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THE EFFECTS OF ENERGY CONSUMPTION ON ECONOMIC GROWTH: A FREQUENCY DOMAIN CAUSALITY ANALYSIS

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Abstract

One of the most important indicators of the production channels of developed and developing countries is undoubtedly the energy problem. In addition, the nexus between economic growth and energy use differs from country to country. The main purpose of this article is to examine the nexus between economic growth and energy consumption in Turkey in the period of 2016 and 2022. Daily electricity consumption is used as an indicator of energy consumption, and industrial production index data is used as an indicator of economic growth. Toda-Yamamoto (1995) and Breitung-Candelon (2006) frequency domain tests were used to determine for the causality. According to the outcomes of the Toda-Yamamoto causality test, a unidirectional causality relationship was found from economic growth to energy consumption in the long run. Breitung- Candelon frequency domain causality test results revealed a short (temporary) and long (permanent) relationship from economic growth to energy consumption. In Türkiye, increases in economic growth (expansion of the production channel), increase the energy need more and thus this situation increases import dependency.

Keywords: *Energy Consumption, Energy Policy, Economic Growth*

JEL Classification: *C32, O11, O47, Q43*

ENERJİ TÜKETİMİNİN EKONOMİK BÜYÜME ÜZERİNDEKİ ETKİLERİ: FREKANS ALANDA NEDENSELLİK ANALİZİ

Öz

Gelişmiş ve gelişmekte olan ülkelerin üretim kanallarının en önemli göstergelerinden biri hiç şüphesiz enerji sorunsalıdır. Ayrıca ekonomik büyüme ve enerji kullanımı arasındaki bağlantı ise ülkeden ülkeye farklılık göstermektedir. Bu makalenin temel amacı 2016 ve 2022 döneminde Türkiye'de ekonomik büyüme ve enerji tüketimi arasındaki bağlantıyı incelemektir. Enerji tüketimi göstergesi olarak günlük elektrik kullanımı, ekonomik büyüme göstergesi olarak ise sanayi üretim endeksi verileri kullanılmıştır. Değişkenler arasındaki nedensellik testi için Toda-Yamamoto (1995) ve Breitung-Candelon (2006) frekans alanı testleri kullanılmıştır. Toda-Yamamoto nedensellik testi sonuçlarına göre, uzun dönemde ekonomik büyümeden enerji tüketimine doğru tek yönlü bir nedensellik ilişkisi vardır. Breitung-Candelon frekans alanı nedensellik testi sonuçlarında ise ekonomik büyümeden enerji tüketimine doğru kısa (geçici) ve uzun (kalıcı) bir ilişki vardır. Türkiye'de ekonomik büyümedeki artışlar (üretim kanalının genişlemesi) enerji ihtiyacını dolayısıyla ithalata olan bağımlılığı daha çok artırmaktadır.

Anahtar Kelimeler: *Enerji Tüketimi, Enerji Politikası, Ekonomik Büyüme*

JEL Sınıflandırması: *C32, O11, O47, Q43*

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1. Introduction

A country's dependence on energy resources has always been one of the most important factors affecting industrial production. Reasons such as the scarcity of energy in nature, the fact that its existence differs according to countries, its discovery depends on discovery and science, as well as the high costs of the production stage cause problems in the supply side of energy in the economy. Therefore, situations such as the natural resources, geographical locations and technological infrastructure of each country bring different approaches in the economic policies to be applied. In this context, the main purpose of economic policies has been to reduce energy dependency and to turn to resources that are less harmful to the environment.

Technological innovations that took place after the industrial revolution accelerated mass production and were seen as the main source of economic development all over the world. Schumpeter (1939) stated that technology is an important element as well as labor and capital, which are considered neoclassical production functions. Schumpeter saw technological innovations as the primary factor in increasing the incomes of the countries. Advancing technology has led to an increase in the demand for energy. The First and Second Oil Crises (1973-1979), which affected the whole world, dragged the energy-dependent industries into a great impasse. It has become a big problem not only to ensure technological progress, but also to meet the energy need, which will provide the main locomotive that will produce and serialize this technology. For these reasons, countries have turned to alternative energy sources. On the other hand, the environmental problems caused by global warming have pushed countries to seek new energy sources that will reduce their dependence on energy and that will have minimum damage to the environment. With the Kyoto Protocol, which was first brought to the agenda with the conference held in Kyoto in 1997, and then signed and put into practice by 191 countries and EU countries in 2005, new measures were taken to reduce the high amount of greenhouse gas emissions of countries. In this framework, the main purpose of the economic policies; implemented is to reduce energy dependence and turn to resources that are less harmful to the environment.

In the other hand, the situation in countries without energy dependence provided income by using natural resource wealth, but this situation caused countries to move away from production even more. In this case, which came to the fore as the "Dutch Disease" by "The Economist" magazine (1977), for the first time, countries with rich natural resources explain their withdrawal from production areas by turning to new resources. Corden (1984) After the discovery of natural gas in the Netherlands in the 1960s, the overvaluation of the real exchange rate adversely affected production. An example of the same situation is the discovery of oil in Venezuela in the 1970s. So, the main problem lies not only in solving the energy problem, but also in the use of resources in efficient areas and in taking steps that will take countries forward with correct practices, and in the implementation of more environmentally friendly policies by directing the future. In the world, especially with the development of technology, the expanding production channel, as well as the economic growth-oriented economic strategies of the countries, have constantly increased the need for energy. Because of all this, it is critical to decide the connections between EG and EC in terms of guiding the energy policies to be implemented. In this context, it is important to determine the relationship between economic growth and energy consumption in terms of guiding the energy policies to be implemented.

In the literature, there are different assumptions about how an increase or decrease in energy consumption (EC) affects economic growth (EG). Generally, the connections between EC and EG has been established by scientists on four assumptions (Squalli, 2007; Bozoklu and Yılancı, 2013; Öncel et al., 2017). The first of these is that while there is a causal relationship from EC to EG, there is no causality from EG to EC. In the second opinion on the subject, they determined a causal relationship from EG to EC and concluded that increases or decreases in EC do not affect EG. The third view was that EC and EG mutually affect each other. According to this view, an increase or

decrease in EC affects EG, or increases or decreases in EG affect EC. According to those who support the last and fourth view is that EG and EC are not in any relationship. According to the results, if the direction of causality is from EC to EG (determining whether the changes in EC affect EG and whether this effect is permanent or temporary), it is concluded that an energy crisis will negatively affect economic growth and, in this direction, an economic policy is implemented. On the other hand, if the direction of the relationship is from EG to EC, it can be concluded that any negative situation in energy does not affect EG in both the long- short term, and economic policies can be directed in this direction. For example, energy saving, environmentally friendly energy systems and similar policies can be preferred.

Türkiye is among the countries with a high foreign exchange deficit and 74% of the energy used is imported from abroad (MFA, 2022). Therefore, as a foreign-dependent country in energy, Türkiye has made progress in renewable energy sources and has turned to other alternatives. Deciding the causality between growth and energy is an important issue for Türkiye. As a result of the obtained, if the direction of the relationship is from energy consumption to economic growth (determining whether the changes in energy consumption affect economic growth and whether this effect is permanent or temporary), it is concluded that any national or international energy crisis that may arise adversely affects economic growth and in that direction. an economic policy is preferable. On the other hand, if the direction of the relationship is from economic growth to energy consumption, it can be concluded that any negative situation in energy does not affect economic growth in both the long and short term, and economic policies can be directed accordingly. For example, energy saving, environmentally friendly energy systems and similar policies can be preferred. In addition to the causality determination, the main motivation of the study is to investigate the long-term and short-term effects of this relationship, to determine the strategies that can be applied in Türkiye's energy and to evaluate which policies would be appropriate in this regard.

The preferred variables to determine the relationship between EC and EG were daily electricity consumption and industrial production index. As data are monthly and cover the period of January 2016 and March 2022. Since the data on energy consumption has been published since January 2016, the analysis starts from this date. Augmented Dickey Fuller (ADF) (1979) and Phillips Perron (PP) (1988) unit root tests were used to define the stability of the variables. The structural break unit root test improved by Ziwot-Andrews (1992) was used to detect the presence of structural break in the variables. Afterwards, after establishing VAR (Vector AutoRegressive) model, the causality test improved by Toda-Yamamoto (1995) was preferred. After frequency domain causality test improved by Breitung-Candelon (2006) was preferred. The relationship among energy use and economic development was interpreted by comparing both causality tests. Toda-Yamamoto causality test was used to determine the direction of long-term causality between the variables. Breitung and Candelon frequency domain causality test was used to evaluate both long-term (permanent) and short-term (temporary) relationships among the variables.

The study consists of four sections. The first section consists of the introduction part. In the next, there is a literature section that includes both Türkiye and the other countries studies on the issue. The third section contains the definition of the data and the method used, and the fourth part includes the analysis findings and outcomes.

2.Literature Review

In the literature, due to the fluctuations in energy prices and high inflation in recent years, interest in both national and international studies on this subject has increased. In studies on the subject, in the first hypothesis is that it is accepted that there is a relationship from EC to EG. **(EC → EG).** According to this view, supportive energy policies will contribute to economic growth. Aslan (2021), Demirgil and Birol (2020), Turkmen et al. (2018), Çınar and Oz (2017), Cağıl and Türkmen (2013), Saatçi and Dumrul (2013), Mucuk and Uysal (2010) reached conclusions in their analysis for Türkiye

that an increase in EC increases EG. In a sectoral study for Türkiye, Koç (2020) concluded that the use of energy used in the transportation, industry and services sectors has a positive effect on growth, while the energy used in the agricultural sector does not affect economic growth. Kızılkaya and Dağ (2019) for China and the Philippines; Gozgor et al. (2017) for OECD countries; Bozoklu and Yılancı (2013) for Finland, Greece and Portugal; Yıldırım and Aslan (2012) for Japan; Apergis and Payne (2009) for six Central American countries; Narayan and Smyth (2008) for G7 countries; Lee (2005) for selected 18 developing countries; Asafu-Adjaye (2000) and Fatai et al. (2004) for India and Indonesia; Oh and Lee (2004) for Korea; Squalli (2007) found a causality from EC to EG in the analysis for Venezuela, Indonesia and Nigeria (Table 1).

Table 1: Comparison of Empirical Results (EC → EG)

Author	Period	Country	Method
Apergis & Payne	1980-2004	Six Central American Countries	Panel FMOLS Method
Asafu-Adjaye	1971-1995	India-Indonesia	VAR
Aslan	1965-2019	Türkiye	ARDL
Bozoklu & Yilanci	1965-2011	Finland, Greece, Portugal	Granger and Breitung- Candelon Causality Test
Çağıl & Türkmen	1989-2010	Türkiye	VAR
Çınar & Öz	1965-2015	Türkiye	VAR
Demirgil & Birol	1980-2018	Türkiye	ARDL
Gozgor et al.	1990-2013	29 OECD Countries	ARDL
Fatai et al.	1960-1999	India-Indonesia	OLS Method- Granger Causality Test
Kızılkaya & Dağ	1971-2014	China, Philippines	Panel Bootstrap Causality Test
Koç	2010-2016	132 Countries	Panel Data Analysis
Lee	1975-2001	18 Development Country	FMOLS Method
Mucuk & Uysal	1960-2006	Türkiye	VAR Method
Narayan & Smyth	1972-2002	G7 Countries	Panel Data Analysis
Saatçi & Dumrul	1960-2008	Türkiye	DOLS-FMOLS
Squalli	1980-2003	Venezuela, Indonesia, Nigerta	Toda- Yamamoto Causality Test
Türkmen et al.	1980-2014	Türkiye	Johensen Coıntegration Test
Yaşar & Sugözü	1995-2018	Austria, Belgium, South Cyprus, Slovakia	Panel Bootstrap Causality Test
Yıldırım & Aslan	1960-2009	Japan	HJC-HQC-SBC Causality Tests

Another argument in explaining the relationship between energy consumption and economic growth is that the increase in industrial production in the economy will increase energy consumption **(EG → EC).** Tran et al. (2022) for 26 OECD Countries; Shahbaz et al. (2017) and Cheng (1999) for India; Bozoklu and Yılancı (2013) for Australia, Canada, England and America; Yildirim and Aslan (2012) for Australia, Canada, Ireland; Huang et al. (2008) for 26 high income country; Mehrara (2007) for 11 selected oil exporting countries; Fatai et al. (2004) for New Zealand and Australia; Kraft and Kraft (1978) for USA; Squalli (2007) for Kuwait and Saudi Arabian countries found that economic growth increases energy consumption in their studies. Kesbiç and Salkım Er (2017) in his study for the EU and Türkiye, Increases in economic growth trigger renewable energy consumption (Table 2).

Table 2: Comparison of Empirical Results (EG → EC)

Bozoklu & Yilanci	1965-2011	Australia, Canada, UK, USA	Granger and Breitung- Candelon Causality Test
Cheng	1952-1995	India	VAR Method
Fatai et al.	1960-1999	New Zealand- Australia	OLS Method- Engle Granger Causality Test
Huang et al.	197-2002	26 High Income Countries	Panel VAR Method
Kesbiç & Salkım Er	2004-2014	EU and Türkiye	Panel Data Analysis
Kraft & Kraft	1947-1974	USA	Granger Causality Test
Mehrara	1971-2002	11 Oil Exporting Countries	Panel Data Analysis
Shahbaz, Hoang, Mahalik & Roubaud	1960-2015	India	NARDL
Squalli	1980-2003	Kuwait, Saudi Arabia	Toda- Yamamoto Causality Test
Tran et al.	1971-2014	26 OECD Countries	VECM
Yıldırım & Aslan	1960-2009	Austria, Canada, Ireland	HJC-HQC-SBC Causality Test

The third view is that there is a bidirectional interaction between EG and EC **(EC=EG)**. According to this argument, EC and EG affect each other bilaterally. Çandarli and Unakıtan (2021), Kurt (2019) for Türkiye; Yaşar and Sugözü (2019) for Spain; Chang et al. (2015) for G7 countries; Ben Jebli and Ben Youssef (2015) for selected 69 countries; Bozoklu and Yılancı (2013) for Austria, Italy, Japan, Netherlands, Portugal, Belgium, Denmark and Norway; Yildirim and Aslan (2012) for Italy, New Zealand, Norway and Spain; Bowden and Payne (2009) for USA; Belke et al. (2011) for 25 OECD countries; Asafu-Adjaye (2000) and Fatai et al. (2004) for Thailand and the Philippines; Oh and Lee (2004) Korea; Paul and Bhattacharya (2004) for India; Yang (2000) for Taiwan; Squalli (2007) for Iran and Qatar; Hondroyianni et al (2002) for Greece found a bidirectional relationship between EG and EC in their study. Usta and Berber (2017) concluded in his study that the amount of energy consumed in the transportation and industry sectors affects economic growth bilaterally (Table 3).

Table 3: Comparison of Empirical Results (EC = EG)

Asafu-Adjaye	1971-1995	Thailand- Philippines	VAR Analysis
Belke et al.	1981-2007	29 OECD Countries	DOLS-FMOLS Method
Ben Jebli & Ben Youssef	1980-2007	69 Countries	DOLS-FMOLS Method
Bowden & Payne	1949-2006	USA	Toda Yamamoto and Granger Causality Test
Bozoklu & Yilanci	1965-2011	Austria, Italy, Japan, Netherlands, Portugal, Belgium, Denmark, Norway	Granger and Breitung- Candelon Causality Test
Chang et al.	1990-2011	G7 Countries	Granger Causality Test
Çandarlı & Unakıtan	1990-2019	Türkiye	VECM
Fatai et al.	1960-1999	Thailand- Philippines	OLS Method- Engle-Granger Causality Test
Hondroyianni et al.	1960-1996	Greece	VECM
Kurt	1950-2015	Türkiye	VECM
Oh & Lee	1970-1999	Korea	VECM
Paul & Bhattacharya	1950-1996	India	Engle-Granger Causality Test
Squalli	1980-2003	Iran, Qatar	Toda- Yamamoto Causality Test
Usta & Berber	1970-2012	Türkiye	Toda Yamamoto Causality Test
Yang	1954-1997	Taiwan	Granger Causality Test
Yaşar & Sugözü	1995-2018	Spain	Panel Bootstrap Causality Test
Yıldırım & Aslan	1960-2009	Italy, New Zealand, Norway, Spain	HJC-HQC-SBC Causality Tests

The fourth view is that there is no relationship between EC and EG **(EC ≠ EG).** According to this view, there is no connection between EG and EC. Kızılkaya and Dağ (2019) for Brazil, Indonesia, India, Mexico, Malaysia and Türkiye; Yaşar and Sugözü (2019) for Austria, Belgium, Southern Cyprus and Slovakia; Yıldırım and Aslan (2012) for Sweden, England, America, Germany, France, Austria, Denmark, Finland and Türkiye; Stern (1993) for USA did not find any causality between

growth and energy in their studies. Koç (2020) has found that the amount of energy used in the agricultural sector does not support economic growth (Table 4).

Table 4: Comparison of Empirical Results (EC ≠ EG)

Kızılkaya & Dağ	1971-2014	Brazil, Indonesia, India, Mexico, Malaysia, Türkiye	Panel Bootstrap Causality Test
Stern	1947-1990	USA	VAR Analysis
Yaşar & Sugözü	1995-2018	Austria, Belgium, Southern Cyprus and Slovakia	Panel Bootstrap Causality Test
Yıldırım & Aslan	1960-2009	Sweden, UK, USA, Sweden, Germany, Austria, Denmark, Finland, Türkiye	HJC-HQC-SBC Causality Tests

In the literature, different results have been obtained for each country on the existence of the relationship between EC and EG. The general argument for Türkiye is that scientists have agreed on the existence of a relationship between EC and EG. There are also different outcomes due to the differences in the years considered, the method preferred in the analysis and the variables used.

3. Model and Data Description

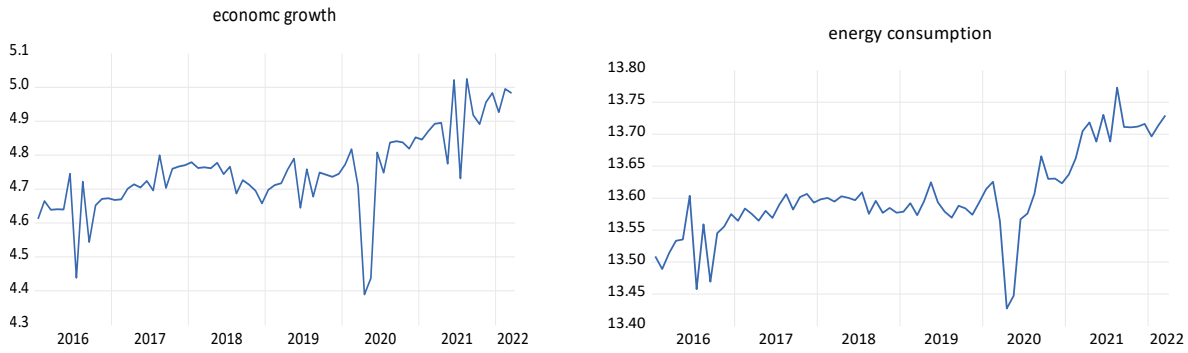
For the analysis of the relationship between economic growth and energy consumption, industrial production index and daily electricity consumption were used. The data is monthly and logarithmic conversions of the variables were used, also examines the period of 2016 and 2022. In the first stage, the variables were tested for the stationarity. For the stationarity test, ADF and PP tests were performed(Table 5). Graph 1 shows the time series figures of the variables

Table 5: Portrait of the Variables

Variables	Symbol	Period	Unit	Source
Industrial production index	lneg	2016:01-2022:03	Level	CBRT
Electricity Consumption	lnec	2016:01-2022:03	MWh- Level	CBRT

Note: The base year is taken as 2015, CBRT: Central Bank of the Republic of Türkiye

Figure 1: Time Series Charts



After the determination of the I (1) level stationarity of the variables, the VAR was established for the Toda-Yamamoto test. The Breitung and Candelon Frequency Domain test allows it to be applied based on both Granger (1969) causality test and it differs from others in terms of providing information on whether the short-middle and long-term relationships among the variables. Breitung-Candelon analysis, in Geweke's (1982) previous study, considered the two-dimensional vector containing Y_t and Z_t together with a finite order VAR model with "p" order. Figure 1

Firstly, VAR model is obtained by adding the maximum stationarity degree of the series to the appropriate lag length determined.[1] The resulting VAR model;

$$Y_t = \alpha_0 + \sum_{i=1}^{p+d_{max}} \alpha_{1i} Y_{t-1} + \sum_{i=1}^{p+d_{max}} \alpha_{2i} X_{t-i} + u_t \quad (1)$$

$$X_t = ß_0 + \sum_{i=1}^{p+d_{max}} ß_{1i} X_{t-1} + \sum_{i=1}^{p+d_{max}} ß_{2i} Y_{t-i} + v_t \quad (2)$$

Hypotheses for causality testing of variables;

H_0 = There is causality.

H_1 =There is no causality.

The VAR model is established again according to the new lag value obtained by the sum of the maximum stationarity degree and the detected lag length, which is another step in the causality analysis of Toda-Yamamoto (1995). In the last stage, the constraints are added to the obtained coefficients and the meaning of these constraints is tested with the WALD.

Breitung-Candelon (2006) contributed to the generation of different frequency values for each interval. Taştan (2015), Ciner (2011), Kırca et al. (2022), the short-middle and long-term frequency values among the variables were formed;

ω= 0.05 Short-term;

ω= 1.50 Mid-term;

ω= 2.50 Long-term causality relationship frequency value,

Then, the time dimension corresponding to the determined "*w*" values is determined. Time zone calculation formula;

T= $\frac{2\pi}{\omega}$

T= The period to which the frequency corresponds

ω = Frequency value

π = Pi value (3.14)

Equation established for analysis;

Lneg = $ß_0 + ß_1 \text{lnec} + u_{it}$ (3)

Lnec = $\alpha_0 + \alpha_1 \text{lneg} + \varepsilon_{it}$ (4)

While equation (3) shows the effect of EC on EG equation (4) shows the effect of EG on EC. The "u" and "ε" coefficients in the equations represent the error terms.

4. Analysis Findings

In the analysis the logarithm of the data was taken and unit root test was applied to test for stationarity. ADF and PP unit root tests of the variables are given in Table 3. All variables in both tests are not stationary at I (0) level values, although become stationary at I (1) level in both ADF and PP tests results.

[1] It is obtained with the formula "p+ d_{max}"

Table 6: ADF and PP Test Results

	ADF Test				PP Test			
	Constant		Trend-Constant		Constant		Trend-Constant	
Variables	**t-Stat.**	**Prob.**	**t-Stat.**	**Prob.**	**t-Stat.**	**Prob.**	**t-Stat.**	**Prob.**
lneg	-2,051	0,264	-3.102	0,113	-4,040	0,002	-6.503	0,132
lnec	-2.560	0,105	-3.776	0,233	-2.191	0,211	-3.771	0,231
Δlneg	-15,46	0,000	-15,385	0,000	-27,311	0,000	-29,490	0,000
Δlnec	-12,46	0,000	-12,377	0,000	-15.866	0,000	-15.975	0,000

Figure-1 shows that there may be a structural break in both variables. For this purpose, the unit root test improved by Ziwot-Andrews (1992), which detects a single structural break, was applied. Ziwot-Andrews unit root test results show that there was a structural break in March 2020 in both industrial production index and electricity consumption data. March 2020 is the month when the first Covid-19 case appeared in Turkey. Türkiye experienced a contraction of 9% in the second quarter.

Tablo 7: Zivot-Andrews Unit Root Test Results

	Constant			Trend-Constant		
Variables	**t-Stat.**	**Prob.**	**Structural Date**	**t-Stat.**	**Prob.**	**Structural Date**
lneg	-4.519555	0.011518	2018Q08	-5.339952	0.026400	2020Q03
lnec	-4.177263	0.001356	2021Q02	-4.851331	0.006714	2020Q03

After determining the stationarity, the lag length was determined with the VAR analysis. After determining the appropriate lag length as 2, autocorrelation and varying variance tests of the model were performed. As a result, no autocorrelation and changing variance problems were found in the model.[2]

Table 8: Toda-Yamamoto Test Results

Independent Variable / **Dependent Variable**	**lneg t stat. (prob)**	**lnec t stat. (prob)**
lneg	**-**	**11.54 (0.00)***
lnec	1.83 (0.60)	-
All	**26.72 (0.00)***	**36.03 (0.00)***

In the Toda-Yamamoto causality test results, a one-way causality relationship was found at the 5% significance level, and there was a long-term causality from the industrial production index to energy consumption. Moreover, there was a causal relationship from EC to EG at the 10% significance level.

Table 9: Breitung and Candelon Test Results

Hypotheses	**Long Term (ω =0.05)**	**Mid term (ω =1.5)**	**Short Term (ω =2.5)**
lneg → lnec	**12.49 (0.00)***	**10.61 (0.00)***	**11.60 (0.00)***
Lnec → lneg	1.05 (0.58)	1.36 (0.50)	1.48 (0.47)

Table 9 shows the Breitung- Candelon test results. In the findings obtained, a long, medium and short-term both permanent and temporary relationship was determined from industrial production to energy consumption at the 5% significance level. And no causality was found from EC to EG. As a result,

[2]Lag length, autocorrelation and varying variance tests are given in the attached tables. * There is a significant causality between the variables at the 5% significance level. The values in the brackets are the probability value of the F statistics calculated for the relevant ω values.

Breitung- Candelon causality test results showed similarity with Toda-Yamamoto causality test results.

Graph 2 and Graph 3 show the graphical representation of the Breitung and Candelon Test Results. In Graph 2, causality is seen from EG to EC, while in Graph 3, it is seen that there is no causality from EC to EG.[3]

Figure 2: Causality from EG→EC

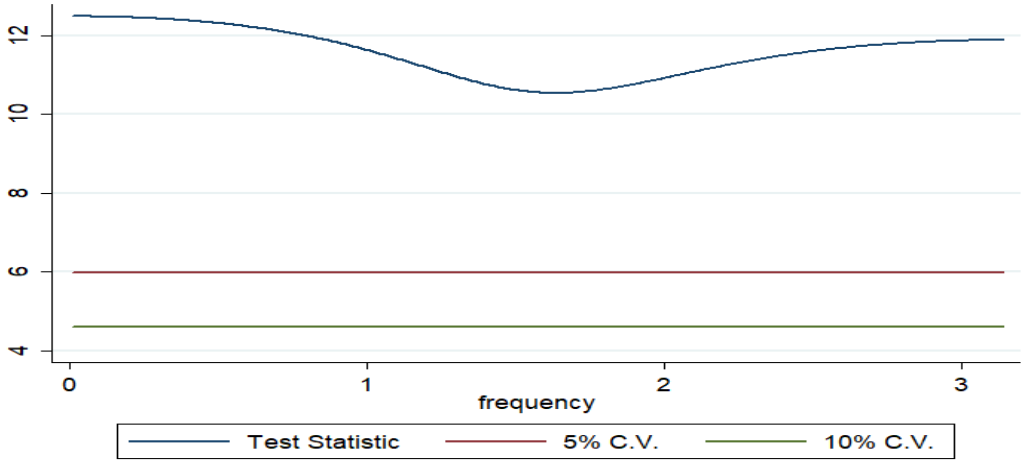
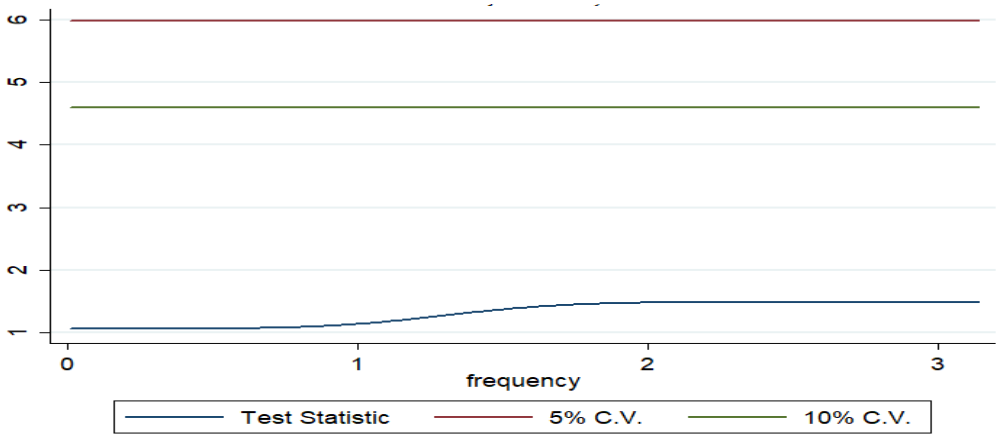


Figure 3: Causality from EC→EG



5. Discussion and Conclusion

The most important indicator of the development level of countries is the distance they have covered in economic growth. The growth of production is related to how the inputs used in production are obtained or how much of it is owned. Many studies have proven that the energy used in production is an important factor. The aim of this study was to examine the link between Turkey's economic growth and energy consumption in the period of 2016 and 2022. According to the findings of the Toda-Yamamoto Causality test, while no causality was found from EC to EG at the 5% significance level, a unidirectional causality was found from EG to EC. Moreover, there was a causal relationship from EC to EG at the 10% significance level. In Breitung and Candelon test results, on the other hand, there is no causality from EC to EG, but a unidirectional causality from EG to EC. The results showed parallelism with the Toda-Yamamoto causality test results. Moreover, the causality connection from

[3]The fact that the line of the variables is above the 5% and 10% significance level lines indicates the existence of a relationship.

EG to EC in the Breitung and Candelon test results creates both a short-effect and a permanent effect. This study has obtained similar results with Tran et al. (2022), Shahbaz et al. (2017), Cheng (1999), Bozoklu et al. (2013), Yıldırım et al. (2012), Fatai et al. (2004), Squalli (2007), Mehrara (2007), Kraft et al. (1978).

Economic growth includes persistent causality for EC in both the short-middle and long-term for the period of 2016 and 2022 in Türkiye. In Türkiye, especially in the 2000s, the reasons such as the breakthroughs in growth towards exports, the technology-oriented production, and the high growth figures in this period increased the need for energy. The long-term effect of obtaining energy with high imports on economic growth supports similar findings with the study. The implementation of economic policies focused on economic growth increases the need for the existence of future economic plans and programs in energy use. The findings show that the increase in economic growth increases the energy dependency more.

Türkiye is a foreign-dependent country in energy use. Problems in energy supply cause many problems in production both in the short and long term. The increase in energy prices, especially after the Russia and Ukraine Crises, confirms the high vulnerability in this sector. Importing a large portion of energy affects growth negatively. İnançlı and Akı (2022); Berk and Cin (2018); Orhan and Nergiz (2014) in their studies found for Turkey that high energy imports increase the foreign trade deficit, which then causes the current account deficit to rise. As a result, Türkiye is dependent on imports to increase its production. In Türkiye 70% of imports are realized with exported products.[4] In other words, Türkiye has to import in order to produce. The more exports increase, the more imports increase. This situation leads to the current account deficit problem in Türkiye. The share of energy in imports is 27%.[5] On the other hand, 74% of the foreign trade deficit is due to energy imports.[6] High import figures constantly increase the need for foreign currency in Türkiye. In countries with a high foreign exchange deficit, such as Türkiye, this situation becomes one of the main sources of inflation (Turna et al., 2021; Kaya, 2018; Abdurehman et al., 2016).

First of all, it is a known problem that one of the essential causes for the foreign exchange deficit problem in Türkiye is foreign dependency in energy. The suggested solutions for this are as follows:

- Continuing the exploration activities of fossil energy sources (accelerating natural gas exploration, especially in the Black Sea Region),

- Initiating alternative projects in cooperation with universities on renewable energy sources,

- Determining new strategic targets connected to the use of energy resources in more efficient areas with high added value in the industry (such as imposing certain limitations on the amount of energy consumed according to the type of production)

- Climate changes with global warming have caused countries to go to new alternatives in terms of energy. Examples such as Germany's solar energy projects, the UK's work on wind energy, and the implementation of local district heating facilities in Sweden can be taken as a basis.

In recent years, energy use is constantly increasing, especially in industrialized countries, both in terms of energy security and due to climate differences caused by global warming, towards renewable energy sources. The study has shown that ensuring a permanent economic growth in Türkiye largely lies in reducing energy dependence. By introducing new measures in the economic policies to be implemented, it can be ensured that the dependence on imports in energy is reduced, and new environmentally friendly projects can be brought to the agenda. In terms of renewable energy sources, priority can be given to producing varied alternatives such as wind energy and solar energy and

[4] https://data.tuik.gov.tr/Bulten/Index?p=Foreign-Trade-Statistics-November-2022-45546
[5]https://www.trade.gov.tr/data/5b9229ab13b876136466584b/Economic%20Outlook%20December%202022.pdf
[6] https://www.mfa.gov.tr/Türkiyes-electricity-strategy.en.mfa

strengthening existing systems. Instead of the growth-oriented assumption that Türkiye has followed in its economic policies, channeling the energy used in production to areas where more efficiency will be obtained will both have a positive effect on energy consumption and reduce the dependence on imports in energy. Rather than focusing on the results of fundamental problems such as inflation, interest, and foreign exchange deficit, Türkiye should take this into account while addressing the main source of the problems and suggesting solutions in the economic policies to be implemented.

AUTHOR CONTRIBUTION

Authors contributed equally to the entire study.

STATEMENT OF CONFLICT OF INTEREST

There is no conflict of interest with any institution, organization, or person.

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APPENDIX

Table 10: Determination of Appropriate Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	432,8488	NA	4,70e-11	-12,43040	-12,30089	-12,37902
1	609,4927	327,6873	4,47e-13	-17,08675	-16,43918*	-16,82983*
2	**628,6842**	**33,37649***	**4,09e-13***	**-17,17925***	**-16,01363**	**-16,71681**
3	644,1250	25,06329	4,21e-13	-17,16304	-15,47937	-16,49507
4	656,3379	18,40789	4,81e-13	-17,05327	-14,85154	-16,17977
5	664,3913	11,20478	6,29e-13	-16,82294	-14,10316	-15,74391
6	671,4930	9,057235	8,63e-13	-16,56502	-13,32718	-15,28046

Table 11: LM Autocorrelation Test

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	25,14363	16	0,0673	1,620450	(16, 174,8)	0,0677
2	**39,86624**	**32**	**0,1600**	**1,273672**	**(32, 197,0)**	**0,1622**
3	58,58411	48	0,1408	1,253051	(48, 190,8)	0,1462
4	67,45074	64	0,3600	1,059369	(64, 178,4)	0,3772
5	95,09417	80	0,1195	1,224875	(80, 164,2)	0,1393
6	105,5560	96	0,2371	1,107457	(96, 149,1)	0,2858

Table 12: Variance Test Result

Chi-sq	df	Prob.
18,19975	12	0,1098