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Asymmetric Impact of Fiscal Policies on Environmental Deterioration: Evidence from the NARDL Model for Türkiye

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ABSTRACT

In this study, an analysis based on the NARDL model has been conducted using data from 1970 to 2020 to investigate the impact of fiscal policy tool, public expenditures, on environmental degradation. This approach has the capability of dissecting the effects of expansionary and contractionary fiscal policies related to public expenditures on environmental degradation and provides coefficient estimations for both short and long run. The results suggest that expansionary fiscal policy leads to a reduction in CO2 emissions in the long run. In contrast, it has been observed that contractionary fiscal policy does not have a significant impact on CO2 emissions in the long run. Accordingly, it has been determined that public expenditures in Turkey do not contribute positively to environmental pollution. Moreover, although an increase in income is associated with increased CO2 emissions in the long run, the validity of the Environmental Kuznets Curve hypothesis is not confirmed for Turkey. Fossil fuel consumption, as theoretically anticipated, raises CO2 emissions in both the short and long run. Thus, prioritizing the use of renewable energy sources becomes a necessity to mitigate environmental degradation. Additionally, public expenditures have no short-run impact on CO2 emissions. The study is believed to make an important contribution by addressing the gap in the literature through the application of an asymmetric approach to analyze the influence of public expenditures on environmental pollution in the context of Turkey. Furthermore, the obtained findings for Turkey are considered valuable for both researchers and governmental authorities. It is imperative to pay heed to the implementation of environmentally conscious and pollution-reducing fiscal policies.

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Furthermore, the promotion of renewable energy utilization should be emphasized to enhance environmental quality.

Keywords: Fiscal Policy, CO2 Emissions, Nonlinear ARDL

Maliye Politikalarının Çevresel Bozulmaya Asimetrik Etkisi: Türkiye için NARDL Modelinden Kanıtlar

ÖZET

Maliye politikası aracı olan kamu harcamalarının çevresel bozulma üzerindeki etkisini araştıran bu çalışmada, Türkiye için 1970-2020 yıllarına ait veriler kullanılarak NARDL modeline dayalı bir analiz gerçekleştirilmiştir. Bu yaklaşım kamu harcamaları yönünden genişletici ve daraltıcı maliye politikasının çevresel bozulma üzerine etkilerini ayrıştırma özelliğine sahiptir. Ayrıca hem kısa hem de uzun dönem için katsayı tahminlerini ortaya koymaktadır. Ulaşılan bulgular, genişletici maliye politikasının uzun dönemde CO2 emisyonlarını azalttığını göstermiştir. Buna karşılık, daraltıcı maliye politikasının CO2 emisyonları üzerinde uzun dönemde anlamlı bir etkisi olmadığı görülmüştür. Bu sonuca göre Türkiye'deki kamu harcamalarının çevresel kirliliğe herhangi bir olumlu katkı sağlamadığı belirlenmiştir. Ek olarak, gelirdeki artışın uzun dönemde CO2 emisyonlarını arttırdığı tespit edilse de Çevresel Kuznets Eğrisi hipotezinin Türkiye için geçerli olmadığı görülmüştür. Fosil yakıt tüketimi teorik beklentiye uygun olarak hem kısa hem de uzun dönemde CO2 emisyonlarını artırmaktadır. Bu açıdan yenilenebilir enerji kaynaklarının önceliklendirilmesinin çevresel bozulmayı azaltmak için bir gereklilik olduğu vurgulanmalıdır. Öte yandan, kamu harcamalarının kısa dönemde CO2 emisyonları üzerinde herhangi bir etkisi bulunmamaktadır. Türkiye'de kamu harcamalarının çevresel kirlilik üzerindeki etkisini analiz etmek için asimetrik bir yaklaşımın kullanılmasına dair literatüründeki boşluğun doldurulmasında çalışmanın önemli katkısı olduğu düşünülmektedir. Ayrıca Türkiye bağlamında elde edilen bulgular hem araştırmacılar hem de kamu otoriteleri için değerlidir. Özellikle çevre dostu ve çevresel bozulmayı azaltıcı nitelikteki maliye politikalarının uygulanmasına dikkat edilmelidir. Ek olarak çevresel kalitenin arttırılması için yenilenebilir enerji kullanımı daha yüksek düzeyde teşvik edilmelidir.

Anahtar Kelime: Maliye Politikası, CO2 Emisyonu, Doğrusal Olmayan ARDL

1. INTRODUCTION

The industrialization movement that commenced in the mid-18th century with the adoption of steam engines witnessed rapid development from the 19th century to the present day. The surge in industrialization brought forth global economic growth. However, the increased industrialization required energy that predominantly relied on non-renewable resources. The dwindling quality of the environment due to the allure of economic growth was disregarded (Ike et al., 2020). Furthermore, factors such as population growth, urbanization, escalating hazardous waste, and the depletion of forests and water sources have significantly triggered environmental degradation. In fact, the most significant challenges that humanity is currently attempting to find solutions for global warming and climate change. (Kete et al., 2017).

Researchers have been actively engaged in extensive efforts in recent years to identify factors influencing environmental degradation. Some of these studies are concentrated on the economic causes of environmental deterioration. Particularly, the Environmental Kuznets Curve (EKC) hypothesis introduced to the literature by Grossman and Krueger (1991, 1993) has been a significant milestone in the examination of economic factors affecting the environment. According to this hypothesis, when a country's income is below a certain threshold, policies are pursued with a focus on increasing economic growth while relegating environmental concerns. Beyond the threshold income level, it is anticipated that the enhancement of economic well-being, through advancements such as new technology and environmentally sensitive energy provision, will lead to a decrease in environmental degradation. Hence, a reverse U-shaped relationship between income level and environmental degradation can be observed (Ike et al., 2020).

The achievement of a country's targeted level of development relies significantly on economic growth. In attaining economic growth, fiscal policy stands as a pivotal instrument. Fiscal policy is conducted by governments. Simultaneously, governments also bear the responsibility for the environmental regulations of a country. Hence, governments implement fiscal policy to facilitate environmentally beneficial economic activities and achieve economic progress (Mar'I et al., 2023). In this context, fiscal policy takes center stage through both public expenditures and tax policies. This is because public expenditures directed towards education, healthcare, technology, and R&D pave the way for future income growth. The gradual increase in income levels, over time, facilitates the reduction of environmental degradation by promoting new technologies and environmentally conscious production. Furthermore, the elevation of income levels establishes an environment wherein public authorities prioritize environmental

regulations (Ullah et al., 2021). Taxes, on the other hand, can be applied in a manner that encourages or discourages production or consumption elements in the market, which contribute to either escalating or mitigating environmental degradation. This application is based on the extent of damage inflicted on the environment, thus providing incentives for environmentally friendly practices or acting as deterrents for harmful ones (Shahnazi and Shabani, 2021).

McAusland (2008) distinguished two categories concerning the impact of public expenditures, the focus of this study, on environmental degradation. These are identified as pollution stemming from production and pollution stemming from consumption based on the source of environmental pollution. Lopez et al. (2011) provide an explanation for the impact mechanisms of public expenditures on production-related environmental pollution, categorizing them into four distinct factors: the income effect, composition effect, technological effect, and scale effect. The income effect implies that improvements in income levels, facilitated by public expenditures, lead to the implementation of approaches and practices that mitigate environmental degradation. The composition effect encourages human capital-intensive activities that reduce environmental deterioration, while discouraging physical capital-intensive activities that exacerbate it. The technological effect involves the impact of public expenditures, particularly directed towards sectors such as education and healthcare, which enhance workforce productivity and consequently reduce environmental degradation. On the other hand, the scale effect highlights the potential consequence of increased public expenditures resulting in rapid economic growth that could contribute to heightened environmental pollution. Consumption-induced environmental pollution is assessed from different perspectives. For instance, public expenditures allocated to sectors like healthcare and education may elevate individual income levels, subsequently driving greater consumption and potentially exacerbating environmental degradation. However, an alternative viewpoint suggests that increased public expenditures might foster the development of regulations, institutions, or authorities that ensure the preservation of environmental quality (Fullerton & Kim, 2008; Halkos & Paizanos, 2016).

The theoretical realm has presented divergent viewpoints on the influence of public expenditures on environmental pollution. Similar to the diversity observed in these perspectives, empirical studies in the literature have also yielded varying findings. The second section entails a literature review where findings from research on the subject are summarized and assessed. The third section encompasses the research design (including data, model, technique, etc.) and analysis results of this study. Lastly, the concluding section presents the outcomes and evaluations, thus finalizing the study.

2. LITERATURE REVIEW

In recent years, there has been an increase in studies focusing on the environmental effects of public expenditures. Particularly, how governments, which play a significant role in implementing environmental regulations for countries, direct their fiscal policies within the framework of environmental sensitivity is of utmost importance. When examining empirical studies, a clear conclusion cannot be drawn regarding the impact of fiscal policy on environmental pollution through public expenditures. Different results have been obtained from various country and data period samples.

Lopez and Palacios (2010) conducted a study examining the impact of public expenditures on air quality using data from the period 1995-2006 across 21 countries. According to their findings, the measurement of air quality composed of pollutants such as sulfur dioxide (SO2), nitrogen dioxide (NO2), and ozone (O3) tends to decrease as public expenditures increase. Halkos and Paizanos (2016) determined in their analysis covering the years 1973-2013 for the United States that an increase in public expenditures leads to a decrease in carbon emissions. Similarly, Katırcıoğlu and Katırcıoğlu (2018) concluded that fiscal policy in Turkey for the period 1960-2013 has a reducing effect on carbon emissions. Ike et al. (2020) reached the same conclusions for the case of Thailand, analyzing data from the years 2002-2014. Yılancı and Pata (2022), in their study spanning the years 1875-2016 and focusing on G7 countries, found evidence that fiscal policy within the framework of public expenditures reduces carbon emissions.

Additionally, there are studies in the literature that utilize subcategories of public expenditures. For instance, in a study covering the period 1976-2018 for Pakistan, Abbass et al. (2022) determined that public expenditures in the education and health sectors reduce CO2 emissions. In another study, Hua et al. (2018) identified that subcategories of public expenditures, specifically R&D and education spending, have a decreasing effect on SO2 emissions.

While the findings from the mentioned studies indicate a potential mitigating effect of fiscal policy on environmental pollution through public expenditures, it's worth noting that contrary results are also possible in other studies. For instance, Morshed et al. (2018) examined the period 1974-2014 for Bangladesh and concluded that public expenditures negatively impact air quality in the long run. Yuelan et al. (2019) identified, in the case of China covering the data period 1980-2016, that expansionary fiscal policy contributes to increased environmental degradation. Le and Ozturk (2020) found that public expenditures lead to increased CO2 emissions across 47 developing countries, considering the years 1990-2014. A similar outcome

was reached by Kamal et al. (2021) for 105 countries during the period 1990-2016. Chishti et al. (2021) discovered that expansionary fiscal policy worsens environmental conditions in BRICS countries during the period 1985-2014. Çimen (2022), using data from the period 1990-2019 for BIMSTEC countries, has determined that public expenditures have a positive impact on CO2 emissions. Mar'I et al. (2023) arrived at the same conclusion for G20 countries using data from the years 1995-2019. Adebayo et al. (2023) conducted a study focusing on Portugal and found that fiscal policy increases CO2 emissions. These divergent findings illustrate the complexity of the relationship between fiscal policy and environmental pollution, which can be influenced by various factors including country-specific contexts, policy implementation, and the nature of the economy.

The Phan et al. (2021), Mughal et al. (2021), and Ullah et al. (2021), among the few studies that investigate the environmental effects of fiscal policies using asymmetric approaches, have concluded that expansionary fiscal policy (positive shocks in public expenditures) has a pollution-reducing effect in the long run. However, a different result was obtained by Ullah et al. (2020) in a study covering the period 1981-2018 for Asian countries. In this study, except for Japan, expansionary fiscal policy increased environmental pollution. Diverse outcomes have also been reached regarding the impact of contractionary fiscal policy (negative shocks in public expenditures) on environmental pollution. In the long run, while according to The Phan et al. (2021), contractionary fiscal policy increases pollution, it decreases pollution according to Ullah et al. (2021), Ullah et al. (2020) and has no effect according to Mughal et al. (2021). In the short run, based on the findings of Mughal et al. (2021) and Ullah et al. (2021), increases in public expenditures lead to an increase in pollution for upward movements, while downward movements, according to Mughal et al. (2021), have no effect on pollution but increase it according to Ullah et al. (2021). Studies that investigate the environmental impact of public expenditures within the framework of fiscal policy using asymmetric approaches also vary in their findings.

In addition to all these studies, Halkos and Paizanos (2013, 2014), using comprehensive data from numerous countries, found that public expenditures have no significant impact on CO2 emissions. On the other hand, Cheng et al. (2020) approached the topic from a different perspective and identified a non-linear inverse U-shaped relationship between fiscal policy and environmental pollution for China during the period 1997-2015.

In a general assessment, it is evident that public expenditures are widely used as an indicator of fiscal policy in the literature. Therefore, in studies investigating the impact of fiscal

policy on environmental pollution, public expenditures play a significant role. However, the findings regarding the effect of public expenditures on environmental pollution differ. Especially in recent years, there has been an increased focus on approaching the topic through asymmetric approaches. This is because differentiating between positive and negative shocks in public expenditures corresponds to simulating expansionary and contractionary fiscal policy scenarios, respectively. Observing the studies conducted based on this idea, divergent findings have been obtained.

Nonetheless, a common outcome emerges from studies using asymmetric approaches: the effect of public expenditures on environmental quality is asymmetric in nature. In this study, influenced by this inference, an econometric analysis based on an asymmetric approach is chosen. The absence of a study in the literature that addresses the impact of public expenditures on environmental pollution in Turkey using an asymmetric approach suggests that the findings of this study could make a significant contribution to the literature.

3. ECONOMETRIC ANALYSIS

This study, which examines the impact of fiscal policy on environmental pollution through public expenditures, presents its analysis within the context of Turkey. In the analysis section of this study, the data, model, and asymmetric approach used are initially explained. In the final stage, the findings and evaluations are addressed.

3.1. Data, Model and Analysis Technique

In the econometric analysis of the study, the dependent variable used as an indicator of environmental pollution is per capita carbon dioxide (CO2) emissions (metric tons). Drawing from the Environmental Kuznets Curve approach, per capita GDP ($), its squared value, and public expenditures (as a percentage of GDP) representing fiscal policy are utilized. Additionally, fossil fuel consumption (as a percentage of total energy consumption) is included in the analysis as a control variable. The data for the variables are annual and cover the period from 1970 to 2020. Data for CO2 emissions is obtained from the Emissions Database for Global Atmospheric Research (EDGAR)[2] by the European Commission, while data for the other variables is sourced from the World Bank database[3]. Summary statistics for the data are presented in Table 1.

[2] For the data obtained report, see Crippa vd. (2022).
[3] Worldbank (2023). https://data.worldbank.org/ (Date of Access: 07.17.2023)

Table 1. Summary statistics

	CO2	GDP	FOSSIL	GE
Mean	3.139	8952.4	81.242	11.955
Maximum	5.386	60001.1	90.563	15.658
Minimum	1.345	0.006	65.654	7.516
Std. Dev.	1.150	14760.2	7.053	2.083
Observations	51	51	51	51

The table displays CO2 carbon dioxide emissions, GDP per capita income, FOSSIL fossil fuel consumption, and GE public expenditures. These abbreviations will also be used throughout the remainder of the study. When looking at the summary statistics, it becomes apparent that the average per capita CO2 emissions in Turkey over the data period are roughly 3.1 tons. This figure is notably lower than the European Union average of 8.6 for the same period. Additionally, it is lower than the global average carbon emission of 4.5. Consequently, in terms of carbon emissions, Turkey falls below both the global and European Union averages. Additionally, the average GDP per capita is approximately 8,952 $, with fossil fuel consumption at 81.2%. When examining public expenditures, it becomes evident that they range from 7.5% to 15.7% and have an average share of around 12% within GDP throughout the data period. Considering the world average is 16.7% and the European Union average is 20.07%, it can be concluded that fiscal policy remains quite stringent in terms of public expenditures.

The theoretical modeling of the mentioned variables follows the Environmental Kuznets Curve approach. Based on Grossman and Krueger (1991, 1993), this hypothesis anticipates that environmental degradation will change according to income. It posits that up to a certain threshold, income levels will have an increasing impact on environmental degradation; afterward, with the development spurred by increasing income, a decrease in environmental degradation will be observed. Based on this approach, the model designed to examine the impact of public expenditures on environmental pollution, which is the central inquiry of the study, is structured as follows:

$$CO2 = f(GDP, GDP^2, FOSSIL, GE)$$

The Nonlinear Autoregressive Distributed Lag (NARDL) approach has been chosen as the analysis technique to investigate the impact of public expenditures' positive and negative shocks on environmental pollution. This is because in contemporary applications, fiscal and monetary policy instruments exhibit asymmetric behaviors (Ullah et al., 2021). The NARDL Model, initially proposed by Shin et al. (2014), carries out the process of decomposing the relevant variable into positive and negative shocks:

$$GE_t^+ = \sum_{j=1}^{t} \Delta GE_j^+ = \sum_{j=1}^{t} \max(\Delta GE_j, 0) \quad (1)$$

$$GE_t^- = \sum_{j=1}^{t} \Delta GE_j^- = \sum_{j=1}^{t} \min(\Delta GE_j, 0) \quad (2)$$

Through the operations seen in equations (1) and (2) here, the positive and negative shocks of public expenditures are decomposed. Simultaneously, this decomposition process embeds the representation of expansionary fiscal policy for positive shocks and contractionary fiscal policy for negative shocks. This decomposition establishes the non-linear structure in the model. Within the linear structure, as proposed by Pesaran et al. (2001) in the ARDL bounds testing approach, the model is as follows:

$$\begin{aligned} \Delta CO2_t = \; & \alpha_0 + \lambda_0 CO2_{t-1} + \lambda_1 GDP_{t-1} + \lambda_2 GDP_{t-1}^2 + \lambda_3 FOSSIL_{t-1} + \lambda_4 GE_{t-1} \\ & + \sum_{i=1}^{p-1} \delta_i \Delta CO2_{t-i} + \sum_{i=0}^{q-1} \tau_i \Delta GDP_{t-i} + \sum_{i=0}^{k-1} \varphi_i \Delta GDP_{t-i}^2 \\ & + \sum_{i=0}^{m-1} \phi_i \Delta FOSSIL_{t-i} + \sum_{i=0}^{n-1} \beta_i \Delta GE_{t-i} + u_t \end{aligned} \quad (3)$$

The model structure here assumes symmetric effects of public expenditures similar to the other variables. However, as a result of the decomposition operations present in equations (1) and (2), the NARDL Model is defined as follows in order to examine both the long-run and short-run asymmetric effects of public expenditures:

$$\begin{aligned} \Delta CO2_t = \; & \alpha_0 + \lambda_0 CO2_{t-1} + \lambda_1 GDP_{t-1} + \lambda_2 GDP_{t-1}^2 + \lambda_3 FOSSIL_{t-1} + \lambda_4 GE_{t-1}^+ + \lambda_5 GE_{t-1}^- \\ & + \sum_{i=1}^{p-1} \delta_i \Delta CO2_{t-i} + \sum_{i=0}^{q-1} \tau_i \Delta GDP_{t-i} + \sum_{i=0}^{k-1} \varphi_i \Delta GDP_{t-i}^2 \\ & + \sum_{i=0}^{m-1} \phi_i \Delta FOSSIL_{t-i} + \sum_{i=0}^{n-1} \beta_i^+ \Delta \mathrm{GE}_{t-i}^+ + \sum_{i=0}^{n-1} \beta_i^- \Delta \mathrm{GE}_{t-i}^- + u_t \end{aligned} \quad (4)$$

Here, the positive and negative shocks of public expenditures in the long run are represented by coefficients λ_4 and λ_5, while their short-run counterparts are denoted as β_i^+ and β_i^- respectively. However, the appropriateness of utilizing the mentioned long-run and short-run asymmetric coefficients is determined through statistical testing. In this context, the first step

involves conducting a bounds test to investigate the presence of a cointegration relationship among the variables. For this purpose, the null hypothesis is formulated as: $\lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$, indicating no cointegration relationship among the variables. If this hypothesis is rejected, it concludes that there is a cointegration relationship among the variables, and the asymmetry tests are then carried out.

To test for the presence of long-run asymmetry, the long-run coefficients are calculated first. For this purpose, the identification is constructed as $\theta^+ = \lambda_4/-\lambda_0$ and $\theta^- = \lambda_5/-\lambda_0$, and the null hypothesis "there is no difference between long-run coefficients" ($\theta^+ = \theta^-$) is tested. If this hypothesis is rejected, it suggests the presence of long-run asymmetry. Conversely, if the hypothesis is not rejected, it indicates that the long-run effect is symmetric. In this case, in equation (4), λ_4 and λ_5 are removed, and only the structure used in equation (3) containing λ_4 is employed.

Finally, when examining the presence of asymmetry in the short run, the null hypothesis "there is no difference between short-run coefficients" is established as $\sum_{i=0}^{n-1} \beta_i^+ = \sum_{i=0}^{h-1} \beta_i^-$, and test is conducted. If the null hypothesis is rejected, it indicates that in the short run, public expenditures exhibit an asymmetric impact on environmental pollution. If the hypothesis cannot be rejected, it implies a symmetrical effect in the short run. Consequently, if the hypothesis is not rejected, the parts of equation (4) containing the coefficientsβ_i^+ and β_i^- are removed from the model, and the part of equation (3) containing the coefficient β_i is utilized. As a final possibility, if both long-run and short-run symmetry are determined, there is no need for the NARDL model, and the ARDL model defined in equation (3) is employed.

3.2. Results

As time series analysis will be conducted in the study, it is essential to examine the stationarity of the series. In this context, ADF (Dickey and Fuller, 1979) and PP (Phillips and Perron, 1988) unit root tests have been employed. The unit root test results obtained are presented in Table 2.

Table 2. Unit root test results

Variables	ADF			PP		
	-	Constant	Constant & Trend	-	Constant	Constant & Trend
CO2	2.868	-0.427	-2.860	3.880	-0.288	-2.941
ΔCO2	-5.752*	-6.776*	-6.702*	-5.728*	-7.185*	-7.328*
GDP	0.755	-0.712	-1.406	0.433	-0.831	-1.768
ΔGDP	-6.012*	-6.236*	-6.169*	-6.186*	-6.355*	-6.296*
GDP^2	-0.143	-0.844	-1.456	-0.412	-1.034	-1.810
ΔGDP^2	-6.166*	-6.188*	-6.117*	-6.313*	-6.320*	-6.258*
FOSSIL	2.031	-2.495	-1.414	2.049	-2.555	-1.480
ΔFOSSIL	-6.609*	-6.994*	-5.991*	-6.622*	-7.000*	-7.275*
GE	0.546	-1.135	-2.196	0.531	-1.301	-2.400
ΔGE	-7.145*	-7.104*	-7.118*	-7.131*	-7.104*	-7.116*

Note: Significance at the 99% confidence level is indicated by (*) asterisk.

According to the unit root test results presented in Table 2, all series are stationary in first differences. With this result, the possibility of cointegration between the series can be examined. In the chosen analysis technique of this study, the NARDL approach, the cointegration relationship is assessed through bounds test. For this purpose, the NARDL model with the optimal lag length as shown in Figure 1 has been estimated.

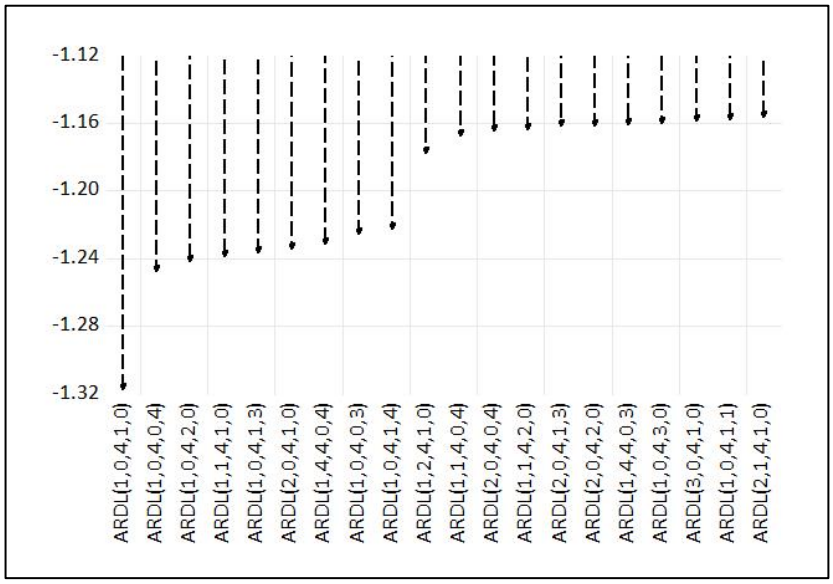


Figure 1. Optimal NARDL model selection

The NARDL (1,0,4,1,0) model, determined as the optimal model, was employed to examine the presence of cointegration between the variables using bounds test. The results of the bounds test can be seen in Table 3.

Table 3. Bounds test result

Hypothesis	F Test	Critical Values (1%)	
There is no cointegration among the variables.	Statistic	I (0)	I (1)
H_0: $\lambda_0 = \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$	8.360	4.628	5.865

According to the results of the bounds test, there is a cointegration relationship among the variables. In the next step, an examination was conducted to determine whether there is an asymmetric effect for government expenditures. However, since the selected NARDL (1,0,4,1,0) model uses zero lag for short-run negative shocks of government expenditures, there cannot be an analysis of short-run asymmetry. Therefore, the test for short-run symmetry could not be conducted. Hence, it has been determined that the impact of government expenditures on environmental pollution in the short run is symmetric. The results of the long-run coefficients symmetry test are presented in Table 4.

Table 4. Long run coefficients symmetry test result

Hypothesis	Test Statistic
There is a symmetric effect in the long run.	3.879*
H0: $\theta^+ = \theta^-$	

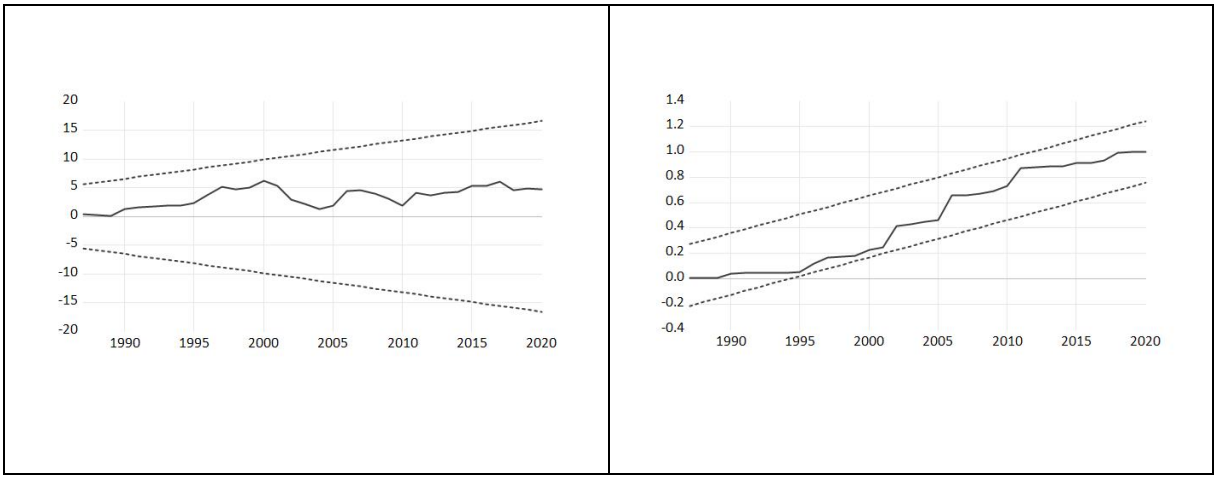
Note: Significance at the 95% confidence level is indicated by (*) asterisk.

When examining the results of the long-run coefficients symmetry test, it can be observed that the impact of government expenditures on carbon emissions in the long run is asymmetric. As a result, the NARDL model predictions will only be valid using the positive and negative decomposition in the long run. However, to ensure the validity of the model, various assumption and coefficient stability tests have been investigated. The results of the assumption tests are provided in Table 5.

Table 5. Results of the NARDL model assumption tests

Tests	Test Statistics	Results
Jarque-Bera	1.000	The residuals are normally distributed.
Breusch-Godfrey	0.046	There is no autocorrelation in the residuals.
White	14.054	There is no heteroscedasticity in the residuals.
Ramsey Reset	0.444	There is no misspecification in the model.

Based on the assumption test results, assumptions are being satisfied, and there is no misspecification in the model. The presence of structural change in the model has been examined using the CUSUM and CUSUM-SQ tests developed by Brown et al. (1975). The test results indicate that the coefficients are stable. These results are shown in Graph 1.



Graph 1. CUSUM and CUSUM-SQ

These results indicate that the NARDL (1,0,4,1,0) model is valid. Therefore, the evaluation of the estimation results can be proceeded. Panel A in Table 6 presents the estimation results of the NARDL model, Panel B displays the short-run coefficients, and Panel C demonstrates the long-run coefficient estimates.

According to the estimation results, in the short run, per capita GDP does not have a significant effect on per capita carbon emissions, but it becomes a significant factor in the long run. Based on the estimated long-run coefficient, when per capita GDP increases by $1000, per capita carbon emissions increase by 4 tons. Additionally, the results do not indicate a specific turning point for income levels, as the long-run coefficient for the GDP squared variable is not statistically significant. However, there is evidence of a significant short-run effect of the GDP squared variable. This suggests that in the short run, changes in income levels may lead to decreasing carbon emissions, but this pattern is not applicable in the long run. On the other hand, fossil fuel consumption is the only variable that shows an increasing effect on environmental pollution in both the short-run and long-run. Specifically, in the long run, when the share of fossil fuel consumption in total energy consumption increases by 10 percentage points, per capita CO2 emissions increase by approximately 1 ton.

However, the most significant finding lies in the results that demonstrate the impact of government expenditures, which constitutes the main focus of the study, on carbon emissions. According to these results, in the short run, government expenditures do not have a significant effect on environmental pollution. However, in the long run, positive shocks in government expenditures have a mitigating effect on CO2 emissions. Based on this outcome, a 10-percentage-point increase in the share of government expenditures in GDP leads to a reduction of approximately 0.8 tons of carbon emissions per capita. It can be concluded that an increase in

government expenditures would have a positive effect on environmental preservation. Nevertheless, due to the asymmetric behavior of government expenditures, a decrease in government expenditures does not influence CO2 emissions. In this context, it has been determined that fluctuations in government expenditures, whether upward or downward, do not contribute to increasing environmental pollution. However, an increase in government expenditures has been found to have a mitigating effect on environmental pollution.

Table 6. NARDL model estimation

Dependent Variable: ΔCO2	Coefficient	Std. Error
Panel A: NARDL (1,0,4,1,0) Model		
$CO2_{t-1}$	-0.456***	0.096
GDP_{t-1}	0.0002***	4.66E-05
GDP^2_{t-1}	-4.17E-09	2.61E-09
$FOSSIL_{t-1}$	0.049***	0.011
GE^+_{t-1}	-0.036**	0.016
GE^-_{t-1}	0.030	0.026
ΔGDP^2_t	-9.10E-09**	3.31E-09
ΔGDP^2_{t-1}	-8.29E-09***	1.53E-09
ΔGDP^2_{t-2}	-6.31E-09***	1.56E-9
ΔGDP^2_{t-3}	-5.28E-09***	1.45E-09
$\Delta FOSSIL_t$	0.098***	0.013
Trend	0.013	0.014
Sabit	-2.871***	0.757
Panel B: Short-Run Coefficients		
ECT	-0.456***	0.055
$\sum_{i=0}^{3} \Delta GDP^2_{t-i}$	-2.90E-08***	5.16E-09
$\Delta FOSSIL_t$	0.098***	0.010
Constant	-2.871***	0.351
Panel C: Long-Run Coefficients		
GDP	0.0004**	0.0001
GDP^2	-9.14E-09	6.41E-09
FOSSIL	0.107***	0.027
GE^+	-0.078*	0.040
GE^-	0.065	0.053

Note: (*) represents significance at the 90% confidence level, (**) at the 95% confidence level, and (***) at the 99% confidence level.

Furthermore, the statistically significant and negative Error Correction Term (ECT) has been obtained. This finding indicates that any shock causing a deviation from the long-run equilibrium is gradually corrected over time, leading the system back to equilibrium. This implies that the impact of a shock causing a deviation from equilibrium dampens over approximately two (2) years, ultimately restoring the long-run balance.

4. CONCLUSION

To achieve development goals, economic growth is of utmost importance. One of the necessary conditions for achieving stable economic growth is the implementation of effective fiscal policy. This study investigates the impact of public expenditures, as a tool of fiscal policy,

on environmental degradation. Using data spanning from 1970 to 2020 for Turkey and based on the premise of the Environmental Kuznets Curve hypothesis, a model has been constructed. In recent years, the notion that fiscal policies exhibit asymmetric behavior has gained prominence. Consequently, asymmetric approaches have started to be preferred as an analytical technique. Accordingly, this study employs the NARDL model, considering this perspective. This approach enables the dissection of the effects of expansionary and contractionary fiscal policies through public expenditures. Moreover, it offers insights into both the short and long-run impacts of positive and negative shocks in public expenditures on environmental pollution.

According to the findings, expansionary fiscal policy reduces CO2 emissions in the long run. This result is consistent with the perspective that increasing public expenditures contributes to decreasing environmental degradation. However, contractionary fiscal policy does not exhibit a significant long-run impact on CO2 emissions. This outcome, derived from the long-run coefficients, is positive from an environmental quality standpoint. This is because public expenditures in Turkey do not contribute to environmental pollution in any way. Additionally, although income levels have a long-run increasing effect on CO2 emissions, the Environmental Kuznets Curve hypothesis is not applicable to Turkey. Fossil fuel consumption increases CO2 emissions both in the long and short runs, aligning with the theoretical expectation. Therefore, prioritizing renewable energy sources becomes a necessity for mitigating environmental degradation. Public expenditures do not have a short-run effect on CO2 emissions. This result is in line with the perspective of Lopez et al. (2011), suggesting that the impact of public expenditures might not manifest in the short run.

The findings derived from this study conducted in the context of Turkey are believed to be beneficial for researchers and public authorities. Particularly, the analysis results make it evident that taking the right steps is attainable through the implementation of environmentally conscious fiscal policy and incentivizing renewable energy production. Additionally, the lack of an existing study that employs an asymmetric approach to analyze the impact of public expenditures on environmental pollution in the context of Turkey is another contribution of this study.

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