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THE IMPACT OF RENEWABLE AND NON-RENEWABLE ENERGY CONSUMPTION ON ECONOMIC GROWTH IN AZERBAIJAN: FB-ARDL AND A-ARDL COINTEGRATION APPROACHES

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Abstract. The objective of this study is to examine the impact of renewable and non-renewable energy consumption on economic growth in Azerbaijan. It is believed that this study will contribute to the literature by using Fourier ADF, Fourier Bootstrap ARDL and Augmented ARDL methods for the first time in this context. The stationarity of the variables was first tested using ADF, Fractional Fourier ADF, Flexible Fractional Fourier ADF and single structural breakpoint ZA stationarity tests, which revealed different degrees of stationarity of the variables. The cointegration relationship between the variables was first examined using the Fourier Bootstrap ARDL bound test, which found no evidence of cointegration. Subsequently, the Augmented ARDL bounds test was used to examine the cointegration relationship between the variables, which revealed a long-run equilibrium relationship. FMOLS, DOLS and CCR long-run estimation methods were used to examine the impact of renewable and non-renewable energy consumption on economic growth and according to the results of all three methods, both renewable and non-renewable energy consumption contribute to the growth of the Azerbaijani economy. Holding other variables constant, a 1% increase in non-renewable energy consumption leads to a 3.28% increase in economic growth. Holding other variables constant, a 1% increase in renewable energy consumption leads to a 1.29% increase in economic growth. The study concludes with policy recommendations for the Azerbaijani economy based on the econometric results.

Keywords: *Fourier ADF, Fourier Bootstrap ARDL, ARDL Bound Test, Renewable Energy, Economic Growth, Augmented ARDL.*

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1. Introduction

The interest in renewable energy sources, which do not harm the environment, is increasing day by day due to global climate change. In this context, the role of wind energy, one of the renewable energy sources, in economies becomes undeniable. The fact that wind energy does not cause the environmental damage caused by solid fossil fuels and contributes to reducing global climate change emerges as the most important advantage. Furthermore, we should not overlook the other advantages it provides in its increasing use (Kaplan, 2015). Here are the main renewable energy sources and their usage types (Owusu & Asumadu-Sarkodie, 2016; Panwar *et al.*, 2011).

- Hydropower (Power generation);

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- Modern biomass (Heat and power generation, pyrolysis, gasification, digestion);
- Geothermal (Urban heating, power generation, hydrothermal, hot dry rock);
- Solar (Solar home system, solar dryers, solar cookers);
- Direct solar (Photovoltaic, thermal power generation, water heaters);
- Wind (Power generation, wind generators, windmills, water pumps);
- Wave (Numerous designs);
- Tidal (Barrage, tidal stream).

This study investigates the impact of renewable and non-renewable energy consumption on economic growth in Azerbaijan. It is observed that there is limited research on this topic concerning the Azerbaijani economy in the literature. Therefore, it is believed that the study will contribute to the literature by exploring the effects of renewable and non-renewable energy consumption on economic growth using new econometric methods. Figure 1 illustrates the trend of non-renewable energy consumption over time in Azerbaijan. It can be seen that the energy obtained from fossil fuels has decreased over time and has reached a certain level where it stabilizes. The reduction in non-renewable energy consumption will be crucial for Azerbaijan in terms of environmental sustainability.

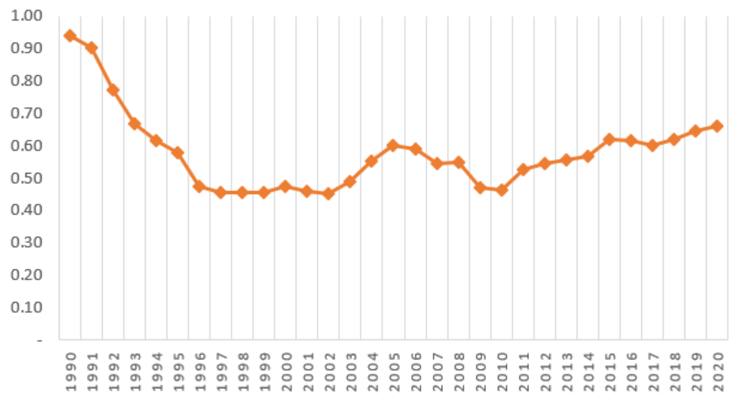

Figure 1. Non-Renewable Energy Consumption in Azerbaijan (Exajoules)

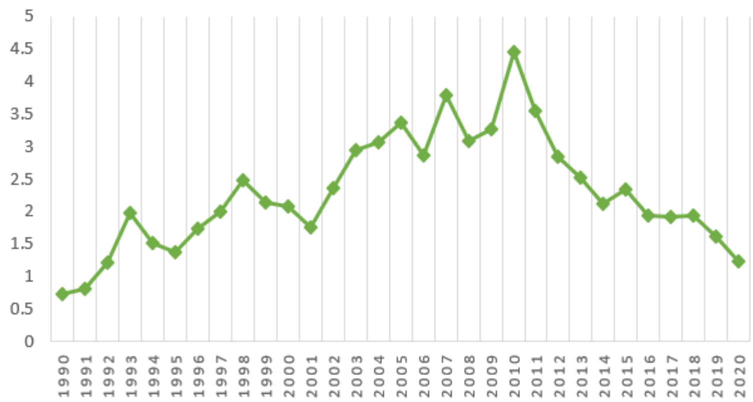

Figure 2. Renewable Energy Consumption in Azerbaijan (% GDP)

In Figure 2, the time series graph of renewable energy consumption variable in Azerbaijan is presented. As depicted in the graph, renewable energy consumption in Azerbaijan increased until 2010 but has been gradually decreasing since then. Following the introduction section of the study, the second section provides a review of previous studies examining the impact of renewable and non-renewable energy consumption on economic growth. The third section introduces the econometric model and the data used in the study. The fourth section presents the econometric methods employed in the study, while the fifth section reports the results obtained from these methods. Finally, in the sixth section, policy recommendations for the Azerbaijani economy based on the findings are provided.

2. Literature Reviews

In this section of the study, the literature review is divided into two main headings. Firstly, it includes previous studies investigating the impact of non-renewable energy consumption on economic growth. Secondly, it focuses on previous studies examining the effect of renewable energy consumption on economic growth.

2.1. The Link Between Non-Renewable Energy Consumption and Economic Growth

In the study conducted by Shahbaz et al. (2020), the impact of capital, labour, renewable and non-renewable energy consumption on economic growth in 38 renewable energy-consuming countries was examined using the Cobb-Douglas production function approach during the period 1990-2018. The Panel Data Pedroni cointegration method was employed in the study and long-run estimation were reported using the DOLS estimator. According to the DOLS estimator, non-renewable energy consumption has a positive impact on economic growth. Öztürk and Saygın (2020) utilized the ARDL approach, while Yanıktepe et al. (2021) employed Johansen cointegration approaches to investigate the impact of non-renewable energy consumption on economic growth in Turkey using different data intervals. In both studies, non-renewable energy consumption was found to positively affect economic growth. The impact of non-renewable energy consumption on economic growth in Iran was investigated in the study by Oryani et al. (2021), which used the ARDL and nonlinear ARDL methods for the period 1970-2017. Non-renewable energy consumption was found to have a positive impact on economic growth according to the results of the long-run estimation. In their studies, Behera and Mishra (2020) utilized Panel Data methods to investigate the impact of non-renewable energy consumption on economic growth in G7 countries, while Rahman and Velayutham (2020) focused on 5 South Asian countries. In both studies, non-renewable energy consumption was found to positively affect economic growth. Lastly, in the study by Bekun et al. (2019), the impact of non-renewable energy consumption on economic growth in Vietnam for the period 1990-2019 was investigated using the ARDL bound test. According to the long-run estimation results of the ARDL model, non-renewable energy consumption was found to positively influence economic growth in Vietnam. Overall, in the empirical literature, non-renewable energy consumption is found to have a positive impact on economic growth. Therefore, we believe that non-renewable energy consumption will have a positive effect on the economy of Azerbaijan in our study.

2.2. The Link Between Renewable Energy Consumption and Economic Growth

The relationship between renewable energy consumption and economic growth was first introduced to the literature by Apergis and Payne (2010). In their study, they investigated the impact of renewable energy consumption on economic growth using the

Panel FMOLS method for 20 OECD countries from 1985 to 2005. They found that renewable energy consumption contributes to economic growth. Subsequently, in Apergis and Payne's study (2011), they examined the impact of renewable energy consumption on economic growth in Central American countries using the panel FMOLS method and similarly concluded that renewable energy consumption has a positive effect on economic growth in these countries. In the study by Eylasov et al. (2024), the impact of renewable and non-renewable energy consumption on economic growth in Turkey was investigated using ARDL and Bayer-Hanck time series methods for the data range of 1990-2020. At the end of the study, it was found that both renewable and non-renewable energy consumption positively affect economic growth. In the study by Javed et al. (2020), the effects of labour, capital and renewable energy resources on economic growth in 12 European countries for the period 2000-2017 were investigated using the Arellano-Bond method. According to the GMM estimation results, renewable energy resources were found to positively influence economic growth. Similarly, Bhattacharya et al. (2016) examined the impact of renewable energy consumption on economic growth using Panel Data methods for 38 countries. The results indicated that for the period 1991-2012, renewable energy consumption positively affects economic growth in these 38 countries. In the study by Can and Korkmaz (2019), using annual data from 1990 to 2016, the impact of renewable energy consumption on economic growth in Bulgaria was investigated. They concluded that renewable energy consumption does not have a significant effect on economic growth. Güzel and Oluç (2021) investigated the impact of renewable energy consumption on economic growth in Turkey for the period 1970-2018 using the ARDL boundary test and concluded that renewable energy consumption has a negative effect on economic growth. Another study conducted for Turkey by Özel and Ekiz (2021) examined the impact of renewable energy consumption on economic growth between 1998-2015 using the Johansen cointegration approach and they found that renewable energy consumption positively affects economic growth. Lastly, Sadorsky (2009) analyzed the impact of renewable energy consumption on economic growth in developing economies using the Panel Pedroni cointegration approach and concluded that renewable energy consumption positively affects economic growth in these countries. Overall, both non-renewable and renewable energy consumption tend to positively influence economic growth. Therefore, it is expected that both renewable and non-renewable energy consumption will positively affect economic growth in the economy of Azerbaijan.

3. Data and Model

In this study, an econometric equation as presented in equation 1 has been established to investigate the impact of non-renewable and renewable energy consumption on economic growth in Azerbaijan and to examine the long-term equilibrium relationship (co-integration) among the variables.

$$LGDP_t = \beta_0 + \beta_1 LREC_t + \beta_2 LEC_t + u_t \quad (1)$$

The constant term β_0 represents the intercept, while u_t denotes the error term in Equation 1. Generally, upon reviewing the literature in this topic, it is observed that both non-renewable and renewable energy consumption have a positive impact on economic growth. Therefore, we expect the coefficients β_1 and β_2 in Equation 1 to be positive. The analysis proceeded by applying a logarithmic transformation to all variables. Detailed information about the variables is provided in Table 1.

Table 1. Variables Detail

Variables	*Symbol*	*Unit*	*References*
GDP per capita	GDP	Constant 2015 US$	WID
Renewable energy consumption	REC	Percent of total final energy consumption	WID
Primary energy: Consumption	EC	Exajoules	Energy Institute

Table 2 presents the descriptive statistics and correlation matrix of the variables. Initially, upon examining the descriptive statistics of the variables in their respective units, it is noted that economic growth and renewable energy consumption exhibit a normal distribution, whereas non-renewable energy consumption does not. Azerbaijan's per capita GDP ranges from a minimum of $1102 to a maximum of $5506 between 1990 and 2020. Upon applying a logarithmic transformation to all variables, it is observed that renewable energy consumption also conforms to a normal distribution. Subsequently, the analysis will proceed with the logarithmic transformation of all variables.

Table 2. Descriptive Statistics and Correlation Matrix

Unit Data	*GDP*	*EC*	*REC*
Mean	3346.439	0.577742	2.288065
Median	2820.840	0.560000	2.120000
Maximum	5506.182	0.940000	4.450000
Minimum	1102.498	0.450000	0.720000
Std. Dev.	1763.336	0.120850	0.876989
Skewness	0.013803	1.431976	0.383074
Kurtosis	1.237243	5.060185	2.780205
Jarque-Bera	4.014595	16.07684	0.820588
Probability	0.134351	0.000323	0.663455
Logarithmic Data	*LGDP*	*LEC*	*LREC*
Mean	7.951574	-0.566772	0.748411
Median	7.944790	-0.585642	0.751416
Maximum	8.613627	-0.064022	1.492904
Minimum	7.005334	-0.793650	-0.328504
Std. Dev.	0.610274	0.189663	0.423729
Skewness	-0.255667	0.918501	-0.670871
Kurtosis	1.431331	3.665605	3.326782
Jarque-Bera	3.516157	4.931074	2.463281
Probability	0.172376	0.084963	0.291813
Correlation Matrix	GDP	EC	REC
GDP	1	0.1198451394533426	0.3041888030006101
EC	0.1198451394533426	1	-0.5927099301138409
REC	0.3041888030006101	-0.5927099301138409	1

In Table 2 and Figure 3, correlation coefficients between the variables are presented. The correlation coefficient between non-renewable energy consumption and economic growth in Azerbaijan is 0.11. This indicates a very slight positive relationship between non-renewable energy consumption and economic growth. The correlation coefficient between renewable energy consumption and economic growth is 0.30, indicating a positive and weak relationship between renewable energy consumption and economic growth. The correlation coefficient between renewable energy consumption and non-renewable energy consumption is -0.59, indicating a moderate negative relationship between these two variables.

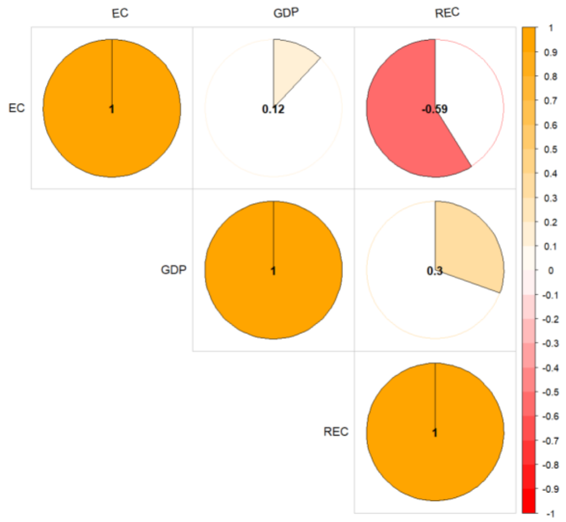

Figure 3. Correlation Matrix as a Pie Graph

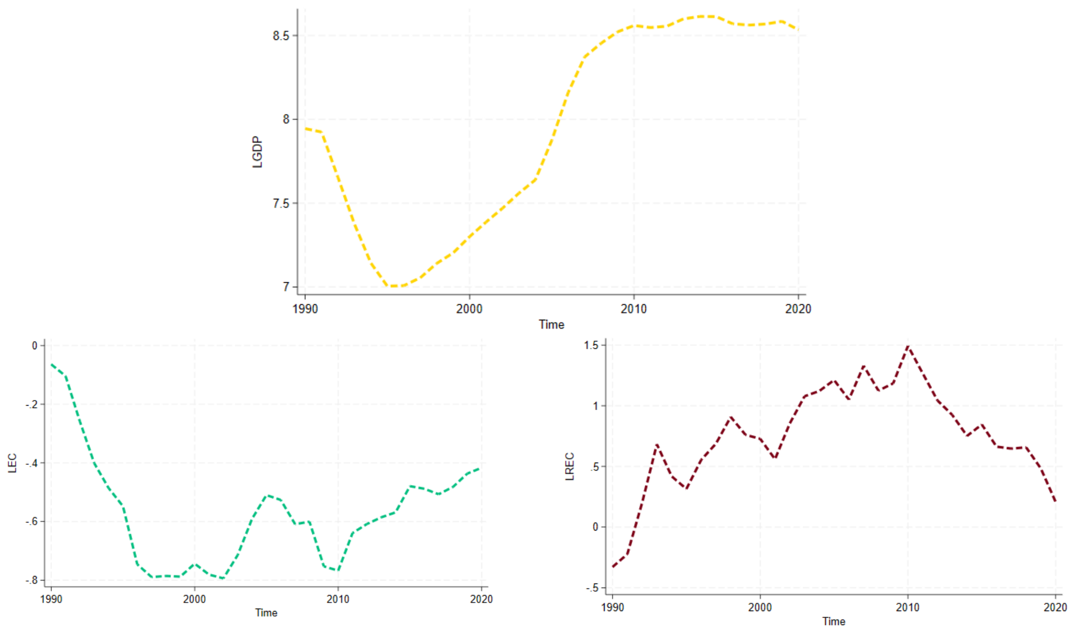

Figure 4. Time Series Plot of Variables

In Figure 4, the time series of the variables used in the study from 1990 to 2020 are depicted. Upon examining all variables, it is evident that there are breakpoints in the variables over time. Regarding Azerbaijan's economic growth variable, there was a decline from 1991 to 1994 due to the first Nagorno-Karabakh War, followed by an increase after the war ended. There was an upward trend in growth from 2005 to 2008, followed by a dispersion around a certain average level from 2008 to 2020, attributed to the 2008 financial crisis. Structural breakpoints occur in both renewable and non-renewable energy consumption variables over time. Therefore, conducting unit root tests that take into account structural breaks will enable obtaining more reliable results when assessing the stationarity of these variables.

4. Methodology

In this section, a brief overview of the econometric methods used in the study will be provided. As depicted in Figure 5, descriptive statistics of the variables are presented initially. Subsequently, the stationarity of the variables is examined using the ADF and Fourier ADF tests, as well as the ZA unit root test considering structural breaks. Fourier Bootstrap ARDL and Augmented ARDL boundary tests are employed to identify cointegration relationships among the variables. Finally, to understand the impact of renewable and non-renewable energy consumption on the Azerbaijani economy, long-run estimation methods such as FMOLS, DOLS and CCR are utilized. The following subsections will delve into unit root and cointegration methods.

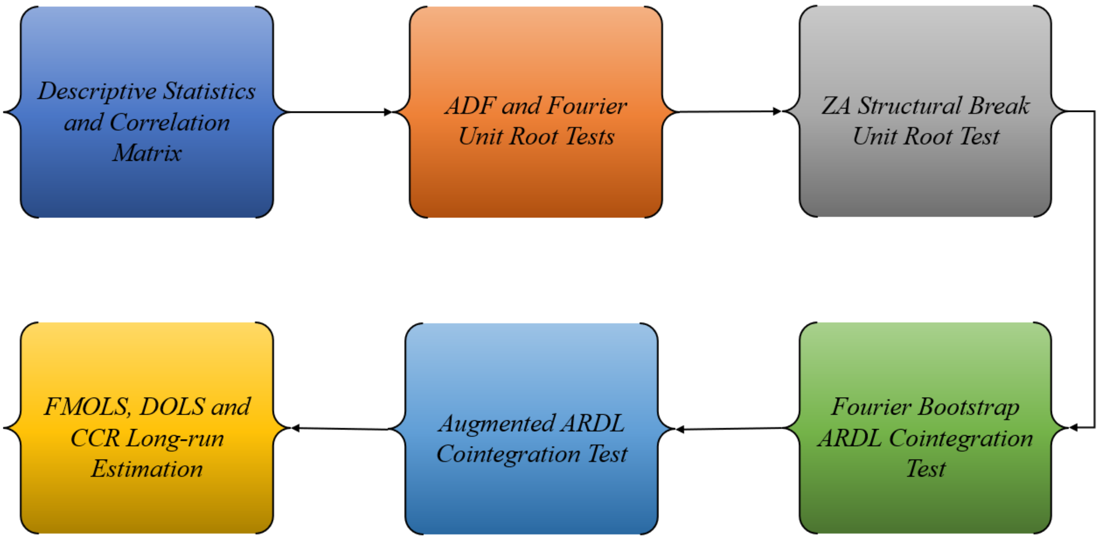

Figure 5. Empirical Methodology

4.1. Unit Root Tests

Analyses conducted without controlling for the stationarity of variables lead to the problem of spurious regression. To address spurious regression, the stationarity of variables should be examined using various unit root tests. There are many unit root tests in the literature and these tests are increasing over time (Eylasov *et al*., 2023a). In this study, the stationarity of economic growth (GDP), non-renewable energy consumption (EC) and renewable energy consumption (REC) variables is tested using Dickey and Fuller (1981) ADF, Enders and Lee (2012) Flexible Fourier ADF, Omay (2015) Fractional Flexible Fourier ADF and finally, Zivot-Andrews (1992) ZA unit root tests, which take structural breaks into account. The DF unit root test was first introduced to the literature by Dickey and Fuller (1979). Due to the autocorrelation issue in the DF unit root test, in the augmented ADF unit root test proposed by Dickey and Fuller (1981), adding one lag of the variable to the model aimed to eliminate the autocorrelation problem (Eylasov *et al*., 2023b). The augmented ADF unit root test is applied to the GDP variable in the study by adding one lag to the model in both the constant and trend models, as written in Equation 2.

$$\Delta LGDP_t = \beta_0 + \beta t + \beta_1 LGDP_{t-1} + \Delta LGDP_{t-1} + u_t \quad (2)$$

In Equation 2, Δ denotes the differenced variable, βt represents the trend, β_0 is the constant term and u_t denotes the error term. If the calculated β_1 test statistic value is found to be larger in absolute value than the critical values provided by MacKinnon (1996), the null hypothesis will be rejected. The hypotheses of the augmented DF unit root test are presented below.

H_0: $There\ is\ Unit\ Root, Series\ is\ not\ Stationary$

H_1: $There\ is\ No\ Unit\ Root, Series\ is\ Stationary$

If the null hypothesis is rejected, the GDP series will be found to be stationary at the level (Aliyev *et al*., 2022; Gasim & Şenyay). As observed in Figure 4, structural breaks are evident in all variables over time. The ADF unit root test does not provide robust results under structural breaks. In the study by Enders and Lee (2012), by adding Fourier terms sin and cos to the model in Equation 2, they introduced the Flexible Fourier ADF unit root test, which provides robust results under structural breaks in the literature. When Fourier terms are added to the model in Equation 2, the equation appears as Equation 3.

$$\Delta LGDP_t = \beta_0 + \beta t + \varsigma_1 sin\left(\frac{2\pi kt}{T}\right) + \varsigma_2 cos\left(\frac{2\pi kt}{T}\right) + \beta_1 LGDP_{t-1} + \Delta LGDP_{t-1} + u_t \quad (3)$$

In Equation 3, π denotes the constant value 3.1415, t represents the trend, T indicates the number of observations and k represents the frequency. The value of k is determined using minimum AIC, SIC, or SSR criteria and is examined up to a maximum of 5. The most important point here is that ς_1 and ς_2 are statistically significant. If they are not significant, the results of the normal Dickey and Fuller (1981) ADF test will be valid. If the Fourier terms are found to be statistically significant and the calculated β_1 coefficient is larger in absolute value than the critical values in the study by Enders and Lee (2012), the null hypothesis will be rejected (Eylasov & Çiçek, 2024). In other words, the GDP series will be stationary at the level according to the Fractional Flexible Fourier ADF test. Unlike the study by Enders and Lee (2012), Omay (2015) proposed the Fractional Flexible Fourier ADF unit root test by controlling the fractional value of the frequency (k) parameter in Equation 3, instead of using discrete values from 1 to 5. The frequency parameter is individually controlled from 0.1 to 5 and the appropriate frequency is determined using minimum SSR. Similarly to the Enders and Lee (2012) test, the statistical significance of the Fourier terms is first checked. If the Fourier terms are statistically significant and the calculated β_1 coefficient is larger in absolute value than the critical values in the study by Omay (2015), the null hypothesis will be rejected. Thus, the GDP series will be stationary at the level according to the Fractional Flexible Fourier ADF test. Finally, in the study, the single-break Zivot and Andrews (1992) ZA unit root test is used to determine the break date of the dependent variable. This date will be added to the Augmented ARDL model as a dummy variable and the cointegration relationship between variables will be investigated.

4.2. Cointegration Tests

In order to examine the cointegration relationship among the variables, Fourier Bootstrap ARDL and Augmented ARDL cointegration tests were employed in this study. After examining the stationary levels of the variables in the literature, various cointegration tests are employed to investigate the cointegration relationship. Generally, when the variables are stationary at the same level, the cointegration relationship between them is examined. With the introduction of the ARDL bounds test by Pesaran et al. (2001), it is possible to examine the cointegration relationship even when the variables are stationary at different levels. Adapted to the variables in this study, the ARDL equation is presented in Equation 4.

$$\Delta LGDP_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta LGDP_{t-i} + \sum_{i=0}^{r} \beta_{2i} \Delta LEC_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta LREC_{t-i} + \gamma_1 LGDP_{t-1} + \gamma_2 LEC_{t-1} + \gamma_3 LREC_{t-1} + \varepsilon_t \quad (4)$$

In Equation 4, Δ represents the first difference operator. Within the framework of ARDL cointegration tests, the presence of cointegration relationship among the variables is investigated through the $t_{dependent}$-statistic and F_{all}-statistic tests. When the null hypothesis $H_0: \gamma_1 = 0$ for the t-dependent variable is rejected, it implies the rejection of the null hypothesis that "there is no cointegration among the variables". On the other hand, when the null hypothesis $H_0: \gamma_1 = \gamma_2 = \gamma_3 = 0$ for all variables is rejected using the F-statistic, it also rejects the null hypothesis of "no cointegration among the variables". Therefore, according to the ARDL bounds test, there exists a cointegration relationship among the variables. Pesaran et al. (2001) established the condition that the dependent variable must be I(1). To relax this condition, the Augmented ARDL bounds test was introduced into the literature by Sam et al. (2019). In the Augmented ARDL bounds test, optionally, a dummy variable can be added to the model. In this study, a dummy variable representing the break date in 2005, as detected by the ZA unit root test for the dependent variable, is included in the model. When the ARDL equation in Equation 4 is rewritten with the inclusion of the dummy variable, it is expressed as Equation 5.

$$\Delta LGDP_t = \beta_0 + \alpha_1 Dummy2005 + \sum_{i=1}^{p} \beta_{1i} \Delta LGDP_{t-i} + \sum_{i=0}^{r} \beta_{2i} \Delta LEC_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta LREC_{t-i} + \gamma_1 LGDP_{t-1} + \gamma_2 LEC_{t-1} + \gamma_3 LREC_{t-1} + \varepsilon_t \quad (5)$$

The model in Equation 5 is also an A-ARDL model. In the study by McNown et al. (2018) and Sam et al. (2019), along with the $t_{dependent}$-statistic and F_{all}-statistic tests for cointegration, the $F_{independent}$-statistic is also used to investigate cointegration among the independent variables. The hypotheses are as follows:

$$t_{dependent} = H_0: \gamma_1 = 0$$
$$F_{all} = H_0: \gamma_1 = \gamma_2 = \gamma_3 = 0$$
$$F_{independent} = H_0: \gamma_2 = \gamma_3 = 0$$

If the statistical values of $t_{dependent}$, F_{all} and $F_{independent}$ are greater than the critical values from the studies of Pesaran et al. (2001), Narayan (2005) and Sam et al. (2019), respectively, the null hypothesis is rejected. Hence, according to the results of all three test statistics, there exists a cointegration relationship among the variables. The

Fourier Bootstrap ARDL approach introduced by Yilanci et al. (2020) enhances the ARDL model proposed by McNown et al. (2018) and Sam et al. (2019) by incorporating Fourier functions. By adding Fourier terms to the model in Equation 4, it transforms into the following form.

$$\Delta LGDP_t = \beta_0 + \Phi_1 sin\left(\frac{2\pi kt}{T}\right) + \Phi_2 cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{p} \beta_{1i} \Delta LGDP_{t-i} + \sum_{i=0}^{r} \beta_{2i} \Delta LEC_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta LREC_{t-i} + \gamma_1 LGDP_{t-1} + \gamma_2 LEC_{t-1} + \gamma_3 LREC_{t-1} + \varepsilon_t \quad (6)$$

Critical values are generated for F_{all}, $F_{independent}$ and $t_{dependent}$ using bootstrap simulation. If the computed test statistic values exceed the bootstrap critical value in absolute terms, it indicates the presence of a cointegration relationship among the variables.

5. Empirical Results

In this section of the study, the stationarity of the variables has been tested using the unit root tests of Dickey and Fuller (1981) Augmented ADF, Enders and Lee (2012) Flexible Fourier ADF and Omay (2015) Fractional Flexible Fourier ADF. Additionally, stationarity has been examined using the unit root test with structural breaks, Zivot and Andrews (1992) single-break unit root test. In Table 3, the results of the ADF, Flexible Fourier ADF and Fractional Flexible Fourier ADF tests are presented initially. According to the results of the ADF unit root test, the economic growth (GDP) variable and renewable energy consumption (REC) are stationary in first differences, while non-renewable energy consumption (EC) is stationary at levels. For the results of the Enders and Lee (2012) and Omay (2015) tests to be valid, the sine and cosine terms must first be statistically significant as Fourier terms. If they are not statistically significant, the normal ADF test results will be valid. According to the results of the Enders and Lee (2012) Flexible Fourier ADF test in Table 3, only the variable of renewable energy consumption (REC) has statistically significant Fourier terms. Therefore, only the REC variable can be interpreted. The REC variable is found to be stationary at levels according to the Flexible FADF test. According to the results of the Omay (2015) Fractional Flexible Fourier ADF test in Table 3, only the Fourier terms of the economic growth (GDP) variable are statistically significant. Therefore, only the GDP variable is interpreted. The economic growth (GDP) variable is found to be stationary at levels. Since the variables are stationary at different orders, both the Augmented ARDL and Bootstrap Fourier ARDL cointegration tests can be used.

A dummy variable can also be used in the augmented ARDL method. To include the dummy variable, both the stationarity of the series and the break date are tested using the Zivot and Andrews (1992) test, considering structural breaks in the study. Table 4 presents the results of the ZA unit root test. According to the ZA unit root test results, the dependent variable, economic growth (GDP), is found to be stationary at levels, with a break date of 2005. In the augmented ARDL method, the break date of the dependent variable is added to the model and the results are reported accordingly.

Initially, the Fourier Bootstrap ARDL bound test was conducted to test the long-run equilibrium relationship between variables and the results are presented in Table 5. The FB-ARDL model selected with the smallest AIC of -4.270 and a frequency value of 0.50 is found to be 3,3,3. According to the FB-ARDL bound test results, since the test statistics F_{all}, $t_{dependent}$ and $F_{independent}$ are smaller than the bootstrap critical values, the null hypothesis will not be rejected. Therefore, according to the FB-ARDL method, there is no cointegration relationship between the variables.

Table 3. ADF and Fourier Unit Root Test Results

Test Name	*ADF*		*Flexible Fourier ADF*			*Fractional Flexible Fourier ADF*		
Variables	*Test st.*	*Lag*	*Test st.*	*Frequency*	*F st.*	*Test st.*	*Frequency*	*F st.*
LGDP	-1.880	1	-2.894	1	5.868	-5.675***	0.20	23.380***
ΔLGDP	-3.451**	1	---	---	---	---	---	---
LEC	-2.881**	0	-2.470	2	3.848	-1.832	0.20	3.670
ΔLEC	---	0	---	---	---	---	---	---
LREC	-2.511	0	-5.62***	1	12.29**	-3.905	0.20	7.695
ΔLREC	-4.600***	0	---	---	---	---	---	---

Notes: *** and ** indicate significant at the 1% and 5% levels. Enders and Lee (2012) Flexible Fourier ADF F statistics critical values are 10.35 at 1%, 7.58 at 5%, 6.35 at 10% for the constant model. In the constant model for frequency=1, the critical values are -4.42 at 1%, -3.81 at 5% and -3.49 at 10%. Omay (2015) F statistics critical values for the constant model are 8.78 at 10%, 10.29 at 5% and 13.48 at 1%. If the frequency values are between $\{0.9, \ldots, 0{,}00001\}$, approximately critical values for 10%, 5% and 1% are -4.50, -3.90 and -3.60.

Table 4. Zivot and Andrews (1992) Structural Break Unit Root Test Results

Variables	*Test statistics*	*Break Date*	*Lag*
LGDP	-9.786***	2005	1
LEC	-4.387	1996	1
LREC	-2.553	2002	0

Notes: *** indicates stationarity at 1% level. ZA critical values are %1 -5.57, %5 -5.08, %10 -4.82 for Model C.

Table 5. Fourier Bootstrap ARDL Bound Test Results

Selected Model		*Optimal Frequency*		*AIC*
FB-ARDL (3,3,3)		*0.50*		*-4.270*
		Bootstrap Critical Values		
Test Statistics		*0.90*	*0.95*	*0.99*
F_{all}	6.032	7.713	9.934	18.341
$t_{dependent}$	-3.777	-3.780	-4.310	-5.690
$F_{independent}$	4.691	9.131	12.213	19.771

According to the FB-ARDL cointegration test, there was no long-run equilibrium relationship between the variables and therefore, the Structural Break Augmented ARDL cointegration test was used. The results of the Augmented ARDL cointegration test and diagnostic tests for model residuals are presented in Table 6. The A-ARDL test statistics F_{all}, t_{dv}, and F_{idv} are greater in absolute value than the critical values of Narayan (2005), Pesaran et al. (2001) and Sam et al. (2019), respectively, indicating the rejection of the null hypothesis. Therefore, a cointegration relationship exists between the variables.

Table 6. Augmented ARDL Bound and Model Residuals Diagnostic Tests Results

Equation	*Lags*	*Dummy*	*Test statistics.*		*Results*	
LGDP = f(LEC, LREC)	2,2,1	2005	F_{all} = 39.016***		*Cointegration*	
			t_{dv} =-8.196***			
			F_{idv}= 7.767**			
Critical Values (k=2)	*0.99*		*0.95*		*0.90*	
References	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
(Narayan, 2005) F_{all}	6.14	7.607	4.183	5.333	3.393	4.41
(Pesaran et al., 2001) t_{dv}	-3.43	-4.1	-2.86	-3.53	-2.57	-3.21
(Sam et al., 2019) F_{idv}	5.41	9.16	3.36	5.90	2.53	4.54
Diagnostic Tests	*Test statistics*		*Prob*			
JB	1.149		0.562			
BG-LM	0.336		0.718			
BPG	1.218		0.338			
ARCH	0.031		0.861			
Ramsey-Reset	0.854		0.366			
CUSUM	Stabile					
CUSUMsq	Stabile					

Note: *** and ** indicate significant at the 1% and 5% levels

In order for the A-ARDL cointegration test in Table 6 to be valid, there should be no autocorrelation, heteroskedastic, non-normality and specification errors in the residuals of the A-ARDL (2,2,1) model. According to the diagnostic test results in Table 6, it can be observed that there is no autocorrelation, heteroskedastic, non-normality and model misspecification in the residuals of the A-ARDL model. The probability values of JB, BG-LM, BPG, ARCH and Ramsey-Reset test statistics are greater than 0.05, hence, the null hypotheses are rejected. On the other hand, the CUSUM and CUSUMsq graphs of the model are shown in Figure 6, indicating that the estimated parameters fall within the confidence intervals, thus demonstrating stability.

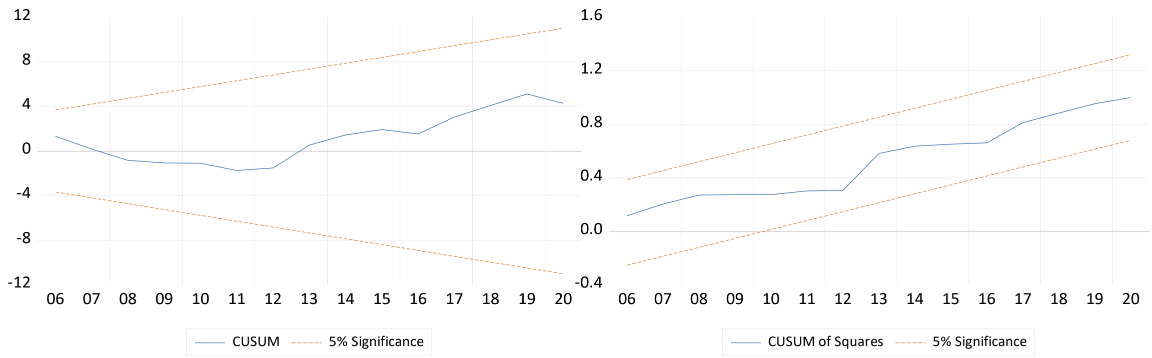

Figure 6. CUSUM and CUSUMsq Graphs

According to the A-ARDL cointegration test result, a long-run equilibrium relationship is found between the variables and the long-run estimation results of FMOLS, DOLS and CCR are presented in Table 7. Based on the FMOLS, DOLS and CCR long-run estimation results, all variables are found to be significant at the 1% level. Additionally, according to all estimation methods, non-renewable energy consumption (EC) and renewable energy consumption (REC) have a positive impact on economic growth (GDP). Keeping other variables constant, a 1% increase in non-renewable energy consumption leads to a 3.28% increase in economic growth. The findings in this study are consistent with the findings of previous studies (Shahbaz *et al*., 2020; Öztürk & Saygın, 2020; Yanıktepe *et al*., 2021; Oryani *et al*., 2021; Behera & Mishra, 2020; Bekun *et al*., 2019; Rahman & Velayutham, 2020). Keeping other variables constant, a 1% increase in renewable energy consumption leads to a 1.29% increase in economic growth. The findings in this study are consistent with the findings of previous studies (Javed *et al*., 2020; Bhattacharya *et al*., 2016; Sadorsky, 2009).

Table 7. FMOLS, DOLS and CCR Long-run Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEC	3.280430	0.722302	4.541635	0.0001
LREC	1.299928	0.319218	4.072222	0.0004
Constant	8.902582	0.355147	25.06730	0.0000
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEC	3.776526	0.751515	5.025218	0.0001
LREC	1.418256	0.328018	4.323707	0.0004
Constant	9.093305	0.428474	21.22253	0.0000
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEC	3.097170	0.653776	4.737354	0.0001
LREC	1.307925	0.303162	4.314274	0.0002
Constant	8.782264	0.279483	31.42324	0.0000

6. Conclusion and Political Recommendation

This study examines the impact of renewable and non-renewable energy consumption on Azerbaijan's economic growth using data from 1990 to 2020. For the first time for Azerbaijan, the study contributes to the literature by applying the Fourier bootstrap ARDL and Augmented ARDL time series methods within the framework of the topic. Firstly, the stationarity of the variables is investigated using ADF, Flexible Fourier ADF, Fractional Flexible Fourier ADF and ZA single break unit root tests and it is found that the variables are stationary at different levels. To explore the long-run equilibrium relationship among the variables, the Fourier Bootstrap ARDL cointegration test is initially used, but no cointegration relationship is found. Subsequently, the Augmented ARDL method is employed to investigate the long-run equilibrium relationship among the variables and a cointegration relationship is found. According to the long-run estimation results of FMOLS, DOLS and CCR, both renewable and non-renewable energy consumption positively affect the Azerbaijani economy. Various measures can be taken to support the consumption of renewable energy, which has a positive impact on Azerbaijan's economy. These include providing economic incentives like tax breaks, incentives and investment opportunities to encourage renewable energy projects. Furthermore, investments should be made to improve renewable energy infrastructure, such as energy storage systems and transmission lines. It's also important to educate the public about transitioning to renewable energy through awareness campaigns and educational programs. Investing in research and development for renewable energy technologies can enhance the efficiency and economic viability of local renewable energy sources. Lastly, organizing training programs and courses to develop a skilled workforce for the renewable energy sector is crucial. These policy suggestions can assist Azerbaijan in effectively utilizing its local renewable energy resources, promoting environmental sustainability and economic growth.

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