economic growth
Raza, Shah & Khan, (2020)	1990-2015	BRICS countries	CIPS, FMOLS	

In this study, unlike the literature, the relationship between natural gas and electricity consumption in residences and macroeconomic factors has been analyzed separately. Therefore, it is anticipated that it will contribute to the literature.

Data, Method and Findings

The purpose of this study is to investigate the relationship between residential electricity consumption and residential natural gas consumption with macroeconomic factors, separately, in 1990-2022 period in Türkiye. The independent variables of the study were determined as economic growth, energy imports and exchange rate. Table 2 provides detailed information about the variables used.

Table 2.
Data set

Variable	Symbols	Source
Natural Gas Consumption In Residences	GAS	EUROSTAT (2023)
Electricity Consumption In Residences	ELK	EUROSTAT (2023)
Economic Growth (GDP)	ECNGRWTH	TCMB (2023)
Energy Imports	ENGIMP	TÜİK (2023)
Exchange Rate	EXCRATE	TCMB (2023)

Methodology

In this study, the relationship between household electricity and natural gas consumption and economic growth, energy imports and exchange rate will be analyzed through a linear regression equation. In order to analyze the data set for the period 1990-2022, the stationarity of the time series should be checked first. As mentioned before, one can try to get an idea by visually examining the graphs. However, this is not enough. In order to check the stationarity of the time series, it is necessary to check whether there is stationarity through one of the tests developed at different times. Otherwise, the regression equation to be applied cannot reflect the real relationship (Granger and Newbold, 1974, p.111-120; Gujarati, 1999, p.713) explains stationarity in time series as "the common variance between two periods depends on the distance between the two periods, not on the period for which it is calculated". In other words, a time series is stationary if the difference between two consecutive data is not due to the time itself but only due to the time interval.

In this study, Augmented Dickey Fuller test (ADF: Extended Dickey-Fuller test) was used to determine stationarity. This test, checks whether the coefficient is statistically equal to zero. The ADF-t statistic resulting from this test is compared with the MacKinnon critical values. If the ADF-t statistic is absolutely greater than the MacKinnon critical value, it means that the analyzed time series is stationary. Otherwise, the series is non-stationary and should be differenced until stationarity is achieved. The equation of the unit root test is as follows (Karaca, 2003, p.3):

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta Y_{t-i} + \varepsilon_i$$

ΔY_t, is the first difference of the variable whose stationarity is checked. t stands for the general trend variable. ΔY_{t-i}denotes the lagged difference terms. This term ensures that the error term is sequentially independent. The robustness of the results of the ADF test depends on the absence of consecutive dependence in the model to be estimated. The term expression of the lag length, k, can be estimated using the Akaike or Schwarz information criterion. The present study prefers the Akaike information criterion.

Autoregressive Distributed Lag Bound Test (ARDL) model was developed by Pesaran et al. (1996). Through this model, the relationship between variables integrated of different degrees can be tested in time series analysis (Bahmani-Oskooee and Chi Wing, 2002, p.150). As it is known, it is possible to examine the long-run relationships between variables with variables integrated of the same degree. The ARDL method, which does not require a unit root test, does not need to classify variables as I (0) or I (1) (Sharifi-Renani, 2008, p.4). The ARDL model cannot be used in cases where it is necessary to take the 2nd degree and higher differences of the variables to be included in the model (Çağlayan, 2006, p.427).

The process steps in using the ARDL model are as follows:

- First of all, it should be determined whether the variables are I(0) or I(1) through unit root tests. Because this model cannot be used for I(2) and above stationary series.
- The lag level at which the Akaike Information Criteria (AIC) and Schwarz Information Criteria (SIC) values are the smallest and therefore there is no autocorrelation is found.
- After finding the appropriate lag, the F statistic is generated. Accordingly, the hypothesis tests are as follows:

$H_0: \xi_1 = \xi_2 = \cdots = \xi_k = 0 \rightarrow \textit{The absence of the cointegration}$
$H_1: \xi_1 \neq \xi_2 \neq \cdots = \xi_k \neq 0 \rightarrow \textit{The presence of the cointegration}$

- If the F statistic is greater than the table value, the H0 hypothesis is rejected. In other words, it is accepted that co-integration exists.

- If the F statistic is smaller than the table value, the H0 hypothesis is accepted and it is concluded that there is no cointegration.
- If the F statistic is between the lower and upper limits of the table, it is considered to be in the unstable region. In this case, the error correction model will be used for cointegration (Kremers, Ericsson and Dolado, 1992; Banerjee, Dolado and Mestre, 1998).

In the present study, the dependent variable and independent variables are observed to be stationary either at level or at first differences. Its biggest advantage is that it can be applied in small samples (Kamaruddin and Jusoff, 2009, p.100). The ARDL method uses the difference of the series as the dependent variable for cointegration. Explanatory variables are included in the model in two different ways. The differences of the explanatory variables in the first group together with the dependent variable and the lags of these differences are determined. Among the variables in this group, the difference of the dependent variable starts at degree one, while the others start at degree zero. In the second group, there are only independent variables and the differences in this group start from the first lag. In order to determine the existence of cointegration, firstly, the most appropriate lag length is found. For this purpose, the case with the lowest AIC and SIC criteria is selected. Then, the hypothesis test is performed by estimating with Least Squares (LS). In this study, the H0 hypothesis is rejected according to the F statistic. The model representation is as follows:

$$\Delta Y_t = \Psi_0 + \sum_{i=1}^{m} \Psi_{1i}\Delta Y_{t-i} + \sum_{i=0}^{m} \Psi_{2i}\Delta X_{1t-i} + \cdots + \sum_{i=0}^{m} \Psi_{ki}\Delta X_{kt-i} + \xi_1 Y_{t-1} + \xi_2 X_{1t-1} + \xi_k X_{kt-1} + u_t$$

The long-run coefficients are then obtained by dividing the coefficients of the independent variables in the bounds test equation by the negative sign of one lagged value of the coefficient of the dependent variable (Şimşek and Kadılar, 2004: 30). The model representation examining the long-run relationship is as follows:

$$Y_t = \Psi_0 + \sum_{i=1}^{m} \Psi_{1i}\Delta Y_{t-i} + \sum_{i=0}^{n} \Psi_{2i}\Delta X_{1t-i} + \cdots + \sum_{i=0}^{r} \Psi_{ki}\Delta X_{kt-i} + \xi_1 Y_{t-1} + \xi_2 X_{1t-1} + \xi_k X_{kt-1} + u_t$$

After determining the long-run relationship, the short-run relationship is estimated. The only difference between the model estimating the long-run relationship and the model estimating the short-run relationship is the presence of the error correction term in the model. Here, the correction term is a lagged value of the residuals of the model estimating the long-run relationship. The correction added to the model shows how much of an imbalance that may arise in the short run can be corrected in the long run. The sign of this coefficient is expected to be negative and statistically significant. The model analyzing the short-run relationship is as follows:

$$Y_t = \Psi_0 + \sum_{i=1}^{m} \Psi_{1i}\Delta Y_{t-i} + \sum_{i=0}^{n} \Psi_{2i}\Delta X_{1t-i} + \cdots + \sum_{i=0}^{r} \Psi_{ki}\Delta X_{kt-i} + \xi_1 Y_{t-1} + \xi_2 X_{1t-1} + \xi_k X_{kt-1} + \mu ecm_{t-1} + u_t$$

Results

Firstly, the relationship between residential electricity and natural gas consumption and economic growth, energy imports and exchange rate is examined using a linear regression equation through the data set in Table 2. For this purpose, the stationarity of the time series was primarily checked. It has been determined that natural gas consumption in residences and electricity consumption in residences are not stationary, however GDP, energy imports and exchange rate are stationary.

Table 3.
The Finding of the ADF Unit Root Tests

Variables	Level	First Differences
GAS	-5.978376 (0.0000)	-5.230055 (0.002)
ELK	-0.800167 (0.8055)	-6.523886 (0.0000)
ECNGRWTH	-3.893376 (0.0070)	-
ENGIMP	-5.978376 (0.0000)	-
EXCRATE	7.312271 (1.0000)	-

Augmented Dickey Fuller test (ADF) was used to determine stationarity. The ADF-t statistics resulting from the ADF test were compared with MacKinnon critical values separately for both residential electricity consumption and residential natural gas consumption. After ensuring stationarity for all variables in the data set used in the study, the regression equation was created and analysis was carried out by subtracting the first order differences of all variables, including the dependent variable. Autoregressive Distributed Lag Bound Test (ARDL) was applied in order to analyze the relationship between variables within the framework of the findings.

Table 4.
The Result of the Regression Analysis for the Electricity Consumption in Residence as the dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.112172	0.049844	2.250458	0.0325
D(ECNGRWTH)	0.027012	0.029192	0.925292	0.3627
D(ENGIMP)	0.002068	0.007273	0.284261	0.7783
D(EXCRATE)	-0.019686	0.030876	-0.637581	0.5289
R-squared	0.073842	Mean dependent var		0.120697
Adjusted R-squared	-0.025389	S.D. dependent var		0.232575
S.E. of regression	0.235508	Akaike info criterion		0.062329
Sum squared resid	1.552999	Schwarz criterion		0.245546
Log likelihood	3.002738	Hannan-Quinn criter.		0.123060
F-statistic	0.744145	Durbin-Watson stat		2.414725
Prob(F-statistic)	0.534819			

Table 5.
The Result of the Regression Analysis for the Electricity Consumption in Residence as the dependent variable and the natural gas consumption as control variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.075834	0.042869	1.768986	0.0882
D(GAS)	0.143129	0.039609	3.613581	0.0012
D(EXCRATE)	-0.012638	0.025887	-0.488180	0.6294
D(ENGIMP)	0.004710	0.006125	0.769027	0.4486
D(ECNGRWTH)	0.005712	0.025108	0.227498	0.8218
R-squared	0.375748	Mean dependent var		0.120697
Adjusted R-squared	0.283266	S.D. dependent var		0.232575
S.E. of regression	0.196898	Akaike info criterion		-0.269662
Sum squared resid	1.046757	Schwarz criterion		-0.040641
Log likelihood	9.314589	Hannan-Quinn criter.		-0.193748
F-statistic	4.062945	Durbin-Watson stat		2.421161
Prob(F-statistic)	0.010489			

As a result of the analysis, no significant relationship was found between electricity consumption in residences and GDP, energy imports and exchange rate. It has been determined that natural gas consumption in residences corresponds to approximately 38% of the change in electricity consumption in residences. It has been revealed that a 1% increase in natural gas consumption in residences will increase residential electricity consumption by 0.14%.

Table 6.

The results of regression analysis without stationarization for the model with electricity consumption as the dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.261044	0.684904	-1.841198	0.0762
GAS	0.288828	0.030516	9.464928	0.0000
EXCRATE	-0.003490	0.021343	-0.163511	0.8713
ENGIMP	-0.003620	0.010695	-0.338468	0.7375
ECNGRWTH	0.038896	0.012117	3.210116	0.0033
R-squared	0.968251	Mean dependent var		2.863837
Adjusted R-squared	0.963715	S.D. dependent var		1.406442
S.E. of regression	0.267907	Akaike info criterion		0.342370
Sum squared resid	2.009670	Schwarz criterion		0.569114
Log likelihood	-0.649112	Hannan-Quinn criter.		0.418663
F-statistic	213.4788	Durbin-Watson stat		0.893008
Prob(F-statistic)	0.000000			

A regression equation was created without subtracting the differences of the series. While electricity consumption in residences is used as the dependent variable in the relevant equation, in the model natural gas used in residences, GDP, energy imports and exchange rate data are included as independent variables. According to the model results, it was determined that natural gas used in residences and GDP are related to electricity consumption in residences.

Table 7.

The results of regression analysis without stationarization for the model with economic growth as the dependent variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	62.88164	1.942297	32.37488	0.0000
ENGIMP	0.212469	0.275040	0.772501	0.4459
EXCRATE	1.232748	0.375825	3.280114	0.0026
R-squared	0.283028	Mean dependent var		66.72080
Adjusted R-squared	0.235230	S.D. dependent var		8.017962
S.E. of regression	7.011800	Akaike info criterion		6.819574
Sum squared resid	1474.960	Schwarz criterion		6.955620
Log likelihood	-109.5230	Hannan-Quinn criter.		6.865349
F-statistic	5.921315	Durbin-Watson stat		0.117804
Prob(F-statistic)	0.006800			

Then, a regression model was created with the explanatory variables of GDP, energy imports and exchange rate. The model included GDP as the dependent variable and energy imports and exchange rate as independent variables. No significant relationship was found between energy imports and GDP, but a significant relationship was found between exchange rate and GDP.

Table 8.
Co-integration test results between economic growth, energy imports and exchange rate

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	5.248996	2.323586	2.259006	0.0319
ECNGRWTH(-1)*	-0.080347	0.036454	-2.204069	0.0359
ENGIMP**	0.187980	0.055439	3.390719	0.0021
EXCRATE**	-0.031253	0.087652	-0.356562	0.7241
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ENGIMP	2.339585	1.209263	1.934720	0.0632
EXCRATE	-0.388976	1.192530	-0.326177	0.7467
C	65.32873	4.895423	13.34486	0.0000

Afterwards, the analysis was further detailed and the ARDL model was applied. GDP was considered as the dependent variable, exchange rate and energy imports were considered as independent variables, and ARDL application was carried out. Model results proved the existence of statistical co-integration between these variables. It has been determined that in the short term, when the GDP dependent variable decreases by 1% in the previous period, the value in the current period will decrease by 0.08%. It has been determined that the relationship between the GDP dependent variable and energy imports is positive and a 1% increase in energy imports will lead to a 0.19% increase in economic growth. It was determined that the relationship between GDP and energy imports is negative.It has been determined that the coefficient of the exchange rate variable is -0.03 and a 1% increase in the exchange rate will cause a 0.03% decrease in economic growth. In the long term, it has been determined that GDP has a positive relationship with energy imports and a 1% increase in energy imports will increase economic growth by 2.34%.

Then, for the purpose of the study, ARDL analysis was applied to determine the relationship between residential electricity consumption and residential natural gas consumption and GDP, energy imports and exchange rate. It was determined that there is a 10% co-integration level between the variables when electricity consumption in residences is the dependent variable and natural gas consumption is included as an explanatory variable in the model.

When energy consumption in residences was included as the dependent variable and natural gas consumption was included as the explanatory variable in the model, Table 9 the result of the analysis and diagnostic tests. As a result of Table 9, the model is stabile and it was concluded that the electricity consumption variable in residences in the short term is negatively affected by the previous value of its series. In other words, it was concluded that a 1% decrease in the previous period would reduce the consumption in the next period by ≅ 0.75%.

Table 9.

Model results and bounds tests by energy consumption in residences was included as the dependent variable and natural gas consumption was included as the explanatory variable in the model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.819887	0.684920	-1.197055	0.2468
ELK(-1)*	-0.745692	0.187086	-3.985818	0.0009
GAS(-1)	0.331568	0.086077	3.851983	0.0012
EXCRATE(-1)	-0.216294	0.072652	-2.977131	0.0081
ENGIMP**	0.005777	0.008929	0.646976	0.5258
ECNGRWTH**	0.025577	0.012655	2.021135	0.0584
D(GAS)	0.135564	0.039374	3.443002	0.0029
D(GAS(-1))	-0.182702	0.069702	-2.621198	0.0173
D(GAS(-2))	-0.135844	0.059160	-2.296232	0.0339
D(GAS(-3))	-0.070476	0.056996	-1.236494	0.2322
D(EXCRATE)	0.076875	0.054733	1.404530	0.1772
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS	0.444645	0.048549	9.158671	0.0000
EXCRATE	-0.290059	0.092038	-3.151510	0.0055
ENGIMP	0.007747	0.012307	0.629474	0.5369
ECNGRWTH	0.034300	0.015206	2.255740	0.0368
C	-1.099498	0.893499	-1.230553	0.2343
Autocorrelation:				
F-statistic	0.149505	Prob. F(4,14)		0.9601
Obs*R-squared	1.188008	Prob. Chi-Square(4)		0.8801
Heteroskedastisite :				
F-statistic	1.208813	Prob. F(10,18)		0.3482
Obs*R-squared	11.65097	Prob. Chi-Square(10)		0.3091
Scaled explained SS	8.970717	Prob. Chi-Square(10)		0.5349
Ramsey Reset:				
	Value	**df**	**Probability**	
t-statistic	1.847884	17	0.0821	
F-statistic	3.414676	(1, 17)	0.0821	
Likelihood ratio	5.308181	1	0.0212	

Electricity use in residences is affected by the consumption of natural gas in residences both in the relevant period and one and two periods ago. Electricity consumption in residences, which is negatively affected by the first and second period consumption of natural gas, is positively affected by the consumption in the relevant period. It was determined that the coefficient value of natural gas consumption in residences one period ago is -0.18 and its value two periods ago is ≅ -0.14.It is expected that the 1% increase in the exchange rate in the previous period will result in a 0.21% decrease in residential electricity consumption in the next period. In other words, electricity consumption in residences reacts downwards to exchange rate changes after one period of time. While it was determined that there is a significant statistical relationship between residential energy imports and residential electricity consumption, it was revealed that a 1% increase in GDP in the relevant period would increase residential electricity consumption by ≅ 0.03%. In the long term, no significant relationship has been found between electricity consumption in residences and energy imports. It was determined that a 1% increase in natural gas consumption in residences would lead to a 0.44% increase in residential electricity consumption, while a 1% increase in the exchange rate would cause a 0.29% decrease during the period under consideration.

Table 10.
Model results and bounds tests by excluding the economic growth variable from the model and including natural gas consumption as the dependent variable in the model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.424614	0.550010	-2.590162	0.0197
GAS(-1)*	-0.484331	0.277815	-1.743359	0.1005
EXCRATE(-1)	0.022597	0.476271	0.047446	0.9627
ENGIMP(-1)	0.202976	0.065526	3.097625	0.0069
ELK**	1.084035	0.514157	2.108373	0.0511
D(GAS(-1))	0.077580	0.237262	0.326982	0.7479
D(GAS(-2))	-0.265601	0.207487	-1.280082	0.2188
D(EXCRATE)	-0.269028	0.206059	-1.305586	0.2102
D(EXCRATE(-1))	0.703511	0.809552	0.869013	0.3977
D(EXCRATE(-2))	2.675135	0.831446	3.217448	0.0054
D(EXCRATE(-3))	-2.324951	0.911585	-2.550450	0.0214
D(ENGIMP)	0.045497	0.031365	1.450590	0.1662
D(ENGIMP(-1))	-0.081825	0.032015	-2.555804	0.0212

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXCRATE	0.046656	0.965971	0.048300	0.9621
ENGIMP	0.419086	0.330974	1.266220	0.2236
ELK	2.238212	0.582952	3.839445	0.0014
C	-2.941407	1.489733	-1.974453	0.0658
F-statistic	0.775114	Prob. F(2,12)		0.4824
Obs*R-squared	3.317775	Prob. Chi-Square(2)		0.1904
F-statistic	0.702883	Prob. F(14,14)		0.7410
Obs*R-squared	11.97006	Prob. Chi-Square(14)		0.6087
Scaled explained SS	2.589553	Prob. Chi-Square(14)		0.9996
	Value	df	Probability	
t-statistic	1.388960	15	0.1851	
F-statistic	1.929210	(1, 15)	0.1851	
Likelihood ratio	3.508719	1	0.0610	

If the natural gas used in residences is included as a dependent variable in the model, it is found to be inversely related to energy imports and exchange rates in the short term. It was determined that a 1% increase in energy imports caused a 0.08% decrease in natural gas consumption. In the long term, it was concluded that when there was a 1% increase in electricity consumption in residences, there was a 2.2% increase in natural gas consumption.

Conclusion

Production increase had started with the industrial revolution in England, and energy consumption increased. However, the increase in production also increased urbanization, which in turn increased the demand for housing. Energy is needed for heating, nutrition and lighting in residences. In Türkiye, approximately twenty-five percent of final energy consumption, approximately thirty-four percent of natural gas consumption, and approximately fifty percent of electricity consumption occur in residences. For this reason, the consumption of electricity and natural gas in residences, which are energy sources, is used as the dependent variable in the study. Economic growth, energy imports and exchange rate among macroeconomic factors were used as independent variables. ARDL analysis was applied using the largest available data set (Granger et al, 1974; Granger et al., 2002).

When the results were examined in terms of electricity consumption in residences, it was determined that while there was a weak relationship with economic growth in the short term, there was a strong relationship in the long term. Since economic growth causes an increase in household welfare, the result obtained appears to be consistent with the literature. No relationship was found between electricity consumption in residences and energy imports. When its relationship with the exchange rate is examined, it is concluded that while it is strong in the short term, its strength is greater in the long term.

When the results were examined in terms of natural gas consumption in residences, it was determined that there was no relationship with economic growth in the short and long term. The main reason for this situation is that natural gas is used in residences to meet essential needs such as heating and nutrition in residences. When its relationship with the exchange rate was examined, it was concluded that it had a negative relationship with three periods ago and a positive relationship with two periods ago. This situation can be explained by the fact that in Türkiye, in order to support and protect households, natural gas used in residences is sold in Turkish Liras and also cheaper compared to industry (BOTAŞ, 2023). It has been found that the increase in energy imports causes a short-term decrease in natural gas consumption in residences.

One of the points to consider here is that almost all of the natural gas in Türkiye is met through imports. Especially, important diplomatic and political events in the countries from which natural gas is imported or the Russia-Ukraine war etc. reduce its use in residences in the short term with a shock effect. In this context, the importance of reducing foreign dependency on energy emerges once again. In our country, which is rich in terms of solar and wind energy, by increasing the production of renewable energy, energy supply security will be ensured and the energy we need will be provided with our own means. Thus, we will transition from being an importer to an exporter in energy and the foreign trade deficit will decrease.

Since the use of renewable energy in residences has started recently in Turkey, there is not enough data available. It is recommended to examine the relationship between renewable energy used in residences and macroeconomic factors when the time range of the data set is expanded in the future.

References

Boru Hatları ile Petrol Taşıma A.Ş. Genel Müdürlüğü (BOTAŞ). (2023). *2023 yili Aralik ayi dogal gaz toptan satis fiyat tarifesi*. Retrieved December 12, 2023, from https://www.botas.gov.tr/Sayfa/satis-fiyat-tarifesi/439

Bouznit, M., Pablo-Romero, M. P., and Sánchez-Braza, A. (2018). Residential electricity consumption and economic growth in Algeria. *Energies*, *11*(7), 1656. https://doi.org/10.3390/en11071656

Bowden, N., & Payne, J. E. (2009). The causal relationship between U.S. energy consumption and real output: A disaggregated analysis. *Journal of Policy Modelling*, *31*(2), 180-188. https://doi.org/10.1016/j.jpolmod.2008.09.001

Elektrik Piyasaları İşletme A.Ş. (EPİAŞ). (2023). *Yüzdesel tüketim bilgileri*. Retrieved October 10, 2023, from https://seffaflik.epias.com.tr/transparency/tuketim/gerceklesen-tuketim/yuzdesel-tuketim-bilgileri.xhtml

Enerji Piyasası Düzenleme Kurulu (EPDK). (2023). *Yayınlar / raporlar*. Retrieved October 10, 2023, from https://www.epdk.gov.tr/Anasayfa/Anasayfa

EUROSTAT (2023), GDP and main components (output, expenditure and income), Retrieved October 10, 2023, from, https://ec.europa.eu/eurostat/web/products-datasets/-/namq_10_gdp

Granger, C. W. J., & Newbold, P. (1974). Spurious regressions in economics. *Journal of Econometrics*, *2*(2), 111-120.

Granger, C. W., and Yoon, G. (2002). *Hidden cointegration* (Economics Working Paper No. 2002-02). University of California. https://escholarship.org/uc/item/9qn5f61j

Güler, İ. (2024). Asymmetric Relationships Between Natural Gas Price Inflation and Macroeconomic Factors: The Case of Turkey. *Fiscaoeconomia*, *8*(1), 342-361. https://doi.org/10.25295/fsecon.136533

Hondroyiannis, G., Lolos, S., and Papapetrou, E. (2002). Energy consumption and economic growth: Assessing the evidence from Greece. *Energy Economics*, *24*(4), 319-336. https://doi.org/10.1016/S0140-9883(02)00006-3

Kar, M., and Kınık, E. (2008). Türkiye'de elektrik tüketimi çeşitleri ve ekonomik büyüme arasindaki ilişkinin ekonometrik bir analizi. *Afyon Kocatepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 10*(2), 333-353.

Koç, Ü. (2020). Sektörel enerji tüketimi ve ekonomik büyüme. *Third Sector Social Economic Review*, *55*(1), 508-521. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.20.03.1289

Lise, W., and Van Montfort, K. (2007). Energy consumption and GDP in Turkey: Is there a co-integration relationship?. *Energy Economics*, *29*(6), 1166-1178. https://doi.org/10.1016/j.eneco.2006.08.010

Narayan, S., and Doytch, N. (2017). An investigation of renewable and non-renewable energy consumption and economic growth nexus using industrial and residential energy consumption. *Energy Economics*, *68*, 160-176. https://doi.org/10.1016/j.eneco.2017.09.005

Odhiambo, N. M. (2009). Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach. *Energy Policy*, *37*(2), 617-622. https://doi.org/10.1016/j.enpol.2008.09.077

Ojonugw, B. A., and Obi, K. O. (2016). Sectoral consumption of non-renewable energy and economic growth in Nigeria. *International Journal of Research in Management, Economics and Commerce*, *6*(7), 15 – 22.

Ray, S., Aditya, I., and Kumar Pal, M. (2023). The influence of energy consumption, economic growth, industrialisation and corruption on carbon dioxide emissions: Evidence from selected Asian economies. In Kumar M. Pal (Ed.), *The impact of environmental emissions and aggregate economic activity on industry: Theoretical and empirical perspectives* (p.93-110). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80382-577-920231008

Raza, S. A., Shah, N., and Khan, K. A. (2020). Residential energy environmental Kuznets curve in emerging economies: the role of economic growth, renewable energy consumption, and financial development. *Environmental Science and Pollution Research*, *27*, 5620–5629. https://doi.org/10.1007/s11356-019-06356-8

Republic of Türkiye Ministry Of Energy and Natural Resources (2022). *Türkiye Ulusal Enerji Planı*. Retrieved October 10, 2023, from https://enerji.gov.tr/Media/Dizin/EIGM/tr/Raporlar/TUEP/Türkiye_Ulusal_Enerji_Planı.pdf

Saidi, K., Rahman, M., and Amamri, M. (2016). The causal nexus between economic growth and energy consumption: New evidence from global panel of 53 countries. *Sustainable Cities and Society*, *33*, 45-56. https://doi.org/10.1016/j.scs.2017.05.013

Sancak, E., and Demirbaş, E. (2011). Küresel ekonomik kriz ve Türkiye konut sektörüne etkileri. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *16*(3), 171-190.

Stern, D. I. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. *Energy Economics*, *22*(2), 267-283. https://doi.org/10.1016/S0140-9883(99)00028-6

Şahbaz, A., and Yanar, R. (2013). Türkiye'de toplam ve sektörel enerji tüketimi ile ekonomik büyüme ilişkisinin ekonometrik analizi. *Finans Politik & Ekonomik Yorumlar*, *50*(575), 31-44.

Türkiye Cumhuriyeti Merkez Bankası (TCMB). (2023). Konut Satış İstatistikleri. 09, 2023, from https://evds2.tcmb.gov.tr/index.php?/evds/serieMarket/#collapse_28

Türkiye Doğal Gaz Dağıtıcıları Birliği (GAZBİR). (2023). *GAZBİR 2022 yılı doğal gaz dağıtım sektörü raporu*. Retrieved October 10, 2023, from https://www.gazbir.org.tr/yillik-raporlar/150

Türkiye İstatistik Kurumu (TÜİK). (2023). *Çevre ve enerji verileri*. Retrieved October 10, 2023, from https://data.tuik.gov.tr/Kategori/GetKategori?p=cevre-ve-enerji-103&dil=1

Usta,C., and Berber, M. (2017). Türkiye'de enerji tüketimi ekonomik büyüme ilişkisinin sektörel analizi. *Ekonomik ve Sosyal Araştırmalar Dergisi*, *13*(1), 173-187.

Yang, H.Y. (2000) A note on the causal relationship between energy and GDP in Taiwan. *Energy Economics*, *22*(3), 309-317. https://doi.org/10.1016/S0140-9883(99)00044-4

Genişletilmiş Tükçe Özet

Enerji sektörü, kendi sektörü de dahil olmak üzere tüm sektörlerin temel girdisidir. Bu bağlamda enerji sektörü, ekonomi için kilit öneme sahiptir. Toplam enerjinin, yüzde otuz dördü sanayide, yüzde yirmi altısı ulaştırma sektörlerinde, yüzde yirmi dördü konutlardai yüzde on altısı ise hizmet sektörlerinde kullanılmaktadır. Doğal gaz özelinde ise, konutlarda yüzde otuz dört, elektirik kullanımında yüzde yirmi yedi, sanayi sektörlerinde yüzde yirmi beş, hizmet sektörlerinde yüzde on bir ve enerji sektöründe yüzde üç oranında tüketim gerçekleşmektedir. Elektirik enerjisi özelinde incelendiğinde ise konutlarda yüzde elli, hizmet sektörlerinde yüzde yirmi yedi, tarımda yüzde on, sanayi sektörlerinde yüzde dokuz, aydınlatmada yüzde dört oranında tüketim olmaktadır. Çalışmada 1990-2022 yıllarında, konutlarda doğalgaz ve elektrik tüketimini etkileyen enerji ithalatı, ekonomik büyüme ve döviz kuru arasındaki ilişki araştırılmaktadır. Türkiye, enerji kaynaklarının temini için ithalata bağımlıdır. Cari işlemler açığının artmasındaki en önemli nedenlerden biri enerji ithalatındaki artıştır. Türkiye ekonomisinde, döviz kuru, enerji fiyatlarını etkilemektedir. Ekonomik büyüme ise literatürde enerji tüketimi ile olan ilişkisi sıklıkla incelenen değişkenlerin başında gelmektedir. Ancak bu çalışmada, konutlarda kullanılan enerji ele alınmaktadır. Bu çalışmada, detaylı inceleme yapabilmek için konutlarda kullanılan doğalgaz ve elektrik tüketimi ayrı ayrı ele alınmıştır. Öncelikle durağanlık analizi yapılmıştır. Konutlarda tüketilen doğalgaz ve elektriğin durağan olmadığı fakat bağımsız değişkenlerin durağanlığı saptanmıştır. ADF testinin uygulanmış ile elde edilen ADF-t istatistikleri, konutlarda elektrik tüketimi ve konutlarda doğalgaz tüketimi için ayrı ayrı MacKinnon kritik değerleri ile karşılaştırılmıştır. Çalışmada kullanılan veri setindeki tüm değişkenler için durağanlık sağlandıktan sonra regresyon denklemi oluşturulmuş ve bağımlı değişken de dahil olmak üzere tüm değişkenlerin birinci dereceden farkları çıkarılarak analiz gerçekleştirilmiştir. Elde edilen bulgular çerçevesinde değişkenler arasındaki ilişkiyi analiz etmek amacıyla Otoregresif Dağıtılmış Gecikme Sınır Testi (ARDL) uygulanmıştır.Analiz sonucunda konutlardaki elektrik tüketimi ile GSYH, enerji ithalatı ve döviz kuru arasında anlamlı bir ilişki bulunamamıştır. Konutlardaki doğalgaz tüketiminin, konutlardaki elektrik tüketimindeki değişimin yaklaşık %38'ine karşılık geldiği tespit edilmiştir. Konutlarda doğal gaz tüketimindeki %1'lik bir artışın konut elektrik tüketimini %0,14 oranında artıracağı ortaya konmuştur. Serilerin farkları çıkarılmadan bir regresyon denklemi oluşturulmuştur. İlgili denklemde konutlarda elektrik tüketimi bağımlı değişken olarak kullanılırken, modelde konutlarda kullanılan doğalgaz, GSYH, enerji ithalatı ve döviz kuru verileri bağımsız değişkenler olarak yer almaktadır. Model sonuçlarına göre konutlarda kullanılan doğalgaz ve GSYH'nin konutlarda elektrik tüketimi ile ilişkili olduğu tespit edilmiştir. Ardından, GSYH, enerji ithalatı ve döviz kuru açıklayıcı değişkenleri ile bir regresyon modeli oluşturulmuştur. Modelde bağımlı değişken olarak GSYH, bağımsız değişkenler olarak da enerji ithalatı ve döviz kuru yer almıştır. Enerji ithalatı ile GSYH arasında anlamlı bir ilişki bulunmazken, döviz kuru ile GSYH arasında anlamlı bir ilişki bulunmuştur. Daha sonra ARDL modeli uygulanmıştır. GSYH bağımlı değişken, döviz kuru ve enerji ithalatı bağımsız değişkenler olarak ele alınmış ve ARDL uygulaması gerçekleştirilmiştir. Model sonuçları bu değişkenler arasında istatistiksel eş-bütünleşmenin varlığını kanıtlamıştır. Kısa dönemde bağımlı değişken olan GSYH bir önceki dönemde %1 azaldığında cari dönemdeki değerinin %0,08 azalacağı tespit edilmiştir. GSYH bağımlı değişkeni ile enerji ithalatı arasındaki ilişkinin pozitif olduğu ve enerji ithalatındaki %1'lik bir artışın ekonomik büyümede %0,19'luk bir artışa yol açacağı tespit edilmiştir. GSYH ile enerji ithalatı arasındaki ilişkinin negatif olduğu tespit edilmiştir.Döviz kuru değişkeninin katsayısının -0,03 olduğu ve döviz kurundaki %1'lik bir artışın *ekonomik büyümede %0,03'lük bir azalmaya neden olacağı tespit edilmiştir. Uzun dönemde ise GSYH'nin enerji ithalatı ile pozitif bir ilişki içinde olduğu ve enerji ithalatındaki %1'lik bir artışın ekonomik büyümeyi %2,34 oranında arttıracağı tespit edilmiştir. Daha sonra çalışmanın amacı doğrultusunda konutlarda elektrik tüketimi ve konutlarda doğalgaz tüketimi ile GSYİH, enerji ithalatı ve döviz kuru arasındaki ilişkiyi belirlemek için ARDL analizi uygulanmıştır. Konutlarda elektrik tüketiminin bağımlı değişken olduğu ve doğalgaz tüketiminin açıklayıcı değişken olarak modele dahil edildiği durumda değişkenler arasında %10 düzeyinde eşbütünleşme olduğu belirlenmiştir. Konutlarda elektrik kullanımı hem ilgili dönemdeki hem de bir ve iki dönem evvel ki konutlardaki doğal gaz tüketiminden etkilenmektedir. Birinci ve ikinci dönem doğalgaz tüketiminden negatif etkilenen konutlardaki elektrik tüketimi, ilgili dönemdeki tüketimden pozitif etkilenmektedir. Konutlarda doğalgaz tüketiminin bir dönem önceki katsayı değerinin -0,18, iki dönem önceki değerinin ise -0,14 olduğu belirlenmiştir. Bir önceki dönemde döviz kurunda meydana gelen %1'lik artışın bir sonraki dönemde konut elektrik tüketiminde %0,21'lik bir azalışa neden olması beklenmektedir. Başka bir deyişle, konutlardaki elektrik tüketimi, bir dönem sonra döviz kuru değişimlerine aşağı yönlü tepki vermektedir. Konutlarda enerji ithalatı ile konutlarda elektrik tüketimi arasında anlamlı bir istatistiksel ilişki olduğu tespit edilirken, ilgili dönemde GSYH'deki %1'lik bir artışın konutlarda elektrik tüketimini %0,03 oranında arttıracağı ortaya konulmuştur. Uzun vadede, konutlardaki elektrik tüketimi ile enerji ithalatı arasında anlamlı bir ilişki bulunamamıştır. Söz konusu dönemde konutlarda doğalgaz tüketimindeki %1'lik bir artışın konut elektrik tüketiminde %0,44'lük bir artışa, döviz kurundaki %1'lik bir artışın ise %0,29'luk bir azalışa neden olacağı tespit edilmiştir. Çalışmada ulaşılan sonuçlar, enerji ithalatının konutlarda kullanılan doğalgaz ve elektriği büyük çaplı etkilememediğini göstermektedir. Ancak ilerleyen zamanda kentleşme, göç gibi nedenlerle nüfus artışı gerçekleşebilir bu da beraberinde barınma ihtiyacını arttırabilir. Böylece konutlarda enerji tüketiminin artacağı dolayısı ile enerji ithalatının tetiklenebileceği öngörülebilir. Bu doğrultuda yenilenebilir enerji kullanımının gerçekleşmesi için yatırımlar yapılması ve bu yatırımları desteklemeye yönelik teşvikler verilmesi önerilebilmektedir.*