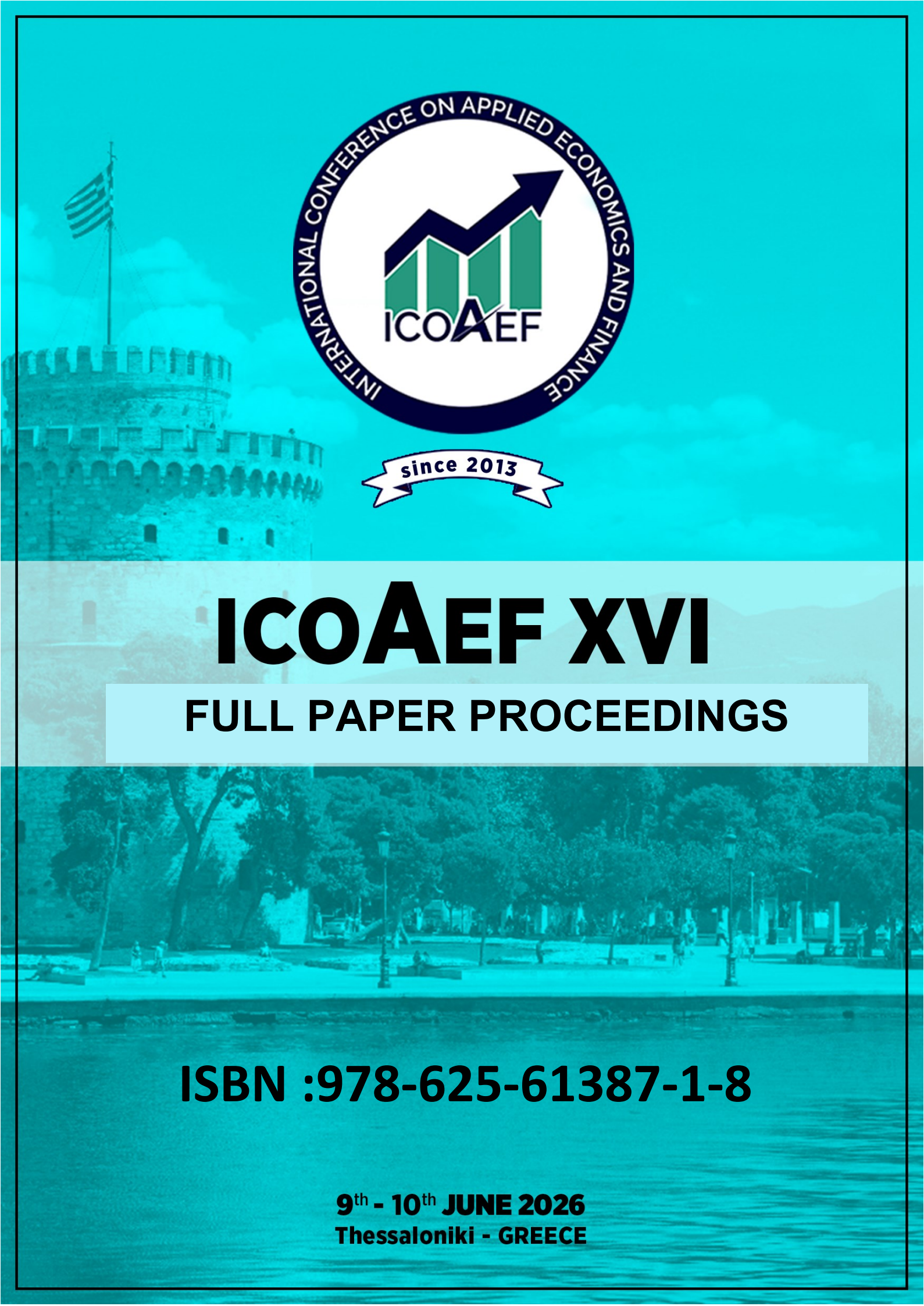


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THE RELATIONSHIP BETWEEN RENEWABLE ENERGY CONSUMPTION, UNEMPLOYMENT, AND INFLATION IN GREECE

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ABSTRACT

In recent years, growing global concerns about climate change, environmental degradation, and the depletion of fossil fuel resources have prompted countries to shift their focus to renewable energy sources. During this process, investments in renewable energy have gained importance not only in terms of environmental sustainability but also in terms of macroeconomic indicators such as economic growth, employment, and price stability. Green transition policies, particularly those implemented in Europe, have made the impact of the energy sector on the economic structure more visible. Greece, a member of the European Union, is prioritizing renewable energy policies to reduce energy dependence, lower carbon emissions, and support sustainable growth. Energy investments have become a key policy tool during the country's economic recovery, particularly after the 2008 crisis. This study investigates the relationship between energy consumption, unemployment, and inflation in Greece. For this purpose, annual time series data from 1981 to 2024 are examined using econometric methods based on the Fourier approximation, which accounts for both sharp and smooth structural breaks. The Fourier ADF unit root test results show that all three variables become stationary after first differencing, indicating the presence of a unit root at the level. Findings from the Fourier ADL cointegration test reveal that macroeconomic indicators influence renewable energy. Accordingly, a one-unit increase in renewable energy consumption increases the unemployment rate by 0.28 units, while a one-unit increase in inflation decreases the unemployment rate by 0.37 units; meanwhile, a one-unit increase in renewable energy consumption decreases inflation by 0.83 units, while a one-unit increase in the unemployment rate decreases inflation by 0.35 units. On the other hand, inflation and unemployment are found to have no statistically significant impact on renewable energy consumption. In conclusion, increased investment in renewable energy leads to higher unemployment while contributing to lower inflation. Therefore, it is important for policymakers to support the green transition with active labor market policies and reskilling programs to minimize job losses.

Keywords: *Renewable Energy, Unemployment, Inflation, Greece.*

JEL Codes: *E24, E31, Q43.*

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1. INTRODUCTION

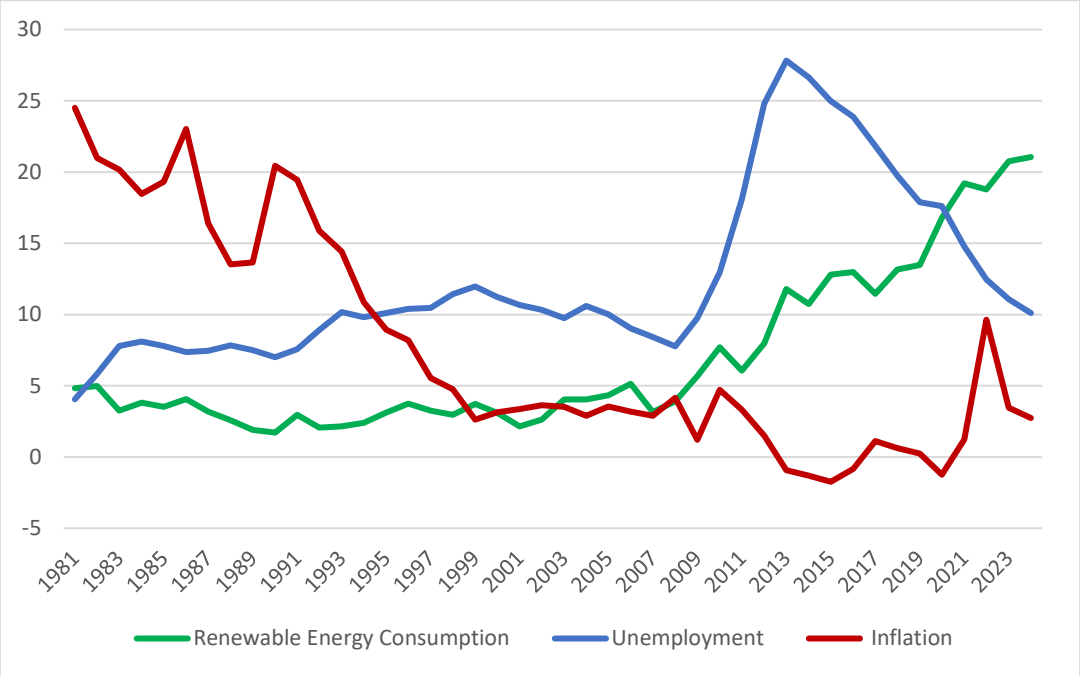
In recent years, with the increasing depletion of fossil fuel resources and the serious environmental pollution problem, countries worldwide have been compelled to accelerate the transition of their energy sectors towards cleaner and more sustainable alternatives (Pham et al., 2026). In this process, renewable energy sources have become a strategic element not only in ensuring environmental sustainability but also in supporting economic and social development. Expanding the use of renewable energy sources such as solar, wind, hydroelectric, and biomass contributes to reducing greenhouse gas emissions while also offering significant opportunities to reduce dependence on energy imports, strengthen energy supply security, and support sustainable growth. Therefore, many countries consider energy transformation as a fundamental component of their long-term development strategies.

Increased investments in renewable energy directly and indirectly affect not only the energy sector but also macroeconomic indicators. The impacts on key indicators such as employment, unemployment, inflation, and economic growth have been extensively discussed in academic literature in recent years. While some argue that the renewable energy sector supports the labor market by creating new employment opportunities (Khobai, 2020), others suggest that the transformation in the production structure, inter-sectoral labor transfers, and technology-intensive production processes may lead to varying employment outcomes (Yılancı et al., 2020; Saboori et al., 2022). Similarly, the effects of renewable energy on the general price level vary depending on the country (Chung and Kim, 2024) and the time period (Deka and Dube, 2021).

Over recent years, Greece has made significant progress in renewable energy thanks to policies and investments aimed at transforming its energy sector. In line with its goals of reducing dependence on fossil fuels, increasing energy supply security, and lowering greenhouse gas emissions, the country has prioritized the utilization of solar and wind energy resources. National energy and climate plans, prepared in line with the European Union's climate and energy policies, have encouraged renewable energy investments and ensured a steady increase in the share of renewable sources in electricity production.

Among European countries, Greece has established a substantial share of renewable energy within its energy portfolio while pursuing ambitious policies to achieve carbon neutrality by 2050. In addition, renewable energy technologies enjoy broad public support across the country (Ioannidis et al.,2023). Thanks to its geographical location, high sunshine hours, favorable wind potential, and island structure, Greece possesses significant advantages for the implementation of renewable energy technologies.

Figure 1. Renewable Energy Consumption, Unemployment, and Inflation in Greece



Source: OWID, 2026; IMF, 2026; WB, 2026.

Figure 1 shows renewable energy, unemployment, and inflation rates in Greece between 1981 and 2024. It is noteworthy that renewable energy consumption has been on an upward trend, especially since the 2008 global crisis. The unemployment rate peaked in 2013 due to the impact of the global crisis and the European debt crisis, and has since declined steadily. Inflation generally tends to fall, and even experiences deflationary trends for a few years. The deflationary trend is largely due to fiscal austerity policies (Mastromatteo and Rossi, 2015). In recent years, an increase has only been seen due to the Covid-19 pandemic.

This study aims to contribute to the literature by analyzing the relationship between renewable energy consumption, unemployment, and inflation in the case of Greece using current econometric methods based on the Fourier approach. Its distinctive features include the use of Fourier-based methods, which allow for the modeling of both abrupt and smooth transitions in structural changes, and the analysis conducted with a current dataset covering the period 1981–2024. The findings are expected to contribute to a better understanding of the macroeconomic impacts of renewable energy policies in the green transition process and to guide policy designs that consider energy, employment, and price stability simultaneously. The study begins with a review of the relevant literature. Following this, the dataset, variables, and econometric method used in the research are introduced. The empirical findings are presented and evaluated. Finally, the results are summarized, policy recommendations are developed based on the findings, and considerations for future research are provided.

2. LITERATURE REVIEW

Several studies exist in the literature examining the relationship between renewable energy and unemployment. Some have yielded mixed results. Yılancı et al. (2020) examined 12 selected countries for the period from 1995 to 2016. Findings from the FADL cointegration test showed that renewable energy consumption increased unemployment in 3 countries and decreased it in 5 countries. Saboori et al. (2022) studied 51 US states for the period 1977-2017. While the fixed effects model suggests that renewable energy reduces unemployment, the Seemingly Unrelated Regression Equations (SURE) model shows that renewable energy increases unemployment in 20 states.

Some studies have found a positive correlation between these variables. Apergis and Salim (2015) examined 80 selected countries for the period 1990-2013 using nonlinear panel causality and cointegration tests. Their findings showed that renewable energy increases unemployment. Furthermore, the importance of the cost of adopting renewable energy technologies and their efficiency levels is emphasized. Rafiq et al. (2018) employed the Westerlund panel cointegration test for 41 selected countries over the 1980-2014 period and found similar results.

On the other hand, the study by Zhao and Luo (2017) investigated the period from 1978 to 2013 in China. Similarly, Xolmurodov et al. (2025) analyzed Uzbekistan for the period 2000–2022. In these studies, which employed the ARDL bounds test approach, it was found that renewable energy increased employment and decreased unemployment, respectively. Tsaurai (2022) evaluated 5 African countries for the period 1992-2019, while Omarova et al. (2025) evaluated 8 selected developed countries for the period 2000-2023. These studies, which used the fixed effects model, reached similar findings.

There are also studies focusing on the relationship between renewable energy and inflation. Some have found an inverse relationship between these variables. Durani et al. (2025) studied China for the period 1990-2021 using the Wavelet quantile correlation approach. The findings revealed that inflation reduces renewable energy consumption in the short, medium, and long term. Kusuma et al. (2025) investigated the period from 1990 to 2022 for Indonesia using the Engle-Granger cointegration test. They argued that renewable energy supports price stability. Cornejo et al. (2025) examined 18 Latin American and Caribbean countries for the period from 2005 to 2021. The findings showed that renewable energy reduces the impact of global energy price volatility on local inflation. Akusta (2026) analyzed Türkiye through the ARDL bounds test approach. The study, which examined the period from 1980 to 2022, revealed that renewable energy supports price stability both directly and indirectly.

Some studies have determined that the variables mentioned move in the same direction. The study by Arslan and Yıldız (2022) examined 20 European Union countries for the period 1985-2018 using the Westerlund panel cointegration test. Test results showed that the use of renewable energy increases inflation in the long term, but has no effect in the short term. Zhang et al. (2024) analyzed G7 countries using the MM-QREG technique and Dynamic GMM. Their study, covering the years 1997-2021, found that renewable energy production and consumption led to inflation. Other studies have obtained similar

findings using the ARDL bounds test approach. Deka and Dube (2021) analyzed Mexico for the period 1990-2019 and found a bidirectional positive relationship between the variables. Deka et al. (2022) examined Brazil for the period 1990-2019 and stated that inflation encouraged the use of renewable energy. Kushawaha et al. (2026) examined India for the period 1974-2023 and observed that renewable energy led to energy inflation.

3. DATA SET AND METHODOLOGY

This study investigates the effects of renewable energy consumption on unemployment and inflation rates in Greece. Renewable energy consumption data are obtained from Our World in Data (OWID), unemployment rate data from the International Monetary Fund (IMF), and inflation rate data from the World Bank (WB) (OWID, 2026; IMF, 2026; WB, 2026). The annual time series covers the years from 1981 to 2024 and consists of 44 observations.

To test for the existence of a cointegration relationship between the series, the Fourier ADL method recommended by Banerjee et al. (2017) is used. This method is known as an improved version of the ADL cointegration test introduced by Banerjee et al. (1998). Fourier functions allow us to account for breaks with an undefined time, number, and structure. Furthermore, because no dummy variables are used, there is no power loss, and it provides powerful results even in small sample sizes (Alola and Adebayo, 2023). In line with this, the following equations have been estimated:

$$UNE_t = \alpha_0 + \alpha_1 sin\left(\frac{2\pi k^* t}{T}\right) + \alpha_2 cos\left(\frac{2\pi k^* t}{T}\right) + \alpha_3 UNE_{t-1} + \alpha_4 REN_{t-1} + \alpha_5 INF_{t-1} + \alpha_6 \Delta UNE_{t-1} + \alpha_7 \Delta REN_{t-1} + \alpha_8 \Delta INF_{t-1} + e_t \quad (1)$$

$$INF_t = \beta_0 + \beta_1 sin\left(\frac{2\pi k^* t}{T}\right) + \beta_2 cos\left(\frac{2\pi k^* t}{T}\right) + \beta_3 INF_{t-1} + \beta_4 REN_{t-1} + \beta_5 UNE_{t-1} + \beta_6 \Delta INF_{t-1} + \beta_7 \Delta REN_{t-1} + \beta_8 \Delta UNE_{t-1} + \varepsilon_t \quad (2)$$

$$REN_t = \gamma_0 + \gamma_1 sin\left(\frac{2\pi k^* t}{T}\right) + \gamma_2 cos\left(\frac{2\pi k^* t}{T}\right) + \gamma_3 REN_{t-1} + \gamma_4 UNE_{t-1} + \gamma_5 INF_{t-1} + \gamma_6 \Delta REN_{t-1} + \gamma_7 \Delta UNE_{t-1} + \gamma_8 \Delta INF_{t-1} + \zeta_t \quad (3)$$

Equations (1), (2), and (3) present the models where *UNE*, *INF*, and *REN* are the dependent variables, respectively. Here, *UNE* represents the unemployment rate, *INF* the inflation rate, *REN* renewable energy consumption, e_t, ε_t, and ζ_t error terms, *sin* and *cos* trigonometric terms, *k* frequency value, *t* trend, and *T* sample size.

For Model 1 $\alpha_3 = 0$; for Model 2 $\beta_3 = 0$; and for Model 3 $\gamma_3 = 0$ the null hypotheses stating that the series are not cointegrated are tested. The following equation is used to calculate the test statistics:

$$t^F_{ADL} = \frac{\hat{\alpha}_3}{se(\hat{\alpha}_3)}, \quad t^F_{ADL} = \frac{\hat{\beta}_3}{se(\hat{\beta}_3)}, \quad t^F_{ADL} = \frac{\hat{\gamma}_3}{se(\hat{\gamma}_3)} \quad (4)$$

Here, $\hat{\alpha}_3$, $\hat{\beta}_3$, $\hat{\gamma}_3$ refer to the ordinary least squares estimator of α_3, β_3, γ_3 and $se(_{\hat{\alpha}_3})$, $se(_{\hat{\beta}_3})$, $se(_{\hat{\gamma}_3})$ refer to the standard error of $\hat{\alpha}_3$, $\hat{\beta}_3$, $\hat{\gamma}_3$. If the calculated value is greater than the table value, the null hypothesis is rejected, and the series are considered cointegrated.

4. FINDINGS

The stationarity of the series is examined using the Fourier ADF unit root test introduced by Enders and Lee (2012). The results are reported in Table 1.

Table 1. FADF Unit Root Test Results

Variables	k	Min SSR	F Statistic	Lag	FADF Test Statistic	ADF Test Statistic
REN	5	63.06923	3.027641	2	2.818765	2.328685
UNE	3	97.72866	1.348001	2	-1.595114	-2.601095
INF	1	263.7767	0.477102	9	-1.431422	-2.179689
DREN	1	61.22258	4.490385	1	-6.111529*	-6.809103*
DUNE	3	57.27261	1.713716	1	-3.374493**	-3.347779**
DINF	3	289.9018	4.078537	6	-1.362659	-7.023994*

Note: * and ** show significance at the 1% and 5% levels, respectively.

Table 1 presents the results of the Fourier ADF (FADF) unit root test for the variables. When the F-statistics are examined, it is seen that the trigonometric terms are not statistically significant. Therefore, the traditional ADF test results were used in the stationarity analysis. According to the ADF test results, renewable energy consumption (REN), unemployment rate (UNE), and inflation (INF) variables contain unit roots at their level values and are not stationary. Therefore, the same procedure was repeated by taking the first differences of the variables. Since the F-test results for the first differences also showed that the trigonometric terms were not significant, the evaluations were again made according to the traditional ADF test results. The findings show that all series become stationary when the first differences are taken. Therefore, it has been determined that all variables are integrated at the I(1) level, and the application of the FADL cointegration test is deemed appropriate. The test results are presented in Table 2.

Table 2. FADL Cointegration Test Results

Dependent Variable	Independent Variables		Optimal k	Minimum AIC	FADL Test Stat.
UNE (1)	REN (2)	INF (1)	2	3.065334	-3.919532***
INF (1)	REN (2)	UNE (1)	1	4.592891	-4.741833**
REN (2)	UNE (1)	INF (1)	5	3.274431	2.148206

Note: ** and *** show significance at the 5% and 10% levels, respectively. The lag length is restricted to a maximum of 3. The optimal number of lags is determined according to the AIC. The values in parentheses indicate the lag length.

Table 2 presents the results of the FADL cointegration test. Examining the findings, it is observed that in the first model, where the dependent variable is the unemployment rate (UNE), and the second

model, where the dependent variable is inflation (INF), a long-term cointegration relationship exists between the variables. This result indicates that renewable energy consumption, unemployment rate, and inflation variables move together in the long run in these models. In contrast, no cointegration relationship was found in the third model, where the dependent variable is renewable energy consumption (REN). Therefore, it is not possible to speak of a long-term equilibrium relationship between the variables in this model. Based on these findings, the estimation of long-term coefficients continues only for the first two models where a cointegration relationship was detected. The results are reported in Table 3.

Table 3. FMOLS Estimations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: UNE				
REN	0.276896**	0.130223	2.126319	0.0400
INF	-0.365467*	0.100465	-3.637752	0.0008
C	13.74557*	1.500075	9.163256	0.0000
SIN	-0.129422	0.980046	-0.132057	0.8956
COS	-2.942298*	0.886097	-3.320513	0.0020
Dependent Variable: INF				
REN	-0.825743*	0.121279	-6.808652	0.0000
UNE	-0.347600*	0.099297	-3.500588	0.0012
C	17.43280*	1.462957	11.91614	0.0000
SIN	1.337090	0.962282	1.389499	0.1728
COS	7.649985*	0.757757	10.09557	0.0000

Note: * and ** show significance at the 1% and 5% levels, respectively. The lag length is restricted to a maximum of 3. The optimal number of lags is determined according to the AIC.

According to Table 3, the estimated coefficients are statistically significant. A 1-unit increase in REN increases UNE by 0.28 units, while a 1-unit increase in INF decreases UNE by 0.37 units, indicating that both variables have a meaningful impact on UNE. For INF as the dependent variable, a 1-unit increase in REN decreases INF by 0.83 units, while a 1-unit increase in UNE decreases INF by 0.35 units. Overall, the results show that REN has a positive effect on UNE and a negative effect on INF, while UNE is also negatively associated with INF.

5. CONCLUSION

Renewable energy has become not only an environmental policy tool but also a crucial element affecting key macroeconomic indicators such as employment and price stability. In Greece, a member of the European Union, the green transition process is a structural policy priority aimed at reducing dependence on fossil fuels, increasing energy diversification, and promoting sustainable growth. In this context, analyzing the macroeconomic impacts of renewable energy consumption is critical for policy design.

This study examines the relationship between renewable energy consumption, unemployment, and inflation using econometric methods based on the Fourier approach for the period 1981-2024. The findings indicate that renewable energy consumption has a positive effect on unemployment and a negative effect on inflation. The findings of this study support Cornejo et al. (2025) Kusuma et al. (2025), and Akusta (2026), who argue that renewable energy promotes price stability, in contrast to Deka and Dube (2021), Arslan and Yıldız (2022), and Zhang et al. (2024), who found that renewable energy leads to inflation. In addition, it supports Apergis and Salim (2015) and Rafiq et al. (2018), who state that renewable energy causes unemployment, in contrast to Omorova et al (2025), Tsaurai (2022) and Xolmuratov et al. (2025), who claim that renewable energy reduces unemployment.

The results show that renewable energy consumption has a mitigating effect on inflation and an increasing effect on unemployment. From an inflationary perspective, this result suggests that increased renewable energy use strengthens energy supply security, reduces production costs in the medium and long term, and alleviates cost pressures on the general price level by supporting supply-side capacity. In this context, renewable energy investments are considered to contribute to price stability by supporting macroeconomic stability through the supply-side channel.

Conversely, the high-technology and capital-intensive production structure of the renewable energy sector can lead to a decrease in demand, particularly for low and medium-skilled labor, potentially increasing unemployment rates. Rather than increasing direct government intervention in the market, it could be argued that the government should focus on increasing flexibility in the labor market, facilitating cross-sectoral integration of workers, and prioritizing reskilling programs to reduce the adaptation costs arising from the green transition process. However, it should be noted that this effect is not homogeneous across the entire economy, and the impact of renewable energy investments on employment may vary depending on the labor intensity of the sectors, the level of technological transformation, and the skill structure of the workforce. Therefore, examining the effects of renewable energy consumption on employment at the sectoral level will contribute to a more accurate interpretation of the findings.

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