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A FOURIER APPROACH ON THE RELATIONSHIP BETWEEN OIL CONSUMPTION AND ECONOMIC GROWTH IN TÜRKİYE

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ABSTRACT

Energy is one of the fundamental elements of sustainable economic development, with energy flows and transformations exerting a decisive impact on economic activities. Particularly, oil continues to hold a strategic position in the global energy market and stands out as a significant energy source for various sectors due to its wide range of applications. This study analyzes the relationship between oil consumption and economic growth in Turkey for the period from 1971 to 2021 using the Fourier Engle-Granger cointegration test and the Fourier Enders-Jones Granger causality test. The cointegration test results indicate a long-term relationship between oil consumption and economic growth. The causality test results support the validity of the feedback hypothesis.

Keywords: Oil consumption, economic growth, cointegration, causality, Türkiye.

TÜRKİYE'DE PETROL TÜKETİMİ VE EKONOMİK BÜYÜME İLİŞKİSİ ÜZERİNE BİR FOURIER YAKLAŞIMI

ÖZ

Enerji, sürdürülebilir ekonomik kalkınmanın temel unsurlarından biri olup, enerji akışları ve dönüşümleri ekonomik faaliyetler üzerinde belirleyici bir etkiye sahiptir. Özellikle petrol, küresel enerji piyasasında stratejik bir konuma sahip olmayı sürdürmekte ve geniş kullanım alanı sayesinde birçok sektör için önemli bir enerji kaynağı olarak öne çıkmaktadır. Bu çalışmada, Türkiye'de petrol tüketimi ile ekonomik büyüme arasındaki ilişki 1971-2021 dönemi için Fourier Engle-Granger eş-bütünleşme testi ve Fourier Enders-Jones Granger nedensellik testi ile analiz edilmiştir. Eş-bütünleşme testi sonuçlarına göre petrol tüketimi ile ekonomik büyüme arasında uzun dönemli bir ilişki bulunmaktadır. Nedensellik testi sonuçları geri besleme hipotezinin geçerliliğini ortaya koymaktadır.

Anahtar Kelimeler: Petrol tüketimi, ekonomik büyüme, eşbütünleşme, nedensellik, Türkiye.

INTRODUCTION

Energy has truly been a cornerstone in the economic development of societies and has shaped their economic transformation. In the early stages of economic development, most economies relied on agriculture and predominantly on human labor; however, with industrialization, energy began to be used intensively in production. The use of coal, followed by oil, gas, and electricity, spurred new industries, increased labor productivity, and led to higher living standards and economic growth. Energy consumption increased in the urbanization phase, which is directly related to the industrialization process. In this context, it can be said that the economic development process follows a parallel course with the increase in energy consumption. The basis of this situation lies in economic growth's dependence on the increased use of production factors, particularly energy (Riaz, 1987). Studies show that energy plays an important role in production and consumption functions in countries in the intermediate stages of economic development, compared to factors such as labor and capital. Especially in recent years, energy has gained attention as one of the fastest-growing production factors, providing substantial momentum toward achieving sustainable development goals. Today, energy is viewed as a primary driver of economic activities, facilitating the production of goods and services through various energy flows and transformations. In this context, countries' economic growth depends largely on energy consumption (Rahman et al. 2018). However, the impact of different energy sources on economic growth varies; for instance, oil consumption has a more pronounced effect on economic growth than other energy sources (Altınay & Karagöl, 2004; Zaman et al. 2011).

Oil consumption can be regarded as a fundamental factor in determining output levels in both the long and short term. This is primarily because the extensive use of oil, particularly in the industrial and transportation sectors, directly impacts the economy. Additionally, rising oil consumption significantly influences employment levels; a decrease in oil consumption leads to reductions in income and employment (Aktaş & Yılmaz, 2008). Furthermore, decisions made by various societal groups regarding energy usage profoundly affect the economic and social performance of economies in both the short and long term (Zaman et al. 2011). The growing energy dependence of countries, exacerbated by globalization, rapidly increasing energy demand, rising oil prices driven by this demand, the depletion of oil resources, and concerns about energy supply security, indicates that energy will emerge as one of the major global challenges in the near future.

In light of the above, this article aims to explore the relationship between oil consumption and economic growth within the context of the Turkish economy. The primary motivation for analyzing this relationship stems from the ongoing debate on reducing Turkey's dependence on oil consumption. Turkey's economy relies heavily on energy-intensive growth and satisfies a significant portion of its energy needs through imports. Therefore, finding a reasonable timeframe for reducing this dependency without adversely affecting economic growth is crucial. In this context, identifying the causality relationship will facilitate the formulation of effective energy policies. The subsequent sections of this study will outline the theoretical framework surrounding the relationship between oil consumption and economic growth, review the existing literature, and analyze the quality and direction of this relationship through a case study of the Turkish economy.

2. Theoretical Framework

Energy is crucial for economic development and significantly impacts economic activities from both the demand and supply sides. On the demand side, energy is a fundamental good that consumers select to maximize their utility functions. From the supply side, energy serves as a vital input in the production function, alongside capital and labor.

According to Yoo (2006), oil is a complementary factor of production along with labor and capital, and other factors of production are affected by changes in oil production. (Terzi & Pata, 2016). Oil continues to be a major energy source due to its flexibility, high energy density, broad applicability across various industries, and global impact. As a non-renewable energy source, oil is extensively utilized in nearly

every aspect of life (transportation, housing, industry, etc.), as a final consumer product and as an energy input (Bildirici & Kayıkçı, 2013). The importance of oil has increased as countries developed, parallel to industrial growth and rising living standards (Waaled et al. 2018).

Oil crises have revealed how vital oil is for economies, stalled global economic development, and affected heavy industries. Although countries have diversified their energy sources, increased energy efficiency, and turned to alternative energy sources aimed at reducing dependence on oil, today, countries continue to be dependent on oil (Shaari et al. 2024; Terzi & Pata, 2016; Waaled et al. 2018). As of 2022, the share of petroleum products in the world's total final energy consumption is 40%, which can be expressed as the highest share among energy sources. Similarly, in Turkey, the share of petroleum products consumption in the total final energy consumption is 37%, which can be expressed as the highest share among energy sources (IEA, 2023).

In countries rich in oil resources, prices for crude oil and refined products tend to be lower. Reduced prices for oil and its derivatives can stimulate higher energy consumption. This rise in oil consumption in such countries impacts budget expenditures, ultimately influencing the level of economic, social, and technological activities. Lower energy costs can also promote industrial production, yielding positive economic effects. However, increased oil consumption can also result in higher fossil fuel combustion, leading to increased greenhouse gas emissions and contributing to global warming (Gazouani & Maktuf, 2024). Today, many oil-exporting nations are significantly dependent on revenues from oil production, with these revenues making up a substantial portion of government budgets. As energy transitions progress, countries face the possibility that these revenues will decline due to the environmental impacts of oil consumption (Emmanuel et al. 2024; IEA, 2023).

In countries where oil resources are scarce and/or dependent on oil, energy consumption increases faster than the energy produced, and the country in question becomes an energy importer. These countries need more oil to sustain their economic development. Oil dependency is thought to be the main reason for the current deficit in oil-importing countries. Moreover, rising oil prices contribute to increased production costs, which burdens the economy excessively. Additionally, oil crises resulting from increases in oil prices or supply shortages adversely affect the economic growth of these countries. Therefore, energy supply security becomes even more important in countries dependent on foreign energy.

3. Summary of Literature

Over the past years, the growing trend among to reduce their energy consumption has increased the interest in determining the causal relationships between energy consumption and economic growth. The situation can be attributed to two main driving forces: the negative effects of fossil fuels on the environment and crude oil price shocks (Behmiri & Manso, 2014). The relationship between oil consumption and economic growth has been explored less extensively in existing literature than the connections between total energy consumption and economic growth. The main purpose of examining the relationship between oil consumption and economic growth is to determine whether the economies in question are dependent on oil to ensure their growth. (Narayan & Wong, 2009). Pindyck (1979) suggested that the impact of energy prices on economic growth is influenced by the role of energy within the production structure. Accordingly, in industries where energy serves as an intermediate input in production, national production will decrease as energy consumption decreases due to price increases (Pindyck, 1979). According to Sharma (2010), recent increases in oil prices and subsequent economic recessions have revived the focus on the relationships between oil consumption and economic activities. Key studies in this field include: Studies in this area: Prasad et al. (2007) for Fiji, Hanabusa (2009) for Japan, Lorde et al. (2009) for Trinidad and Tobago, Narayan and Wong (2009) for Australia, Narayan and Narayan (2010) for Vietnam and Ghalayini (2011) for G-7 countries.

In the existing literature, the causal relationship between oil consumption and economic growth is expressed by four testable hypotheses, namely growth, conservation, feedback, and neutrality (Choi & Yoo, 2016). *Growth hypothesis* ($P \rightarrow B$) expresses a one-way causal relationship from oil consumption to economic growth. An increase in oil consumption supports economic growth, whereas a shortage of oil supply negatively impacts economic growth. *Conservation Hypothesis* ($P \leftarrow B$) expresses a one-way causality relationship from economic growth to oil consumption. As individuals' income levels increase due to economic growth, oil consumption increases. Oil use in production and transportation processes

also increases with growth. *Feedback Hypothesis* ($P \leftrightarrow B$) expresses a bidirectional causality relationship between oil consumption and economic growth. Oil consumption and economic growth mutually affect each other; the increase in oil consumption supports growth, while economic growth increases oil demand. Therefore, it is recommended that policymakers take steps to strengthen the energy infrastructure and increase oil supply in order to stimulate growth. The *Neutrality hypothesis* ($P - B$) suggests that there is no direct causal link between oil consumption and economic growth. Applied studies in this field are presented in Table 1. The studies mentioned are listed chronologically in terms of author(s), country/period of study, method used in the study and causality relationship.

TABLE 1 | Applied Studies

Author(s)	Country/Period	Method	Causality
Hoai (1993)	Tayland 1966-1991	Cointegration test, Granger causality test	$P \leftrightarrow B$
Yoo (2006)	Korea 1968-2002	Johansen cointegration test, ECM	$P \leftrightarrow B$
Zou & Chau (2006)	China 1953-2002	Johansen cointegration test, Granger causality test, VAR	$P \rightarrow B$ (short term) $P \leftrightarrow B$ (long term)
Karagöl & Erbaykal (2006)	Türkiye 1971-2003	Johansen and Juselius cointegration test, Granger causality test	$P - B$ (short term) $P \leftarrow B$ (long term)
Zhao et al. (2008)	China 1963-2005	Johansen and Johansen-Juselius cointegration test, Granger causality test, VECM	$P \leftrightarrow B$
Aktaş & Yılmaz (2008)	Türkiye 1970-2004	Johansen cointegration test, ECM	$P \leftrightarrow B$
Narayan & Wong (2009)	Australia 1985-2006	Panel cointegration test, Panel Granger causality test	$P \leftarrow B$
Zikovic & Vlahinic-Dizdarevic (2009)	European countries 1980-2007	Johansen cointegration test, Granger causality test	$P \leftarrow B$ (Croatia, Latvia, Lithuania, Moldova) $P \rightarrow B$ (Austria, Czech Republic, Malta, Slovakia, Bosnia and Herzegovina, Bulgaria)
Royfaizal (2009)	Japan 1992-2006	ARDL, Granger causality test	$P \leftarrow B, F$
Bhusal (2010)	Nepal 1975-2009	Johansen cointegration test, VECM	$P \leftrightarrow B$
Almulali (2011)	MENA countries 1980-2009	Panel cointegration test, Panel causality test	$P \leftrightarrow B$
Zaman et al. (2011)	Pakistan 1972-2008	Johansen cointegration test, Granger causality test, VECM	$P \rightarrow B$ (transportation and industrial sectors)
Fuinhas & Marques (2012)	Portugal 1965-2009	ARDL	$P \leftarrow B$
Bildirici & Kayıkçı (2013)	Eurasian countries 1993-2010	Panel cointegration test, Panel causality test	$P \leftrightarrow B$
Behmiri & Manso (2012)	27 OECD countries 1976-2009	Panel cointegration test, Panel causality test	$P \leftrightarrow B$
Behmiri & Manso (2013)	Sub-Saharan African countries 1985-2011	Panel cointegration test, Panel causality test	$P \leftrightarrow B$ (oil-importing countries) $P \rightarrow B$ (oil exporting countries)
Behmiri & Manso (2014)	Latin American Countries 1980-2012	Panel cointegration test, Panel causality test	$P - B$ (Caribbean and South America) $P \rightarrow B$ (Central America)
Park & Yoo (2014)	Malaysia 1965-2011	Johansen cointegration test, VECM	$P \leftrightarrow B$
Alam & Paramati (2015)	18 developing country 1980-2012	Panel cointegration test, Panel causality test	$P \leftrightarrow B$
Ziramba (2015)	South Africa 1970-2008	VECM, Toda-Yamamoto causality test	$P \rightarrow B$
Terzi & Pata (2016)	Türkiye 1974-2014	Gregory-Hansen cointegration test, Hsiao's Granger causality test	$P \rightarrow B$
Choi & Yoo (2016)	Brazil 1965-2010	Johansen cointegration test, Granger causality test	$P \leftrightarrow B$
Waleed et al. (2018)	Pakistan 1965-2015	VECM, Granger causality test	$P \leftrightarrow B$
Lahiani et al. (2019)	USA 1955-2016	Quantile ARDL Quantile Granger causality test	$P \rightarrow B$ (smallest quantiles) $P \leftrightarrow B$ (medium quantiles) $P - B$ (high quantiles)
Daly et al. (2024)	Saudi Arabia 1970-2021	ARDL, Toda-Yamamoto causality test	$P \rightarrow B$

As shown in Table 1, the relationship between oil consumption and economic growth in the literature has been tested in studies conducted on single countries or groups of countries during different periods. The analytical methods used in these studies are generally based on traditional cointegration and causality tests. With the advancement of time series analysis methods, it has become possible to uncover economic relationships that can significantly impact countries' macroeconomic policies. The Fourier approach used in this study is also one of the recently developed methods. The main difference between this approach and the Gregory-Hansen cointegration test with structural breaks is that the Fourier function is employed to model small but significant structural changes instead of using dummy variables to capture sudden structural breaks in economic variables. While there are generally identical results in the studies regarding the existence of a long-term relationship between oil consumption and economic growth, there are also conflicting results regarding the direction of the relationship. In this case, the development level of the country in question (developed or developing country) and the period and method used in the study may be different.

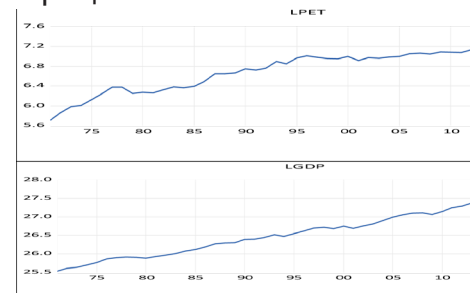
In addition, although the classification is shown in Table 1, the results reached in some studies need to be examined in detail. Among these studies, Zou and Chau (2006) focused on China and concluded that changes in the Chinese economy have a minimal impact on oil consumption changes. This situation can primarily be attributed to China's energy consumption structure, where a significant majority of total energy consumption is derived from coal. Consequently, the energy demand driven by economic growth is largely explained by the intensive use of coal, resulting in a relatively small share of oil consumption attributable to economic growth. Nevertheless, oil consumption is considered a fundamental input in both the short and long term, primarily because its usage in the industrial sector directly affects the economy. However, this finding tends to encourage greater oil consumption. The result of the study is that the rapidly increasing oil imports create a substantial burden on China, warranting attention to this issue. Royfaizal (2009) found that the long-term price elasticity of crude oil imports in Japan is -0.08, while the income elasticity is 1.35. This means that economic growth will not be affected when the possibility of using an alternative energy source to crude oil or depletion of crude oil reserves is taken into account.

4 Data, Methods and Empirical Results

In Turkey, which is among the fastest-growing markets in the world and has undergone a structural transformation from agriculture to industry, oil is a basic energy source necessary for economic development. However, since domestic oil production in Turkey is quite low, the demand for oil raw materials is largely met through imports (Uğurlu & Ünsal, 2009). Within the framework of the theoretical explanations made in this study, the relationship between oil consumption and economic growth will be analyzed for the period 1971-2021 for Turkey. The model to be used in the study is shown in equation (1).

$$LGDP = f(LPET) \quad (1)$$

The variable GDP (Gross Domestic Product, at constant prices, \$) in Equation (1) represents economic growth, and the data set for this variable is taken from WB-WDI. PET is the oil consumption (PJ) variable related to the total final consumption of petroleum products, and the data set related to this variable was obtained from the IEA. Logarithms of the series were taken, and graphs related to the series are given in Figure 1

FIGURE 1 | Graphs Related to Series

In Figure 1, it is seen that there is a trend in both series and the graphs of the series raise doubts about trend stationarity. The econometric analysis conducted in this study includes a unit root test to assess the stationarity of the variables, a cointegration test to explore the long-term relationships between the variables, coefficient estimation, and causality tests to establish the direction of causality.

4.1 Unit Root Test and Results

In the econometric analysis of this study, the stationarity of the variables considered in the model was first analyzed using the unit root test to rule out the possibility of spurious regression. Lee-Strazicich (2003) structural break unit root test was applied in this study. It is known that structural changes in the economy also affect the structural characteristics of the data used as economic indicators. In this context, ignoring this situation in a time series where structural breaks exist may lead to misleading results in terms of stationarity analysis. In this test, breaks are determined endogenously, and break dates are determined by the grid scanning method (Dumrul, 2010). The Lee-Strazicich unit root test considers the breaks related to two different models, Model A and Model C. Model A shows the break on the constant, while Model C shows the breaks on both the constant and the trend. The data generation process in the test is shown in equation (2).

$$Y_t = \delta' Z_t + \varepsilon_t \quad \varepsilon_t = \beta \varepsilon_{t-1} + u_t \quad u_t \sim i.i.d. N(0, \sigma^2) \quad (2)$$

In equation (2), (Y_t) and (Z_t) represent the dependent variable and exogenous variable vectors, respectively.

The model allows two breakouts at level A and for $t \geq T_{Bj} + 1$, $j=1, 2$ $D_{jt}=1$ and others are 0 and it is defined by the vector $Z_t = [1, t, D_{1t}, D_{2t}]'$. Model C allows two breaks in the constant and trend and for $t \geq T_{Bj} + 1$, $j=1, 2$ $D_{jt} = t - T_{Bj}$ and others are 0 and it is defined by the vector $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]'$ (Lee & Strazicich, 2003). D_{1t} and D_{2t} represent the breaks in the constant, and (DT_{1t}) and (DT_{2t}) are dummy variables used to examine the break in the trend. The null hypothesis and alternative hypothesis for Model A can be explained by equations (3) and (4).

$$H_0: Y_t = \mu_0 + d_1 B_{1t} + d_2 B_{2t} + y_{t-1} + v_{1t} \quad (3)$$

$$H_A: Y_t = \mu_1 + \gamma t + d_1 D_{1t} + d_2 D_{2t} + v_{2t} \quad (4)$$

Equations (3) and (4) are the stationary error terms for the (v_{1t}) and (v_{2t}) models. When $j = 1, 2$ is equal to $t = T_{Bj} + 1$, $B_{jt} = 1$; otherwise, it is equal to zero. $d = (d_1, d_2)'$ is the coefficient matrix for the dummy variables. In order to create the null and alternative hypotheses for Model C; the D_{jt} term should be added to equation (3) and the DT_{jt} term should be added to equation (4) (Lee & Strazicich, 2003). The regression shown in equation (5) obtains the two-break LM unit root test statistic.

$$\Delta y_t = \delta' \Delta Z_t + \phi \tilde{S}_{t-1} + u_t \quad \tilde{S}_t = y_t - \tilde{\Psi} - Z_t \tilde{\delta} \quad t = 2, \dots, T \quad (5)$$

The critical values needed to test the null hypothesis are determined. The null hypothesis set for the LS test in Lee-Strazicich (2003) posits that the series are non-stationary, while the alternative hypothesis asserts that the series are stationary.

TABLE 2 | Unit Root Test Results

Variable	Model	Lagged Length	Breaking Dates	t-statistic	Critical Value	Significant Level
LPET	A	1	1993 2000	-1.741110	-3.563000	%5
	C	7	1998 2014	-5.442531	-6.185000	
LGDP	A	2	1993 2010	-3.005428	-4.073000	%5
	C	3	1999 2013	-5.702210	-6.175000	
Δ LPET	A	7	1982 1991	-4.293419	-3.563000	%5
	C	7	1992 2003	-7.208666	-6.288000	
Δ LGDP	A	3	1987 1994	-4.958824	-3.563000	%5
	C	3	1992 1998	-6.615774	-6.201000	

According to the LS test statistics, while LPET and LGDP variables are not stationary at 5 % significance level, when I(0) differences are taken, I(1) becomes stationary. In other words, according to the LS structural break unit root test results for Turkey as of models A and C, the null hypothesis, that is, the series is not stationary at the level with

structural breaks, is accepted. The fact that these variables are stationary in their first differences means that the effects of shocks such as crises and policy implementations will continue in the long term. The break dates for the series are compatible with the crisis dates experienced both in the world and Turkey.

4.2 Cointegration Test and Results

Shocks or developments experienced in time series related to the economy may cause structural breaks in the series itself as well as in the relationships with other variables. If the relationships between variables that change over time are significant, biased results may be obtained. Therefore, ignoring structural breaks can lead to spurious results in cointegration analyses. For this reason, especially in economies like Turkey that experience frequent structural breaks, incorporating these changes into econometric models is important for the validity of the analyses (Yilanci & Eriş, 2013). Various cointegration methods have been developed to prevent this bias. In the second stage of the econometric analysis, the Fourier Engle-Granger cointegration test, developed by Yilanci (2019), will assess the long-term relationship between the variables. This test is applied through a two-stage process (Yilanci, 2019).

$$y_{1t} = d_t + \beta' y_{2t} + u_t \quad (6)$$

$t = 1, 2, \dots, T$. Dependent variable y_t is a scalar, and $x_t = (x_{1t}, \dots, x_{mt})'$ is a $(m \times 1)$ independent variable vector. d_t is a deterministic function.

$$d_t = \alpha_0 + \gamma_k \sin\left(\frac{2\pi kt}{T}\right) + \delta_k \cos\left(\frac{2\pi kt}{T}\right) \quad (7)$$

α_0 is the traditional deterministic term with or without a linear term, containing a constant; T , is the number of observations; k is the Fourier frequency selected based on the value that minimizes the sum of squared residuals (Yilanci, 2019). The model is re-estimated to achieve the minimum residual sum of squares. Subsequently, the ADF unit root test is applied to the residuals obtained from this model, following a procedure similar to the cointegration test developed by Engle and Granger (1987). In other words, the Fourier Engle-Granger cointegration test is obtained by adding Fourier functions to the Engle-Granger equation. The Fourier function method allows for determining the appropriate frequency component in the estimation of the model, instead of selecting specific break dates or forms. In addition, this approach provides reliable and unbiased results by performing accurate modeling even in cases where structural breaks are unknown (Sağlam, 2018). The extended model with the deterministic variable vector (d_t) is presented in equation (8) (Yilanci, 2019).

$$y_{1t} = \alpha_0 + \gamma_k \sin\left(\frac{2\pi kt}{T}\right) + \delta_k \cos\left(\frac{2\pi kt}{T}\right) + \beta' y_{2t} + u_t \quad (8)$$

In the Fourier Engle-Granger cointegration test, the null hypothesis states that there is no cointegration, while the alternative hypothesis states that there is cointegration. Table 3 shows the results of the Fourier Engle-Granger cointegration test.

TABLE 3 | Cointegration Test Results

Fourier Engle-Granger t-stat.	Frequency Value	Min. SSR Value	Critical Values		
-4.445708	1	0.062907	1%	5%	10%
			-4.906	-4.302	-3.988

The Fourier Engle-Granger test statistic results reveal that the null hypothesis cannot be rejected at both the 5% and 10% significance levels, as indicated by the critical values provided by Yilanci (2019). This finding implies the presence of a cointegration relationship between the variables, indicating that fluctuations in oil consumption exert a long-term influence on Turkey's economic growth.

4.3 Coefficient Estimation

After detecting the cointegration relationship between oil consumption and economic growth, the estimation of the long-term coefficients of

the parameters is important for indicating the magnitude and direction of the relationship between the variables. In this study, the parameter magnitudes are estimated using Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), and Canonical Cointegrating Regression (CCR) for interpretation purposes. FMOLS and DOLS estimators can correct the biases caused by the relationship and endogeneity problem between the explanatory variables and the residuals, and can also correct the errors caused by sample bias. The CCR estimator asymptotically corrects the endogeneity problem caused by the long-term correlation, and also eliminates the biases caused by the traditional least squares method. These tests incorporate structural changes into the model. The results of the analysis for the FMOLS, DOLS, and CCR methods are summarized in Table 4.

TABLE 4 | Long-run Coefficient Estimates

Dependent Variable: LGDP						
Variable	FMOLS		DOLS		CCR	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
LPET	0.347929	0.0001	0.323759	0.0019	0.339217	0.0000
C	25.25837	0.0000	25.40777	0.0000	25.29890	0.0000
@sin	0.840238	0.0000	0.878903	0.0002	0.860600	0.0000
@cos	-1.717373	0.0000	-1.734336	0.0000	-1.706848	0.0000

The results from FMOLS, DOLS, and CCR tests show a high level of consistency in both statistical significance and the estimated coefficients' numerical proximity. Empirical findings indicate that a 1% increase in oil consumption results in approximately a 0.34% rise in economic growth. In other words, an increase in oil consumption positively influences economic growth. Moreover, the estimated coefficients are statistically significant at the 5% significance level.

4.4 Causality Test and Results

In this study, the direction of the relationship between oil consumption and economic growth was determined by causality testing. The causality test also shows whether there is a contribution of another variable in the prediction of the future value of a time series, in addition to its past values. The Granger causality test, which is widely applied to test the causality relationship, is criticized for not considering structural breaks. Enders and Jones (2016) expanded the Granger causality test to take into account structural breaks by including Fourier functions in the VAR model and developed the Fourier Granger causality test. The VAR model in which the causality relationship is tested in the Fourier Granger causality test is shown in equation (9).

$$Y_t = \alpha_{01} + \sum_{i=1}^p \alpha_{1i} Y_{t-i} + \sum_{i=1}^p \beta_{1i} X_{t-i} + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_2 \cos\left(\frac{2\pi kt}{T}\right) + e_{1t}$$

$$X_t = \alpha_{02} + \sum_{i=1}^p \alpha_{2i} Y_{t-i} + \sum_{i=1}^p \beta_{2i} X_{t-i} + \phi_3 \sin\left(\frac{2\pi kt}{T}\right) + \phi_4 \cos\left(\frac{2\pi kt}{T}\right) + e_{2t} \quad (9)$$

In the Fourier Granger causality test, the null hypothesis asserts that no causal relationship exists between the variables, whereas the alternative hypothesis suggests a causal relationship exists. The results of the Fourier Granger causality test are presented in Table 5.

TABLE 5 | Causality Test Results

	Wald Test Stat.	Asymptotic prob. value	Bootstrap prob. value	lagged length (k)	Frequency value (p)
$P \rightarrow B$	21.393	0.185	0.08	3	2
$P \leftarrow B$	25.384	0.036	0.03	3	2

The analysis was conducted by taking into account the Akaike information criterion, and the bootstrap number was determined as 10000. In the Fourier Granger causality test, the null hypothesis is rejected at a significance level of 10%. The study found a bidirectional causality relationship between oil consumption and economic growth. Specifically, an increase in oil consumption contributes to economic growth, while economic growth also drives an increase in oil consumption. This indicates that the feedback hypothesis between oil

consumption and economic growth is valid for Turkey during the period analyzed. This result shows that reducing oil consumption in Türkiye without turning to alternative energy sources will have a negative impact on economic growth. This finding of the study is similar to the results of Hoa (1993), Zou and Chau (2006), Zhao et.al. (2008), Aktaş and Yılmaz (2008), Bhusal (2010), Almulali (2011), Bildirici and Kayıkcı (2013), Behmiri and Manso (2012), Park and Yoo (2014), Alam and Paramati (2015) Choi and Yoo (2016) Waleed et.al. (2018).

5 Conclusion

Turkey's rapidly increasing population, migration movements, and growing economy cause energy consumption to increase faster than its production capacity. Turkey's energy consumed and produced exhibits a different structure in terms of its subtypes. In fact, Turkey's energy demand is largely met by imported sources such as oil and natural gas; energy production is met by lignite and renewable energy sources, which are far from meeting the country's demand. In such a case, Turkey's external dependency increases, and any problem with the energy supply negatively affects its economic development. Therefore, providing an adequate and secure energy supply is one of the main priorities of Turkey's energy policies. Oil is the energy source with the largest share in Turkey's energy consumption. It serves as a fundamental input across various sectors, including industry, transportation, electricity generation, and manufacturing. The possible causality between oil consumption and economic growth offers important implications that policymakers should consider when forming energy policies.

This study analyzed the relationship between oil consumption and economic growth in Turkey. The fact that the Fourier approach has not been used before in studies on oil consumption and economic growth analysis in Turkey makes this study original. The results from the cointegration test indicate a long-term relationship between the two variables. Furthermore, the causality test revealed a bidirectional causality, suggesting that changes in oil consumption and economic growth mutually influence each other. The results of this study reveal that oil consumption plays an important role in economic growth in Turkey. However, fossil fuels, including oil, are shown as one of the sources of global warming and environmental pollution problems, and fossil fuel use is desired to be reduced within the framework of new environmental policies. In addition, oil price increases have a negative effect on economic growth in the Turkish economy, which has a structure dependent on foreign oil. In such a case, policymakers should implement energy-saving policies aimed at reducing oil use by taking into account the feedback effect of economic growth on oil consumption. In this context, energy saving should be encouraged in both the residential and industrial sectors. It should be developed in a way that uses less sectoral energy in the economy but affects economic growth to the same extent. Such an initiative can be achieved through an appropriate combination of energy taxes and energy substitution. In this context, in Turkey, rich in renewable energy resources, renewable energy infrastructure should be strengthened, renewable energy investments should be increased, and capacity increases in renewable energy facilities should be supported with subsidies and tax incentives.

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