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Analysis of the asymmetric relationship between stock markets and environmental quality: an analysis on Turkey

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Abstract. *The aim of this study is to reveal the impact of stock market-based financial development on environmental quality in Turkey. In this context, the variables of Carbon (CO_2) emissions, Ecological footprint, and load capacity factor are used as indicators of environmental quality, while the Borsa Istanbul 100 main index, along with the Financial and Industrial main sub-indexes, serve as indicators of stock market-based financial development. The analysis covers the period from 1991 to 2021, and the data consists of annual observations. Non-linear ARDL (Autoregressive Distributed Lag) method, which takes into account asymmetric effects, is employed as the econometric approach in the analysis. According to the findings of the study, the developments in the stock markets represented by the Borsa Istanbul 100, Financial, and Industrial indexes asymmetrically and significantly influence environmental quality in Turkey in both the short and long term.*

Keywords: load capacity factor, nonlinear ARDL, stock market development, environmental quality, Turkey.

JEL Classification: C58, G10, F18, Q01.

1. Introduction

As financial development increases in an economy, on the one hand, the borrowing capacity of entrepreneurs increases, and on the other hand, the allocation of resources towards appropriate investment projects is facilitated. Misallocation of resources into wrong investment projects leads to the wastage of scarce resources and diverts the economy away from its potential performance. Conversely, directing investments into the right projects accelerates the relevant economy and brings it closer to its potential performance. (Shobande and Ogbeifun, 2022a; Baloch et al., 2021; Li and Ramanathan, 2020). Furthermore, as the level of financial development increases, the validity of the efficient market hypothesis becomes more pronounced, particularly in financial markets such as the stock and capital markets.

Considering that the level of financial development triggers economic growth and performance, it is expected that financial development may increase energy demand and negatively affect environmental quality through economic growth. However, as the level of financial development rises, there is an increase in environmentally-friendly, low carbon emission, and sustainable investments aimed at preventing environmental degradation. (Baloch et al., 2021). In this case, it can be expected that financial development would positively impact environmental quality.

Financial development is of paramount importance in ensuring the smooth functioning of the payment system and facilitating companies' and entrepreneurs' access to cash and capital. Moreover, as a company's market value increases, its credibility and borrowing capacity also rise accordingly. Companies with expanded credit and borrowing opportunities are better equipped to make efficient investments and engage in research and development activities. In this context, the development of the stock market is equally crucial as financial development, as it facilitates access to cash and capital for companies and entrepreneurs who own shares. The development of the stock market is also considered one of the indicators of financial development. Considering this information, both financial development and stock market development can contribute to facilitating access to cash and capital for companies and entrepreneurs. On the one hand, this may lead to increased investments, consequently raising energy demand and environmental degradation. On the other hand, it can trigger investments in new technologies and sustainable ventures, contributing to a reduction in carbon emissions (Shobande and Ogbeifun, 2022b). However, it is important to note that the scope and boundaries of such developments, such as investments in new technologies and low-carbon technologies, may vary significantly between sectors, for instance, between firms operating in the agriculture sector and those in the chemical industry. Therefore, the differences in scope and boundaries of new technology investments and low-carbon technology development across sectors should not be overlooked. In this regard, based on the aforementioned explanations, understanding the impact of financial development and stock market development on environmental quality in different sectors and directions becomes crucial in preventing and achieving the goal of zero net emissions.

In compliance with the aim of this study, the impact of stock market development on environmental quality will be investigated not only in terms of Turkey's overall stock market development but also by utilizing the performance of sub-indexes created in Borsa Istanbul. As can be observed in the subsequent section of the study, the existing literature on the relationship between sub-indexes and environmental degradation is limited. Among the few studies that focus on sub-indexes or sectors, Zeeshan et al. (2021), Ahmad et al. (2019), Zafar et al. (2019), and Shahbaz et al. (2016) solely concentrate on the banking sector, neglecting other sectors or sub-indexes. Conversely, in the study by Habiba and Xinbang (2022), the focus is on financial development as a whole and its four sub-indexes. The main distinction of this study from the mentioned works is its focus on sub-indexes in the stock market, encompassing not only the banking or financial sub-indexes but also including the industrial index.

The examination of the relationship between economic variables and the environment began in the 1990s. In the study conducted by Grossman and Krueger (1991), which analyzes the relationship between economic growth and environmental quality through air pollution, they identified an inverse-U shaped relationship between economic growth and environmental quality. Theodore Panayotou, in his work Panayotou (1993) and inspired by the hypothesis put forth by Simon Kuznets regarding income distribution, refers to the inverse-U shaped relationship between economic development and environmental degradation identified in Grossman and Kruger (1991) as the Environmental Kuznets Curve (EKC). According to the EKC, environmental degradation increases until a certain income threshold is reached per capita, after which, as per capita income increases, environmental degradation decreases.

With the study conducted by Rees (1992), the concept of Ecological Footprint (EF) was introduced to the literature. According to this concept, EF represents a measure of pollution in the air, water, and soil. It is important to note that while EF unilaterally expresses humanity's needs and demands concerning natural resources and the environment, it neglects nature's response to these demands (Altintas and Kassouri, 2020). In this regard, Siche et al. (2010) put forward the load capacity factor (LCF) hypothesis, which takes into account nature and the environment's response to human activities. The load capacity factor hypothesis aims to address the deficiency in the EF concept with the introduction of the biocapacity concept. Accordingly, the LCF is obtained by dividing biocapacity by EF (LCF = Biocapacity / EF).

As expressed in the preceding paragraphs, the literature addressing the relationship between economic and financial development levels and environmental degradation witnesses changes and advancements in the techniques used for measuring environmental degradation. In this context, our study examines the relationship between Load Capacity Factor (LCF), CO_2 emissions, and Ecological Footprint (EF) with Borsa Istanbul 100 (BIST 100), Financial, and Industrial indexes. To this end, the study continues with a literature review where examples from relevant literature are presented. Subsequently, there is a section introducing the econometric model and dataset used in the analysis. Following that, the empirical findings section presents the results of the conducted econometric analysis and the related outcomes. Finally, the study concludes by offering the overall results and assessments to the reader's attention.

2. Literature

Countries with efficient and effective capital markets have gained significant advantages in terms of economic growth. One of the key institutions in these markets is stock exchanges, which represent organizations where stocks of various companies from different sectors are traded. Consequently, the number, size, and profitability of companies operating in different sectors will increase investor interest in the relevant stock market, leading to its growth and financial development. However, the impact of stock investments on the environment has been a subject of curiosity and has been explored in various ways in the literature. In this context, Ferraro and Uchida (2007) investigated the disclosure of pollutant release and transfer register data for 1,072 publicly listed firms on the Tokyo Stock Exchange to understand its effect on investor behavior. They found that investors showed weak sensitivity to firms' environmental performance. The environmental pollution caused by these firms did not have the expected negative impact on their stock returns, and thus, no significant decrease was observed in the stock market.

In the study conducted by Ziaei (2015) for 13 European and 12 East Asian and Oceanian countries, the mutual interaction between financial indicator shocks, i.e., credit market and stock market shocks, and energy consumption and CO_2 emissions was examined. The variables were analyzed using the Panel Vector Auto Regression (PVAR) method for the period from 1989 to 2011. The analysis revealed that the strength (intensity) of the energy consumption shock on stock return rates was higher in European countries compared to East Asian and Oceanian countries. Additionally, in Asian and Oceanian countries, the stock market shock had a positive impact on energy consumption deviation, and stock market variables had stronger effects on energy consumption in countries with developing asset markets. Moreover, the said energy consumption had significant effects on CO_2 emissions in both developing and developed country groups with varying degrees of impact. In the study by Paramati et al. (2016), covering the period from 1991 to 2012 for 20 emerging market economies, they investigated the impact of both foreign direct investment inflows and stock market development on clean energy usage. Gross domestic product, clean energy and energy consumption, foreign direct investment, and stock market development series were analyzed using Westerlund panel cointegration and heterogeneous panel causality tests. The analysis revealed that stock market development had a significantly positive effect on clean energy consumption and an adverse effect on CO_2 emissions. For Pakistan, Shahbaz et al. (2016) examined the asymmetric impact of financial development on environmental quality during the period from 1985Q1 to 2014Q4. The variables were analyzed using asymmetric ARDL cointegration and asymmetric Granger causality tests. The study found that positive and negative shocks in stock market-based financial development had a positive and negative but statistically insignificant effect on CO_2 emissions, respectively. On the other hand, general financial development based on banks and stocks had a positive but statistically insignificant effect on CO_2 emissions.

Ahmad et al. (2019) investigated the impact mechanisms between energy consumption, financial development, international trade, environment, and economic growth for 29 provinces and cities in China. They set the research period as 1997 to 2019. In the study, it was found that bank-based financial development increased CO_2 emissions, while stock market-based financial development reduced CO_2 emissions. Al-muali et al. (2019) examined the effects of the stock market on air pollution in Malaysia during the period from 1980 to 2017. Data related to CO_2 emissions, population density, gross domestic product, energy intensity, and the percentage of stock traded were analyzed using the non-linear ARDL method. The short-term results showed that an increase in stock trading led to an increase in CO_2 emissions, while a decrease did not have a significant impact on CO_2 emissions. Furthermore, looking at the long-term results, an increase in stock trading was found to increase CO_2 emissions, while a decrease in stock trading significantly reduced CO_2 emissions in the long term.

Destek (2019) examined the impact of financial development indicators (general financial development index, banking development index, stock market development index, and bond market development index) on environmental degradation for 17 developing countries. The study found that the general financial development index and the increase in stock market activity reduced environmental degradation, while the increase in banking and bond market activity did not have a significant effect on the environment. Zafar et al. (2019) conducted a study investigating the role of disaggregated financial development and renewable energy variables in carbon emissions during the period from 1990 to 2016, focusing on G-7 and N-11 countries. The study revealed that stock market activities in G-7 countries increased CO_2 emissions, while in N-11 countries, they led to a reduction in CO_2 emissions.

In the study conducted by Ahmad et al. (2020), a positive one-way causality relationship from financial development to CO_2 emissions was obtained. The authors emphasized that in this relationship, the intensity of the impact of banking sector-based financial development on CO_2 emissions was more dominant than stock market-based financial development. In another study examining the relationship between financial development and environmental quality, Aluko and Obalade (2020) found a negative relationship, indicating that financial development enhances environmental quality. They also stated that better environmental quality is associated with increased efficiency, depth, and accessibility of the financial sector. Rahman et al. (2020) investigated the dynamic effects of stock markets, economic globalization, and financial development on environmental quality. Their study revealed that stock market development negatively affects environmental quality by increasing CO_2 emissions, and the financial sector plays a significant role in environmental quality. They also found that financial development contributes significantly to the levels of CO_2 emissions. Shoaib et al. (2020) analyzed the causal relationships between financial development and CO_2 emissions in G8 and D8 countries during the period from 1999 to 2013. The data was analyzed using the Dumitrescu-Hurlin panel causality test and PMG-panel ARDL technique. The analysis results indicated that easy access to finance through stock markets increases production investments and CO_2 emission levels.

In the study conducted by Ibrahim and Vo (2021), the relationship between countries' innovation levels and the financial development-pollution nexus was investigated for 27 industrialized countries. The data was analyzed using the Two-step System Generalized Method of Moments (GMM) and the Dumirescu-Hurlin (2012) panel causality methods.

The analysis revealed that well-developed financial development is associated with environmental degradation, while advanced innovation mitigates the adverse impact of financial development on pollution. Additionally, no causality was found between financial development and pollution. Habiba et al. (2021) demonstrated that stock market development reduces carbon emissions in all G20 countries and advanced economies, but increases carbon emissions in developing economies. They also indicated that financial institutional development leads to an increase in carbon emissions in G20 and advanced economies. Mhadhbi et al. (2021) examined the symmetric and asymmetric relationship between stock market development and carbon emissions in their study. According to their findings, stock market development indicators in developing market economies have negative effects on environmental quality, considering both positive and negative shocks in the market. They also highlighted that negative shocks in the stock market have a greater impact on carbon emissions in developing market economies compared to positive shocks.

In the study conducted by Raghutla et al. (2021), the researchers investigated the extent to which stock market capitalization influences the demand for clean energy in major investment countries. They found that financial sector development supports clean energy projects and increases clean energy capacity. As a result, the increase in clean energy capacity contributes to a reduction in CO_2 emissions, thus enhancing environmental quality. In another study examining the relationship between financial development and CO_2 emissions in the Sub-Saharan African region, Xuezhou et al. (2021) concluded that financial development improves environmental quality, and better environmental quality is associated with increased depth, efficiency, and accessibility of the financial sector. However, the study also pointed out that financial growth may lead to an increase in energy demand and CO_2 emissions due to the expansion and diversification of firms' investment portfolios, which can jeopardize environmental quality. Zeeshan et al. (2021) analyzed the relationship between the financial structure and environmental quality of 20 developed countries with robust and strong financial systems. They observed that banking development has a positive impact on environmental quality, while stock market development has a weak and insignificant effect on the environmental quality of developed countries. In a study by Zhang et al. (2022) focusing on the nine highest carbon-emitting countries, a direct relationship between stock market development and carbon intensity was found. The research indicated that stock market development leads to an increase in carbon intensity in these countries. Conversely, in the group of 18 upper-middle-income countries with the highest growth rates, the opposite trend was observed, as demonstrated by Çetin et al. (2022), where financial development reduced CO_2 emissions. Habiba and Xinbang (2022) found that general financial development and sub-indexes significantly reduced CO_2 emissions in both developed and developing countries. However, they reported that general financial institution development and sub-indexes had a negative effect on CO_2 emissions in developed countries, while in contrast, these financial institution indexes had a positive effect on CO_2 emissions in developing countries. In their study focusing on BRICS countries, Hu et al. (2022) determined that the stock market expansion index reduced carbon pollution in all countries except India. Finally, Musah (2022) investigated the impact of stock market development on ecological footprint (EF) and environmental quality in 17 EU member countries from 1995 to 2014. The results showed that stock market development decreased EF and improved environmental quality in these countries.

In the study conducted by Shobande and Ogbeifun (2022a), the researchers investigated whether stock market investments in OECD countries increase greenhouse gas emissions. Data for the period from 1980 to 2019 were analyzed using Panel-standard fixed effects, Arellano-Bover, and Blundell-Bond dynamic methods. The analysis revealed that an increase in stock prices leads to an increase in emissions. In a study focused on Nigeria, Yu et al. (2022) found that in the short term, financial development has a positive impact on carbon emissions, while stock market performance did not significantly affect environmental pollution. However, in the long term, both financial development and stock market performance were found to significantly increase environmental pollution, indicating a one-way relationship between financial development, stock market performance, and carbon emissions. Usman et al. (2023) analyzed data for the Next-11 countries and observed that stock market and banking sector development reduced ecological footprint (EF), contributing positively to environmental quality. Yang et al. (2023) investigated the impact of financial development on CO_2 emissions in 283 Chinese cities from 2006 to 2019. The results showed that financial development has an increasing effect on CO_2 emissions. Limited studies have addressed the Load Capacity Factor (LCF) proposed by Siche et al. (2010), which allows for a more detailed assessment of environmental degradation, considering both biological capacity (supply side) and EF (demand side). Among these studies, Adebayo et al. (2022), Akadiri et al. (2022), Alola et al. (2023), and Zheng et al. (2023) found that renewable energy consumption increased LCF, while Huilan et al. (2022), Agila et al. (2022), and Xu et al. (2022) observed that it decreased LCF. Kirikkaleli and Adebayo (2022) and Khan et al. (2022) detected a negative relationship between economic growth and LCF. Only a limited number of studies have examined the relationship between LCF and financial development. Akhayere et al. (2022) investigated the impact of energy use, trade openness, and financial development on LCF in Turkey for the period 1965-2018. They found that primary energy use, trade openness, and financial development had a negative effect on LCF. Zhao et al. (2023) studied BRICS-T countries and examined the impact of renewable energy, technological innovation, stock market development, and natural resources on LCF from 1990 to 2018. Their findings revealed that stock market development negatively affected LCF and environmental quality. In studies that used CO_2 emissions, EF, and LCF as indicators of environmental quality, Adebayo and Ullah (2023) found that financial development had a negative impact on environmental quality in China, while Pata et al. (2023) found no significant effect of financial development on LCF in the United States. Pata and Tanriover (2023) observed that financial development reduced LCF in ten tourism destinations. Doytch (2023) investigated the relationship between financial development, income, and energy consumption using the Income Kuznets Curve and Financial Kuznets Curve. The study found that both Kuznets curves were applicable to indicators of stock market development and income for 48 Asian economies. Latif and Faridi (2023) examined the environmental outcomes of financial development in Asian economies using the Financial-based Environmental Kuznets Curve (FM-EKC) hypothesis. The study found a reverse U-shaped relationship between financial development and environmental quality in the examined countries.

In the reviewed literature, it has been observed that there is a limited number of studies examining the relationship between the stock market and environmental quality. These studies often neglect the supply side of environmental degradation and mostly use CO_2 emissions as an indicator of environmental pollution, with a smaller number using EF variables. Studies that consider both the supply and demand sides of environmental degradation and investigate the relationship between the Load Capacity Factor (LCF) variable and the stock market are very limited. Moreover, it is noteworthy that the sector-specific representation of stock markets, which is one of the indicators of financial development, has not been extensively addressed for the relevant countries in these studies. Therefore, this study aims to fill this gap in the literature and contribute to it by examining the relationship between the overall stock market and its sub- indexes and the LCF variable for Turkey.

3. Data and methodology

In this study, the relationship between stock market development and environmental degradation criteria for Turkey has been analyzed. For this purpose, three indexes listed on the Istanbul Stock Exchange and their respective spot closing prices were used as indicators of stock market development. The values of the indexes used in the study were obtained from www.investing.com. The CO_2 emission values from the world development indicators (WDI), EF, and LCF values were obtained from the national footprint accounts (NFA) as the indicators of environmental degradation. The analyzed index values were expressed in the local currency. Considering the inception periods of the used index values, the dataset was limited to 31 years and three indexes. The variables used in the study are shown in Table 1. The analysis covers annual data from 1991 to 2021. To stabilize the dataset, all analyses were performed by taking the natural logarithm of the used data.

Table 1. *Dataset of Indexes and Environmental Variables*

Stock markets	Symbol
BIST 100	XU100
Financial	XUFIN
Industrial	XUIND
Carbon emissions	CO_2
Ecological footprint	EF
Load capacity factor	LCF

Source: Author.

Descriptive statistics for the analyzed dataset are presented in Table 2. According to Table 2, among the indexes, the financial index has the highest mean value, while the BIST 100 index has the lowest mean value. Additionally, the BIST 100 index has the lowest standard deviation value. All indexes exhibit positive skewness values, indicating that the series are right-skewed. The kurtosis values for all the indexes are positive and leptokurtic. Based on the Jarque-Bera test statistics, only the financial index follows a normal distribution.

Among the environmental degradation criteria presented in Table 2, carbon emissions have the highest mean value. Similarly, while carbon emissions have the highest value, the load capacity factor has the lowest value. Based on the skewness values, the ecological footprint (EF) exhibits negative skewness and is left-skewed. On the other hand, carbon emissions and the load capacity factor have positive skewness values, indicating that their series are right-skewed.

Table 2. *Descriptive Statistics for Variables*

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
XU100	473.496	391.170	1857.650	0.400	480.115	1.068	3.648	6.437	0.040
XUFIN	597.439	601.680	1754.060	0.240	535.358	0.432	1.988	2.287	0.318
XUIND	533.194	308.970	3404.160	0.490	747.690	2.365	8.857	73.229	0.000
CO_2	4.020	4.055	5.263	2.858	0.785	0.020	1.583	2.592	0.273
EF	2.987	3.023	3.476	2.354	0.352	-0.371	1.833	2.470	0.290
LCF	0.580	0.562	0.821	0.440	0.115	0.522	2.176	2.287	0.318

Source: Author's calculation.

All series related to environmental degradation criteria exhibit positive and leptokurtic kurtosis values. According to the Jarque-Bera test values, all series of environmental degradation criteria show the characteristic of normal distribution.

Three separate models have been established to investigate the relationship between the Borsa Istanbul stock market, represented by the BIST 100 as the main index and the financial and industrial indexes as the underlying indexes, and the environmental degradation indicators represented by the LCF, CO_2, and EF variables. The models are as follows:

Model 1: lnLCF = lnXU100 + lnXUFIN + lnXUIND + ε

Model 2: $\ln CO_2$ = lnXU100 + lnXUFIN + lnXUIND + ε

Model 3: lnEF = lnXU100 + lnXUFIN + lnXUIND + ε

After the establishment of the models, first, the BDS linearity tests were conducted to determine whether the series used in the analysis are linear or not. According to the results obtained from the linearity tests, it was determined that none of the dependent and independent variables are in linear form and they exhibit a nonlinear structure. The detailed results of these tests can be found in the appendix section of the study. Additionally, it is one of the objectives of the study to examine the short and long-term relationships between these variables and to identify any asymmetric effects in these relationships. Considering the stated objectives and the results of the linearity tests, the Non-linear Autoregressive Distributed Lag (NARDL) test was selected as the most appropriate analysis method. The relevant method and the NARDL-based error correction model (ECM) can be expressed as follows:

$$y_t = \sum_{j=1}^{p} \phi_j y_{t-j} + \sum_{j=0}^{q} \left(\theta_j^{+'} X_{t-j}^{+} + \theta_j^{-'} X_{t-j}^{-} \right) + \varepsilon_t \tag{1}$$

$$\Delta y_t = \rho \xi_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(\pi_j^{+'} \Delta X_{t-j}^{+} + \pi_j^{-'} \Delta X_{t-j}^{-} \right) + e_t \tag{2}$$

Here, Y is the dependent variable, and X is the independent variable for both the NARDL model and the NARDL-based ECM. φ and ϒ represent the autoregressive parameters, while ξ symbolizes the nonlinear error correction term. Additionally, θ and π denote the delay parameters for the NARDL model and NARDL-based ECM, respectively, and ρ represents the long-term parameter. Finally, ε and e respectively represent the error terms for the NARDL model and NARDL-based ECM (Shin et al., 2014: pp. 288-291).

4. Empirical results

After determining the econometric method to be used, first, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were conducted to check the stationarity of the variables and identify at which stage they became stationary. The test results are presented in the table 3 below.

Table 3. *Unit Root Test Results*

	ADF		PP	
	Level	First Difference	Level	First Difference
lnLCF	- 3.595**	- 4.525***	- 4.771***	-
lnCO_2	- 3.292**	- 3.606**	- 3.504**	- 3.501**
lnEF	- 4.432***	-	- 7.904***	-
lnXU100	- 1.848	- 3.947***	- 0.912	- 7.615***
lnXUFIN	- 2.92*	- 3.606**	- 1.74	- 7.368***
lnXUIND	- 0.251	- 6.26***	0.542	- 6.577***

Note: *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.
Source: Author's calculation.

As shown in the table above, according to the ADF unit root test, the lnEF variable is stationary at the level with a significance level of 1%, while the lnLCF, lnXU100, and lnXUIND variables become stationary at the first difference with a significance level of 1%. Additionally, the lnXUFIN variable also becomes stationary at the first difference with a significance level of 5%. On the other hand, according to the PP unit root test, the lnLCF and lnEF variables are stationary at the level with a significance level of 1%, while the lnXU100, lnXUFIN, and lnXUIND variables become stationary at the first difference with a significance level of 1%. Finally, the lnCO_2 variable is stationary at the first difference with a significance level of 5%. Thus, all the variables used in the analysis are either stationary at the level or become stationary at the first difference. The absence of any variable becoming stationary at second or higher orders indicates that the variables used in the analysis are in a suitable form for the NARDL model in terms of stationarity.

After conducting the unit root tests, suitable lag lengths were determined for the established NARDL models. Accordingly, for all three models, the appropriate lag length was identified as two lags. The detailed information about the suitable lag lengths for the NARDL models can be found in the appendix section of the study. Based on the test results, it was found that there is no problem in using the series used in the analysis in the applied econometric method. After determining the lag lengths of the models, it was established that the models will be estimated using the NARDL method. The forecasting results of the established models using the NARDL method are presented in the table 4 below.

Table 4. *NARDL Test Results*

	Short Run Coefficients (Std. Error)		Long Run Coefficients (Std. Error)		NARDL Bound Tests	
LCF (NARDL 1)	ΔlnXU100(+)	- 0.975*** (0.151)	lnXU100(+)	2.5822*** (0.5)	F - Statistic	10.901
	ΔlnXU100(-)	- 0.193 (0.238)	lnXU100(-)	- 3.077*** (0.314)	10 %	LB = 1.75 UB = 2.87
	ΔlnXUFIN(+)	0.492*** (0.098)	lnXUFIN (+)	- 1.588*** (0.29)	5 %	LB = 2.04 UB = 3.24
	ΔlnXUFIN (-)	0.174 (0.169)	lnXUFIN (-)	2.264*** (0.198)	1 %	LB = 2.66 UB = 4.05
	ΔlnXUIND(+)	0.532*** (0.062)	lnXUIND (+)	- 0.856*** (0.194)		
	ΔlnXUIND (-)	- 0.011 (0.099)	lnXUIND (-)	0.913*** (0.137)		
	lnLCF(-1)	0.299** (0.104)				
	ECT(-1)	- 0.701*** (0.054)				
CO_2 (NARDL 2)	ΔlnXU100(+)	0.471*** (0.184)	lnXU100(+)	0.28 (0.223)	F - Statistic	5.999
	ΔlnXU100(-)	- 1.662** (0.597)	lnXU100(-)	- 1.677* (0.826)	10 %	LB = 2.98 UB = 4.26
	ΔlnXUFIN(+)	- 0.067 (0.131)	lnXUFIN(+)	- 0.067 (0.133)	5 %	LB = 3.58 UB = 5.07
	ΔlnXUFIN(-)	1.363*** (0.198)	lnXUFIN(-)	1.714** (0.648)	1 %	LB = 5.05 UB = 6.93
	ΔlnXUIND(+)	- 0.477*** (0.076)	lnXUIND(+)	- 0.306* (0.106)		
	ΔlnXUIND (-)	0.27*** (0.098)	lnXUIND (-)	- 0.032 (0.225)		
	lnCO_2(-1)	0.009 (0.255)				
	ECT(-1)	- 0.991*** (0.13)				
EF (NARDL 3)	ΔlnXU100(+)	- 0.366** (0.122)	lnXU100(+)	- 1.453*** (0.367)	F - Statistic	11.874
	ΔlnXU100(-)	- 2.596*** (0.336)	lnXU100(-)	- 3.478*** (0.656)	10 %	LB = 2.78 UB = 3.94
	ΔlnXUFIN(+)	0.32*** (0.07)	lnXUFIN(+)	0.972*** (0.232)	5 %	LB = 3.33 UB = 4.65
	ΔlnXUFIN(-)	1.682*** (0243)	lnXUFIN(-)	3.07*** (0.493)	1 %	LB = 4.69 UB = 6.36
	ΔlnXUIND(+)	- 0.016 (0.066)	lnXUIND(+)	0.272* (0.118)		
	ΔlnXUIND(-)	0.917*** (0.114)	lnXUIND(-)	0.327* (0.173)		
	lnEF(-1)	0.038 (0.069)				
	ECT(-1)	- 0.962*** (0.072)				

Note: *, **, and *** indicate 10%, 5%, and 1% significance levels, respectively.
Source: Author's calculation.

Based on the results obtained from the NARDL 1 model, it is observed that in the short term, positive movements in the BIST 100 index significantly and negatively affect LCF. Additionally, increases in both the financial and industrial indexes, as well as one-period lagged values of LCF, have a significant and positive impact on LCF in the short term.

Moreover, shocks occurring in LCF are quickly dampened with a coefficient of approximately 0.7. On the other hand, in the long term, increases in the BIST 100 index and decreases in both the financial and industrial indexes have a significant and positive effect on LCF, while decreases in the BIST 100 index and increases in both the financial and industrial indexes negatively influence LCF.

According to the results obtained from the NARDL 2 model, in the short term, positive movements in the BIST 100 index and negative movements in both the financial and industrial indexes significantly increase CO_2 emissions. Additionally, a decrease in the BIST 100 index and an increase in the industrial index significantly reduce CO_2 emissions in the short term. Moreover, shocks occurring in CO_2 emissions are quickly dampened with a coefficient of approximately 0.99. On the other hand, in the long term, decreases in the BIST 100 index and increases in the industrial index have a significant reducing effect on CO_2 emissions, while decreases in the financial index increase CO_2 emissions.

Finally, according to the results obtained from the NARDL 3 model, both increases and decreases in the BIST 100 index significantly reduce EF in the short term. Additionally, increases and decreases in the financial index and decreases in the industrial index significantly increase EF in the short term. Moreover, shocks occurring in EF for any reason are eliminated with a coefficient of approximately 0.96. On the other hand, in the long term, both upward and downward movements of the BIST 100 index significantly reduce EF, while both positive and negative movements in the financial and industrial indexes significantly increase EF.

After presenting the results of the econometric forecasts, the diagnostic tests conducted for the established models are also shown in the table 5 below.

Table 5. *Robustness Checks*

	LCF (NARDL 1)	CO_2 (NARDL 2)	EF (NARDL 3)
R^2	0.97	0.75	0.96
R^2adj	0.95	0.68	0.94
F – Statistic		11.13 (0.000)	34.23 (0.000)
Log likelihood	90.01	68.61	81.78
RR	1.3 (0.26)	0.95 (0.36)	1.54 (0.17)
BG LM	3.7 (0.15)	1.25 (0.32)	2.59 (0.15)
BPG	0.32 (0.96)	0.28 (0.99)	0.7 (0.75)
JB	4.12 (0.13)	4.79 (0.09)	0.48 (0.79)

Source: Author’s calculation.

In this context, according to the Ramsey Reset test, Breusch-Godfrey serial correlation test, and Breusch-Pagan-Godfrey changing variance test, all three NARDL models are stable models that do not exhibit autocorrelation and have constant variance (homoscedasticity). On the other hand, according to the Jarque-Bera normality test, the first and third NARDL models exhibit normal distribution, while the second NARDL model exhibits normal distribution at the 5% significance level. Additionally, the Cusum and Cusum-Q tests conducted for all three models indicate that there are no structural breaks in the models. Detailed results of the Cusum and Cusum-Q tests can be found in the appendix section of the study.

5. Conclusion and Policy Recommendations

Increasing the environmental quality for sustainable development has become a crucial aspect for countries. In this context, studies evaluating variables related to improving environmental quality (Zeeshan et al., 2021; Hu et al., 2022; Usman et al., 2023) have clearly highlighted the importance of financial development. However, research focusing on the relationship between financial development and environmental quality in the context of Turkey (Akhayere et al., 2022) has been limited. This study examines the asymmetric effects of stock market development, representing a single dimension of financial development, on environmental quality in Turkey. For this purpose, spot closing price values of three different BIST 100, Financial, and Industrial indexes available in Borsa Istanbul, along with the indicators of environmental degradation, namely CO_2 emissions, EF, and LCF, for the period of 1991-2021, have been utilized. To measure the nonlinear relationship between stock markets and environmental degradation indicators, a nonlinear Autoregressive Distributed Lag (ARDL) model has been employed in this study.

The short-term results obtained from the study reveal that an increase in the BIST 100 index leads to a reduction in LCF and EF, while it increases CO_2 emissions. Moreover, an increase in both the financial and industrial indexes results in higher LCF, while an increase in the industrial index leads to a reduction in CO_2 emissions, and an increase in the financial index causes an increase in EF. On the other hand, a decrease in the BIST 100 index leads to a decrease in both EF and CO_2 emissions, while a decrease in both the financial and industrial indexes results in an increase in CO_2 emissions and EF. The long-term results, which show similar outcomes with minor differences, indicate that an increase in the BIST 100 index leads to an increase in LCF, while a decrease in the index causes a reduction in LCF. Furthermore, an increase in both the financial and industrial indexes results in a decrease in LCF, while a decrease in these indexes leads to an increase in LCF. Additionally, a decrease in the BIST 100 index and an increase in the industrial index contribute to a reduction in CO_2 emissions, whereas a decrease in the financial index causes an increase in CO_2 emissions. It is observed that both an increase and a decrease in the BIST 100 index lead to a reduction in EF, while an increase and a decrease in the financial and industrial indexes result in an increase in EF.

In the long term, developments in the stock markets representing the industrial sector appear to reduce energy consumption and mitigate CO_2 emissions. However, it is evident that these developments have a negative impact on the demand side of the environment. This suggests that the majority of companies listed in the industrial index tend to excessively and unsustainably deplete environmental resources. To address this issue and enhance Turkey's biocapacity, it is essential to adopt policies promoting efficient resource utilization, increasing the adoption of environmentally-friendly and renewable energy resources, and implementing measures to improve energy efficiency. Furthermore, policymakers need to adhere to international agreements concerning biological diversity, climate change, and protected areas related to environmental issues. Imposing sanctions on non-environmentally-friendly companies and providing incentives and support for environmentally conscious companies are crucial steps to improve environmental quality. By embracing such policies, Turkey can work towards a more sustainable future, preserving its natural resources, and safeguarding the environment for generations to come.

In the long term, the developments in the stock markets where companies constituting the financial index trade are observed to negatively affect the demand side of the environment similar to the impact on the industrial index. Consequently, it can be argued that the companies forming this stock market mainly consist of entities and sectors that contribute to increased consumption and have adverse environmental effects. In this context, policymakers can support environmentally-conscious companies, sectors, and investments by providing low-cost financing options and implement measures that increase the cost of financing for sectors or companies engaged in activities that contribute to environmental degradation. By doing so, they can make it more challenging for these companies to obtain funding, while facilitating funding for environmentally sensitive firms and investments by financial institutions. In this way, the promotion of financing environmentally-friendly companies and investments can lead to improvements in environmental quality.

The long-term development in the BIST 100 index, which represents the main benchmark index consisting of the largest 100 companies, has been found to positively impact both the supply and demand sides of the environment. This finding may be attributed to an increase in the share of renewable energy consumption in the production and manufacturing activities of the listed companies, facilitated by easier access to financing. Therefore, to promote a sustainable economy, relevant authorities are recommended to enforce strict environmental regulations and instruct and implement policies for all companies listed in the stock market to adopt more environmentally-friendly technologies and support their financing. Considering all the results together, policymakers are advised to build robust institutional structures that support renewable energy consumption, provide incentives for companies to embrace environmentally enhancing investments and technologies, offer tax advantages for investors in environmentally conscious firms, and provide credit support for production and manufacturing companies engaged in activities that improve environmental quality and reduce excessive exploitation of natural resources.

Future studies can be expanded for the stock market by including a wider range of different sectors. Additionally, by using monthly data and analyzing it with various econometric methods, more detailed results can be obtained. Furthermore, similar research could be conducted on different country groups to enable comparisons between countries or regions.

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Appendix

Table A1. *BDS test outcomes*

	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6
lnLCF	0.192*	0.327*	0.421*	0.487*	0.531*
lnCO2	0.192*	0.333*	0.436*	0.503*	0.549*
lnEF	0.193*	0.331*	0.423*	0.476*	0.51*
lnXU100	0.133*	0.235*	0.314*	0.373*	0.425*
lnXUMAL	0.155*	0.274*	0.342*	0.401*	0.449*
lnXUSIN	0.115*	0.185*	0.256*	0.314*	0.306*

%1, %5 ve %10 anlamlılık düzeyleri, sırasıyla, *, **, *** şeklindedir.
Source: Author's calculation.

Table A2. *Model 1 Lag Selection*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	27.98	-	2.12e-06	- 1.71	- 1.52	- 1.65
1	108.13	131.68	2.20e-08	- 6.29	- 5.34	- 6
2	143.31	47.75*	6.06e-09*	- 7.66*	- 5.95*	- 7.14*
3	157.98	15.71	8.25e-09	- 7.57	- 5.1	- 6.81

Source: Author's calculation.

Table A3. *Model 2 Lag Selection*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	27.1	-	2.26e-06	- 1.65	- 1.46	- 1.59
1	114.73	143.97	1.37e-08	- 6.77	- 5.81	- 6.48
2	147.36	44.28*	4.54e-09*	- 7.95*	- 6.24*	- 7.43*
3	160.75	14.35	6.76e-09	- 7.77	- 5.29	- 7.01

Source: Author's calculation.

Table A4. *Model 3 Lag Selection*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	30.17	-	1.81e-06	- 1.87	- 1.68	- 1.81
1	107.17	126.51	2.36e-08	- 6.23	- 5.28	- 5.94
2	141.93	47.17*	6.68e-09*	- 7.57	- 5.85*	- 7.04*
3	159.66	18.99	7.31e-09	- 7.69*	- 5.22	- 6.93

Source: Author's calculation.

Figure 1. *Model 1 Cusum and Cusum-q Tests' Outcome*

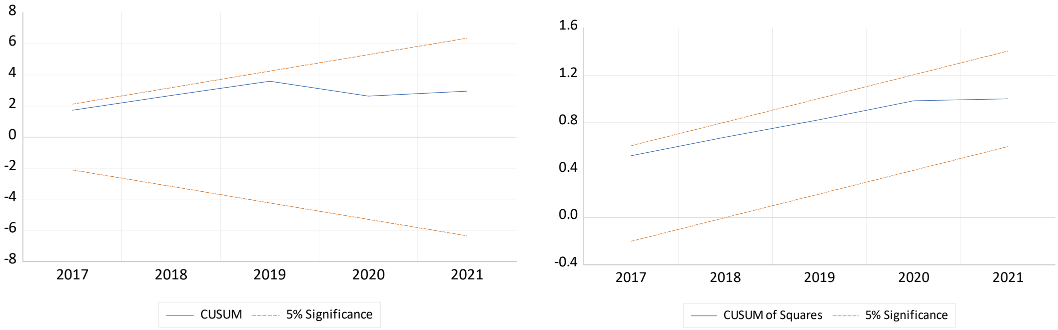

Figure 2. *Model 2 Cusum and Cusum-q Tests' Outcome*

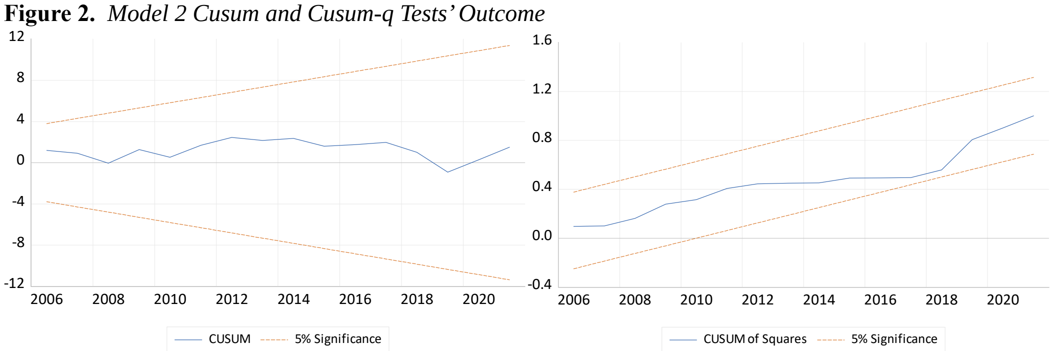

Figure 3. *Model 3 Cusum and Cusum-q Tests' Outcome*