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An Analysis on The Nexus Between Green Environment and Financial Development of Turkic States

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Türki Cumhuriyetlerde Yeşil Çevre ve Finansal Kalkınma Arasındaki Bağlantıya İlişkin Bir Analiz

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Abstract

This study aims to investigate the financial sector's impact on environmental degradation in the Turkic States and Türkiye. The financial industry is an important tool in preventing environmental degradation in almost every field in newly developing economies. For this purpose, three separate models were developed in the study to evaluate the impact of financial development on the ecological footprint as an indicator of environmental degradation between 1998-2020. In the analysis, the cointegration relationship between the variables was first tested, and then parameter estimates were made with the FMOLS method. According to the results obtained, the environmental Kuznets curve is valid. The ecological footprint and financial development are negatively related. It was seen that the relationship between financial development and growth reduced the ecological footprint; however, there was no connection between financial development and renewable energy. This may mean that the renewable energy sector is not yet effective enough.

Keywords: *Financial development, ecological footprint, sustainable development, Turkic states.*

Makale Bilgileri

Makale Türü: Araştırma Makalesi

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Öz

Bu çalışmanın amacı Türki Cumhuriyetleri ve Türkiye'de finans sektörünün çevresel bozulmalar üzerindeki etkisini araştırmaktadır. Finans sektörü yeni gelişen ekonomilerde hemen her alanda olduğu gibi çevresel bozulmaların önlenmesi açısında da önemli bir araç niteliği taşımaktadır. Bu amaçla çalışmada 1998-2020 yılları arasında çevresel bozulmanın göstergesi olarak finansal kalkınmanın ekolojik ayak izine olan etkisini değerlendirmek için üç ayrı model geliştirilmiştir. Analizde öncelikle değişkenler arasındaki eşbütünleşme ilişkisi test edilmiş, ardından FMOLS yöntemi ile parametre tahminleri yapılmıştır. Elde edilen sonuçlara göre Çevresel Kuznets eğrisi geçerlidir. Ekolojik ayak izi ile finansal kalkınma negatif ilişkilidir. Finansal kalkınma ile büyüme arasındaki ilişkinin ekolojik ayak izini azalttığı görülmüştür; ancak finansal gelişme ile yenilenebilir enerji arasında bir bağlantı yoktu. Bu, yenilenebilir enerji sektörünün henüz yeterince etkili olmadığı anlamına gelebilir.

Anahtar kelimeler: *Finansal gelişim, ekolojik ayak izi, sürdürülebilir kalkınma, Türki Cumhuriyetler.*

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1. Introduction

Climate change, pollution, increased natural disasters, declining biodiversity, water and drought stress and other such problems are beginning to be felt in almost every country in the world. According to Intergovernmental Panel on Climate Change (IPCC) 2023 report, the temperature at which the earth is surfaced raised by 0.99 °C [0.84–1.00] °C between 2001 and 2020 compared to 1850–1900. Significant harm and increasingly irreparable losses have been inflicted upon terrestrial, freshwater, cryosphere, coastal, and open ocean ecosystems because of climate change. Increases in the intensity of high heat are to blame for the extinction of hundreds of native species; both on land and in the ocean, mass mortality events have been documented. Some ecosystems are experiencing irreversible consequences due to permafrost melting or glacier retreat, which is causing alterations in certain mountain and Arctic ecosystems and hydrological changes (IPCC, 2023). These effects form the basis of the steps to be taken by countries to take the necessary precautions. However, developing countries especially may be late in taking precautions against climate change, if they have not yet reached their potential growth rates. In contrast, at COP 21 governments agreed that to fulfill the objectives of the Paris Agreement, more robust and ambitious climate action had to be mobilized immediately (United Nations Framework Convention on Climate Change, 2023). The main effects of climate change are generally examined by tracking greenhouse gas emissions or measuring the ecological footprint. The ecological footprint (EF) provides more comprehensive data than greenhouse gas emissions. Accordingly, six different footprints are included in the calculation: carbon footprint, fishing area footprint, agricultural land footprint, forest products footprint, pasture footprint, and built-up area footprint (Global Footprint Network, 2023). EF shows two fundamental links: the accuracy of data on resource use and waste generation and the effectiveness of bio recycling. For this reason, EF also seeks answers to the question of how much countries use their natural resources (Holden, 2004; Uddin et al., 2023). Figure 1 shows world EF data according to biocapacity. When these two sets of data are compared, it becomes clear how much human demand there is for biologically productive surfaces (also known as the EF) and how much biocapacity there is for the globe (or the productive surface of an area) to be regenerated (Global Footprint Network, 2023).

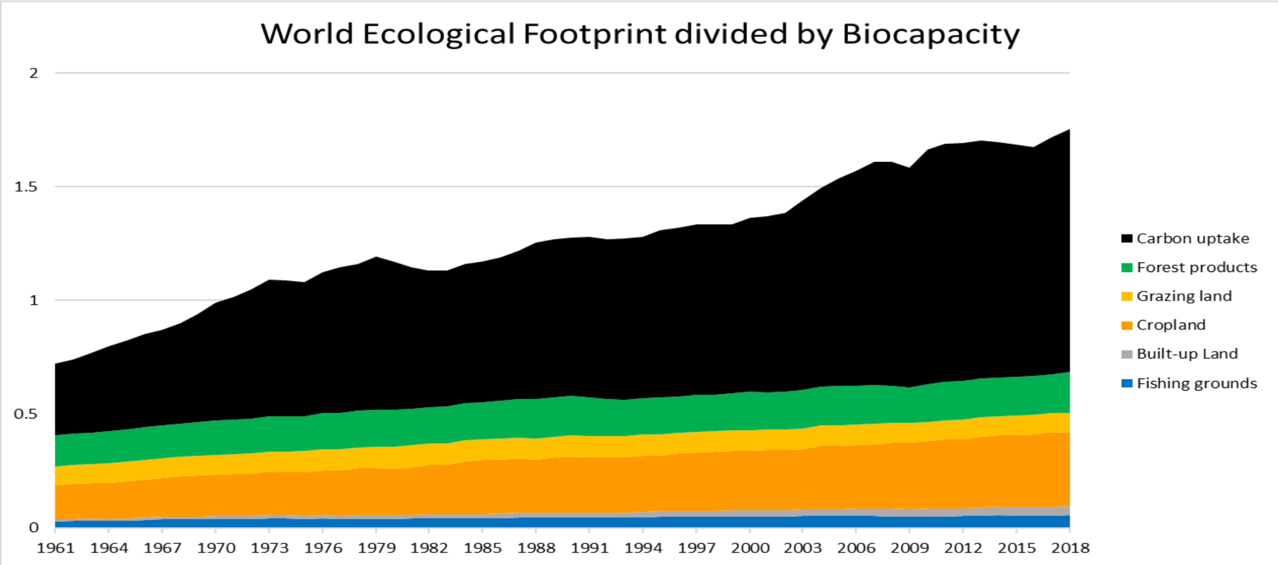

Figure 1. World EF by biocapacity
Source: Global Footprint Network (2023).

Carbon emissions are the EF's most intense area, as shown in Figure 1. Rising emissions are the most significant aspect of EF, particularly as industrialization picks up speed. Other statistics include the following, sorted by size: footprints of agricultural land, forest products, pastures, fishing areas, and built-up areas. Figure 2 shows the EF of the Turkic States. Since the Turkic States were part of the Union of Soviet Socialist States (USSR) before 1993, the data is given as of 1993.

The impact of environmental degradation on countries and their compensation are important in terms of both financial, economic, health and development. For this purpose, Türkiye and the Turkic States (Azerbaijan, Kazakhstan, Uzbekistan, Kyrgyzstan and Turkmenistan) were selected as samples in the study. This preference allows examining countries that share common characteristics in terms of both economic integration potential and environmental policy development stages. The Turkic States are making efforts to reduce the pressure that their economic structures based on natural resources create on environmental sustainability. These countries are in the process of transitioning to low-carbon development strategies. Therefore, the development of environmentally friendly financial instruments plays a critical role in this transition. Türkiye is at an advanced level compared to these countries in terms of both financial system development and regional diplomacy capacity. Türkiye's experience in the field of green finance (e.g. green bond issuance, sustainable banking initiatives) can constitute an important reference in terms of regional cooperation and policy transfer.

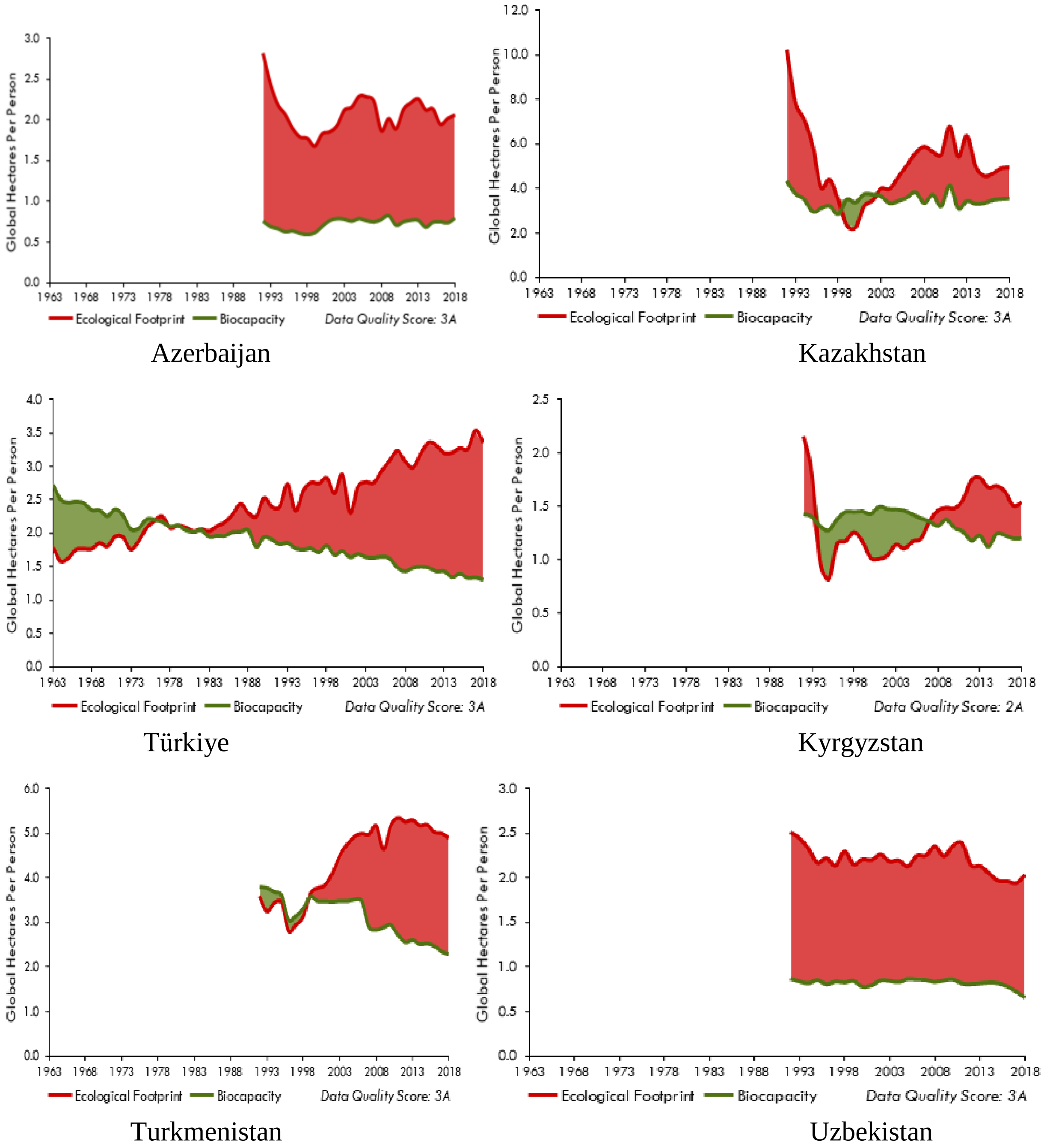

Figure 2. EF for Countries
Source: Global Footprint Network (2023).

When the data is examined, individuals in all countries demand more from productive surfaces (biocapacity). That is, the renewal rate of resources is much lower than the resource demand. Among these countries, only Kazakhstan has a higher resource renewal rate (biocapacity). As stated, the effects of environmental degradation also affect economic factors such as economic growth, sustainable development, international trade, financial development etc. In existing literature, the nexus between these economic factors and environmental deterioration has been studied using a variety of samples, time periods, and analysis techniques. The relationship between EF and financial development (FDI) will be investigated in this study. It includes basic elements such as financial development, the ability to attract foreign investments, and directing renewable energy investments. Zakaria and Bibi (2019), in many areas, including R&D through foreign investment by improving the ecological conditions of the host country, affordable financing for ecological plans and innovations in technology, and incentives for businesses that follow environmental laws, the development of a progressive and efficient financial sector is effective. The environmental impacts of FDI are discussed in the literature within the framework of two main approaches: the "Haven" effect and the "Halo" effect. The pollution haven hypothesis states that multinational companies tend to invest in developing countries where environmental policies are laxer. This may result in the relocation of polluting sectors from developed countries with strict environmental regulations to countries with more flexible legal frameworks (Cole, 2004; Eskeland and Harrison, 2003). In contrast, the "halo effect" hypothesis argues that multinational companies bring more advanced environmental technologies and management practices to developing countries, thereby improving environmental performance in host countries. In this approach, FDI is assumed to improve environmental quality rather than reduce it (Pargal and Wheeler, 1996; Zhang, 2007).

These two opposing views provide important clues about how policies should be shaped in the context of the environmental consequences of FDI. In particular, the extent to which environmental regulations affect investment decisions and the environmental burdens or contributions carried by multinational corporations can be better understood by testing these hypotheses.

Furthermore, markets and actors in financially developed economies have inexpensive and simple access to outside funding. Financial development has the potential to impact production prospects by enabling investment and establishing a mechanism for sustained economic growth. Environmental effects of financial development can be either favorable or unfavorable. Four channels are utilized to investigate these impacts (Acar et al., 2023):

i. Countries can turn to environmentally friendly investments with capital accumulation that facilitates investments.
ii. Environmental damage can be minimized by utilizing technology more frequently because of financial development.
iii. financial development is necessary for long-term economic development. However, at this stage additionally, it is well recognized that environmental development is negatively impacted by economic expansion.
iv. Finally, incentives for environmentally friendly products can be provided through regulations in the financial sector.

For these reasons the study's input into existing literature can be divided into two subsections. i) As far as we are aware, this research is the first to examine the relationship between financial contributions and environmental footprints. ii) The Turkic States included in the analysis as a sample represent the first study conducted in this field.

Accordingly, the study consists of 5 parts. The first part of the study includes literature on EFs. In the second part, the methodology and data are explained, and in the third part, the analysis results are given. The last section is the section containing policy recommendations.

2. Literature

The relationship between economic growth and environmental quality has been the subject of numerous research recently, especially in relation to the Environmental Kuznets Curve (EKC). Grossman and Krueger (1995) found that initially increasing environmental degradation in low-income countries can be reversed at higher income levels through technology, policy changes, and citizens' environmental demands. Panayotou (1993) stated in his study that although the environmental Kuznets curve is inevitable as a result of structural transformation and technological progress, policy distortions (energy subsidies, over-exploitation of resources) and market failures (uncertainty of property rights) deepen this curve. He also determined that developing countries can flatten this curve with the internalization of environmental costs and sustainable policies. When we look at the studies that include renewable energy and the openness index in addition to this relationship, it is seen that the differences arise from the change in environmental quality indicators, the period examined, and the method used.

In their study examining 14 MENA nations for the period of 1996–2012, Al-Mulali and Ozturk, (2015) concluded that environmental devastation was exacerbated by energy consumption and the openness index. They also discovered a causal association between the EF over the short and long term and the variables included in the research. However, Al-Mulali et al., (2015) examined the validity of the EKC for 93 countries classified by income using EF as a measure of environmental deterioration. The research has demonstrated that energy use and the openness index worsen environmental degradation in most countries, spanning all socioeconomic strata. Based on the findings of PMG-ARDL study in 16 European Union nations, Alola et al., (2019) verified that the use of fossil fuels contributes to a decline in environmental state and found that utilizing renewable energy increases environmental sustainability. Furthermore, whereas real GDP growth was found to lower environmental quality over the medium and long terms, the openness index was found to lower environmental harm. Destek, (2020) looked at the connections between the use of renewable energy, economic expansion, openness, and ecological impact in 24 OECD nations between 1980 and 2014. They deduced from the data that a rise in the use of renewable energy sources and increased transparency lowers the EF, and that the EKC is invalid in OECD nations. Usman et al., (2020) looked at 33 upper-middle-income nations between 1994 and 2017 to see how economic growth, the usage of renewable energy, openness, and EF interacted. Based on actual findings, the EF increases by 0.175% for every 1% growth in GDP. However, openness has been found to have a negative effect on EF in Africa and America, even though renewable energy use was found to have a negative association with the EF in Asia, Europe, and America. Usman et al., (2021) explored the connections between openness, economic growth, utilization of renewable energy, and EF for the 15 most polluting countries between 1990 and 2017. Based on the results, they concluded that while economic expansion is more to blame for environmental deterioration, renewable energy and openness play a big role in combating it. However, a unidirectional causative association was found between the openness index and the EF, even though a bidirectional causal relationship was found between economic growth, the usage of renewable energy, and the EF. Ali et al., (2021) examined the connections between economic growth, EF, openness, and renewable energy in 128 counties between 1995 and 2019. The EKC has been found to be valid at several turning points in country groupings with high, low, and intermediate incomes. The usage of renewable energy increased across all income categories, leading to a drop in EF, while an increase in the EF was also shown to be induced by the increase in the openness index. However, when the openness index rises in both high- and low-income nations, the EF also grows. The EKC is genuine, according to Nathaniel et al., (2021) analysis of the relationship between economic development, energy use, openness index, and ecological impact for N-11 countries. According to Wang et al., (2022), clean energy contributes to a reduction in environmental pollution over the long and short term in G7 countries. However, it has been found that economic growth and the openness index have a strong positive association with the EF, increasing ecological pollution. When Dada et al., (2022) looked at how Nigeria's EF changed between 1990 and 2017, they discovered that both the openness index and economic growth degraded the state of the ecosystem.

Numerous findings from research on the connections between EF and financial development demonstrate that these connections have both positive and negative consequences (Du et al., 2012). Al-Mulali et al., (2015) examined the relationship between EF and financial development for 93 nations divided into income categories and concluded that financial development lessens environmental deterioration. As a result, it is asserted that the data validates the hypothesis that bank loans are primarily granted to businesses who finance environmentally beneficial initiatives. However, low-interest loans to manufacturers to help them buy new machinery and equipment promote economic expansion, which leads to environmental degrading as people's desire for the natural world increases, claim Danish and Suad (2018).

Destek, (2019) indicates the link between environmental quality and financial development between 1977 and 2013. According to their findings, unidirectional causal relationship between EF and financial development has been found, although in China and Malaysia, financial development has a negative coefficient of influence on environmental deterioration. Majeed and Mazhar, (2019) looked at 131 nations' financial progress and EF between 1971 and 2017. The analytical results showed that all financial development indicators, including domestic loans from the financial sector, considerably contribute to the improvement of environmental quality by lowering the EF. When 152 economies were studied between 1990 and 2017, Naqvi et al., (2020) found that, except for high-income nations, financial development increases the EF across all relevant income levels. Usman et al., (2021) indicates that financial development contributes to the reduction of environmental degradation for the 15 nations with the greatest emissions between 1990 and 2017. Nonetheless, it has been discovered that there is a reciprocal relationship between EF and financial progress. In assessing the correlation between Brazil's EF and financial development from 1983 to 2017, Akinsola et al., (2022) concluded that the EF was adversely impacted by financial development. They said that clients who use the financial industry for funds and other services had to take several steps to lower their carbon footprints. Financial development and EF were found to be causally related in both directions by Usman et al. (2021), who also reported that in the 15 nations with the greatest emissions, environmental deterioration was greatly avoided thanks to financial development. Conversely, however, Usman and Hammar, (2021) reported that the EF decreased by 0.0927% between 1990 and 2017 in the nations that make up the Asia Pacific Economic Cooperation (APEC) with every 1% advancement in financial growth. They also discuss the reciprocal relationship that exists between EF and financial progress. Ahmed et al., (2021) used the results of the symmetric and asymmetric ARDL tests to get the conclusion that financial development increased Japan's EF. Although long-term outcomes deviate from short-term projections, Dada et al., (2022) conclude that Malaysia's financial development has a considerable negative short-term impact on the EF. This means that while financial development degrades environmental sustainability, it has a long-term positive and considerable impact on the ecological imprint. The EF of Singapore suffered from financial development between 1980 and 2016, according to Ngoc and Awan, (2022). According to Uddin et al., (2023), who discovered a positive link nexus financial development and EF in 119 developed and developing countries between 2002 and 2018, a bidirectional causal relationship was found to be valid between these two variables in both developed and developing countries. Acar et al., (2023) report that between 1996 and 2017, Azerbaijan's EF decreased.

Odugbesan (2020) tested the effects of economic growth, energy consumption and urbanization on carbon emissions in MINT countries using the ARDL bounds test and error correction model (ECM). As a result of empirical findings, economic growth and energy consumption increase environmental pollution, while urbanization reduces environmental impacts. Li et al. (2022) examined the relationship between urbanization, energy consumption, foreign direct investments, carbon emissions and economic growth for emerging seven (E7) countries using Principal Component Analysis (PCA) and correlation analysis. As a result of the findings, it was concluded that while urbanization and energy consumption increase environmental pollution, foreign direct investments reduce environmental pollution.

On the other hand, when studies on ecological footprint, which is one of the important indicators of environmental pollution, are examined, Javeed et al. (2023) examined the relationship between renewable energy consumption, ecological footprint, economic growth, globalization, and population density with FM-OLS and Granger causality analysis in Asia. The results show that with a 1% increase in economic growth, globalization, and population the ecological footprint increases by 0.55%, 0.08%, and 0.03%, respectively. On the other hand, renewable energy improves the environmental quality by 0.04%. Moreover, it revealed a bidirectional causality between ecological footprint and globalization and between EFP and energy intensity. Wang et al. (2025) found an inverted U-shaped relationship between economic efficiency and ecological footprint according to the FMOLS analysis results and concluded that financial development and renewable energy consumption also reduce environmental impacts. In addition, Shkiotov et al. (2025) examined the effects of financial development, openness, economic growth and renewable energy consumption on ecological footprint in EAEU countries. According to the panel data analysis and Granger causality test results, financial development has a negative effect on the ecological footprint, while economic growth and openness have a positive effect. Renewable energy consumption improves environmental quality.

3. Model and Data

In this study, the effectiveness of the financial sector on the environment for the Turkic States and Türkye was investigated. Three different models were created with reference to Acheampong's (2019) work to investigate the effects of financial development on EF between 1998 and 2020. Beyond their shared linguistic and cultural heritage, the six selected Turkic States (Azerbaijan, KazakhstanH, Kyrgyzstan, Uzbekistan, Turkmenistan, and Türkiye) have increasingly aligned their environmental sustainability and financial development policies through regional cooperation frameworks. In particular, under the umbrella of the Organization of Turkic States (OTS), these countries have articulated common goals in areas such as green growth, energy transition, and economic integration. Moreover, most of these countries share structural similarities, such as reliance on natural resources, a post-Soviet transition economy background (except Türkiye), and exposure to comparable environmental challenges. While potential heterogeneity—especially due to Turkmenistan's relatively closed economy—remains a valid concern, the empirical methodology employed in the study accounts for such differences through econometric techniques designed to manage cross-sectional dependence and heterogeneity. Therefore, the selected sample is considered both regionally coherent and analytically justifiable.

In this study, the shared linguistic heritage of the selected countries serves merely as an initial reference point. The primary justification lies in the increasing economic, environmental, and institutional convergence among these countries—manifested through formal cooperation under the Organization of Turkic States (OTS).

In recent years, the OTS has launched joint initiatives and adopted strategic documents on green economy, environmental sustainability, energy transition, and financial integration. Notably, the Turkic World Vision 2040, adopted in 2021, identifies environmental cooperation and sustainable development as core regional priorities. In addition, member states have undertaken joint commitments toward boosting intra-regional trade, establishing common financial infrastructure, and promoting eco-friendly investments.

Thus, the countries included in the analysis are not only linked by cultural ties but also share institutional proximity, comparable economic transformation trajectories, exposure to similar environmental challenges, and a common political agenda of regional integration. In this sense, the sample selection is grounded in measurable economic and institutional dynamics, rather than being driven by ideological or cultural motives. The study, therefore, aims to examine ongoing regional development practices and integration processes, rather than promoting any civilizational or ethnic narrative.

The models are as follows:

$$INEFP_{i,t} = \alpha_0 + \alpha_1 INREN_{i,t} + \alpha_2 INPOP_{i,t} + \alpha_3 INTR_{i,t} + \alpha_4 INFDI_{i,t} + \alpha_5 INGDP + \alpha_6 INGDP_{i,t}{}^2 + \varepsilon_{i,t} \quad (1)$$

$$INEFP_{i,t} = \beta_0 + \beta_1 INREN_{i,t} + \beta_2 INPOP_{i,t} + \beta_3 INTR_{i,t} + \beta_4 (INFDI * INGDP)_{i,t} + \beta_5 INGDP + \beta_6 INGDP_{i,t}{}^2 + \varepsilon_{i,t} \quad (2)$$

$$INEFP_{i,t} = \gamma_0 + \gamma_1 INREN_{i,t} + \gamma_2 INPOP_{i,t} + \gamma_3 INTR_{i,t} + \gamma_4 (INFDI * INREN)_{i,t} + \gamma_5 INGDP + \gamma_6 INGDP_{i,t}{}^2 + \varepsilon_{i,t} \quad (3)$$

The terms period, cross-section, and error are represented in the model by the letters t, I and, $\varepsilon_{i,t}$ respectively. It also refers to $INEFP_{i,t}$ the natural logarithm of the EF in Model 1 and the natural logarithm $INGDP_{i,t}$ of GDP per capita$INGDP^2{}_{i,t}$, GDP per capita squared, $INTR_{i,t}$ trade openness, $INPOP_{i,t}$urbanization, $INFDI_{i,t}$ foreign direct investment, and $INREN_{i,t}$renewable energy use as independent variables. The one in Model 2 was used to measure the effectiveness of the foreign direct investment, and the one in Model 3 was $(INFDI * INGDP)_{i,t}$ used to measure the effectiveness of the financial sector in the renewable energy sector $(INFDI * INREN)_{i,t}$.

The *"share of renewable energy consumption in total final energy consumption (REN)"* variable used in this study is sourced from the World Development Indicators (WDI) database, based on data compiled by the IEA. This indicator generally includes both modern renewable sources (such as solar, wind, geothermal, hydro, and biofuels) and traditional biomass (e.g., wood and animal waste used for cooking and heating, especially in rural areas).

As such, the REN variable reflects not only the transition to sustainable energy but also the continued reliance on traditional energy systems in some countries. This broader composition has been taken into account in the interpretation of the results, and the analysis does not assume a one-to-one link between REN and modern green energy investments.

While it is rightly noted that Foreign Direct Investment (FDI) is often treated as an outcome of financial development, in certain contexts—especially in developing economies—it may also serve as a proxy or component reflecting aspects of financial development itself. This study justifies the use of FDI net inflows (% of GDP) as a proxy for financial development based on both theoretical insights and empirical relevance specific to the sampled countries.

In many emerging economies—including the Turkic States analyzed in this study—domestic financial markets remain shallow, capital accumulation is limited, and capital markets are underdeveloped. In such settings, FDI plays a crucial role in deepening the financial sector, enhancing access to capital, and facilitating financial intermediation. Research by Alfaro et al. (2004) and Hermes & Lensink (2003) supports the view that FDI not only depends on financial development but can also actively contribute to it.

Moreover, in countries with low domestic savings and limited access to global financial markets, FDI serves as a key indicator of financial integration and institutional capacity to absorb and allocate international capital. In this study, where the emphasis is on investment-oriented financial development rather than bank-based indicators alone, FDI is treated not merely as an exogenous influence but as an embedded dimension of financial development.

Additionally, the selection of FDI was informed by practical considerations, including data availability, consistency, and cross-country comparability. Standard proxies such as domestic credit to the private sector were either unavailable or incomplete for certain countries in the sample. In this context, FDI inflows are conceptualized as a meaningful and context-appropriate measure of financial development for the countries and period under study.

One limitation of this study is the use of FDI inflows as the sole proxy for financial development. While FDI offers practical advantages in terms of data availability and comparability across the selected countries, it may not fully capture the multidimensional nature of financial systems. Future studies are encouraged to incorporate more conventional indicators such as domestic credit to the private sector or construct a composite index to provide a more comprehensive assessment of financial development.

In this context, EF is global acreage (ga); GDP per capita, US$ at 2015 constant prices; openness, % share of trade in GDP; urbanization, % share of urban population in total population; foreign direct investments represent the % share of net inflows in GDP; renewable energy consumption refers to the share of renewable energy consumption in total energy consumption. EF data were obtained from the global footprint database (2023) and other data were obtained from the world bank database (2024). The EKC hypothesis is being tested in this study of using the GDP square. In this context, for the EKC hypothesis to be valid $\alpha_{1,}\ \beta_{1,}\gamma_{1,}\rangle 0$, and $\alpha_{2,}\ \beta_{2,}\gamma_{2,}\langle 0$ its results must be obtained.

To achieve this, the cross-sectional dependency in panel data has been examined using the CD test. A change or break in one of the panel's constituent units won't have an impact on the other units due to cross section dependency. It is improbable, though, that the components of the panel will remain indifferent to one another. As a result, it is imperative to assess the level of commitment among the panel's constituent units first. The CD test examines the connections between units and was created by Breusch and Pagan in 1980 and Pesaran in 2004. This is how the CD test was computed:

$$CD\sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\quad\sum_{j=i+1}^{N}\quad\rho_{ij}{}^{\wedge}\right) \tag{4}$$

The model utilizes T to represent the panel's temporal dimension and N to denote the panel's cross-sectional dimension (Pesaran, 2000:1; 7). Following the determination of the panel's cross-sectional dependence, an estimation was made using the CIPS unit root analysis created by Pesaran (2007). Equation 5's CADF statistics are the source of the CIPS unit root analysis.

$$\Delta y_{i,t} = a_i + \rho_i y_{it-1} + \beta_i y^{-}{}_{t-1} + \sum_{j=0}^{k}\quad\tau_{ij}\Delta y_{it-1}{}^{-} + \sum_{j=0}^{k}\quad\delta_{ij}y_{it-1} + \varepsilon_{i,t} \tag{5}$$

In the equation a_i, Deterministic describes the quantity of lags. k, the $y^{-}{}_{t}$ cross-sectional mean of time. Accordingly, the CIPS unit root model is as follows:

$$CIPS = \left(\frac{1}{N}\right)\sum_{i=1}^{N}\quad t_i(N,T) \tag{6}$$

The study's computation of the Westerlund Error Correction Test (2007) determined the variables' long-term connection. Within the scope of cointegration analysis, Westerlund (2007) established two separate tests, the mean group and panel test, to evaluate the alternative hypothesis and the null hypothesis, namely, that cointegration is absent. At this stage, he created four cointegration test statistics according to the error correction model $(G_\alpha, G_t, P_\alpha, P_t)$. According to the analysis, the variables should be stationary in I (1).

Finally, the FMOLS (Fully Modified Ordinary Least Squares) estimator developed by Pedroni (2000) was used as a cointegration estimator in the study. It is formulated in the form of FMOLS Panel estimator

$$\beta^{\wedge}{}_{GFM} = N^{-1}\sum_{i=1}^{N}\quad\beta_{FMi}^{*}. \tag{7}$$

4. Empirical Results

Financial development's effects on the environmental footprint of the Turkic States have been examined as part of the study's purview. Using the CD test, the study's first step was analyzing the cross-sectional dependence between the variables. In addition, the study also includes homogeneity test results. Table 1 presents the acquired results.

Table 1. CD and Homogeneity Test Results

	INEFP	INGDP	INFDIN	INPOP	INREN	INTR
Pesaran CD test	-0.13	17.64	6.70	16.10	1.77	0.09
P-Value	0.097	0.000	0.000	0.000	0.076	0.027
Delta Test Results	Model 1		Model 2		Model 3	
	Statistics	P-value	Statistics	P-value	Statistics	P-value
Δ	2.835	0.005	4.448	0.000	2.244	0.025
Δ_{adj}	3.297	0.001	5.174	0.000	2.610	0.009

In light of the information, the null hypothesis that there is horizontal cross-sectional dependence is rejected. Put otherwise, the variables exhibit Cross-sectional dependence. The homogeneity test results indicate that the existence of country- specific heterogeneity among sample countries. Consequently, tests that cross-sectional dependence will be used to calculate the cointegration relationship between the variables. At this point, the Horizontal Section Dependency was taken into consideration while applying for the CIPS test. Table 2 presents the findings.

Table 2. Outcomes of Panel Unit Root Test

Variables	CIPS	
	level	**Differences**
INEFP	-1.693 (0.597)	-3.654 (0.000)***
INREN	-2.230 (0.583)	-8.398 (0.000)***
INPOP	1.394 (1.000)	-6.727 (0.001)***
INTR	-1.440 (0.791)	-2.822 (0.004)***
INFDI	-1.740 (0.933)	-3.519 (0.000)***
INGDP	-2.210 (0.128)	-2.399 (0.005)***

Prob.; *,10%; **, %5; ***, %1

Table 2's results show that every variable is stationary in the first degree. In other words, every variable is cointegrated at level I (1). Following this phase, the long-term relationships for all models were examined between EF, renewable energy, openness, financial development, and per capita economic income. Furthermore, the countries' environmental Kuznets curves were tested for existence. Westerlund ECM Cointegration analysis was used to estimate the presence of a long-term link. Table 3 presents the findings.

Table 3. Panel Cointegration Test Outcomes

Test	Model 1	Model 2	Model 3
G_T	-4.105 (0.000)***	-5.593 (0.000)***	-4.102 (0.000)***
G_α	-2.568 (0.000)***	-2.463 (0.998)	-3.152 (0.000)***
P_T	-7.629 (0.007)**	-7.118 (0.020)**	-7.064 (0.022)**
P_α	-2.372 (0.959)	-2.357 (0.960)	-2.539 (0.955)

Prob.; *,10%; **, %5; ***, %1

Three test statistics with a normal distribution are used to examine the Westerlund Cointegration Test results. $(G_{\alpha}, G_t, P_{\alpha}, P_t)$. The group estimate of these tests is represented by Gα and Gt, whereas the unit estimate is represented by Pα and P t. In the Westerlund cointegration test, homogeneity test results are important in terms of interpretation of statistical results. Accordingly, in case of homogeneity in the model, the panel results should be considered, and in case of heterogeneity, the group results should be considered. According to the delta test results, the existence of homogeneity in the models was rejected. Accordingly, the group test results are important. In model 1 and model 3, the group test results show the existence of cointegration. In model 2, according to the Gt result, there is cointegration in the model.

Finally, the study employed the FMOLS cointegration estimator. FMOLS estimator provides accurate estimation of long-term parameters free from endogeny and autocorrelation errors after cointegration is detected with Westerlund ECM test. Therefore, it is frequently used for consistent long-term analyses in academic research.

Table 4. Cointegration Estimator Outcomes

Variables	Model 1	Model 2	Model 3
INFDI	-0.369530***		
INGDP	8.504867***	8.592101***	8.833627***
INGDP2	-1.167704***	-1.178082***	-1.236703***
INPOP	-1.090650	-1.090961	-0.630139
INTR	0.673479**	0.560179**	-0.018387
REN	-0.006319*	-0.004198*	0.005218
INFDI*INGDP		-0.094356*	
INFDI*INREN			-0.011260

Prob.; *,10%; **, %5; ***, %1

The EKC hypothesis was determined to be corrected in all models based on the results. Urbanization has no effect on EF in all Models 1, but trade openness does raise the EF. It lessens the environmental impact of using renewable energy. But in model 3, which investigated how financial investments, and the renewable energy sector interacted with the environment, the findings were deemed statistically insignificant. The outcomes of Model 2 suggest that the financial industry's growth in Türkiye and the Turkic States has a beneficial effect on the environment. The link nexus the financial development sector and the renewable energy sector, however, has been irrelevant. Consequently, it may be said that these nations' investments in renewable energy have not yet achieved a high enough level of effectiveness.

5. Conclusion

In this study, the effectiveness of the financial sector on the environment for the Turkic States was investigated. The time series of the datasets created for this purpose was created with annual data between 1998-2020. The dataset includes data from Azerbaijan, Kazakhstan, Türkiye, Kyrgyzstan, Turkmenistan, and Uzbekistan. EF, foreign direct investment, trade openness, urbanization, renewable energy consumption and GDP Per Capita variables were created and analyzed by panel cointegration estimation method.

The first model's EF was found to be increased by the variables of openness and per capita income, while it was found to be decreased by the variables of financial development and renewable energy consumption, based on the results of the FMOLS panel cointegration estimation method. In the second model, the EF is lowered by the connection between renewable energy use and financial development and growth, but openness and per capita income raise it. The EF was found to be enhanced only by the per capita income variable in the last model to be used.

In general, it is seen that renewable energy consumption and financial development in the Turkic countries reduce the EF. This is a result that is expected especially within the scope of renewable energy and is in parallel with other studies in literature such as the studies of Shkiotov et al. (2025), Wang et al. (2025) and Dada et al. (2022). The underground resources held by the Turkic States provide them with great advantages in terms of energy. However, the importance of renewable energy investments increases even more, both the fact that the environmentally oriented developing world has started to turn to renewable energy sources and makes its investments in this direction, and the importance of leaving a more livable world to future generations.

Similar results are seen in the results of the analysis on financial development and growth. The higher the Turkic States raise their level of financial development, the lower their EF levels. This situation does not give the same result for all countries with increasing financial development. Underground resources, which are much more environmentally friendly than the fossil fuels owned by the Turkic States, can be shown as the reason why the energy investments of the countries reduce their EFs compared to other countries. In this direction, it can be said that as the Turkic States increase their energy investments, which have a large share in their financial development, their EF levels will also decrease.

In addition to the variables that reduce the EF, the national income per capita, which is the only variable that increases the EF in 3 models, draws attention. The increase in per capita income in Turkic States increases demand and therefore industrialization. In addition, the increase in national income also increases the use of fossil fuel-powered vehicles. This situation shows that national income influences increasing the EF. Finally, in model 1 and model 2, it is seen that the openness variable also increases the level of EF. This is also an expected result in the end. Because, as the level of openness increases, the increase in the efficiency of the transportation sector can increase pollution.

In general, many Turkic States are rich in energy resources, especially natural gas and oil reserves. This can trigger growth in the energy sector and thus economic growth, but it can also lead to environmental problems if the process is not well managed. In addition, these countries are known to have significant renewable energy resources. When the data obtained are evaluated from this point of view, renewable energy consumption reduces the EF in these countries. However, the interaction between financial development and renewable energy is statistically insignificant. This may mean that financial development is not effective enough. Financial development is often a growth driver. However, this growth can deepen environmental problems if it does not focus on sustainable practices to protect nature. Therefore, directing financial institutions to invest in environmentally friendly projects in countries with high energy potential is important to support sustainable development.

As a result, Turkic States should continue to increase their renewable energy investments and increase their financial development in this direction to reduce their EFs to lower levels and to attract green financing investments to their countries. The fact that the study is the first study in the accessible literature that deals with the relationship between EF and financial development in the sample of Turkic States in terms of openness, renewable energy, urbanization, and national income reveals its subjectivity. For this reason, the study is a guide for other studies to be carried out on these issues for the Turkic States.

This study has certain limitations. First, the time frame of the dataset (1998–2020) and the limited number of variables may affect the generalizability of the results. Additionally, the inability to fully account for economic and political differences among the Turkic States could impose constraints on the interpretation of the findings.

For future research, studies incorporating a broader time span and additional variables (e.g., technological innovations, environmental policies) are recommended. Furthermore, qualitative research assessing the effectiveness of green financing practices in the Turkic States could provide valuable contributions to the literature in this field.

6. Policy Recommendation

This section of the study includes concrete and applicable policy recommendations that will reduce environmental degradation in the Turkic States and Türkiye.

Development of Green Credit Mechanisms through Financial Institutions: The banking system of the Turkic countries and Türkiye can be organized to create green investment classifications (green taxonomy). They can be encouraged to offer green credit products that will finance renewable energy, clean technology and environmental infrastructure investments through interest support or tax incentives. In addition, banks can integrate environmental impact analysis criteria into their credit evaluation processes.

Increasing Regional Cooperation in Renewable Energy and Carbon Reduction: By developing cooperation between these countries, a common carbon reduction strategy and regional carbon pricing infrastructure can be established in line with the European Union's Carbon Border Adjustment Mechanism (CBAM).

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