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AN ECONOMETRIC ANALYSIS ON THE DETERMINANTS OF ENERGY CONSUMPTION IN TURKEY[1]

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ABSTRACT

Turkey has experienced rapid population growth, rapid urbanization and industrialization in recent years. Therefore, Turkey's demand for energy has been increasing over the years. Also the main issue is Turkey's foreign dependency on energy resources. Researching the determinants of energy consumption is important in terms of developing policies for more efficient use of energy. For this reason, the determinants of energy consumption in Turkey were analyzed using the ARDL Boundary Test and the Toda-Yamamoto causality test, based on data from 1980-2020. While fossil fuel energy consumption as the dependent variable in the model, GDP, export rate and the ratio of fixed capital investments to GDP are independent variables. As a result of the analysis, it was determined that there is a longrun relationship between the variables. An increase in GDP by 1%, increases energy consumption by 0.34%. An increase in exports by 1 percent increases energy consumption by 0.57% in the long run while an increase in fixed capital investments by 1 percent, increases energy consumption by 0.15%. As a result of the causality analysis, it was concluded that there is one-way causality from GDP growth to energy consumption. Policymakers should actively implement policies aimed at reducing energy consumption, developing alternative energy sources, and promoting more efficient energy usage.

Keywords: *Energy Consumption, Economic Growth, Fixed Capital Investments, Export, ARDL Bound Test.*

Jel Codes: *F63, O44, P4.*

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TÜRKİYE'DE ENERJİ TÜKETİMİNİN BELİRLEYİCİLERİ ÜZERİNE EKONOMETRİK BİR ANALİZ

ÖZET

Türkiye son yıllarda hızlı nüfus artışı, hızlı kentleşme ve sanayileşme ile karşı karşıyadır. Bu durum yıllar içinde enerjiye olan talebi arttırmaktadır. Diğer taraftan Türkiye, enerjide önemli oranda dışa bağımlı bir ülkedir. Dolayısıyla enerji tüketiminin belirleyicilerinin tespit edilmesi, enerjinin daha verimli kullanılmasına yönelik politikaların geliştirilmesi açısından önem arz etmektedir. Bu doğrultuda çalışmada 1980-2020 yıllarına dair verilere dayanılarak Türkiye'de enerji tüketiminin belirleyicileri ARDL Sınır Testi ve Toda- Yamamoto nedensellik testi kullanılarak analiz edilmiştir. Çalışmada bağımlı değişken olarak fosil kaynaklı enerji tüketimi; bağımsız değişken olarak ise GSYİH, ihracat oranı ve sabit sermaye yatırımlarının GSYİH'ye oranı analize dahil edilmiştir. Yapılan analiz sonucunda değişkenler arasında uzun dönemli bir ilişkinin olduğu tespit edilmiştir. GSYİH'daki %1'lik artış enerji tüketimini %0,34 arttırmaktadır. İhracatta %1'lik bir artış uzun dönemde enerji tüketimini %0,57 oranında, sabit sermaye yatırımlarındaki %1'lik artış ise %0,15 oranında arttırmaktadır. Yapılan nedensellik analizi sonucu GSYİH artışından enerji tüketimine doğru tek yönlü nedensellik olduğu sonucuna varılmıştır. Politika yapıcılar; enerji tüketimini azaltacak, alternatif enerji kaynaklarını geliştirecek ve enerjinin daha verimli kullanılmasını sağlayacak politikaları aktif olarak uygulamalıdır.

Anahtar Kelimeler: *Enerji Tüketimi, Ekonomik Büyüme, Sabit Sermaya Yatırımları, İhracat, ARDL Sınır Testi.*

JEL Kodları: *F63, O44, P4.*

1. INTRODUCTION

Neoclassical growth models have, for a long time, disregarded the impact of energy input in the production process. However, advancements in technology, resulting in increased mechanization, have made production processes more energy-intensive, thus increasing the importance of energy in production. Today, energy is a fundamental input for nearly all economic activities, especially in industrial production and transportation.

Energy resources are distributed unevenly among countries. When considering that in 2019, 78% of the world's energy consumption was based on fossil fuels (BP, 2023), the reliable and cost-effective procurement of these resources has become a fundamental issue for countries (Altuğ and Demirtaş, 2021: 249). Especially in countries dependent on energy imports, problems in energy supply can have adverse effects on their economies (Samuel et al., 2013: 482). Inability to meet energy demand or rising energy costs can lead to economic instability. Countries are developing new technologies and focusing more on renewable energy sources to meet their energy needs (Esen, 2016: 283). Therefore, the use of alternative energy sources, energy efficiency, and energy security are topics that occupy policymakers' agendas intensely. Identifying the factors that influence energy consumption also guides policy choices.

While economic growth theories have recognized the importance of energy in recent years, the impact of economic growth on energy consumption remains somewhat uncertain. If there is a bidirectional relationship between energy consumption and economic growth, economic growth will increase energy demand. On the other hand, an increase in energy demand will also affect economic growth. In such conditions, taking energy-saving measures is appropriate for stable economic growth. However, if there is a unidirectional relationship from economic growth to energy consumption, energy-saving policies may have a negative impact on economic growth. If there is a unidirectional relationship from economic growth to energy consumption, it means that energy-saving policies will not have an impact on economic growth (Yıldırım et al., 2019: 185).

In the last few decades, energy consumption in Turkey has shown a rapid increase, particularly in the post-1980 period. Changes in the overall production structure, population growth, rapid urbanization, and especially the widespread use of natural gas in the early 1990s significantly increased energy demand. The final energy consumption, which was 677 PJ (Petajoule) in 1971, reached 1102 PJ in 1980 and 1691 PJ in 1990. By 2020, energy consumption had increased by 37.5% compared to 1990, reaching 4,504 PJ (IEA, 2023). Turkey is a country highly dependent on external sources for its energy resources. According to 2020 data, 77% of total energy supply was met from foreign sources (IEA, 2023). In 2020, Turkey ranked seventh among the world's net natural gas importing countries with 47 bcm (billion cubic meters) (IEA, 2021). To meet the increasing energy demand, Turkey, heavily reliant on energy imports, remains vulnerable to fluctuations in global energy prices and geopolitical factors affecting energy supply routes.

The objective of this study is to explore the factors influencing energy consumption in Turkey. Particularly, whether GDP has an impact on energy consumption has become increasingly important in determining energy policies for a country dependent on energy imports. While previous research has explored the connection between energy consumption and economic growth in Turkey, this study enables analysis using the most current data. In addition to economic growth, variables such as exports and fixed capital investments are also considered to potentially influence energy consumption. Therefore, the study includes an examination of the relationship between these variables and energy consumption. In this study, data from Turkey for the period from 1980 to 2020 are analyzed using the ARDL Bounds Test and the Toda-Yamamoto causality test.

2. THEORETICAL FRAMEWORK

Energy is a fundamental input for national economies. It is inconceivable to have economic growth independent of energy. Therefore, there is an extensive literature linking energy to economic growth. The theoretical framework of this literature is based on endogenous and exogenous growth models.

The basis of the exogenous growth model is formed by Solow's (1957) studies. According to the analyses using the Cobb-Douglas production function, the growth rate of the population and technological development are external variables that determine economic growth. The model involves two inputs: capital and labor (Katırcıoğlu et al., 2016: 1061). However, the neo-classical Solow model focused more on the consequences rather than the reasons for technological change, and technological innovations could not go beyond being an external factor. In Solow's model, technological changes without a clear origin remained beyond the scope of the system (Manga et al., 2015: 48).

The Cobb-Douglas production function is as follows:

$$Y_t = K^{\alpha}_t (A_t L_t)^{1-\alpha}$$

The output level Y represents the high-level technological innovations and the level of productivity denoted by A, the capital stock K, and the labor used to produce output, L. According to the neoclassical growth theory, the return on capital increases in a diminishing manner, hence α is assumed to be less than 1 (Tang et al., 2016: 1508).

Energy will encourage technological changes that increase labor force. Energy consumption will accelerate the process of capital restructuring due to the presence of new technologies. Additionally, Schumpeter's process of creative destruction relates energy consumption to economic growth in connection with the level of technology. Creative destruction enables the development of new technologies, and energy accelerates the innovation process, leading to economic growth (Tang et al., 2016: 1508).

Therefore, even though not directly included in the model, energy consumption can be related to the Solow growth model. However, energy consumption is not considered a direct factor influencing economic growth in this model. The main determinants in the model are capital accumulation, labor, and technology. Energy can be addressed in the model by relating it to technology.

In neoclassical growth models, an increase in input quantity leads to an equal increase in output quantity. In other words, a constant returns to scale production function is assumed. Accordingly, considering that energy resources are scarce and the world population is continuously increasing, it was expected that energy would become relatively scarce compared to labor and capital factors and its cost would increase over time. However, in developed and developing countries, the increase in per capita energy consumption over the years requires increasing returns to scale. Therefore, models that internalize technological developments are considered to be more realistic (Şengül and Tuncer, 2006: 4).

Endogenous growth models are primarily used to explain the correlation between energy consumption and economic growth (Mucuk and Uysal, 2009, 106). Below is Romer's production function model:

Y= F(A,K,L)

Y represents the total output level, A represents technology, K represents the total real capital stock, and L represents the total labor force in the model.

In this model, it is possible to consider energy as internalized within technology since energy consumption requires technology. Efficient use of energy will also lead to an increase in the output level (Mucuk and Uysal, 2009, 107).

In endogenous growth models, which have gained importance with the studies of Romer (1986) and Lucas (1988), economic growth is addressed in a more dynamic manner. Innovation and human capital are given significant roles and considered as fundamental factors that fuel economic growth.

3. LITERATURE REVIEW

The relationship between energy consumption (EC) and economic growth/GDP has been widely analyzed in the literature. This relationship was first explored by Kraft and Kraft (1978). The unidirectional relationship from GNP growth to EC was determined using the data of the United States of America for the period 1947-1974. In another study, Abosedra and Baghestani (1989) reached similar conclusions using US data for the period 1947-1987. However, Stern (1993) obtained different results in his study on the US economy. He found evidence that EC was the cause of GNP for the period from 1947 to 1990.

Results for different countries in the literature are also uncertain. Yu and Choi (1985) analyzed the relationship between GNP and EC in Poland, the United Kingdom, and the Philippines for the years 1950-1976, and in South Korea for the period 1954-1976, and in United States for the years 1947-1979. According to the results obtained, causality was found in South Korea from GNP to EC, and from EC to GNP in the Philippines, a one-way causality relationship was found. However, no causality relationship was identified for the other countries. Erol and Yu (1987) conducted an analysis of the relationship between EC and income for five industrialized countries (Japan, West Germany, the United Kingdom, Italy, Canada and France). For the period of 1950-1982, they found that there was no causality between EC and real GNP in the United Kingdom and France. However, in Italy and West Germany, they observed a unidirectional causality from real GNP to EC. In Canada (1950-1980) and Japan, they found a unidirectional causality relationship from EC to real GNP. Soytaş and Sarı (2006) found bidirectional causality between EC and income in 4 of the G-7 countries (Canada, Italy, the United

Kingdom, and Japan) using the data for the period 1960-2004. In France (1970-2002) there is a causal relationship from EC to income, while in the United States (1960-2004) and In Germany (1971-2003) there is a causal relationship in the opposite direction. Asafu-Adjaye (2000), four developing Asian countries (India, the Philippines, Indonesia, and Thailand), tested the causality between reel GDP and EC. For India and Indonesia in the period of 1973-1995, they reached a unidirectional causality from EC to income. In the case of the Philippines and Thailand for the period of 1971-1995, they identified a bidirectional causality relationship between EC and income. Using data for Canada from 1961 to 1997, Ghali and El-Sakka (2004) concluded that there is bidirectional causality between energy use and production growth.

Some of the studies have analyzed the relationship between EC and economic growth for country groups using panel data analysis methods. Different findings have also been obtained in studies focusing on country groups. Lee and Chang (2008), using data from 1971 to 2012 for 16 Asian countries, concluded that there is a long-term positive relationship between EC and real GDP. For these countries, there is a unidirectional causality relationship from EC to GDP in the long term. The same results are also valid for APEC and ASEAN in the long term. The study conducted by Öztürk, et al. (2010) explored the correlation between energy consumption and real GDP across low-income, lower-middle-income, and upper-middle-income countries from 1971 to 2005. They found cointegrated relationships in each of the income groups. In low-income group countries, they identified unidirectional causality from GDP to EC, while in middle-income groups, they found bidirectional causality. However, the analysis across all income groups did not reveal a strong relationship between the variables. Marques et al. (2016) used the ARDL bounds test to analyze the relationship between economic growth and global EC from 1965 to 2013. The research findings indicate the presence of a sustained relationship between energy consumption (EC) and economic growth. Additionally, it was observed that both in the short run and the long run, energy has a positive impact on economic growth. Lee and Chang (2007) analyzed 22 developed and 18 developing economies, using data from the period 1965 to 2002. Their study, conducted using a panel VAR model, confirmed the relationship between EC and GDP. In the developed countries, they found that the relationship was bidirectional. However, in the developing countries, the relationship was unidirectional, with an increase in per capita GDP leading to an increase in EC. Durmuş et al. (2019) found a bidirectional causality relationship between GDP and energy consumption in BRICS-T countries during the period 1990-2014.

Studies in the literature have explored the connection between these variables in the context of Turkey, resulting in mixed findings. In a study by Wietze and Kees (2005), it was found that there is cointegration between EC and economic growth in Turkey for the period between 1970 and 2003. Additionally, they established a unidirectional causation running from GDP to EC. Squalli and Aydın (2010) used quarterly data for Turkey from the period between 1996(1) and 2004(4) and found that a 1% change in EC led to a 1.03% increase in economic growth. Karagöl et al. (2007) conducted an analysis of the relationship between economic growth and electricity consumption in Turkey using the ARDL bounds test for the period from 1974 to 2004. In their study, they found cointegration between the variables, indicating a long-term relationship. Furthermore, they identified a positive immediate correlation while detecting a negative extended-term link between the variables. Aytaç (2010) in a study covering the period from 1975 to 2006 in Turkey did not find a causality relationship between EC and economic growth. Similarly, Altınay and Karagöl (2004), in their study for the period 1950-2000 in Turkey, concluded that there was no causality relationship between GDP and EC. These results imply that the correlation between EC and economic growth in Turkey might fluctuate based on the timeframe and the particular analytical approach applied.

In the existing literature, some research analyzes a range of variables beyond economic growth to understand their impact on energy consumption. For example, Mudakkar et al. (2013) examined the relationships between GDP, FDI, Financial Development, and Inflation with EC in South Asian Association for Regional Cooperation (SAARC) countries from 1975 to 2011, obtaining different results for each country. Fernandes and Reddy (2021) found causality from industrialization, exchange rate, financial development, and trade openness variables to EC in China for the period 1980-2018. In India and Thailand, causality was found from industrialization to EC, while in Indonesia, GDP, and in Malaysia, trade openness had a one-way impact on EC. Additionally, Sarkodie and Adom (2018) concluded that in Kenya for the period 1971-2014, price, population density, urbanization, and renewable energy were effective on energy demand.

4. DATA SET, MODEL AND ECONOMETRIC METHOD

4.1. Data Set

The determinants of energy consumption were investigated in the study. Annual data for the period 1980-2020 in Turkey were used. The data were obtained from the World Bank, Our World in Data, and British Petroleum. In the model, E represents the dependent variable, which is the total fossil fuel-based energy consumption for each year. GDP represents the real gross domestic product in USD, X represents the annual export growth rate, and FCF represents the ratio of fixed capital investments to GDP (%). The model used in the analysis is as follows:

$$E_t = a_0 + a_1 GDP_t + +a_2 LNX_t + a_3 FCF + \mu_t \qquad (1)$$

4.2. Unit Root Tests

Before conducting econometric analysis, it is necessary to determine the stationarity of the series. Therefore, widely used unit root tests such as Augmented Dickey Fuller (ADF) and Phillips Perron (PP) will be applied. Based on the stationarity levels of the variables, decisions will be made regarding the cointegration and causality tests to be used.

Table 1. ADF ve PP Unit Root Test Results

Determinants	ADF	Critical Value (%1)	Phillips-Perron	Critical Value (%1)
E	I(1) -5,99	-3,61	I(1) -6,00	-3,61
GDP	I(1) -6,16	-3,61	I(1) -6,16	-3,61
X	I(0) -4,40	-3,60	I(0) -4,42	-3,60
FCF	I(0) -6,64	-3,61	I(0) -6,64	-3,61

* Trend and Intercept Results

According to the unit root test results in Table 1, it is observed that the variables E and GDP are stationary in their first differences, while the variables FCF and X are stationary in their levels. Due to the variables being stationary at different levels, the long-term relationship will be analyzed using the ARDL Bounds Test Approach. Additionally, the causal relationship between the variables will be tested using the Toda-Yamamoto method, which allows conducting Granger causality analysis without considering the stationarity levels.

4.3. ARDL Bound Test and Amprical Results

The ARDL Bounds Test, developed by Pesaran et al. (2001), is a model used to test the cointegration relationship between variables that are not equally stationary. According to the model, it is possible to apply the bounds test based on whether the variables are I(0) or I(1). Since critical values in Peseran et al. (2001) are tabulated based on whether the variables are I(0) or I(1), the variables should not be stationary at the second difference level (Demirtaş et al., 2021). Furthermore, the Bounds Test has better statistical properties compared to the Engle-Granger test and provides more reliable results in small samples (Şeker et al., 2015: 351). Lastly, when the ARDL test is used with the error correction model, it provides information about both the long-run and short-run effects (Khanal, 2021: 445).

In this case, the unrestricted error correction model for the ARDL bounds test approach is given by Equation (1):

$$\Delta E = a_0 + \sum_{i=1}^{m} \beta_{1i}\, \Delta E_{t-i} + \sum_{i=0}^{n} \beta_{2i}\, \Delta GDP_{t-i} + \sum_{i=0}^{r} \beta_{3i}\, \Delta X_{t-i} + \sum_{t=0}^{l} \beta_{4i} \Delta FCF_{t-i} + \delta_1\, E_{t-1}$$
$$+ \delta_2 GDP_{t-1} + +\delta_3 LNX_{t-1} + \delta_4 FCF_{t-1+}\varepsilon_i$$

In the equation a, Δ, ε_i represent the constant term, the difference operator, and the error term, respectively. The estimation result of the regression equation in the equation will be used to test the long-term relationship using the F-statistic.

H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ If this null hypothesis is accepted (statistically non-significant), it implies that there is no cointegration between the variables, meaning there is no long-term relationship among them.

$H_0: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$ If this null hypothesis is rejected (statistically significant), it indicates that there is cointegration between the variables, meaning there exists a long-term relationship among them.

In cases where the F-statistic obtained is smaller than the lower critical value, the null hypothesis remains unchallenged, suggesting no cointegration exists between the variables. Under these circumstances, it implies that a long-term relationship is not present among the variables. If the calculated F-statistic is greater than the upper critical value, the null hypothesis will be rejected, and it implies that there is no long-term relationship between the variables. This implies that the variables lack a consistent long-term relationship (Demirtaş ve Tarı, 2021: 157). When the calculated F-statistic falls between the lower and upper critical values, this situation is referred to as the inconclusive region, and no definitive conclusion can be drawn. In such cases, the presence of a long-term relationship remains uncertain. If a long-term relationship is identified, the next step is to estimate and interpret the coefficients of the long-term relationship (Payne et al., 2011: 142). These coefficients provide insights into the long-run dynamics and impacts of the variables on each other.

The model created to estimate the long-term coefficients is given in equation (2).

$$\Delta E = a_0 + \sum_{i=1}^{m} a_{1i}\,\Delta E_{t-i} + \sum_{i=0}^{n} a_{2i}\,\Delta GDP_{t-i} + \sum_{i=0}^{r} a_{3i}\,\Delta X_{t-i} + \sum_{i=0}^{l} a_{4i}\Delta FCF_{t-i} + \varepsilon_t \quad (2)$$

The error correction model (3) created for the estimation of the short-term relationship is as follows.

$$\Delta E = a_0 + \sum_{i=1}^{m} \gamma_{1i}\,\Delta E_{t-i} + \sum_{i=0}^{n} \gamma_{2i}\,\Delta GDP_{t-i} + \sum_{i=0}^{r} \gamma_{3i}\,\Delta X_{t-i} + \sum_{i=0}^{l} \gamma_{4i}\Delta FCF_{t-i} + \gamma_5 ECM_{t-1} + \varepsilon_t \quad (3)$$

The variable denoted by ECM_{t-1} in the equation represents the error correction term. The ECM term indicates how much of a short-term imbalance will be corrected in the long run (Zhang et al., 2014: 585).

In the first step, the appropriate lag length of the ARDL model needs to be determined. The lag length that gives the lowest value according to the information criteria (AIC, SIC, HQ) is selected as the appropriate model. In this study, the Akaike Information Criterion (AIC) was considered, and the value "4" was chosen as the lag length. Next, the LM Test was conducted to check for any autocorrelation issues in the model. It was found that there was no autocorrelation problem in the model.

Table 2. ARDL Bound Test Results

	1% Significance Level Critical Value	
F statistic value	Lower Bound	Upper Bound
6,34	4,28	5,86

As seen in Table 2, the F-statistic value is 6.34, which is greater than the upper critical value of 4.28. In this case, the null hypothesis indicating that there is no cointegration relationship among the variables has been rejected. According to the obtained result, it can be concluded that there is a cointegration relationship among the variables.

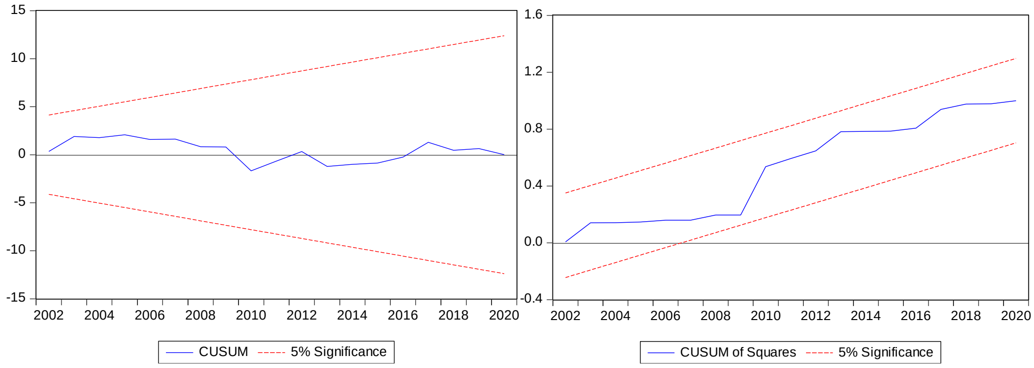
For the analysis of long-term cointegration among the variables, an ARDL (1,4,4,4) model was established. The diagnostic test results related to the model are presented in Table 3.

Table 3. Diagnostic Test Results

Test	Test Statistic Value	Prob. Value
R^2	0,997	-
Adjusted R^2	0,996	-
LM	-	0,9058
Varying variance	-	0,2950
Normality		0,922
Ramsey	0,398	0,785

According to the diagnostic test results seen in Table 3, there is no problem with the model. CUSUM and CUSUMQ charts in Chart 1 have been used to determine the stability of the model. It can be observed that the model is within the confidence interval, indicating that the estimated coefficients will be stable.

Figure 1. ARDL (1, 4, 4, 4) Model CUSUM and CUSUMQ Graphs



The calculated long-run coefficients are presented in Table 4. As seen in the table, all variables are statistically significant at a 1% level of probability. All variables have a positive impact on energy consumption. Increases in GDP, X, and FCF will lead to an increase in energy consumption. According to this, a 1% increase in GDP will lead to a 0.34% increase in energy consumption in the long run. Additionally, a 1% increase in the share of total exports in GDP will result in a 0.57% increase in energy consumption in the long run. Moreover, the positive effect of the ratio of fixed capital investments to GDP will be 0.15%. Given that energy is a direct input associated with the production level, it seems reasonable for GDP, X, and FCF variables to be positively affected.

Table 4. Long-Run Coefficients

Variables	Coefficients	t-Statistic Value	Prob. Value
GDP	0,346	13,261	0,0000
X	0,575	5,587	0,0000
FCF	0,154	4,136	0,0004

The short-run coefficients are estimated using the ARDL model based on the error correction mechanism. Table 5 presents the short-run coefficients.

Table 5. Short Run Coefficients

Variables	Coefficients	t-Statistic Value	Prob. Value
CointEq(-1)	-0,595	-6,194	0,000
GDP	0,186	2,305	0,032
FCF	0,015	2,175	0,000
X	0,043	0,889	0,384

According to the table, the error correction term is -0.595, and this value is statistically significant. After short-term shocks, approximately 59% of deviations from the long-term equilibrium can be corrected within one year. A 1% increase in GDP in the short run will result in a 0.18% increase in energy consumption. Also, a 1% increase in the ratio of fixed capital investments to GDP will lead to a 0.01% increase in energy consumption in the short run.

4.4. Toda-Yamamoto Causality Test Results

The results of the Toda-Yamamoto (1995) test, an improved version of the Granger causality test, are presented in Table 6. Firstly, the best VAR model is determined, and then a lag is added to estimate the VAR model. In this study, a VAR(3) model is estimated. Finally, the Wald statistic is calculated to conduct the Toda-Yamamoto causality test.

Table 6. Toda-Yamamoto (1995) Causality Test

Casuality Direction	t- Statistics	Prob. Value
GDP → E	13,492	0,0012
X →E	13,530	0,0014
FCF →E	3,657	0,0558
X → FCF	3,495	0,0615

As seen in the table, there is one-way causality from GDP to energy consumption at a significance level of 1%, and one-way causality from the share of total exports in GDP to energy consumption at a significance level of 1%. Additionally, there is one-way causality from fixed capital investments to energy consumption at a significance level of 10%, and one-way causality from the export ratio to fixed capital investments.

5. CONCLUSION

For developing countries, energy is a critical factor in achieving economic growth and development objectives. A country like Turkey, which has limited fossil resources, is heavily reliant on energy imports, and this situation poses challenges in terms of energy supply security.

In this study, the relationship between energy consumption and GDP was examined using data from Turkey for the period of 1980-2020, utilizing the ARDL Bounds Test and the Toda-Yamamoto causality test. The results indicate the presence of both long-term and short-term relationships between energy consumption and GDP. According to the results of the ARDL Bounds Test, a 1% increase in

GDP in the long run is associated with a 0.34% increase in energy consumption. The findings of the study, showing a unidirectional causality from income to energy consumption, appear to be consistent with research results for many other developing countries. Lee and Chang (2007) conducted a study on eighteen developing countries and found unidirectional causality from economic growth to energy consumption. Additionally, the study's results align with the findings of Wietze and Kees (2005) for Turkey.

As the Turkish economy grows, the demand for energy will increase accordingly. Given Turkey's high dependence on energy imports and its limited number of energy suppliers, it is crucial to focus on increasing the number of energy source providers. Diversifying energy sources and developing strategic storage facilities for fossil fuels are seen as strategic pathways. In the long term, to mitigate potential energy shortages, it is necessary to diversify energy sources and rely more on domestic resources. In this regard, increasing investments in renewable energy and expanding the use of nuclear energy are vital.

On the other hand, the unidirectional causality from income to energy consumption suggests that energy-saving policies may not have a significant impact on economic growth. In this case, it is recommended that these policies be actively utilized. Additionally, efforts to increase energy efficiency will also contribute to reducing the current account deficit caused by energy imports.

The study also considers the impact of export and fixed capital investment variables on energy consumption. The export variable significantly and positively affects energy consumption in the long run. Fixed capital investment, on the other hand, positively and significantly increases energy consumption both in the long and short term. A 1% increase in the share of total exports in GDP will result in a 0.57% increase in energy consumption in the long run. Moreover, the positive effect of the ratio of fixed capital investments to GDP will be 0.15%. Also, a 1% increase in the ratio of fixed capital investments to GDP will lead to a 0.01% increase in energy consumption in the short run.

Taking into account the relationship between exports, fixed capital investment, and energy consumption, the unidirectional nature of this relationship, from exports to energy consumption and from fixed capital investment to energy consumption, indicates that policies aimed at increasing energy efficiency are unlikely to have an impact on exports and investment.

In summary, policymakers should actively implement policies aimed at reducing energy consumption, developing alternative energy sources, and promoting more efficient energy usage. Given the issues of global warming and climate change, the importance of energy policies aimed at minimizing energy consumption is better understood.

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