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Ekonomik Büyüme, Çevresel Vergiler, Demokrasi, Dışa Açıklık ve Kentleşme Türkiye'de Ekolojik Ayak İzini Etkiliyor mu?

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Öz

Bu çalışmada, Türkiye'de 1994-2022 dönemi için demokrasi, çevresel vergiler, gayrisafi yurt içi hasıla (GSYİH), dışa açıklık ve kentleşmenin ekolojik ayak izi (EAİ) üzerindeki uzun dönemli etkileri incelenmektedir. Çalışmada Fourier Bootstrap Destekli ARDL ve Toda–Yamamoto nedensellik analizleri kullanılmıştır. Çalışma bulgularına göre, demokrasi düzeyi ve ekonomik büyüme ekolojik ayak izi üzerinde uzun dönemde pozitif ve istatistiksel olarak anlamlı bir etkiye sahip olup çevreyi bozmaktadır. Buna karşın, çevresel vergiler, dışa açıklık ve kentleşmenin ekolojik ayak izi üzerinde negatif etkiye sahip olup uzun dönemde çevre üzerinde olumlu etkiye sahiptir. Bu ampirik sonuçlar, sürdürülebilir vergi politikaları, uluslararası teknoloji transferleri ve sürdürülebilir kentsel büyüme stratejilerinin potansiyel faydalarına işaret etmektedir. Eşbütünleşme bulgularının dayanıklılık testi için Fourier Toda-Yamamoto nedensellik analizi uygulanmıştır. Nedensellik analizi sonuçları, demokrasinin, çevresel vergilerin ve kentsel nüfusun ekolojik ayak izi üzerinde tek yönlü etkisinin olduğunu, buna karşılık GSYİH'nin ve dışa açıklığın EAİ üzerinde anlamlı bir etkisinin olmadığını göstermektedir. Sonuç olarak, demokratikleşme ve ekonomik büyüme ekolojik etkileri artırırken, çevresel vergilerin ekolojik ayak izini azaltmada etkili araçlar olduğu anlaşılmaktadır. Ancak ekonomik kalkınmanın ekolojik sürdürülebilirlik ile uyumlu bir şekilde sürdürülmesi, Türkiye açısından karmaşık bir sorun oluşturmaya devam etmekte, bu da ülkenin ekonomik hedefleriyle uyumlu, iyi tasarlanmış çevre politikalarına duyulan ihtiyacı ortaya koymaktadır.

Anahtar Kelimeler: Ticari Dışa Açıklık, Demokrasi, Ekolojik Ayak İzi, Ekonomik Büyüme, Kentleşme

Do Democracy, Economic Growth, Environmental Taxes, Trade Openness and Urbanisation Impact Ecological Footprint in Türkiye?

Abstract

This paper explores the long-run effects of democracy, environmental taxes, gross domestic product (GDP), trade openness, and urbanisation on the ecological footprint (EFP) for Türkiye over the period 1994-2022. It adopts the Fourier bootstrap, Augmented ARDL, and Toda–Yamamoto causality methods. The findings indicate that democracy and economic expansion have a positive and statistically significant impact on the ecological footprint in the long run, thereby increasing environmental degradation. In contrast, environmental taxes, trade openness, and urbanisation exert a negative effect on the EFP in the long run, suggesting an environmentally improving role. These results highlight the potential benefits of sustainable tax policies, international technology transfer, and sustainable urban growth strategies. To test the robustness of the cointegration results, the Fourier Toda–Yamamoto causality analysis is also applied. The causality findings reveal a unidirectional causal effect running from democracy, environmental taxes, and urban population to the ecological footprint, whereas GDP and trade openness do not show a significant causal impact on EFP. Overall, the results suggest that environmental taxes can serve as an effective policy tool, while balancing economic growth with ecological sustainability remains a major challenge for Türkiye.

Keywords: Trade Openness, Democracy, Ecological Footprint, Economic Growth, Urbanisation

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Introduction

Industrialisation, with a history of nearly 200 years, has been an important driver of economic growth and development in both developed and developing countries today. Large-scale, continuous production and efforts to increase productivity that emerged with the industrialisation process have been recognised and adopted as key indicators of growth and development in both developed and developing countries (Barca and Bridge, 2015; Karaduman, 2022; OECD, 2010). While pursuing the production and efficiency necessary for the economic growth of national economies, the potential environmental damage caused by the processes used to achieve these benefits may have been overlooked. Until 1972, when environmental degradation became quite visible to everyone.

In response to the growing awareness of environmental degradation, a series of international initiatives were organised, beginning with the 1972 Stockholm Conference, continuing with the 1992 Rio de Janeiro Summit, the 1997 Kyoto Protocol, the 2002 Johannesburg Sustainable Development Summit, the 2012 Rio Sustainable Development Conference, the 2012 Doha Climate Summit and the 2015 Paris Climate Agreement, in which Türkiye also participated. The themes of these events are united by the shared need to take measures to ensure environmental sustainability.

Due to global climate change, global surface temperature increased by 1.1°C during 2011-2020 compared to 1850-1900, driven by greenhouse gas emissions and causing global warming. The continuing increase in greenhouse gas emissions has brought the issue of sustainability in energy use, land use and production-consumption patterns to the agenda (IPCC, 2023). Global temperature changes over the last 150 years due to human activities have caused polar glaciers to melt. Moreover, ecological risks such as rising sea levels, increasing risks of natural disasters and desertification, species extinction, declining freshwater resources, and decreasing biodiversity continue to worsen (Satır Reyhan and Reyhan, 2016; Aksoy and Atasagun, 2023).

Ecological risks and various forms of environmental degradation cause negative consequences, such as extreme weather events, natural disasters, and diseases. Awareness of ecological risks and understanding of these risks by all actors become easier by ensuring their calculability and visibility. While tools such as CO_2 emission and nuclear energy measurements contribute to assessing environmental degradation, the ecological footprint provides a more comprehensive evaluation by incorporating carbon, land use, and resource consumption metrics in the context of observing the effects of human activities on ecology (Acheampong *et al.*, 2022; Ahmed *et al.* 2022a; Charfeddine and Mrabet, 2017; Uzar, 2021). The ecological footprint indicator, originally introduced in the research of Wackernagel and his colleagues, made the effect of human activities on ecology calculable and visible (Wackernagel and Rees, 1995; Rees and Wackernagel 2008; Rees and Wackernagel, 2023). In this context, the ecological footprint is seen as a tool that quantifies the ecological impact of human activities and provides a realistic picture of countries' ecological levels (Wackernagel and Rees, 1995; Rees and Wackernagel, 2023). Broadly, the ecological footprint measures the rate at which nature recovers the resources consumed by human activity and the time it takes for nature to absorb the waste generated by the use of these resources (GFN, 2025). In ecological footprint calculations, in addition to the carbon footprint, focus is also placed on settlements, forests, agriculture and fishing areas. Thus, it is seen as an important tool for measuring the sustainability of energy use, settlement density, forest products such as paper and timber, agricultural products, and seafood (GFN, 2025). For these reasons, the ecological footprint stands out as a more holistic and comprehensive indicator among the measurement methods used to detect environmental degradation.

It is widely held that the sustainability of economic development depends on ecological sustainability. In this respect, the importance of the ecological footprint concept is emphasised in ensuring sustainable development and securing the quality of life for living beings within the limits of nature (Wackernagel and Rees, 1995; Rees and Wackernagel, 2008; Rees and Wackernagel, 2023).

Protecting the environment and striving for sustainability has become essential to ensure the long-term development and longevity of nations. In the context of the UN Sustainable Development Goals (SDGs), Goal 7 emphasises accessible and clean energy, Goal 11 emphasises sustainable urban development, Goal 12 emphasises responsible consumption and production, and Goal 13 emphasises the need for climate-related initiatives, all of which stress the need to integrate ecological considerations into development strategies. In particular, Goal 12 recommends the greening of taxes by removing harmful

incentives that cause environmental damage, while Goal 13 proposes the integration of climate-related measures into national policies, strategic frameworks and action plans (SDGs, 2024). In this respect, environmental taxes are an important mechanism for advancing the goals set by the UN SDGs. Specifically, SDGs goals 7, 12 and 13 recommend environmental taxes as an effective policy instrument to mitigate climate change and halt ecological degradation (SDGs, 2024). Consequently, the extent to which environmental taxation fosters ecological sustainability has garnered considerable attention within empirical research in this domain.

When considering the precautions and measures needed to prevent environmental degradation within the framework of public finance and taxes, the prevailing approach holds that environmental degradation stems from negative externalities and that employing tax instruments is an effective way to internalise them. Moreover, there is also the view that ensuring environmental sustainability through environmental taxes will create positive externalities. In this context, Ahmad and Satrovic (2023) cite Samuelson (1954) and argue that environmental sustainability can be seen as a public good, while environmental degradation is a public bad. Conceptually, the approach that environmental sustainability can be achieved and environmental degradation can be reduced through taxes is theoretically based on the work of Arthur Pigou (1920). According to Pigou (1920), the negative externality of production-based pollution imposes a social cost on society. Therefore, addressing the negative externality and bringing it closer to an optimal point to reduce the social cost imposed on the public, as stated in the polluter-pays principle, can be achieved through environmentally friendly taxes, which function as an effective public policy instrument.

Economic growth is central to explaining environmental degradation. To gain a competitive advantage and achieve sustainable development, economies expand production and external activities. While rising GDP supports economic progress, high growth rates intensify resource use and energy demand, thereby heightening environmental pressures. Previous empirical studies have often demonstrated that economic growth usually exacerbates degradation (Ahmed and Wang, 2019; Alper *et al.*, 2023). Pollution is viewed as an unavoidable by-product of production, with countries' contributions roughly proportional to their growth levels (Ploeg and Withagen, 1991). As per-capita income levels rise, consumption increases accordingly, and ecological footprints expand significantly. Thus, per-capita footprints are lowest in low-income countries, higher in middle-income countries, and highest in high-income countries (Alper *et al.*, 2023). Taken together, this evidence indicates that the pursuit of economic growth and development remains a major driver of environmental degradation, as highlighted at the outset of this discussion.

Building on the idea that economic growth and environmental degradation are closely interconnected, the hypothesis first introduced by Kuznets (1955) and later labelled the Environmental Kuznets Curve (EKC) was initially designed to account for the relationship between income and inequality, and was subsequently adapted by Grossman and Krueger (1995) to the study of environmental outcomes. In the EKC literature, it is commonly argued that, at low-income levels, economic growth is accompanied by rising pollution, whereas at higher stages of development additional increases in income are associated with declining environmental pressure, so that the income–environment relationship follows an inverted U-shaped pattern (Dinda, 2004; Stern, 2004; Yandle *et al.*, 2004; Koçak, 2014; Stern, 2017; Koçak and Kızılkaya, 2020). In the present paper, however, the purpose is not to test this specific non-linear hypothesis but rather to investigate the long-run link between economic performance and environmental indicators. Therefore, in contrast to standard EKC specifications that rely on income levels and their squared terms, the empirical model employs GDP per capita growth, which captures the pace of economic expansion rather than the income levels needed to identify the inverted U-shaped pattern.

Additionally, in recent years, considerable attention has been paid to the roles of industrialisation, international trade, and urbanisation as determinants of environmental change. Almost all economies, both developed and developing, have sought to enhance development based on these factors (Shahzad, 2020). As a natural consequence of intensified economic activity, international trade volumes and urban population densities have risen significantly, contributing to greater energy demand, resource use, and waste generation, all of which exert substantial pressure on environmental systems.

A country's level of economic progress is also often linked to its level of democracy. In most developing countries, democratic institutions and practices are still relatively underdeveloped compared with those in more economically developed countries. In this context, it is widely believed that environmental quality, sustainable development, economic development, and the quality of public environmental policies are related to democratic institutionalisation. In addition to economic development goals, the existence of strong tax policies aimed at protecting the environment and their effective implementation depend on the functioning of the institutional structures of countries. In countries with a high level of democracy and effective institutional functioning, expected outcomes include compliance with plans, regulations, rules, and practices aimed at preventing environmental degradation.

The standard of institutional quality, typically higher in developed nations, is essential for the successful implementation of environmental policies. Remarkably, the extent of democracy in a country profoundly affects how well public policies manage to align economic progress with ecological preservation. Institutional quality has many determinants, such as the rule of law, bureaucratic efficiency, the country's regime type, transparency, and the level of democracy. However, the level of democracy stands out as a more valid indicator among these indicators (Koçak and Kızılkaya 2020). The belief that institutional functioning, an important factor in a sustainable environment, will be ineffective in a country with a low level of democracy is not surprising. In addition, a stable economy with a high level of democracy and the rule of law creates an environment of trust for investors, providing an advantage in attracting investments to the country. In developing countries with low levels of democracy, politicians may focus on short-term goals, such as winning elections, rather than long-term goals, such as creating policies to protect the environment (Keefer, 2007). In this respect, the level of democracy of countries provides insight into both economic development and environmental quality.

Although scholarly discussions on the relation between democracy and environmental sustainability have yet to reach a definitive consensus, research in this field continues to evolve and expand. In countries with well-developed political institutions and strong democracies, environmental protection policies are expected to be developed and implemented in line with sustainable development goals. Similarly, according to theoretical expectations, in countries that have not yet reached the desired level of democracy, there may be difficulties in producing policies to prevent environmental degradation. Studies conducted across different countries and country groups have yielded varying results regarding the relationship between levels of democracy and environmental sustainability (Akalın and Erdoğan, 2021; Acheampong, 2022; Ahmed *et al.*, 2022b).

In the literature, factors potentially linked to environmental degradation continue to be examined, and the body of research is expanding. Nevertheless, there are relatively few studies that analyse the relationship between environmental degradation and public policy practices, institutional factors, economic indicators and social-demographic variables together.

To more effectively address environmental degradation, it is essential to evaluate all significant determinants collectively, thereby offering a more realistic and comprehensive perspective. In this respect, it is anticipated that the comprehensive approach preferred in this paper will contribute meaningfully to the literature. By addressing the key factors potentially linked to environmental degradation in Türkiye within a unified framework, this paper aims to fill a gap in the existing literature.

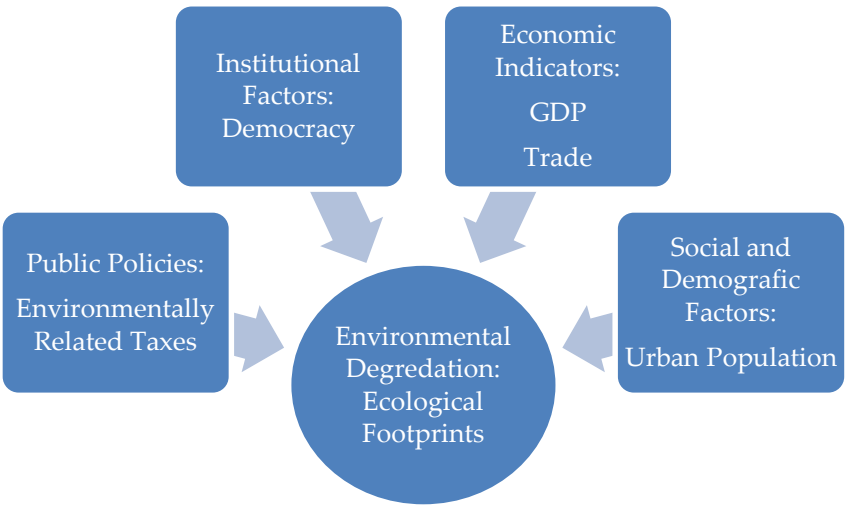

Figure 1. *Factors Affecting Environmental Degradation*

This paper focuses on identifying how the ecological footprint, a key measure of environmental quality, relates to specifically environmental taxes, economic growth and the degree of democracy in Türkiye. As shown in Figure 1, the general framework of the paper was established based on the assumption that environmental quality is affected by public policies, institutional factors, economic indicators and social-demographic factors. In the paper, the effects of environmental taxes as a public policy tool, the level of democracy, which is one of the most important institutional factors, growth and trade openness indicators from economic indicators, and urbanisation indicators, which are important socio-demographic factors, on the ecological footprint, which is one of the most comprehensive environmental sustainability indicators, are examined.

The following section provides the literature review. The next section describes the methodology used in the analysis. After that, the empirical results are reported, followed by the findings and discussion. The paper concludes with recommendations.

Literature Review

Previous research on environmental degradation has largely focused on examining its relationship with various economic determinants. A substantial body of literature has investigated how factors such as trade liberalisation, rising income levels, global integration, urban expansion, clean energy adoption, dependence on conventional fuels, environmental taxation, cross-border capital flows, and financial sector development affect or shape environmental outcomes. However, despite decades of research, no definitive consensus has been reached, as methodological variations across studies continue to produce divergent findings. Whereas some studies have concentrated on bivariate interactions, others have adopted multivariate modelling frameworks to obtain broader insights; nevertheless, even within multivariate settings, differences in control variable specification, econometric methodology, temporal coverage, and the socioeconomic characteristics of the countries analysed make cross-study comparisons difficult. Given these challenges, it is essential to conduct country-specific analyses using robust econometric techniques and up-to-date datasets to provide a more comprehensive understanding of the nexus between economic dynamics and environmental sustainability.

Early empirical studies by Tamazian *et al.* (2009) for BRIC economies demonstrated that both economic growth and financial development can improve environmental quality through efficiency gains and institutional modernisation. In contrast to these findings, Apergis and Payne (2010) reported that economic growth and energy consumption worsened environmental outcomes in eleven post-Soviet economies, underscoring the importance of structural composition. Similarly, Ozturk and Acaravci (2013) revealed that growth and trade expansion intensified environmental degradation in Türkiye, whereas the effect of financial development remained statistically insignificant. Later evidence, including Rahman and Alam (2021) for Bangladesh, Voumik and Ridvan (2023) for Argentina, and Akbar *et al.* (2025) for China and 102 other countries, confirms and extends previous research by suggesting that sustained economic

expansion tends to increase environmental pressure unless accompanied by effective regulatory and technological transitions.

The literature on the environmental implications of trade liberalisation shows a variety of approaches and remains less consistent. While Rafiq *et al.* (2016) found that trade openness mitigated pollution across 22 emerging economies by facilitating technology diffusion, Al-Mulali and Öztürk (2015) observed the opposite in 14 MENA countries, where trade, energy consumption, and industrialisation jointly worsened environmental quality. Similarly, Shahbaz *et al.* (2017) demonstrated that trade openness adversely affected environmental outcomes across 105 countries, and Pata (2019) confirmed a long-run causal link from trade and income per capita to environmental degradation in Türkiye. In contrast, Akbar *et al.* (2025) documented that trade openness improved environmental performance in China, suggesting that the environmental effects of global integration depend heavily on each country's production structure and policy framework.

In recent years, researchers have shown increasing interest in how urbanisation affects ecological footprints. Ponce de Leon Barido and Marshall (2014) established that urbanisation aggravated pollution in 80 developed and developing countries. This pattern was further corroborated by Rafiq *et al.* (2016) for emerging economies, Ahmed *et al.* (2020) for China, and Rahman and Alam (2021) for Bangladesh. Likewise, Voumik and Ridvan (2023) reported that population growth and industrialisation intensified pollution in Argentina. Taken together, these results are consistent with the hypothesis that urban growth, when not supported by adequate environmental planning and infrastructure, tends to elevate emissions and resource consumption.

Fiscal instruments have been widely investigated as potential tools to reconcile economic and ecological objectives. Lin and Li (2011), using a difference-in-differences approach across five Northern European countries between 1987 and 2007, found that carbon taxation had a significant positive impact on environmental quality only in Finland, whereas in the remaining countries the effect was negative but not statistically significant. This finding highlights the context-dependent effectiveness of fiscal measures and underlines the importance of domestic policy design, enforcement mechanisms, and public acceptance in achieving measurable ecological improvements.

Empirical findings on the democracy-environment nexus have been widely researched but remain mixed. Early studies, such as those by Congleton (1992) and Fredriksson *et al.* (2005), demonstrated that higher levels of democracy enhance policy enforcement and civic accountability, thereby improving environmental quality. Subsequent large-sample analyses by Li and Reuveni (2006) and Romuald (2011) confirmed that democratic institutions generally restrict environmentally harmful behaviour and foster sustainability. Likewise, Castiglione *et al.* (2012) and Adams *et al.* (2016) found that the rule of law and democratic environment reduce CO_2 emissions, while You *et al.* (2015), employing quantile regression for 99 nations (1980–2005), revealed that democracy lowers emissions primarily among high-emitting countries, indicating a heterogeneous rather than uniform impact. Evidence from Türkiye by Hotunluoğlu and Yılmaz (2018), Güngör *et al.* (2021), Ahmed *et al.* (2022c), and Çetin *et al.* (2022) further supports the positive long-term environmental role of democratic progress.

In contrast to these supportive findings, several studies report nonlinear or adverse outcomes. Lv (2017) observed that democracy raises emissions once income exceeds a certain threshold, and Charfeddine and Mrabet (2017) found that democracy increases the ecological footprint under FMOLS but not under DOLS. Similarly, Wang *et al.* (2018) noted that democracy heightens $PM_{2.5}$ concentrations only in high-emitting G20 economies. More recent research, including Akalın and Erdoğan (2021), Ursavaş (2021), Ahmed *et al.* (2022b), Acheampong *et al.* (2022), and Ursavaş and Apaydın (2024), suggests that greater democracy can exacerbate environmental pressures, particularly in emerging or rapidly industrialising contexts. Conversely, Al-Mulali and Öztürk (2015), Çetin *et al.* (2022), and Ahmed *et al.* (2022c) demonstrated that democracy mitigates ecological degradation in OECD and South Asian economies. Therefore, while democracy often facilitates environmental stewardship through participatory and institutional channels, its effectiveness depends critically on the quality of governance, economic maturity, and policy implementation capacity.

Despite decades of research, no consensus has emerged on how democracy, trade openness, environmental taxation, and urbanisation jointly influence environmental outcomes. As far as we know,

no prior research has comprehensively investigated these interactions in Türkiye using updated econometric techniques. To address this gap in the literature, the present paper aims to provide a country-specific analysis using recent datasets and advanced methods to offer a deeper understanding of how institutional, fiscal, and structural factors interact to shape environmental sustainability.

Methodology

Data and Model Specification

This research draws upon annual data from Türkiye spanning 1994 to 2022. This timeframe appears well-suited for analysis, as it aligns with the period during which adverse environmental developments escalated markedly, particularly following Türkiye's accession to the customs union trade arrangement with the European Union. In addition, this period is selected because it is the range for which consistent data are available. A detailed description of the variables included in this analysis can be found in Table 1.

Table 1. *Variable's Descriptions*

Variables	***Description of Variables***	***Sources***
EPF	Ecological Footprint Per Capita	Global Footprint Network
FIW	Freedom in the World Democracy Index	Freedom House
TAX	Environmentally Related Tax Revenue % of GDP	OECD
GDP	GDP Per Capita Growth (Annual %)	World Development Indicators
TOI	Trade as a Share of GDP	World Development Indicators
LNUP	Urban Population (denoted LNUP, measured as total numbers).	World Development Indicators

The dependent variable used is ecological footprints per capita (EFP), the freedom in the world (democracy) index (FIW)[4], environmentally related tax rev % of GDP (TAX), GDP per capita growth (annual %) (GDP), trade as a share of GDP (TOI), and urban population (denoted LNUP, measured as total numbers). Only the urban population variable is considered in natural logarithms.

Consistent with theoretical knowledge and the surveyed literature, the following core econometric model (1) is formulated:

$$EFP_t = \beta_0 + \beta_1 FIW_t + \beta_2 TAX_t + \beta_3 GDP_t + \beta_4 TO_t + \beta_5 LNUP_t + \varepsilon_t \quad (1)$$

where β_0 is the intercept; β_1, β_2, β_3, β_4, and β_5 are respective slope parameters of FIW, TAX, GDP, TOI and LNUP; and the term ε_t represents the stochastic disturbance, which is presumed to maintain stationary properties throughout the dataset[5].

In econometric analyses, multicollinearity can arise when independent variables are highly correlated (over 80% or 90%). Table 2 shows that no such problem exists.

Table 2. *Correlation Matrix*

Variables	***EFP***	***FIW***	***TAX***	***GDP***	***TO***	***LNUP***
EFP	1.000	-0.017	0.323	0.425	0.574	0.786
FIW	-0.017	1.000	-0.745	-0.180	0.473	0.187
TAX	0.323	-0.745	1.000	0.217	-0.207	0.266
GDP	0.425	-0.180	0.217	1.000	0.256	0.207
TO	0.574	0.473	-0.207	0.256	1.000	0.705
LNUP	0.786	0.187	0.266	0.207	0.705	1.000

[4] The Democracy Index is calculated by taking the average of two indicators, political rights and civil liberties, provided by Freedom House. The democracy index obtained from our source is commonly used in the literature as the average of the two indicators in question. If the calculated average index value of these two variables is 1, it indicates a perfect democracy. If it is 7, it indicates an autocratic regime.

[5] Given that the econometric model consists of GDP per capita growth rate rather than income level, the relationship with ecological footprint is assumed to be in a linear form. Unlike per income levels, growth rates do not exhibit a monotonic trend but rather fluctuate cyclically, making the Environmental Kuznets Curve (EKC) hypothesis theoretically less appropriate in the model. Including GDP per capita ($) together with its square (EKC form) in the model reduces the statistical significance of the other variables, compromising the model's reliability.

In addition to the correlation analysis, the VIF values for the variables were examined. All variance inflation factor (VIF) values for the independent variables in the model must be below the critical threshold of 10 to ensure that multicollinearity is not present (Gujarati, 1995; Albayrak, 2008). As shown in Table 3, the VIF values for the variables ranged from 1.25 to 4.48. The results support the reliability of the estimates obtained from the analysis.

Table 3. *Variance Inflation Factor (VIF)*

Variables	***VIF Values***
FIW	3.597
TAX	4.568
GDP	1.251
TO	4.266
LNUP	4.480

Unit Root Tests

Unit root analyses are critical for assessing the stationarity properties of time series and mitigating the risk of spurious regression in long-run estimates (Nelson and Plosser, 1982). For this reason, this paper applies the ADF unit root test formulated by Dickey and Fuller (1981) and the Fourier ADF unit root test proposed by Enders and Lee (2012), which accounts for smooth structural breaks. Thereafter, the most suitable econometric approach is selected based on the results of the unit root tests.

The hypothesis associated with the Augmented Dickey–Fuller (ADF) unit root test (δ) and the hypothesis for the Fourier ADF unit root test (ρ), which incorporates smooth structural breaks through Fourier trigonometric terms, are outlined below:

Null hypothesis (H_0): The time series has a unit root (i.e., it is non-stationary)

$$H_0: \delta=0 \text{ or } \rho=1$$

Alternative hypothesis (H_1): The time series is stationary

$$H_0: \delta<1 \text{ or } \rho<1$$

The null hypothesis of a unit root (H_0: $\delta=0$ or $\rho=1$) is rejected if the test statistic is less than the corresponding critical value, which indicates that the time series is stationary - I(0). Otherwise, the null hypothesis cannot be rejected, suggesting that the series contains a unit root and is non-stationary - I(1).

In order to report the findings of the Fourier ADF unit root test, the significance of the Fourier trigonometric terms must be tested first, using the F-statistic and its critical values. The null hypothesis (H_0) of the F test posits that the trigonometric terms are statistically insignificant, implying no smooth structural breaks, while the alternative hypothesis (H_1) suggests that the terms are statistically significant, pointing to the presence of smooth structural breaks. If H_0 for the F test cannot be rejected (i.e., F-statistic<Fcritical-value), the results of the conventional ADF unit root test should be reported. However, if H_0 for the F test is rejected, the results of the Fourier ADF unit root test should be presented instead.

A detailed discussion of the ADF unit root test, with specific attention to the Fourier ADF variant, can be found in the papers of Enders and Lee (2012) and Bozoklu *et al.* (2020).

Fourier Bootstrap Augmented ARDL Cointegration Approach

After confirming that the variables are either I(0) or I(1), but not I(2), the next step is to examine whether they are cointegrated. This paper applies the Fourier bootstrap augmented ARDL (FB-AARDL) modelling approach to cointegration, originally introduced by Pesaran *et al.* (2001) and subsequently refined by McNown *et al.* (2018), Solarin (2019), and Yılancı *et al.* (2020), owing to its superior econometric performance relative to alternative techniques. Firstly, the FB-AARDL framework relies on a single ARDL equation, thereby minimising the number of parameters to be estimated, unlike earlier cointegration methodologies such as those proposed by Engle and Granger (1987) and Johansen (1991). Furthermore, this approach eliminates the need to pre-test the series to determine their integration order, as it accommodates variables that are entirely I(0), entirely I(1), or a combination of both. Lastly, its

suitability for small-sample datasets, such as the one employed in this research, is reinforced by its ability to address both serial correlation and endogeneity when an appropriate number of lags is included. The FB-AARDL framework is specified in Equation (2):

$$\Delta EFP = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta FIW_{t-i} + \sum_{i=1}^{p} \alpha_2 \Delta TAX_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_4 \Delta TO_{t-i} + \sum_{i=1}^{p} \alpha_5 \Delta LNUP_{t-i} + \lambda_1 FIW_{t-1} + \lambda_2 TAX_{t-1} + \lambda_3 GDP_{t-1} + \lambda_4 TO_{t-1} + \lambda_5 LNUP_{t-1} + \delta_6 \sin\left(\frac{2\pi kt}{T}\right) + \delta_7 \cos\left(\frac{2\pi kt}{T}\right) + \varepsilon_t \quad (2)$$

where the variables retain their previously stated definitions; Δ represents the first difference operator; p signifies the lag order determined through the Schwarz Information Criterion (SIC); α_0 is the intercept; ε is the stochastic error term; α_i = 1, 2, 3, 4, 5 are the short-run dynamic coefficients; λ_i= 1, 2, 3, 4, 5 are long-run coefficients of the model; π is the pi number; k denotes the frequency number - increments in intervals of 0.1 and taking values from 0.1 to 5; t represents the trend, T indicates the sample size, and ε is the error term.

The augmented ARDL approach outlined by McNown *et al.* (2018), as followed by Sam *et al.* (2019) and Yılancı *et al.* (2020), involves testing three specific hypotheses to confirm the presence of a long-run association between the dependent variable and the regressors. These hypotheses are defined as follows:

H_{0A}: It tests the significance of all variables' lagged values.

H_{0B}: It focuses specifically on the significance of the dependent variable's lagged values.

H_{0C}: It evaluates the significance of the independent variables' lagged values.

To establish cointegration, all three null hypotheses (H_{0A}, H_{0B}, and H_{0C}) must be rejected, thereby confirming a long-run relationship among the variables under study (McNown *et al.*, 2018). In other words, the presence of a cointegrating relationship among the variables is substantiated when the F-overall, t-dependent, and F-independent statistics collectively exceed the corresponding bootstrap critical thresholds.

Toda-Yamamoto Causality Test

The Toda-Yamamoto causality test is based on the Vector Autoregressive (VAR) model. In this test, after determining the appropriate lag length (p) for the VAR model and the maximum degree of integration (d_{max}) of the series used in the analysis, a VAR model of order ($p+d_{max}$) is estimated. Thereby, the Toda-Yamamoto causality approach estimates a VAR model of order ($p+d_{max}$) consisting of Equations 3 and 4 below (Toda and Yamamoto, 1995):

$$Y_t = \omega_0 + \sum_{i=1}^{p} \varphi_{1,i} Y_{t-i} + \sum_{i=!}^{p} \sigma_{1,i} X_{t-i} + \sum_{j=p+1}^{p+d_{\max}} \vartheta_{1,i} Y_{t-i} + \sum_{j=p+1}^{p+d_{\max}} \gamma_{1,i} X_{t-i} + \varepsilon_{1,t} \quad (3)$$

$$X_t = \alpha_0 + \sum_{i=1}^{p} \varphi_{2,i} Y_{t-i} + \sum_{i=1}^{p} \sigma_{2,i} X_{t-i} + \sum_{j=p+1}^{p+d_{\max}} \vartheta_{2,i} Y_{t-i} + \sum_{j=p+1}^{p+d_{\max}} \gamma_{2,i} X_{t-i} + \varepsilon_{2,t} (4)$$

The appropriate lag length (p) can be determined using information criteria, while the maximum degree of integration (d_{max}) is identified through unit root tests. To detect the existence of a causal relationship between variables, the null hypothesis (H_0: φ_i= 0) is tested using the Wald test statistic. The computed MWALD test statistic follows a chi-square (χ^2) distribution with degrees of freedom equal to the number of restrictions. If the calculated MWALD test statistic exceeds the critical chi-square value, the null hypothesis is rejected, indicating causality as discussed above (Toda and Yamamoto, 1995).

Empirical Results

Unit root tests

Table 3 presents the standard ADF unit root test findings, while Table 4 illustrates the outcomes of the Fourier ADF unit root test. Accordingly, the empirical results indicate that the dependent variable, the ecological footprint (EFP), becomes stationary after first differencing, implying that it is integrated of order one, I(1). They also specify that the integration orders of the independent variables are mixed, that is, the variables are either stationary at their original level or become stationary after taking first differences, as indicated by all applied unit root tests.

Table 3. *ADF Unit Root Test Results*

Variables		*ADF*	
		Constant	*Constant and time trend*
Level	EFP	-1.615 (0.460)	-3.511*** (0.059)
	FIW	-0.691 (0.832)	-1.080 (0.914)
	TAX	-2.087 (0.251)	-1.519 (0.798)
	GDP	-5.502* (0.000)	-5.399* (0.000)
	TOI	1.472 (0.998)	-1.222 (0.886)
	LNUP	-2.720*** (0.085)	1.787 (0.681)
1st Difference	ΔEFP	-7.927* (0.000)	-7.830* (0.000)
	ΔFIW	-3.811* (0.000)	-4.375* (0.000)
	ΔTAX	-5.822* (0.000)	-7.239* (0.000)
	ΔGDP	-8.394* (0.000)	-8.222* (0.000)
	ΔTOI	-4.956* (0.000)	-5.600* (0.000)
	ΔLNUP	-6.191* (0.000)	-5.088* (0.002)

Note: *, **, *** denote significance levels at the %1, %5, 10% levels, respectively. The values in brackets are probabilities. Lag Length based on Akaike Information Criterion (AIC).

Table 4. *Fourier ADF Unit Root Test Results*

	Variable	*Min. SSR*	*k (frequency)*	*Fourier ADF stat. ($\tau_{DF\text{-}t}$)*	*F(k)*
Level	EFP	0.381	1	-1.984	15.576*
	FIW	1.740	1	-4.206	12.734*
	TAX	2.757	1	-2.777	2.358
	GDP	282.566	3	-4.346*	6.490
	TOI	256.816	5	-1.889	1.093
	LNUP	0.001	1	-1.447	3.143
1st Difference	ΔEFP	0.562	5	-4.847*	15.794*
	ΔFIW	1.740	1	-4.206	12.737*
	ΔTAX	2.994	4	-4.078*	2.146
	ΔGDP	532.515	3	-3.967*	4.755
	ΔTOI	339.664	5	-1.749	2.005
	ΔLNUP	0.001	5	-2.325	2.247

Note: The symbol (*) denotes the %5 significance level. The critical value of F(k) corresponding to the 5% significance level is 9.14, as reported by Enders and Lee (2012). The critical values of the Fourier ADF statistics ($\tau_{DF\text{-}t}$) at the 5% significance level for k=1,2,3,4,5 are -4.35, -4.05, -3.78, -3.65, and -3.56, respectively (Enders and Lee, 2012).

Fourier Bootstrap Augmented ARDL Test Results

Because the unit root test results confirm that the dependent variable is I(0) (stationary at level), selecting an appropriate method for long-term estimation becomes crucial, particularly given the small dataset. The FB-AARDL cointegration approach provides flexibility in handling both I(0) and I(1)

variables, making it well-suited for our dataset. Additionally, structural shifts within economic and environmental data often distort standard estimation techniques. By incorporating Fourier transforms, this approach effectively accounts for both smooth and abrupt structural shifts, ensuring more precise long-run estimates.

Table 5 summarises the results of the cointegration analysis. To establish the existence of a cointegration relationship using the FB-AARDL methodology, the test statistics - expressed in absolute values - must exceed the corresponding critical values, also expressed in absolute terms, for all hypotheses. Accordingly, all three null hypotheses (H_{0A}, H_{0B}, and H_{0C}) must be rejected.

The findings of the FB-AARDL method presented in Table 5 unequivocally confirm the presence of a cointegration relationship between the dependent variable (EFP) and the regressors (FIW, TAX, GDP, TOI, and LNUP), as all test statistics are greater than the bootstrap critical values (in absolute terms). Furthermore, the frequency value is fractional in all cases, indicating the persistence of structural breaks across the datasets.

Table 5. *Findings from FB-AARDL cointegration approach*

Country	*Frequency*	*Lags*	*Null-Hypothesis*	*Test stat.*	*Bootstrap critical values*			*Result*
					0.90	*0.95*	*0.99*	
Türkiye	0.10	2, 2, 2, 2, 2, 2	$H0_A$	19.920	6.593	8.049	14.368	Cointegration
			$H0_B$	-7.813	-3.488	-4.184	-6.283	
			H0c	22.232	5.893	7.914	13.143	

Note: Number of bootstrap replications = 1000.

Long-run coefficient estimation results

Table 6 presents the long-run coefficient estimates derived from the FB-AARDL cointegration approach. The positive coefficients on the FIW and GDP regressors imply that greater democratic freedoms and economic expansion in Türkiye are associated with increased ecological pressures, possibly reflecting the environmental costs of expanded civil liberties, economic activity, and higher levels of consumption that often accompany democratic progress. On the other hand, the negative coefficient of the TAX variable suggests that fiscal taxation policies have been effective in curbing environmentally harmful behaviours, possibly through fiscal incentives for cleaner technologies or reduced dependence on fossil fuels. In a similar vein, the negative coefficient of the TOI variable indicates that as Türkiye has integrated into global markets, it has derived benefits from technology transfers that augment productivity or accrue positive environmental advantages by adapting to the increasingly stringent environmental production standards prevalent in international trade networks, thereby alleviating the resulting environmental impacts. Finally, the significantly negative coefficient of the LNUP variable highlights the potential of growing urbanisation to foster more sustainable consumption and production patterns in Türkiye, facilitated by the concentration of infrastructure and services in urban centres. These findings stress the necessity of balanced economic, policy, and urbanisation strategies in addressing environmental challenges.

Table 6. *Long-run coefficient results*

Dependent variable: EFP			
Independent Variables	*Coefficient*	*t-statistic*	*Probability*
C	985.620	5.152	0.002
FIW	0.306	5.044	0.002
TAX	-0.419	-8.463	0.000
GDP	0.077	7.297	0.000
TOI	-0.024	-4.923	0.002
LNUP	-58.815	-5.261	0.001

Robustness check

The validity and appropriateness of the model are assessed through a series of diagnostic examinations, incorporating tests for heteroscedasticity, serial correlation, normality, and specification, in addition to an evaluation of model stability. The results, summarised in Table 7, confirm that the model is

correctly formulated, free of serial correlation, and homoscedastic. Therefore, the findings derived from the estimations can be interpreted with confidence and provide a reliable foundation for policy formulation.

Table 7. *Model Diagnostics*

Tests	*F-statistic*	*Probability*
Breusch-Pagan-Godfrey	2.203	0.144
Breusch-Godfrey	1.524	0.322
Ramsey RESET	1.458	0.354
Jarque-Bera	0.472	0.789

Note: Case-2.

Beyond the diagnostic analysis, the stability of the model is examined through the Cumulative Sum (CUSUM) and CUSUM squares tests for recursive residuals (see Figure 2). These tests illustrate that all estimated coefficients remain within the 5% critical bounds, thereby validating the presence of a long-term association among the modelled variables and affirming the stability of the estimated parameters.

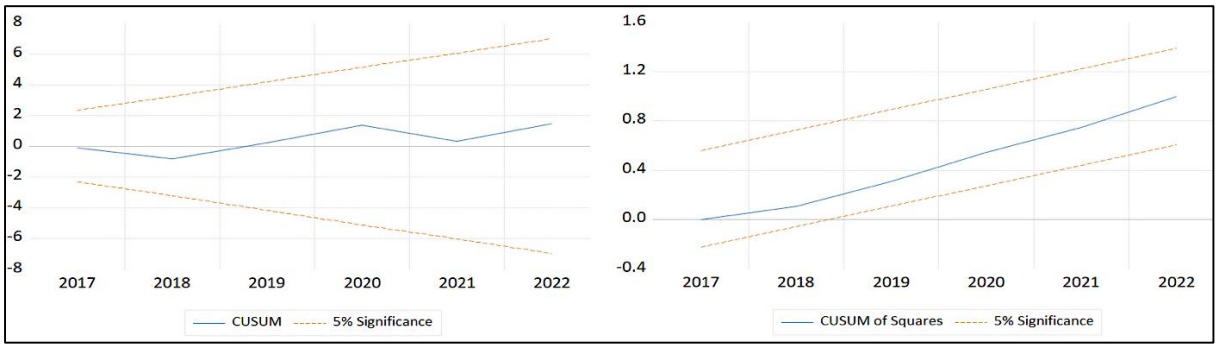

Figure 2. *CUSUM and CUSUMsq recursive estimates, indicating the stability of the coefficients derived from the model*

Toda-Yamamoto Causality Test Results

The cointegration test results provide evidence for the existence of a long-term relationship among the observed variables. Furthermore, the Toda-Yamamoto causality test is conducted to assess whether a causal relationship exists between the variables. Both the optimal lag (p) and the maximum integrated order (d_{max}) is 1. The results of the Granger Toda-Yamamoto augmented causality test are presented in Table 8, providing a concise overview of causal relationships among the variables, the χ^2 statistics and the probability values. At the 5% significance level, the Toda–Yamamoto causality test provides empirical support for the proposition that FIW, TAX, and LNUP cause EFP, as the null hypotheses asserting the absence of causality for these variables are rejected. However, the null hypotheses that GDP and TOI do not cause EFP are not rejected, meaning there is no evidence that these variables cause EFP. Additionally, the null hypothesis that all variables together do not cause EFP is rejected, showing a significant joint effect of the variables on EFP. These results show that FIW, TAX, and LNUP have a clear causal effect on EFP, while GDP and TOI do not.

Table 8. *Toda-Yamamoto causality test results*

Null-hypothesis	*Chi-square*	*d.f.*	*probability*	*Result*
FIW does not cause EFP	13.262*	2	0.001	Rejected
TAX does not cause EFP	8.034*	2	0.018	Rejected
GDP does not cause EFP	2.874***	2	0.237	Accepted
TOI does not cause EFP	1.471	2	0.479	Accepted
LNUP does not cause EFP	14.985*	2	0.000	Rejected
All do not cause EFP	28.416	10	0.001	Rejected
Critical Values				
Significance Level (α)		**d.f.**		**χ^2**
0.10 (10%)		1		2.705
0.05 (5%)		1		3.841
		10		18.307
0.01 (1%)		1		6.635

Note: *, **, *** denote significance levels at the %1, %5, 10% levels, respectively.

Discussions

The main objective of the paper is to provide empirical evidence on the relationship between institutional, fiscal, and structural factors and environmental quality. It examines the effects of democracy, environmental taxation, economic growth, trade openness, and urbanisation on Türkiye's ecological footprint (EFP) during the 1994-2022 period by employing the Fourier Bootstrap-ARDL and Toda–Yamamoto causality approaches. The empirical results demonstrate the existence of a long-run cointegration relationship among the variables and reveal that democracy (FIW) and economic growth (GDP) intensify ecological degradation, whereas environmental taxation (TAX), trade openness (TOI), and urbanisation (LNUP) contribute to environmental improvement.

Interestingly, the positive impact of democracy on environmental degradation suggests that democratic rights, such as expanded civil freedoms and political participation in Türkiye, may have increased energy demand, consumption, and industrial activity without a corresponding strengthening of environmental institutions. This result is broadly consistent with previous research, as documented by Lv (2017), Charfeddine and Mrabet (2017), Wang *et al.* (2018), Ursavaş (2021), Ahmed *et al.* (2022b), Acheampong *et al.* (2022), and Ursavaş and Apaydın (2024), who demonstrated that higher levels of democracy can exacerbate environmental pressures, particularly in developing countries where institutional structures remain weak. However, this finding contrasts with the conclusions of Congleton (1992), Fredriksson *et al.* (2005), Li and Reuveni (2006), Romuald (2011), Castiglione *et al.* (2012), You *et al.* (2015), Adams *et al.* (2016), Akalın and Erdoğan (2021), Çetin *et al.* (2022), and Ahmed *et al.* (2022c), who argued that democracy typically supports environmental quality through enhanced accountability and regulation. Similarly, the negative and statistically significant impact of economic growth on the ecological footprint confirms the validity of the growth-environment trade-off frequently reported in the literature. The result is in line with the works by Apergis and Payne (2010), Ozturk and Acaravci (2013), Ahmed *et al.* (2020), Rahman and Alam (2021), Çamkaya *et al.* (2022), Voumik and Ridvan (2023), and Akbar *et al.* (2025), who concluded that economic expansion tends to increase environmental degradation in emerging economies. In contrast to these findings, the studies of Tamazian *et al.* (2009) and Polat *et al.* (2024) suggest that economic growth can coexist with environmental improvement under certain policy conditions. In addition, the significant negative coefficient on environmental taxation provides compelling evidence that fiscal measures play a crucial role in mitigating environmental damage. This outcome resonates with previous results reported by Lin and Li (2011), who found that well-designed carbon tax mechanisms can improve environmental quality.

Furthermore, the empirical results indicate that trade openness also exhibits a beneficial environmental effect. The outcome signifies that Türkiye's integration into global markets has facilitated the adoption of cleaner technologies and adherence to international environmental standards. Such a finding supports Rafiq *et al.* (2016) and Akbar *et al.* (2025), although it differs from the results found by Ozturk and Acaravci (2013) and Çamkaya *et al.* (2022). Perhaps the most remarkable result to emerge from the analysis concerns the impact of urbanisation. Our findings illustrate that urbanisation tends to decrease environmental degradation in Türkiye. A possible explanation is that urban concentration in Türkiye may have enabled more efficient infrastructure, public services, and energy use, thereby reducing the overall ecological footprint. The result runs strikingly counter to the earlier studies by Ponce de Leon Barido and Marshall (2014), Al-Mulali and Öztürk (2015), Rafiq *et al.* (2016), Ahmed *et al.* (2020), and Rahman and Alam (2021).

The causality analysis further reinforces these findings by revealing that there is a unidirectional causality running from democracy, environmental taxation, and urbanisation to ecological footprint. This highlights that changes in these factors directly influence Türkiye's environmental outcomes, while GDP and trade openness, despite being statistically significant in the long run, do not Granger-cause short-term variations in the ecological footprint.

The limitations of this research should also be acknowledged. They stem from the restricted dataset and variable coverage, which may not fully capture short-term fluctuations or other institutional factors influencing the EFP. Moreover, as with most country-specific studies, the generalisation of these results is limited, meaning the relationships identified for Türkiye may differ across economies with varying

governance, policy, and economic structures. Future research is therefore required to test the robustness of these relationships across different national contexts and extended datasets.

Conclusion and Recommendations

The global economic race over the past two hundred years has contributed significantly to environmental damage worldwide. For nearly half a century, international meetings have been organised to assess the extent of these damages, evaluate their potential consequences for our planet, and establish preventative measures. These efforts have culminated in the formulation of Sustainable Development Goals (SDGs). Environmental protection and the adoption and use of environmentally friendly taxes are among the basic recommendations of the public policy dimension of Sustainable Development Goals. Although research on environmental pollution is not particularly new in the literature, research on the main determinants of environmental degradation is still developing. In this regard, the empirical papers present that environmental degradation is influenced not only by economic growth and development but also by public policies and the institutional characteristics of countries. For instance, the level of democracy is considered to be one of the most important indicators of the institutional quality of countries. It is assumed that democracy has an effect on preventing environmental degradation and protecting the environment. There is also no consensus in the literature on the effects of environmental taxes, and the level of democracy on the environment shows that the results may have different consequences for developed and developing countries. Briefly, in this paper, we have analysed the effects of democracy, environmental taxes, GDP, trade openness, and urbanisation on ecological footprint (EFP) for Türkiye from 1994 to 2022. Since the data on environmental taxes used in this paper are limited in time, the scope of it was limited to 29 years. We adopted the Fourier bootstrap, Augmented ARDL, and Toda-Yamamoto causality methods to analyse the data. Our results both confirm and challenge certain findings from previous studies.

The findings obtained show that, in Türkiye, the level of democracy has a positive impact on the EFP, indicating that as democratic structures expand, ecological pressure tends to intensify. This implies that while democratisation promotes economic opportunities, individual freedoms and social welfare, it can also lead to higher energy demand, consumption, and production, thereby increasing the ecological footprint. The result supports the notion that the level of democracy alone does not guarantee environmental sustainability unless accompanied by environmentally oriented regulations and green fiscal mechanisms. In addition to that, the negative coefficients on environmental taxation and trade openness demonstrate that both fiscal policy instruments and international engagement contribute to promoting environmental quality. Environmental taxes appear to effectively discourage unsustainable practices and encourage the adoption of cleaner technologies, while greater integration into global markets facilitates the diffusion of environmentally sound production methods and fosters compliance with international regulatory standards. Likewise, the positive impact of urbanisation on the EFP reflects that well-planned urban concentration can improve resource efficiency and foster sustainable consumption. Taken together, these findings highlight that the level of democracy alone does not ensure environmental sustainability; rather, it must be supported by well-designed fiscal instruments, coherent urban policies, and regulatory frameworks that align economic development with ecological preservation.

Given Türkiye's pressing environmental challenges, a coherent, integrated policy approach is required that effectively aligns economic development, democracy, and environmental protection. The empirical findings have important insights for policymakers. First, our econometric evidence supports the view that fiscal measures aimed at reducing pollution will reduce the burden on ecosystems. It is therefore essential to introduce a strict tax measure, provide financial support to sustainability-oriented companies and introduce comprehensive regulations to reduce emissions. Secondly, the positive environmental impacts of open trade policies demonstrate the benefits of harmonising national legislation with global agreements such as the EU's Green Deal. At the same time, initiatives to attract international capital to environmentally sensitive sectors can significantly improve environmental outcomes. However, there is always a tension between economic growth and increasing environmental degradation. To effectively address this issue, the government should provide incentives to promote environmentally friendly industrial practices, ensure mandatory sustainability reporting by companies and systematically integrate circular economy principles into national development strategies.

In addition, the empirical findings in this paper evidence that urban development has the potential to reduce environmental impacts. Therefore, better public transport networks and greater promotion of energy-efficient architecture and urban planning could minimise resource use and reduce negative environmental impacts in Türkiye. Regulatory arrangements aimed at strengthening institutional capacity, such as oversight mechanisms for environmental organisations and green budgeting, are equally important, as the expansion of democratic rights may unintentionally lead to increased industrial production and consumption. Policymakers should therefore establish clear environmental rules, include more participatory governance processes and improve enforcement mechanisms. Last but not least, the transition to renewable energy sources remains essential to achieve sustainable environmental stability. Increased investment in solar, wind, and other renewable energy sources can sustainably reduce environmental degradation. By integrating these policies into a well-developed, forward-looking strategy, Türkiye can ensure a sustainable balance between economic growth and environmental protection.

Etik Beyan

"Ekonomik Büyüme, Çevresel Vergiler, Demokrasi, Dışa Açıklık ve Kentleşme Türkiye'de Ekolojik Ayak İzini Etkiliyor mu?" başlıklı çalışmanın yazım sürecinde bilimsel kurallara, etik ve alıntı kurallarına uyulmuş; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Bu araştırma da etik kurul kararı zorunluluğu bulunmamaktadır.

Ethical Declaration

During the writing process of the study "*Do Democracy, Economic Growth, Environmental Taxes, Trade Openness and Urbanisation Impact Ecological Footprint in Türkiye?*" scientific rules, ethical and citation rules were followed. No falsification was made on the collected data and this study was not sent to any other academic publication medium for evaluation. Ethics Committee Permission is not required.

Araştırmacıların Katkı Oranı Beyanı

Yazarların çalışmadaki katkı oranları eşittir.

Statement of Contribution Rate of Researchers

The contribution rates of the authors in the study are equal.

Çatışma Beyanı

Çalışmada herhangi bir potansiyel çıkar çatışması söz konusu değildir.

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There is no potential conflict of interest in the study.

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Statement of Use for Artificial Intelligence and Its Types

During the preparation of this manuscript, an AI-assisted tool, specifically ChatGPT, was used to a limited extent solely for translation into English and for improving the language, grammar, and readability of

selected sentences. Following its use, the authors carefully reviewed and revised all AI-assisted content, and accept full responsibility for the accuracy, integrity, and final content of the published article.

Veri Paylaşım Beyanı

Bu çalışmanın verilerini bulguların doğrulanması amacıyla makul bir talep üzerine "etik ilkeler ve yayın politikası"nın ilgili kısmında belirtilen şartlara göre paylaşabileceğimizi beyan ederiz.

Data Sharing Statement

We declare that, upon reasonable request for the purpose of verifying the findings, we can share the data of this study according to the conditions specified in the relevant section of the "ethical principles and publication policy".

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GENİŞ ÖZET

Bu çalışma, 1994-2022 döneminde Türkiye'de demokrasi düzeyi (FIW), çevresel vergiler (TAX), ekonomik büyüme (GDP), ticaret açığı (TOI) ve kentleşme (LNUP) değişkenlerinin ekolojik ayak izi (EFP) üzerindeki etkilerini incelemektedir. Çalışmanın temel amacı, söz konusu değişkenlerin çevresel sürdürülebilirlik üzerindeki rollerini birlikte değerlendirmek ve elde edilen bulgular doğrultusunda politika yapıcılara yol gösterecek sonuçlar ortaya koymaktır. Bu çerçevede ekolojik ayak izi, çevresel bozulmayı yalnızca karbon emisyonları üzerinden değil, kaynak kullanımı ve insan faaliyetlerinin doğa üzerindeki toplam baskısı üzerinden değerlendiren kapsamlı bir gösterge olarak ele alınmaktadır. Araştırmada, Fourier Bootstrap destekli ARDL eşbütünleşme yöntemi ve Toda-Yamamoto nedensellik analizi kullanılmıştır. Bu yöntemlerin tercih edilmesinin nedeni, serilerdeki yapısal kırılmaları dikkate alabilmeleri ve değişkenler arasındaki uzun dönemli ilişkileri daha güvenilir biçimde incelemeye imkân vermeleridir. Çalışmanın ampirik sonuçları, Türkiye'de incelenen dönemde değişkenler arasında uzun dönemli bir eşbütünleşme ilişkisi bulunduğunu göstermektedir. Bulgulara göre, demokrasi düzeyi ve ekonomik büyüme, ekolojik ayak izi üzerinde olumlu ve istatistiksel olarak anlamlı etkilere sahiptir. Bu sonuç, demokratikleşme ve büyüme süreçlerinin Türkiye'de çevresel baskıyı artırıcı bir yön taşıdığını göstermektedir. Demokrasi değişkeninin pozitif etkisi, siyasal özgürlüklerin artmasının tek başına çevresel iyileşme üretmediğini ortaya koymaktadır. Çalışmada bu durum, demokratik genişlemenin tüketim, enerji kullanımı ve üretim faaliyetleri üzerindeki genişletici etkileriyle ilişkilendirilmektedir. Başka bir ifadeyle, demokratikleşme ekonomik ve toplumsal talepleri büyütürken, çevreyi koruyacak kurumsal kapasite ve düzenleyici mekanizmalar aynı ölçüde güçlenmediğinde ekolojik ayak izi artabilmektedir. Ekonomik büyümenin pozitif etkisi de benzer şekilde değerlendirilmektedir. Artan ekonomik faaliyetler, gelir artışı ve buna bağlı olarak yükselen üretim ve tüketim düzeyi, doğal kaynaklar üzerindeki baskıyı artırmakta ve ekolojik sürdürülebilirliği zorlaştırmaktadır. Buna karşılık, çevresel vergiler, ticaret açıklığı ve kentleşme değişkenlerinin ekolojik ayak izi üzerinde negatif ve anlamlı etkileri olduğu tespit edilmiştir. Çevresel vergilerin negatif katsayısı, bu politikanın çevresel açıdan zararlı faaliyetleri sınırlayabildiğini ve daha temiz üretim biçimlerini teşvik edebildiğini göstermektedir. Dolayısıyla bu bulgu, çevresel vergilerin yalnızca mali bir araç değil, aynı zamanda sürdürülebilirlik hedeflerine hizmet eden etkili bir kamu politikası aracı olduğunu ortaya koymaktadır. Ticaret açıklığının negatif etkisi ise Türkiye'nin uluslararası piyasalara entegrasyonunun çevre

dostu teknolojilere erişim, üretim standartlarının iyileşmesi ve dış ticaret yoluyla yayılan çevresel normlar sayesinde olumlu sonuçlar doğurabileceğine işaret etmektedir. Kentleşme değişkenine ilişkin bulgu da çalışmanın dikkat çekici sonuçlarından biridir. Kentleşmenin ekolojik ayak izi üzerindeki negatif etkisi, plansız kentleşmenin çevreye zarar verdiği yönündeki yaygın beklentinin aksine, Türkiye örneğinde belirli koşullar altında kentsel yoğunlaşmanın çevresel baskıyı azaltabileceğini göstermektedir. Çalışmada bu sonuç, altyapının yoğunlaşması, hizmet sunumunun merkezileşmesi, kamusal kaynakların ortak kullanımının artması ve bazı alanlarda verimlilik kazanımlarının ortaya çıkmasıyla açıklanabilir. Bu nedenle kentleşme, doğru planlandığında çevresel sürdürülebilirliği destekleyebilecek bir unsur olarak değerlendirilmektedir. Toda-Yamamoto nedensellik analizi sonuçları da uzun dönem bulgularını önemli ölçüde desteklemektedir. Bulgulara göre demokrasi, çevresel vergiler ve kentleşme, ekolojik ayak izine doğru tek yönlü bir nedensellik göstermektedir. Buna karşılık, ekonomik büyüme ile ticaret açıklığından, ekolojik ayak izine doğru anlamlı bir nedensellik ilişkisi tespit edilmemiştir. Bu sonuç, büyüme ve ticaret açıklığının uzun dönemde anlamlı etkiler üretmesine rağmen, ekolojik ayak izi üzerindeki yönlendirici etkinin daha çok kurumsal yapı, çevresel vergilendirme ve kentleşme dinamikleri üzerinden ortaya çıktığını göstermektedir. Çalışma genel olarak değerlendirildiğinde, Türkiye'de çevresel sürdürülebilirliğin tek bir ekonomik göstergeyle açıklanamayacağını açıkça ortaya koymaktadır. Demokratikleşme ve ekonomik büyüme çevresel baskıyı artırırken, çevresel vergiler, ticaret açığı ve kentleşme çevresel iyileşmeye katkı sunmaktadır. Bu nedenle, çalışmada politika yapıcılar için ortaya konabilecek temel sonuç, ekonomik kalkınma hedefleri ile ekolojik sürdürülebilirlik arasında daha dengeli bir ilişki kurulması gerektiğidir. Çalışma, özellikle çevresel vergilerin artırılması ve çevre dostu teknolojilere erişimi kolaylaştıran dışa açıklık politikalarının desteklenmesini, ayrıca sürdürülebilir kentleşme stratejilerinin geliştirilmesini öne çıkarmaktadır. Ayrıca, demokratikleşme sürecinin hedeflenen çevresel sonuçları başarabilmesi için, söz konusu sürecin güçlü kurumsal yapı, etkili düzenlemeler ve çevre odaklı kamu politikalarıyla desteklenmesi gerektiği anlaşılmaktadır. Sonuç olarak, araştırma Türkiye'de çevresel sorunların çözümü için bütüncül, planlı ve uygulanabilir bir politika bileşimine ihtiyaç olduğunu göstermektedir. Bulgular doğrultusunda önerilen politika yönelimleri şunlardır. İlk olarak, çevresel vergilerin adil, uygulanabilir ve hedef odaklı biçimde tasarlanması gerektiği vurgulanmaktadır. İkinci olarak, uluslararası ticaretin çevresel faydalarını artırmak için çevre dostu teknoloji transferinin desteklenmesi ve küresel çevre standartlarıyla uyumun güçlendirilmesi önem taşımaktadır. Üçüncü olarak, kentleşmenin olumlu etkisini artırmak amacıyla sürdürülebilir ulaşım sistemleri, enerji verimli binalar ve güçlü kamusal altyapı yatırımları öne çıkarılmaktadır. Çalışma ayrıca ekonomik büyüme ile çevresel koruma arasındaki gerilimin azaltılması için çevre dostu üretim biçimlerinin özendirilmesini, sürdürülebilirlik odaklı şirketlerin desteklenmesini ve daha tutarlı çevre politikalarının uygulanmasını gerekli görmektedir. Bu yönüyle araştırma, Türkiye'de çevresel hedeflere ulaşmanın yalnızca büyümeyi sürdürmekle değil, büyümeyi çevreyle uyumlu hale getirmekle de mümkün olduğunu göstermektedir. Ayrıca çalışma, bu yaklaşımın sürdürülebilir şehirler, sorumlu üretim ve tüketim ile iklim eylemi hedefleriyle uyumlu olduğunu belirtmektedir. Yenilenebilir enerjiye yönelim, kurumsal denetim mekanizmalarının güçlendirilmesi ve çevre odaklı planlamanın yaygınlaştırılması, uzun vadede ekolojik ayak izinin azaltılmasına katkı sağlayacak tamamlayıcı unsurlar olarak değerlendirilmektedir. Türkiye bağlamında bu bütünleşik yaklaşım merkezi bir önem taşımaktadır.