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FINANCIAL DEVELOPMENT, RENEWABLE ENERGY CONSUMPTION AND INDUSTRIAL OUTPUT RELATION: TESTING FOURIER ARDL FOR TURKEY

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Abstract:

Energy plays a vital role in every aspect of the economy and in recent years renewable energy is highly debated for its pros and cons. While renewable energy consumption is important for sustainable growth and reduction of environmental damage it has some negative effects on the industrial production. The aim of the study is to examine the relationship between renewable energy consumption, financial development and industrial output for Turkey. Annual data between 1980 and 2019 were used in the study. Fractional Fourier Augmented Dickey-Fuller Unit Root Test and the Fourier Autoregressive Distributed Lag Bound Tests were used to analyze the relationship between variables. As a result of the study, a positive relationship was found between financial development and renewable energy consumption, while a negative relationship was found between industrial output and renewable energy consumption. Our empirical findings have important policy implications. According to these policy implications, the focus should be on a green-based economy with various subsidies, selective taxation procedures and incentive policies to increase the demand for renewable energy use.

Key words: *Fourier ARDL, Financial Development, Renewable Energy Consumption, Industrial Output*

1. Introduction

Renewable energy is a highly occupied field of study in the economics literature recently due to the fact that renewable energy has a positive effect on energy conversion and reduces environmental pollution. Added to these, regional conflicts that impede the flow of energy to Europe also make renewable energy an alternative source for energy shortage. There is a vast literature about it yet the studies mainly focus on variables that

have impact on renewable energy. Carbon footprints, economic growth, technological innovation and fossil fuel consumption are mostly studied sub-topics. Moreover, financial development effect of renewable energy is also discussed.

Increase in renewable energy consumption is related to innovative trends and higher economic development levels, and this situation is frequently expressed in the literature. For this reason, it is thought that financial development will also have an impact on renewable energy consumption and that the positive effects of financial development will positively affect renewable energy consumption. In addition, although it is thought that the industry's renewable energy consumption will have positive impact on the environment, it is considered necessary to prove these expressed thoughts by using econometric analysis methods in the literature. As a matter of fact, the importance of renewable energy consumption on the environment and society, as well as the financial development and the determination of the efficiency level of industrialization will guide the policies to be implemented by both academic and public authorities. In this direction, it is concluded that it is important to study the subject.

When the literature is examined, it is seen that financial development and renewable energy variables are examined in more than one study, and in addition, relatively rare industry variables are examined. Yilmaz (2021), who takes the years 1980-2018 as a basis and evaluates the G7 countries, the existence of a causality relationship towards renewable energy has been determined and the study has been created using the Panel Causality test. Anton (2020), another study based on the years 1990-2015, examined the effect of financial development on renewable energy consumption with the help of panel data analysis. Although the study was carried out in 28 European Union countries, the existence of a relationship between the variables was confirmed as a result of the study. A similar conclusion was reached in the study of Lahiani (2021). The author, who aimed to examine the relationship between the mentioned variables between January 1975 and April 2019, showed the existence of the relationship in his study in which he applied the NARDL model. Several studies also reveal that empirical research mainly concentrates on quantitative analysis. Moreover, while it is seen that the analyses are concentrated in panel data analysis and ARDL test, it is seen that the current test called Fourier analysis is not applied in any test applied. The fact that the Fourier ARDL test is not found in the studies in the literature supports the fact that this study is a study that is applied with the most up-to-date methods in the literature and compares the relevant variables. The analysis, which was brought to the literature by Pesaran (2001) and developed by Yılanıcı (2020), is more qualified than other studies with its structure that minimizes the margin of error in the literature.

When the importance of the applied test is expressed in the literature, the fact that the coefficient consistency analysis is performed reveals its importance in the literature (Pesaran and Shin, 1995). The emergence of the Fourier version of the ARDL test, developed in 2020, and subsequently the emergence of the Fourier ARDL by applying it on the ARDL test, has a high importance in the literature and the application of the relevant test in the studies is important in the international arena. This interest of the Fourier ARDL test in the literature can be explained by the fact that the test was constructed using dummy variables (Yılanıcı, et al. 2020).

From this point of view, the Fourier ARDL test, which includes the last version expressed in the study, will be applied. For the application of the test, it is important to determine the stationarity levels of the data sets. In this direction, the 1980-2019 Turkey data of renewable energy consumption, financial development and industry variables, which will be examined in this study, will be examined within the Fractional Fourier ADF unit root test, and the stationarity levels of the series will be evaluated, and then, if the series are evaluated as appropriate, they will be subjected to the Fourier ARDL test. In the literature review carried out after the introduction of the study, the studies in the field will be evaluated in terms of both the method and the variables they used, and the possible contribution of this study to the literature will be expressed. After the relevant section, the data section will be included and the tests to be applied as well as the graphics of the variables will be included. While the fourth part of the study will express the test results, the last part will include the "result and discussion" section, where the data obtained are expressed and interpreted.

With the related study, it will be aimed to determine the effect levels of financial development and industry variables, which are thought to be effective on renewable energy, with the help of the Fourier ARDL test. It is thought that the study will contribute to the literature with the help of the method used and the up-to-dateness of the method as well as the variables examined together.

2. Literature Review

In the relevant part of the study, some of the studies that were created by making use of the variables used in this study and examining the relationship between the variables are included. What is aimed in this section is important in terms of determining whether the subject is discussed in the literature and if so, what kind of method is adopted. In Table 1, aim of the article, the researchers, the date of publication, the time period covered in the study, the country selected as the sample in the study, the method applied, the variables to be examined in the study are stated, and the results of the relevant studies are given in one sentence.

Table 1: Literature Review of Articles

Aim of Articles	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
The purpose of this research is to look at the possibilities of biomass consumption in terms of sustainable development.	Asghar, Et al. (2023)	1990-2017	21 Asian Countries	Cointegration Tests Panel Data Analysis	Biomass Energy Sustainability Development	Biomass has a positive effect on long-term development. Green finance reduces carbon emissions.
Its goal is to	Gan, Et al.	2004-2019	30	Panel Data	Carbon	Green Finance

investigate the influence of green money on the intensity of carbon emissions.	(2023)		Provinces of China	Analysis	Emission Green Finance	has been shown to directly reduce the intensity of carbon emissions. He claims that the effect of GF on lowering CEI is not dynamic or linear.
It was developed to investigate the impact of environmental constraints on green total factor output (GTFP).	Jin, Et al. (2023)	2003-2020	Provinces of China	Endogeneity Tests Robustness Tests	Human Capital	The results vary depending on the nations analyzed. The government should spend in developing an ecological environment conducive to regional sustainable development and in revising environmental restrictions.
This study was created to examine the relationship between India's financial development, renewable energy use, technical developments and CO ₂ emissions.	Qayyum, Et al (2021)	1980-2019	India	ARDL VECM	Financial Development Renewable Energy Consumption Technological Innovations Carbon Emissions	CO ₂ emissions of financial development have a positive effect. It is thought that increasing renewable energy consumption will reduce CO ₂ emissions. Economic expansion and urbanization negatively affect environmental quality.
It was created to determine the relationship between variables	Usman, Et al. (2021)	1990-2017	Asia Pacific Economic Cooperation Countries	STIRPAT Panel Data Analysis Dumitrescu/Hurlin (D-H) Non-Causality Test	Technological Innovations Financial Development Renewable Energy Ecological	In the long term, technological innovation, economic expansion, and population

					Footprint	growth all have detrimental consequences on environmental quality. Financial development, technical advancements, renewable energy usage, economic expansion, population number, and ecological impact all have a bidirectional causal link.
The aim of this study is to examine the relationship between carbon emissions per capita, use of renewable energy, forestry and agricultural added value.	Koondhar, Et al (2021)	1998-2018	China	ARDL	Carbon Emissions Renewable Energy Consumption Forestry Agriculture Financial Development	Carbon emissions have dropped in the near term as renewable energy consumption has grown; nevertheless, carbon emissions have increased in tandem with agricultural financial expansion. The variables are only causative in one direction.
It was created to examine the relationship between renewable energy consumption and environmental efficiency.	Assi, Et al (2021)	1998-2018	ASEAN +3 Economies	P-ARDL Dumitrescu-Hurlin Panel Causality Test	Renewable Energy Consumption Financial Development Environmental Pollution Innovations	The findings indicate that usage of renewable energy is impacted by financial expansion. Renewable energy use is inversely correlated with economic freedom and

						environmental pollution. However, there is a favorable correlation between innovation, renewable energy, and real GDP.
It was created to examine the dynamics of carbon emissions.	Wang, Et al (2020)	1990-2017	N-11 Countries	Unit Root Test	Financial Development Human Capital Renewable Energy Consumption Gross Domestic Product Carbon emissions.	The data show a favorable association between carbon emissions and financial development as well as GDP. In contrast, technical advancement and the use of renewable energy are negatively associated to carbon emissions.
It was created in order to determine the relationship between the variables.	Kassi, Et al. (2020)	1990-2017	123 Countries	Panel Data Analysis	Financial Development Renewable Energy Consumption Economic Growth	As a result of the study, the existence of the relationship between the variables was determined.
It was created to determine the relationship between variables.	Mukhtarov, Et al (2020)	1993-2015	Azerbaijan	ARDL	Financial Development Renewable Energy Consumption Energy Prices	Financial development and economic expansion have a favorable and statistically significant impact on Azerbaijan's renewable energy use. Energy prices have a detrimental impact on the use of renewable

						energy.
The purpose of this article is to investigate the impact of financial development on renewable energy use.	Anton, Et al.(2020)	1990-2015	28 EU Countries	Panel Data Analysis	Renewable Energy Consumption Financial Development	Our findings indicate that the growth of the capital markets has little impact on how much renewable energy is used in the new EU Member States.
It was created to determine the relationship between variables	Qamruzzaman, Et al (2020)	1990-2017	113 Countries	NARDL Casualty Test	Renewable Energy Consumption Financial Development Economic Trade Openness Freign Capital Flows	When the variables were examined, a long-term causality relationship was found between the dependent variable of renewable energy consumption and other variables.
It was created to examine the relationship between renewable energy consumption and environmental efficiency.	Iorember, Et al. (2020)	1990-2016	Nigeria	ARDL VECM	Renewable Energy Consumption Environmental Quality	The findings demonstrate that the use of renewable energy enhances environmental quality whereas financial development degrades it.
It was created to determine the relationship between variables	Pata (2018)	1974-2014	Turkey	FMOLS EKC ARDL Gregory-Hansen and Hatemi-J Cointegration	Renewable Energy Consumption Urbanization Financial Development Income Carbon Emission	The largest increases in CO ₂ emissions came from economic growth, followed by urbanization and financial development. However, the use of renewable energy is not at a level that

						will minimize CO ₂ emissions.
In this study, it is aimed to investigate the connection between economic growth, renewable energy, energy consumption, fixed capital creation, globalization, trade openness and urbanization.	Yazdi, Et al. (2017)	1992:Q1–2014:Q4	Iran	ARDL Granger Casuality	Renewable Energy Consumption Financial Development Economic Growth Globalization	It was observed that all the variables in the study were cointegrated and that the variables had a long-term relationship.
It is aimed to determine the relationship between Renewable Energy Industries and Financing Efficiency variables in China.	Liu, Et al. (2018)	2008-2015	China	Empirical Analysis	Renewable Energy Industries Financing Efficiency	It has been concluded that the development of the renewable energy industry will be provided by the development of the financial market.
It is aimed to evaluate the effect of industry investments on renewable energy consumption.	Liu, Et al (2019)	2010-2015	China	SWOT Analysis	Renewable Energy Industires Investment	If China can solve the challenges, China's renewable energy industry's financial and investment issues will be resolved. Furthermore, if suitable rules are implemented, it will give a huge incentive to the Chinese renewable energy sector.
It is aimed to examine the	Atsu, Et al (2021)	1970-2019	South Africa	ARDL DOLS	Energy Consumption	It shows that ITC and fossil

effect of energy consumption and innovative trends on the environment.				FMOLS	ICT Financial Development Environmental Degradation	fuel use contribute to CO ₂ emissions, but renewable energy consumption and financial development minimizes CO ₂ emissions.
The Renewable Energy Consumption was created to examine the relationship between Financial Development.	Dimnwobi, Et al. (2022)	1981-2019	Nigeria	ARDL	Renewable Energy Consumption Financial Development	As a result of the study, it is reached that financial development has been effective on renewable energy consumption between the relevant years.
The Renewable Energy Consumption was created to examine the relationship between Financial Development and ICT.	Yu, Et al. (2022)	1996-2018	35 Countries	Panel Data Analysis	Renewable Energy Consumption Financial Development ICT	It is seen that both financial developments and information and communication technology have an impact on renewable energy consumption.
Financial and Renewable Energy Consumption It is aimed to examine how industrial development has an effect.	Liu, Et al.(2022)	1996-2020	China	ARDL	Renewable Energy Consumption Financial Development Industrial Development	As a result of the study, it is seen that economic innovations and financial developments support the increase in renewable energy consumption.
What is the effect of financial developments on energy consumption? It is aimed to seek an answer to the	Ma, Et al. (2022)	1990-2018	10 Developed and 10 Developing Countries	Panel Cointegration Estimation Method	Renewable Energy Consumption (Non-Hydro) Financial Development Demographic Changes	According to the findings of the study, foreign direct investment plays a key role in assisting the non-hydro

question of whether demographic factors are effective.						renewable energy industry in developing nations to flourish.
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It is seen that there is more than one study in the literature that evaluates the variables in the field. When the studies are examined, it is seen that qualitative studies are concentrated in renewable energy and finance, while qualitative intensity is observed in the studies when renewable energy, finance development and industry are mentioned, and it is seen that studies containing ARDL limit test and panel data analysis are common in the literature. Although both types of study groups are included in the literature review, quantitative studies that are close to this study will be considered, and it is considered necessary to express the difference between the study and the studies in the literature. When the studies related to this movement are examined, the following evaluations will be reached.

When the studies in the literature are examined, it is seen that there are studies examining the relationship between financial development, industry and renewable energy. Examining the relationship between 1981-2020 among the cited studies, which examines Nigeria specifically, Dimnwobi, Et al. (2022) is included in the study. When the results of the study are examined, it is observed that financial development has been effective on the development of renewable energy consumption between the relevant years.

There are other studies examining the variables expressed. Yu, et al. (2022), to examine the relationship between renewable energy, financial development and information and communication technology, and published by evaluating 35 countries, shows that both variables have an effect on financial development.

Evaluating the industrial development as well as financial development and renewable energy consumption, Liu et al (2022) evaluated the data between 1996 and 2020 in China in particular. Although the study aims to examine the effect of the variables expressed on renewable energy, it is seen that economic innovation and financial development support the increase in renewable energy consumption as a result of the study.

Ma, et al. (2022), on the other hand, changed the variable by adding the effect of demographic changes to the relationship between financial development and renewable energy (non-hydraulic). Although the authors' work includes an empirical analysis, a total of 20 countries were analyzed between 1990 and 2018, and it was concluded that foreign direct investment had a significant share while helping the non-hydro renewable energy industry to expand in poor countries.

And the last study, Atsu, et al. (2021) brought it to the literature. Variables examined in the study Yu, Et al. (2022), ICT, energy consumption and financial development were evaluated in the study. The difference of the study from Yu's study on the basis of variables can be explained by evaluating the fossil fuel consumption variable as well as renewable energy consumption. Although South Africa was chosen as the sample in the study, the time period to be examined covers a period of 49 years, 1970-

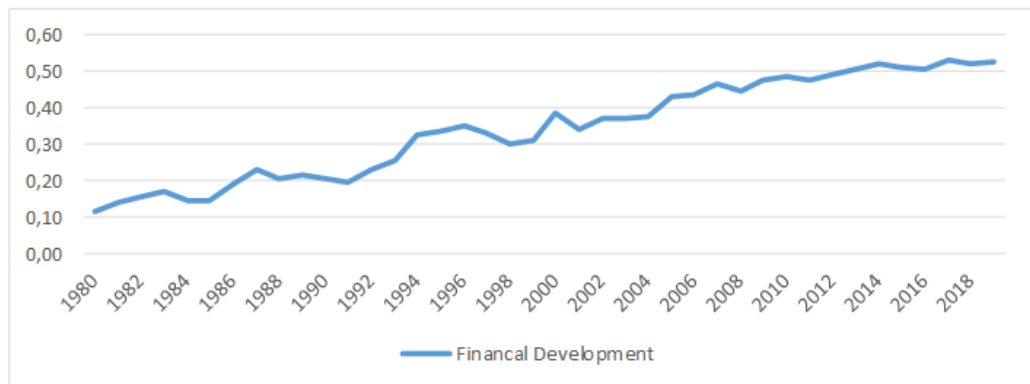
2019. The qualitatively constructed study shows that ITC and fossil fuel use contribute to CO₂ emissions, but renewable energy consumption and financial development minimizes CO₂ emissions.

From this point of view, it is seen that there are qualitative studies that are close to our study and that quantitative methods such as ARDL test and panel data analysis are used, in addition to this, the studies expressed are still up to date. When the methods applied in the mentioned studies are examined, it is seen that the most up-to-date test technique, which is expressed as Fourier analysis, is not used. From this point of view, it is thought that this study will contribute to the literature by separating it from other studies.

3. Data and methodology

The aim of the study is to examine the link between financial development, renewable energy and industry characteristics. An evaluation will be made in the light of the values of the variables discussed in the study in Turkey between 1980-2019 and it will be aimed to determine the effect level of the variables. The Fourier ARDL test was used in the study while determining the relationship between the variables. The fact that this test was chosen in the study can be explained by the fact that it is the most up-to-date version of the ARDL test. The data of the variables to be discussed in the study between 1980 and 2019 are shown in Figure 1, Figure 2 and Figure 3, respectively.

Figure 1: Financial Development Ratio by Years (1980-2019)

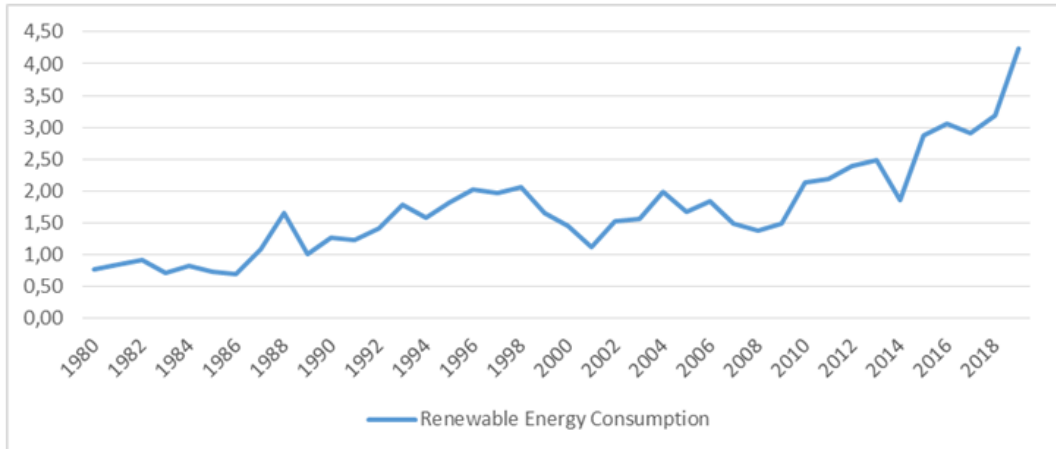


Source: (IMF)

When Figure 1 is examined, the values of the financial development variable, which is among the variables, between 1980 and 2019 are expressed in terms of ratio. The table is important in determining the increase and decrease trends in financial development compared to years. When the table is examined, the financial development rate, which was between 0.10 and 0.20 in 1980, increased to 0.50-0.60 in 2018, and there is no full stability in the increase compared to years. Although there are small decreases in financial development rates, it is seen in the chart that after the significant decrease in 1992, an upward trend continued until 1996. If a general evaluation is made; it can be said that there has been an increase in financial development compared to years.

Another variable to be examined is the financial development and renewable energy consumption variable to be evaluated. Figure 2 shows the renewable energy consumption rates between 1980 and 2019.

Figure 2: Renewable Energy Consumption by Years (1980-2019)



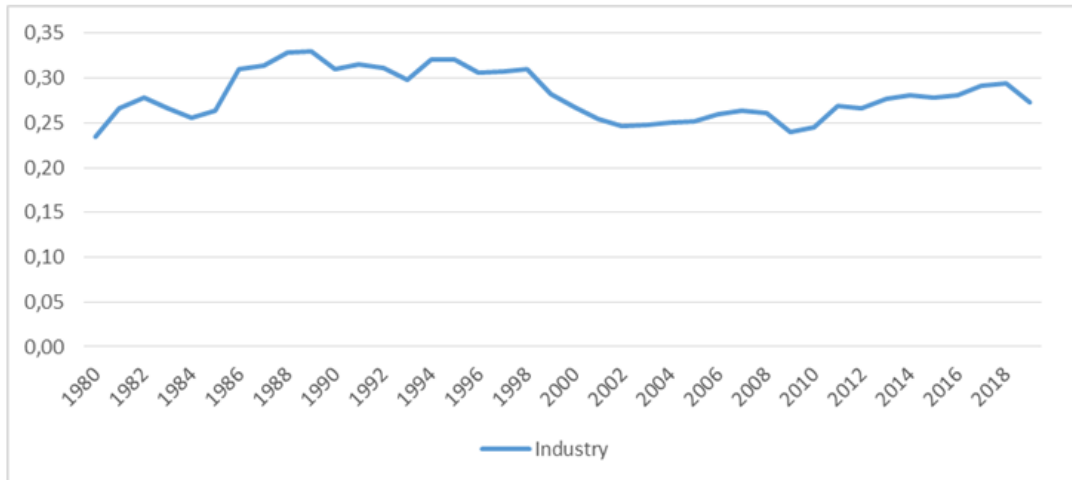
Source: (Our World in Data)

Renewable energy consumption in Figure 2 shows a more volatile course compared to financial development, and increase and decrease trends are observed to be sharper. When the figure is evaluated, while the rate of renewable energy consumption, which was between 0.50-1.00 in 1980, remained at a similar level until 1986, it showed an increasing trend after 1986 and exceeded the level of 1.50 in 1988. Consumption, which decreased to 1.00 in 1990, continued its increase in the following years. Although the values decreased in 2000, 2008 and 2015, they increased on a general basis and approached 4.50 in 2018. Consumption decreases were usually observed in the periods of economic crisis or sudden shocks.

The last variable examined in the study is industrial output and it is expressed as industry. Industrial output values in the 1980-2019 time period selected as a sample in the figure are expressed on a ratio basis. When the value was examined in 1980, it was examined that it was an approximation value to 0.25. Although the value was expressed between 0.30-0.35 values until 1998, it decreased until 2002 after 1998 and increased in 2002 with small decreases and weighed 0.30 in 2018.

Specific to this study, quantitative analysis will be carried out by taking into account the data included in the tables and covering the years 1980-2019. As a result of the quantitative analysis, it is aimed to determine the direction and ratio of the relationship between the variables and to examine its existence. From this point of view, Fourier ARDL test will be used in the study. Fourier analysis has an important place in the literature in terms of including the most up-to-date versions of the tests and minimizes the margin of error.

Figure 3: Industry by Years (1980-2019)



Source: (World Bank)

The critical values in the tests included in the study were assessed using the data from Bozoklu's (2020) study. First of all, as a result of adding sine and cosine values to the analysis calculations, which became known in the literature with the study of Enders-Lee (2012), it reached a higher level than the tests in the literature and its validity was made indisputable compared to other inverses. Therefore, it would be correct to say that the test has the highest validity in the literature.

The formulation of the Fourier ADF test, which is known in the literature as the improved version of the ADF test, whose formulas are included, can be examined in 3 steps, respectively.

$$Y_t = \alpha(t) + \rho Y_{t-1} + Y_t + \epsilon_t \quad (1)$$

$$\alpha(t) = \alpha_0 + \sum_{k=1}^n \alpha_k \sin(2\pi kt/T) + \sum_{k=1}^n \beta_k \cos(2\pi kt/T); \quad n \leq T/2, \quad (2)$$

$$\Delta y_t = \rho Y_{t-1} + c_1 + c_2 t + c_3 \sin(2\pi kt/T) + c_4 \cos(2\pi kt/T) + e_t \quad (3)$$

The formulation of the Fractional Fourier ADF test, which is known in the literature as the improved version of the Fourier ADF test, whose formulas are included, can be examined in 3 steps, respectively.

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \lambda Y_{t-1} + \mu_t \quad (4)$$

$$\Delta Y_t = \delta_0 + \delta_1 \sin\left(\frac{2\pi kt}{T}\right) + \delta_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta_3 Y_{t-1} + \sum_{i=1}^p \alpha_i \Delta Y_{t-i} + v_t \quad (5)$$

$$Y_t^* = \alpha_0 t + \beta_0 t + \lambda_1 \sin^*_{1,t} + \lambda_2 \cos^*_{1,t} + \mu_t \quad (6)$$

When the studies in the literature are examined, this test, which has an undeniable importance in quantitative analysis, was first examined by Peseran (2001) and allowed the creation of a test whose name is used in the literature. The author who paved the way for the test to be developed and used widely is known as Yılançı et al. (2020). Yılançı et al, who made an important contribution to the literature with his Fourier version, stated the existence of a general formula and 4 separate constraints in the test. Expressed formulas and constraints are given below.

$$d(x) = \sum_{k=1}^n a_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n b_k \cos\left(\frac{2\pi kt}{T}\right)$$

(7)

$$\Delta \text{REN} = \beta_0 + y_1 \sin\left(\frac{2\pi kt}{T}\right) + y_2 \cos\left(\frac{2\pi kt}{T}\right) + \beta_1 \text{REN}_{t-1} + \beta_2 \text{FIN}_{t-1} + \beta_3 \text{IND}_{t-1} + \sum_{i=1}^{p-1} \delta'_i \Delta \text{FIN}_{t-1} + \sum_{i=1}^{p-1} \phi'_i \Delta \text{IND}_{t-1} + e_t$$

(8)

$$H_{0A} : \beta_1 = \beta_2 = \beta_3 = 0$$

(9)

$$H_{0B} : \beta_1 = 0$$

(10)

$$H_{0C} : \beta_2 = \beta_3 = 0$$

(11)

It is considered critical to organize the formulas based on the variables to be tested in the tests to be employed. From this perspective, the general formula to be developed with the variables described in this research will be as follows.

- (i) If F_A , F_B , and t are significant, REN, FIN, and IND have a cointegration connection.
- (ii) If F_A , F_B , and t are meaningless, there is no cointegration link between REN, FIN, and IND.
- (iii) If F_A , F_B are significant but t is not, the first degenerate condition occurs.
- (iv) If F_A and t are both large but F_B is not, a second degenerate scenario occurs.

Using the formula above, the empirical findings of the inquiry are presented in the empirical findings part of the study.

4. Empirical findings

In the fourth part of the study, the test results expressed in the third part are included, and firstly, the descriptive values of the variables will be given in Table 2. Descriptive values are important in terms of including more than one degree, such as minimum and maximum values for the variables.

Table 2: Descriptive Values of the Variables

	REN	FIN	IND
Mean	1.721.116	0.343267	0.280816
Median	1.613.063	0.345797	0.277313
Maximum	4.233.540	0.528983	0.329747
Minimum	0.70281	0.116196	0.234944
Std. Dev	0.771241	0.134948	0.02695
Skewness	1.050.862	-0.13464	0.224576
Kurtosis	4.335.522	1.628.916	1.844.837
Jargue-Bera	1.033.477	3.253.975	2.560.230
Proability	0.005699	0.196521	0.278005
Sum	6.884.463	1.373.067	1.123.265
Sum Sq. Dev	2.319.771	0.710229	0.028326
Observations	40	40	40

The first of the findings obtained as a result of the analysis following the descriptive values is expressed as the Fourier Augmented Dickey Fuller test results. The results in Table 3 are respectively; What are the variables, frequency value (k), min KKT value, FFADF test statistical value, appropriate lag length, F-Test value and 1%, 5% and 10% critical values required for comparison with FFADF test statistical value. can be achieved.

Table 3: FFADF Test Results (Stationarity Analysis)

Variables	k	Min KKT	FFADF Test Statistic	Optimal Lag Length	F Test Statistic	FFADF %1 Critical Value	FFADF %5 Critical Value	FFADF %10 Critical Value
REN	0,1	4,176405	-1,409771	1	3,078545	-4,87987	-4,26469	-3,95616
ΔREN	5	4,031826	-7,718655	0	3,700515	-4,21133	-3,5507	-3,22669
FIN	0,4	0,016930	-3,948201	1	7,778428	-4,88261	-4,27395	-3,97253
ΔFIN	4,4	0,022818	-4,802108	3	1,893553	-4,2405	-3,58436	-3,25675
IND	1,2	0,005369	-4,401232	5	11,57072	-4,96096	-4,36321	-4,06218

When the values are examined, it is seen that the value levels at which the variables to be analyzed in the study are stationary have been determined. From this point of view, it can be stated that the test applied allows to examine the level at which the variables are stationary and the test values they have at the relevant level. It can be stated that stationarity is determined by comparing the FFADF critical values to determine the stationarity levels of the variables and the values discussed are taken from the studies of Enders-Lee (2012).

Accordingly, the variables should be examined in order. If it is necessary to test the renewable energy consumption variable first, the FFADF test statistical value was observed as -1.41 in the test results. When the FFADF test statistical value was analyzed at 1%, 5% and 10% significance levels, it was examined as small in critical value. The fact that the statistical value is less than the significance levels leads to the conclusion that the series has a unit root, but it also allows the finding that the series is not stationary. Therefore, it gives the result that the series is not stationary at the level.

When the first-order difference of the series was taken, the FFADF test statistical value was observed as -7.72. Although the FFADF test statistical value is greater than -4.21 at 1% critical value, -3.55 at 5% critical value, and -3.23 at 10% critical value in absolute value, it gives the result that the series does not contain a unit root and hence the series is stationary. It is concluded that the REN statistical value is stationary in the first difference.

Another variable, financial development, has a FFADF test statistical value of -3.95. When the relevant value is compared with the critical values of 1%, 5% and 10%, it is examined that this value is lower than all 3 levels of significance. This result, which is reached as a result of the test, gives the result that there is a unit root in the series and the series is not stationary. The fact that the financial development series in value at the level is not stationary makes it necessary to take the first-order difference of the series.

When the -4.80 FADF test statistical value, which is obtained when the first degree difference is taken, is compared with the values at 1%, 5% and 10% significance levels, it

is seen that all three values are higher than the significance levels. This gives the result that there is no unit root in the series and in addition, the series is stationary.

The last variable to be examined and to be compared with the significance levels of the FFADF test statistical value within the study is expressed as Industry. When the FFADF test statistical value is examined at the level value, the value of -4.40 is less than the value of -4.96 at the 1% significance level. It is concluded that the series is not stationary at the 1% significance level. In addition, when the 5% (-4.36) and 10% (-4.06) significance levels are evaluated, it is seen that the FFADF test statistical value is higher than the significance levels. This gives the result that the series does not contain a unit root and is stationary in level value.

In short, while the renewable energy consumption series and the financial development series are stationary in the first order, the industry index is stationary at level value. When the appropriate lag lengths of the variables are examined, it is seen that the appropriate lag length for renewable energy is 0 when the first-order difference of the series is taken. For the financial development variable, this value was calculated as 3 when the difference of the first order series was taken, and as 5 at the level value for the last variable, the industry.

Table 4: Fourier ARDL Test Results

AIC	F _A	Bootstrap Critical Values			t	Bootstrap Critical Values			F _B	Bootstrap Critical Values		
		%10	%5	%1		%10	%5	%1		%10	%5	%1
0,220272	7,900743	5,638067	6,904055	11,03967	-3,761297	-3,431177	-3,939267	-5,202070	9,568438	7,196740	9,090414	14,35680

Another test to be applied within the study is expressed as the Fourier ARDL test. Fourier ARDL test results are observed in Table 4. Using the Bootstrap Estimator, F_A, F_B and t values were expressed in the light of Akaike Information Criteria, in addition to this, it was possible to compare these values with the values at 1%, 5% and 10% significance levels.

Vaules demonstrate that the F_A value of 7.90 is higher than the 5% and 10% significance levels when analyzed in terms of absolute value, while it is lower than 11.03 at the 1% significance level. When the "t" statistical value is examined as a result of the test, it is seen that the statistical value of -3.76 in absolute value is greater than -3.43 at the 10% significance level. When the expressed value is analyzed at 5% and 1% significance level, it is small. When the F_B statistical value is examined, it is observed that it is less than 10% and 5% significance level and greater than 1% significance level. The result obtained shows the existence of a long-term relationship between the variables according to the FARDL test results. When the long-term results of the variables expressed are analyzed, Table 5 emerges.

Table 5: Long-Term Estimation Results

Variables	Coefficient	Standard error	t-statistic	Prob.
FIN	5,445020	0,480274	11,33732	0,000
IND	-13,96255	4,376253	-3,190526	0,0030
C	3,784953	1,261088	3,001340	0,0050

Table 5 demonstrates the long-term estimation results of the research. The coefficients, standard error values, t-statistics and probability values of the variables are given in the table. When the values are examined, the 1% change in financial development has a 5.45 effect on renewable energy consumption. In addition, the 1% change in the industry value has an effect of -13.96 on renewable energy consumption.

5. Conclusion and discussion

In recent years, various solutions have come to the fore with climate change and the increase in the factors that threaten environmental quality. Renewable energy is one of the essential solutions that play an influential role in reducing environmental pollution and the energy crisis. In the article, the relationship between renewable energy consumption, financial development and industrial output for Turkey was investigated with the help of data for the period of 1980-2019. Fractional Fourier Augmented Dickey-Fuller Unit Root Test, and Fourier Autoregressive Distributed Lag Bound Tests were used in the analysis. The main results of the study revealed that there is a statistically significant relationship between renewable energy consumption and financial development and industrial output value. In addition, it has been determined that there is a positive relationship between financial development and renewable energy consumption. When the values at the end of the analysis are examined, it is seen that 1% change in financial developments has an effect of 5.45% on renewable energy consumption. The empirical findings have led to some important policy implications that policymakers should consider. Various policies should be followed to increase the positive effect of financial development on renewable energy consumption. For this, the private sector and the public sector must work together. Green financial systems should be expanded with various regulations and practices. In order to increase the share of green energy in energy consumption, new projects and investment incentives should be made, and mechanisms should be established to facilitate access to funds for projects that will increase environmental quality. In addition, applications such as carbon tax to businesses that use these energy sources in order to reduce the use of non-renewable energy may cause energy production to be turned in favour of renewable energy sources. If there is an increase in the demand for renewable energy due to financial development, there will be a decrease in foreign dependency on energy. Thus, while the current account deficit decreases, there may be an increase in economic growth and development.

On the other hand, a negative relationship was found between the industrial output and renewable energy consumption. It has been determined that 1% change in the sector value has an effect of -13.96% on renewable energy consumption. In line with this result, various policies should be implemented to encourage the use of renewable energy. The biggest obstacle to the widespread use of renewable energy in production activities is the

high costs of activities such as installation and distribution. For this, various policies and technological developments are needed. In this direction, support programs should be prioritized in order to increase research in the field of renewable energy technology. Turkey is a wealthy country in terms of renewable energy resources. Therefore, enterprises that prioritize these research in the country should be supported with R&D subsidies. Investments and R&D supports in related fields will cause the use of green energy to become widespread. On the other hand, sustainable energy use is needed in order to create the added value in the sustainable industry sector. Sustainable energy is also possible with renewable energy sources. In this direction, incentives to direct investors to renewable energy and tax regulations related to the use of renewable energy should be made. Sanctions for the comprehensive preparation and implementation of green energy transition policies will play an essential role in the sustainable development of the country's economy.

When the results of the study are compared with the literature, it is seen that country groups are investigated with similar but not identical models. Qamruzzaman et al. (2020) found a long-run causality relationship between renewable energy consumption and financial development for 113 countries. Kassi et al. (2020) found a relationship between financial development, renewable energy consumption and economic growth for 123 countries. Usman et al (2021) found that there is a bidirectional causality relationship between financial development, economic expansion and ecological impact for Asia Pacific countries. Assi et al (2021) found that there is a relationship between renewable energy use and financial expansion in ASEAN countries. While Anton et al. (2020) show that there is a very low relationship between financial development and renewable energy consumption in EU countries, we found that this relationship is high for Turkey in our study.

When compared with the time series studies in the literature, it is seen that there are similar studies. In similar studies in terms of different countries; Dimnwobi et al. (2022) found that there is a relationship between financial development and renewable energy consumption in Nigeria. Yazdi et al. (2017) found that there is a long-run relationship between renewable energy consumption, financial development and economic growth for Iran. Liu et al. (2022) also found that financial development increases renewable energy consumption for China. Qayyum et al. (2021) found that for India, financial development reduces carbon emissions and economic progress negatively affects environmental quality. Muhtarov et al. (2020) found a positive relationship between renewable energy, financial development and economic growth for Azerbaijan. In our study, while financial development positively affects renewable energy consumption in Turkey, industrial production negatively affects it. In this respect, the result is different from the Azerbaijani economy.

A similar study for Turkey is Pata (2018). Pata (2018) found that financial development and economic growth increase carbon emissions in Turkey. In this respect, it is one of the rare studies in which Turkey is investigated with a similar model. In our study, on the other hand, we did not directly use the carbon emission variable, but instead used renewable energy consumption and found a positive relationship with financial development and a negative relationship with industrial production. When the results of

our study are compared with the literature, it is thought that it will contribute to the literature in terms of the country applied and the test used.

In our study, a negative relationship was found between industrial development and renewable energy consumption. Increasing renewable energy consumption will contribute to environmentally friendly growth. From this perspective, it is possible to make important recommendations to policy makers. More renewable energy consumption in industrial production should be encouraged and supported. When steps are taken in this direction, the areas that will provide renewable energy should also develop. The development of a new sector will mean more employment. As a result, encouraging renewable energy consumption in industrial production will contribute to the economy in direct and indirect ways.

As a result, when the relationship between renewable energy consumption and financial development and industrial output is considered in general, it has been determined that a green-based economy should be focused on with various subsidies namely selective taxation procedures and incentive policies to increase the demand for renewable energy use.

6. References

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