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The Influence of Islamic Financial Development, Political Stability, Economic Growth, and Urbanization on Environmental Quality in OIC Countries

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Abstract: This study aims to examine the effects of Islamic financial development, political stability, economic growth, and urbanization on environmental quality in the member countries of the Organization of Islamic Cooperation (OIC). The analysis utilizes data from the period 2013 to 2023 and investigates both marginal and dynamic interactions among the variables using econometric methods, including machine learning algorithms, Kernel Regularized Least Squares (KRLS), and Generalized Method of Moments (GMM). The findings indicate that economic growth contributes to environmental improvement under low-emission conditions but has a detrimental effect under high-emission scenarios. Political stability positively influences environmental quality in low-emission contexts, while it exerts a negative impact in high-emission settings. Urbanization generally helps reduce emissions; however, in high-emission regions, it increases environmental pressure. Islamic financial development is found to increase emissions on average, though it may contribute to emission reductions when implemented through environmentally friendly financial practices in low-emission contexts.

Keywords: Islamic Financial Development, Political Stability, Environmental Quality, Economic Growth, OIC member countries

Jel Codes: O11, O16, Q43

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Introduction

Today, financial development is regarded as one of the fundamental drivers of economic growth (Ibrahim & Alagidede, 2018). The acceleration of capital flows and the expansion of investment opportunities contribute to the deepening of financial systems (Qamruzzaman & Jianguo, 2020). As a result, the evolving financial structure promotes sustainable growth by enhancing productive investment channels and enabling more efficient resource allocation (Quartey, 2008; Ouyang & Li, 2018). Gurley & Shaw (1955), Goldsmith (1969), Hicks (1969) & Levine (1999) asserted that well developed financial markets stimulate economic growth by mobilizing savings and facilitating investment. However, the deepening of financial markets and the subsequent acceleration of economic growth can also lead to increased production and industrial activity, thereby intensifying pressure on natural resources and paving the way for environmental degradation (Shahbaz et al., 2015; Stern, 2007; Sadorsky, 2010; Panayotou, 1993). A financial structure that encourages higher credit distribution at lower costs leads to increased industrialization activities. Therefore, since the developing industry requires more energy consumption, it may initially cause environmental quality to deteriorate (Dasgupta et al., 2001; Sadorsky, 2010; Khan et al., 2017; Danish et al., 2018). Greenhouse gas emissions are the primary problems that cause environmental degradation. The most harmful greenhouse gas among these emissions is known as CO_2 (IPCC, 2013). In light of these dynamics, the environmental implications of financial development have received growing attention in the literature, particularly regarding its impact on CO_2 emissions (Zhang, 2011; Boutabba, 2014; Çetin & Bakırtaş, 2019; Abduh et al., 2022; Bui, 2020; Hasan et al., 2021; Tamazian et al., 2009; Zaidi et al., 2019; Raghutla & Chittedi, 2021).

While countries develop various policies to mitigate the environmental impacts of financial development, Islamic finance has emerged as a supportive mechanism through its emphasis on ethical and sustainable investment models (Shahid et al., 2024). In particular, Islamic finance, which is based on interest-free and ethical finance understanding, has become a strong sector in recent years (Hassan et al., 2020). With its emphasis on risk sharing and its direct connection to the real economy, Islamic finance introduces a distinct approach within financial markets. According to Liu & Lai (2021), Islamic finance has become a part of the international financial system by fulfilling the elements of a sustainable financial system (Shahid et al., 2024; Hachicha & Ben Amar, 2015; Alhammadi, 2024; Brescia et al., 2021; Hassan et al., 2020).

Islamic finance is making great progress in most Muslim countries. This type of finance, which has expanded its sectoral assets, has managed to reach 4.5 trillion dollars in sectoral assets according to 2022 data (ICD, 2022). In addition, especially the member countries of the Organisation of Islamic Cooperation prioritise climate and environmental protection in their sectoral policies. These countries include projects implemented on climate risk in their financial development strategies. In addition, many of these countries participate in the global value chain (GVC) member countries partnership strategy (MCPS) of the Islamic Development Bank, which includes the analysis of climate risk. In addition, Green Sukuk, which are recognised as green bonds and pioneered by Indonesia and Malaysia in particular, are another prominent example. These funds are used to fund low-carbon initiatives (OECD, 2020; Irfany, 2024). However, Islamic finance competes within conventional financial markets and therefore regulates its application areas largely within the framework of conventional standards (Nadwi et al., 2024). This has paved the way for the emergence of studies suggesting that Islamic finance also has the potential to increase energy consumption and may cause environmental degradation, especially in terms of CO_2 emissions (Nofianti & Okfalisa, 2017; Fatoni, 2021; Abduh et al., 2022; Global Change Data Lab., 2022).

Islamic finance differs from conventional finance due to its interest-free banking approach based on moral and religious values. At this point, the effects of Islamic finance on environmental degradation and sustainable development are discussed from different perspectives (Nofianti & Okfalisa, 2017; Fatoni, 2021; Abduh et al., 2022; Shahid et al., 2024; Hachicha & Ben Amar, 2015; Alhammadi, 2024). Moreover, supporting political stability, industrialisation, urbanisation and economic growth in countries adopting Islamic finance may have different impacts on environmental quality. In this context, analysing the impact of Islamic financial development, political stability, economic growth and urbanisation on environmental quality in Islamic countries is of great importance for sustainable development. Studies on Islamic financial development and environmental degradation are quite limited in the literature (Sadorsky, 2010; Irfany et al., 2024a).

This study aims to examine the effects of Islamic financial development, political stability, economic growth, and urbanisation on environmental quality in OIC member countries. In this study, CO_2 emissions were selected as the main indicator and used as the dependent variable to measure environmental quality, in parallel with the approaches of Zhang et al., (2020) and Halıcıoğlu (2009). The most important contribution of the study to the literature is that the studies examining the

relationship between Islamic financial development and the environment are quite limited. While previous studies have focused on the relationship between financial development and the environment, this study examines the relationship between Islamic financial development, urbanisation, and political stability. This is because environmental quality is affected not only by economic and financial activities but also by political and demographic changes in countries. There are many opinions that urbanisation and political stability have a significant impact on the environment (Sadorsky, 2014; Shahbaz et al., 2015; Adebayo et al., 2022; Kirikkaleli & Osmanlı, 2023; Deng et al., 2024). Another unique aspect of the study is that the model established in the study is estimated by a Machine Learning (ML) algorithm. In the study, Hainmueller & Hazlett (2014) KRLS quantile regression method, which can reach strong interactions even among the most complex variables and reveal the marginal effects of variables at different quantiles (0.25, 0.50, and 0.75), was used. The robustness check of the model results estimated by this method is also provided by the Generalised Method of Moments (GMM) dynamic regression model. The results of the study allow for proper decision-making for the government and companies in the future, the basis of green banking and green financing policies, especially for Sharia banking in OIC member countries, and the possibility of providing explanations to researchers on various other forms of unexamined issues.

This study consists of four sections, including the introduction. The second section includes studies focusing on the relationship between Islamic financial development and the environment. The third section introduces the methodology and dataset of the study, followed by a discussion of the findings. The final section presents policy recommendations based on the results.

Literature Review

Islamic Financial Development and Environmental Quality

Islamic financial development encourages ethical and sustainable investments in environmentally friendly sectors such as renewable energy by avoiding interest and speculation (Maulidiyah & Auwalin, 2021; Muhmad et al., 2021). Various studies have shown that Islamic finance has positive effects on environmental quality and has the potential to support environmental sustainability (Jalil & Feridun, 2011; Shahbaz et al., 2013b; Iqbal & Mirakhor, 2011; Ibrahim et al., 2021; Siddiquee, 2019; Myers & Hassanzadeh, 2013; Ali et al., 2020; Jan et al., 2021; Alhammadi, 2024). According to the study of Tretter et al., (2018), the Islamic finance sector in

developing countries has been associated with lower carbon emissions compared to conventional finance systems. Tiwari & Nasir (2013) also noted that increasing local credit provided to the private sector in the short and long term reduced environmental emissions in the case of South Africa. Iskandar et al., (2020) found that CO_2 emissions from residential buildings and commercial and public services sectors in Indonesia were significantly associated with the development of Islamic finance in the country. Therefore, the country should promote environmentally friendly activities towards energy conservation through Islamic finance development to control CO_2 emissions and protect the environment. In addition, Yasirwan et al., (2024) analyzed the impact of Islamic finance, economic growth, and globalization (economic, social, political, and general aspects) on CO_2 emissions for four countries where Islamic finance is implemented. According to the findings, they concluded that Islamic finance reduces CO_2 emissions in the long run.

However, some studies suggest that Islamic finance may negatively affect environmental quality and examine this relationship with empirical methods. The common point of these studies is that they argue that environmentally friendly investments are insufficient in Islamic finance practices and that the system mostly adopts economic growth and profit-oriented investment strategies instead of environmentally friendly projects (Islam et al., 2013; Farhani & Öztürk, 2015; Salahuddin et al., 2018; Irfany et al., 2024a; Irfany et al., 2024b). In the study conducted by Nengsih et al., (2023), Islamic financial development in Indonesia has a statistically significant and negative impact on environmental quality at a significance level of 10%. Abduh et al., (2022) covering the six top Islamic finance countries of the world in the period 2013-2018, Islamic financial development increased energy consumption and significantly contributed to the deterioration of environmental quality. Ivanka et al., (2024) highlighted that Islamic financial development in Indonesia has a negative impact on environmental quality, but this negative impact is not statistically significant and does not have significant significance in both the short and long term. Al-Silefanee et al., (2022) stated that the expansion and depth of Islamic finance caused a non-linear increase in CO_2 emissions with a U-shaped relationship, but the increase in Islamic social responsibility and consumer education, and awareness about Islamic banking reduced the increasing effects of energy consumption on CO_2 emissions. Mahmood & Masih (2018), who explored the relationship between Islamic bank performance and CO_2 emissions, found the existence of a correlation between Islamic banks and CO_2 emissions. However, they concluded that this correlation was positive in some cases and negative in some cases. In this context, they emphasized the need to examine the tendencies of po-

licymakers to provide guidelines that will motivate the Islamic banking sector to reduce CO_2 emissions.

Economic Growth and Environmental Quality

One of the most common theories in the literature examining the relationship between economic growth and environmental quality is the Environmental Kuznets Curve (EKC) hypothesis. According to this hypothesis put forward by Grossman & Krueger (1991), although economic growth initially causes environmental degradation, emissions decrease after a certain income level due to increased environmental awareness and the adoption of clean technologies. In the literature, the validity of the Environmental Kuznets hypothesis has been the subject of numerous studies for different periods and country groups. The results of empirical studies on the EKC hypothesis are complex and vary across countries Stern, (2004); Dinda, (2004). In this context, the scope of analysis has been expanded by including explanatory variables such as financial development, urbanization, industrialization and energy consumption in the models, which are common in studies examining the effects of economic growth on environmental quality. In this context, Tamazian et al., (2009); Jalil & Feridun (2011); Shahbaz et al., (2013b); Sulaiman et al., (2013); Boutabba (2014); Farhani et al., (2014); Apergis & Öztürk (2015); Charfeddi & Khediri (2016); Omri et al., (2015); Sinha & Shahbaz (2018) concluded that the Environmental Kuznets hypothesis is valid with their studies, while Farhani & Öztürk (2015); Bhattacharya et al., (2017); Doğan & Öztürk (2017); Bora & Atasoy (2018) concluded that the Environmental Kuznets hypothesis is not valid with their studies. These results reveal that countries need to manage their energy consumption more effectively in order to implement sustainable environmental policies and achieve sustainable economic growth. In this context, encouraging the use of renewable energy sources is of critical importance.

Urbanization and Environmental Quality

It is emphasized that urbanization is a rapidly increasing process with economic growth and population growth worldwide, and it is stated that this process directly and indirectly affects CO_2 emissions through infrastructure development, energy consumption and changes in transportation systems. There are many studies in the literature examining CO_2 emissions focused on urbanization. In these studies, it has been revealed that the effect of urbanization on CO_2 emissions generally varies depending on factors such as income level, industrialization level and energy consumption models. For example, Shahbaz et al., (2017) showed that urbani-

zation causes CO_2 emissions by increasing energy consumption. Sadorsky (2014) stated that urbanization increases dependence on fossil fuels and, as a result, CO_2 emissions increase. In parallel with these examples, there are many empirical studies proving that urbanization increases CO_2 emissions (Wang et al., 2014; Liu & Bae, 2018; Acheampong, 2019; Sadorsky, 2014; Lee, 2019; Raheem & Ogebe, 2017; Asumadu-Sarkodie & Owusu, 2017; Liu et al., 2014).

On the other hand, there are also studies that find that urbanization has positive effects on CO_2 emissions (Poumanyvong & Kaneko, 2010; Martínez-Zarzoso & Maruotti, 2011; Nguyen et al., 2017; Pata, 2018; Wang et al., 2019). Empirical literature reveals that the direction of the relationship between urbanization and CO_2 emissions varies depending on the development levels of countries.

Political Stability and Environmental Quality

Studies on how political stability affects CO_2 emissions reveal different results when different geographical regions and economic conditions are taken into account. Empirical studies on the subject show that political stability reduces CO_2 emissions, while political instability increases CO_2 emissions. Fatah & Altaee (2024) concluded that political stability reduced CO_2 emissions in nine Arab resource-rich countries (ANRAC) from 1996 to 2019. Kirikkaleli & Osmanlı (2023) examined the relationship between political stability and environmental quality using the 1990-2019 data for Türkiye with the NARDL, DOLS method. The results obtained from the study show that political stability increases environmental quality. Similarly, Sohail et al., (2022) analyzed the relationship between political stability and CO_2 emissions using 1990-2019 data for Pakistan with the help of ARDL. The results show that political stability reduces CO_2 emissions. Similarly, Abid (2016) for SSA countries, Vu & Huang (2020) for Vietnam, and Benlemlih et al., (2022) found that political stability has a positive impact on the environment in the short term in 145 countries; however, this impact is not sustained in the long term. In contrast to these findings, Dong et al., (2021), using panel data from 66 countries, found that the effect of political risks on CO_2 emissions is both heterogeneous and asymmetric. This result generally suggests that the scale and technical effects of political risks will reduce CO_2 emissions.

Data and method

Data

The study investigates the relationship between Islamic financial development, political stability, economic growth, urbanization and environmental quality using annual data for the period 2013-2023 in 16 member countries of the Organization of Islamic Cooperation (OIC): Bangladesh, Brunei, Indonesia, Iran, Jordan, Kazakhstan, Kuwait, Lebanon, Nigeria, Oman, Pakistan, Qatar, Saudi Arabia, Sudan, United Arab Emirates, Türkiye. These countries were selected considering the data limitations for the period 2013-2023. In particular, the limited availability of Islamic financial development data played a decisive role in this selection process. In previous empirical studies (Elfeituri, 2022; Mensi et al., 2020), the ratio of Islamic banking assets to GDP is used to evaluate the Islamic financial development. However, this study focuses on the total size of these assets to measure Islamic banking activities. In addition, the reports of the International Financial Services Board consider the total assets of Islamic banks as an important indicator of financial deepening (Minhajuddin & Ibrahim, 2022). Accordingly, the Islamic financial development (IFD) variable is used to represent the total assets of Islamic banking in our study (Mawardi et al., 2024).

Considering that CO_2 emissions are generally used in measuring environmental damage at the country level by Zhang et al., (2020) & Halıcıoğlu (2009), CO_2 emissions were preferred as the main indicator of environmental quality in this study and were considered as the dependent variable in the study. Political stability (PS), urbanization (URB) and economic growth (GDP) variables are used as explanatory variables. Political stability refers to the ability of a country's governance structure to continue in a secure and sustainable manner and is determined by the political risk index. The level of this element can be an important factor in the implementation of environmental policies and the path to net zero emissions. GDP per capita (in constant 2010 US dollars) is considered an indicator of a country's economic development and can affect both the production and consumption sides of CO_2 emissions. Urbanization, expressed as the urban population ratio, is examined as an important variable affecting emission dynamics and environmental pressures. The real economy and ethical principles-oriented structure of IFD can facilitate the financing of more sustainable projects by encouraging direct asset-based and long-term investments. This can contribute to the reduction of CO_2 emissions by increasing the provision of resources for projects such as renewable energy or low-carbon technologies. Definitions and sources of variables are shown in Table 1.

Table 1

Variable definitions and data sources

Variable	Variables Description	Definition	Source
CO_2	Carbon dioxide emissions	Carbon intensity of GDP (kg CO_2 per constant 2015 US$ of GDP)	World Bank World Development Indicators (WDI)
IFD	Islamic financial development	Islamic Banking, Total Assets (in Millions)USD	The Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC)
PS	Political stability	Political Stability and Absence of Violence/Terrorism: Percentile Rank	World Bank Governance Database (WGI)
GDP	Economic growth	GDP per capita (constant 2015 US$)	World Bank World Development Indicators (WDI)
URB	Urbanization	Urban population	World Bank World Development Indicators (WDI)

The logarithmic linear regression model used in the study is shown in Equation (1).

$$LNCO_{2it}=\beta_0+\beta_1 LNIFD_{it}+\beta_2 LNPS_{it}+\beta_3 LNGDP_{it}+\beta_4 LNURB_{it}+\mathcal{E}_{it} \quad (1)$$

In the equation, i is the cross-section, t is the time, β_0 is the constant term, $\beta_{1,2,3,4}$ are the long-term coefficients, and ε_{it} is the error term.

Table 2 presents a summary of the statistical properties of the variables over the analysis period.

Table 2

Summary statistics

	CO_2	GDP	PS	URB	IFD
Mean	0.694610	16104.14	33.36386	37915013	422.6874
Median	0.596600	9201.632	27.00000	12244378	75.60900
Maximum	1.636755	76486.97	94.80000	1.65E+08	7172.000
Minimum	0.232348	767.2488	0.900000	312501.0	3.903000
Std. Dev.	0.320547	17763.80	27.44012	43408382	1092.845
Observations	176	176	176	176	176

When the summary statistics of the variables are examined for OIC member countries, the lowest value of the CO_2 variable is calculated as 0.232348 and the highest value is 1.636755, the mean is 0.694610, and the median is 0.596600. The presence of 176 observations for all variables indicates that the panel has a balanced data set.

Table 3

Correlation matrix

	$LNCO_2$	LNIFD	LNPS	LNGDP	LNURB
$LNCO_2$	1.0000				
LNIFD	0.212685	1.0000			
LNPS	0.359901	0.047681	1.0000		
LNGDP	0.383612	0.208605	0.782675	1.0000	
LNURB	-0.268796	0.0513342	-0.646159	-0.658793	1.0000

According to the information in Table 3, LNIFD has a slightly positive but weak relationship with $LNCO_2$ emissions in OIC member countries. LNPS and LNGDP affect $LNCO_2$ emissions in the same direction, while LNURB exhibits an inverse relationship with $LNCO_2$ emissions.

Empirical Methodology and Results

KRLS regression and GMM dynamic regression

KRLS (Kernel-based Regularized Least Squares) was developed by Hainmueller & Hazlett (2014) as a machine learning-based approach. This method can be applied in regression analysis without being dependent on strict model constraints or certain preconceptions. KRLS, which determines the most appropriate function for the data

set using Gaussian kernels, thus eliminates biases that may arise from incorrect model construction (specification). This approach, which examines the marginal effect of the independent variable on the dependent variable for each observation point, sheds light on heterogeneous (non-linear) relationships by taking advantage of the distribution of the effects in question. In addition, by taking the average of the marginal effects, the general effect level and statistical significance of the independent variable can be determined (Adebayo et al., 2024; Özkan et al., 2023).

The Generalized Moments Model (GMM) is an effective tool for estimating unknown parameters and has the ability to eliminate endogeneity problems that may arise from the possible correlation between the dependent variable and the error term (Arellano & Bond, 1991). In this study, the Difference-GMM (D-GMM) method popularized by Arellano & Bond (1991) is used by adding the lagged value of the dependent variable to the model (Roodman, 2009). The System-GMM (S-GMM) approach, developed with additional assumptions by Arellano & Bover (1995) and Blundell & Bond (1998) and used together with the original equations, increases efficiency by using more instrumental variables and provides solutions to autocorrelation and variance problems. In this context, the Blundell Bond GMM test suitable for the N>T condition was preferred.

Table 4

KRLS quantile regression results

$LNCO_2$	Avg.	SE	t	P>|t|	0.25	0.50	0.75
LNGDP	0.0453	0. 0176	2.575	0.011**	-0. 3078	-0. 0400	0. 1621
LNPS	0. 0542	0. 0306	1.772	0.078*	-0. 0419	0. 0156	0. 1716
LNURB	-0. 0417	0. 0159	-2.617	0.010**	-0. 2462	-0. 0714	1. 1444
LNIFD	0. 0451	0. 0108	4.179	0.000***	-0. 0916	0. 0311	0. 1573
R^2	0.9309						

Note: *** p<0.01, ** p<0.05, * p<0.10.

Table 4 shows the ML-based KRLS QR results. According to these results, the average marginal effect of LNGDP on $LNCO_2$ is 0.0453 and is statistically significant. LNGDP has a negative and statistically significant coefficient at 0.25 and 0.50 quantile levels, while it has a positive and significant coefficient at the 0.75 quantile level. While LNGD contributes to economic growth and environmental improvement in low-emission cases, economic growth may have a pollution-increasing effect in high-emission cases. The average marginal effect of LNPS is 0.0542. The average effect of the LNPS variable on $LNCO_2$ is positive (0.0542) and can be associated with the

increase in economic growth and industrialization in general. LNPS has a negative and statistically significant coefficient at the 0.25 quantile level and a positive and statistically significant coefficient at medium and high quantile levels of 0.50 and 0.75. This result suggests that the impact of political stability is not uniform and may have different outcomes depending on country or region-specific environmental and economic conditions. An increase of approximately 1% in LNURB is associated with a decrease of approximately 0.0417% in $LNCO_2$ on average. This suggests that CO_2 emissions in general may decrease with increasing urbanization. The strong negative effect in the lower quantile indicates that urban development in low-emission regions is supported by environmental regulations, while the positive effect in the upper quantile indicates that urban growth increases environmental pressure in high-emission regions. A 1% increase in LNIFD is associated with a 0.0451% increase in $LNCO_2$ on average. In general, increased Islamic financial development leads to an increase in CO_2 emissions. This result is parallel to the results of the following studies in the literature (Islam et al., 2013; Farhani & Öztürk, 2015; Salahuddin et al., 2018; Irfany et al., 2024a; Irfany et al., 2024b). LNIFD is negative and statistically significant in the lower quantile. This may have led to a reduction in emissions through environmentally friendly practices or efficient investment models in low-emission situations. This relationship is observed to be positive in higher quantiles, indicating that the increasing development of LNIFD leads to significant increases in $LNCO_2$ emissions in high-emission countries.

Table 5

Robustness check results with the GMM dynamic regression test

LCO_2	Coefficient	Robust std. err.	z	P>z
LCO_{2L1}	0.5369	0.0599	8.95	0.000***
LNGDP	-0.3060	0.0642	-4.77	0.000***
LNPS	-0.0483	0.0086	-5.61	0.000***
LNURB	-0.1146	0.0398	-2.88	0.004***
LNIFD	0.0144	0.0101	1.43	0.014**
Sargan-Hansen test	chi2(16) = 12.43843 Prob > chi2 = 0.7133			
Arellano-Bond test	Ar(1) : -1.9217 Prob > |z| = 0.154 AR(2) : -0.4467 Prob > |z| = 0.655			

Note: *** p<0.01, ** p<0.05.

Table 5 presents the panel regression estimation results using the system GMM method. According to the results, past CO_2 emissions (LCO_2L1) have a strong and positive effect on current CO_2 emissions. This indicates that CO_2 emissions are highly persistent, meaning that past values are important in determining today's emissions. The negative coefficient of the LNGDP and LNPS variables shows that the slope coefficient of these variables is consistent at low quantile levels (0.25) of the KRLS estimator. Here, the importance of marginal interactions that the ML-based KRLS estimator can capture at different quantile levels is clear. In addition, the findings obtained from the Sargan-Hansen & Arellano-Bond tests show that the instrumental variables in the model are valid and that there is no unexpected serial correlation in the error terms. These findings support the reliability of the model.

Dumitrescu-Hurlin panel causality test

The Dumitrescu-Hurlin panel causality test is a method used to investigate Granger causality in panel data sets. This test takes into account heterogeneous relationships for each unit in the panel; that is, the causality relationship may differ in each panel unit. The null hypothesis of the test suggests that there is no causal relationship in all units, while the alternative hypothesis argues that Granger causality exists in at least one unit. Thus, it allows obtaining more reliable results regarding the dynamic relationships between variables by taking into account the cross-sectional heterogeneity in panel data sets (Dumitrescu & Hurlin, 2012).

Before interpreting the results of the Dumitrescu-Hurlin test, it is very important to perform a homogeneity test to determine whether the causal relationships in the panel data set are homogeneous or heterogeneous. This test increases the reliability and interpretability of the results of the DH test by checking whether the causal relationships between the panel units are similar. If there is heterogeneity in the panel, it is necessary to consider different causal dynamics for each unit. Therefore, the homogeneity test results are given in Table 6 below.

Table 6

Homogeneity test results

	$\tilde{\Delta}$	$\tilde{\Delta}_{Adj}$
Test Statistic	3.415	5.065
Prob	0.001***	0.000***

Note: *** $p<0.01$.

The fact that the $\tilde{\Delta}$ and $\tilde{\Delta}$Adj statistics obtained in the homogeneity test are significant at the 1% significance level led us to reject the assumption that the slope coefficients are homogeneous. This situation reveals that the coefficients differ across observations. Therefore, considering the heterogeneous structure of the panel data, the Dumitrescu-Hurlin panel causality test should be applied.

Table 7

Dumitrescu-Hurlin panel causality test results

Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
LNGDP↛ LCO_2	2.7538	4.9605	0.000***
LCO_2 ↛ LNGDP	3.0697	5.8541	0.000***
LNPS↛ LCO_2	2.8564	5.2506	0.000***
LCO_2 ↛ LNPS	2.4373	4.0653	0.000***
LNIFD↛ LCO_2	1.8177	2.3128	0.020**
LCO_2 ↛ LNIFD	2.9080	5.3967	0.000***
LNURB↛ LCO_2	3.9525	8.3510	0.000***
LCO_2 ↛ LNURB	2.9396	5.4859	0.000***

Note: *** $p<0.01$, ** $p<0.05$.

In order to reveal the causal relationships between Islamic financial development, political stability, economic growth, urbanization and CO_2 in OIC member countries, the panel causality test based on the Granger procedure suggested by Dumitrescu-Hurlin (2012) was applied and the findings are presented in Table 7. According to the results obtained from the Table 7, it is seen that all the variables used in the study have a causal relationship with $LNCO_2$ emissions. This means that LNGDP, LNPS, LNIFD and LNURB directly affect $LNCO_2$ emissions. Therefore, holistic policies that combine green sukuk incentives and low-carbon urban infrastructure investments should be adopted. Thus, economic growth, financing models and urban transformation processes are aligned with the goal of reducing emissions.

Conclusion and Discussion

This study analyzes the effects of Islamic financial development, political stability, economic growth, and urbanization on environmental quality in the OIC member countries between 2013 and 2023. Robust coefficient estimates are obtained using the machine learning-based KRLS quantile regression estimator and validated with

the GMM dynamic regression estimator. Causal relationships between the variables are examined using the panel causality test of Dumitrescu and Hurlin (2012). According to the results of the analysis, LNIFD decreases environmental quality by increasing $LNCO_2$ emissions in the OIC member countries. LNIFD generally increases $LNCO_2$ emissions; however, it has the potential to reduce emissions with environmentally friendly finance practices in low-emission situations. While LNGDP improves environmental quality at low and medium emission levels, it causes environmental degradation at high emission levels. The effect of LNPS on the environment is positive at low emissions and negative at high emissions, and this situation shows that the effect of political stability may vary depending on the country and regional conditions. The general effect of LNURB is to reduce emissions, but it increases environmental pressure in high-emission regions. Considering the results obtained from the study, although the OIC member countries support environmentally friendly investments by adopting environmental sustainability goals, the increasing effect of IFD on CO_2 emissions can be associated with some structural problems arising from the political-economic structures of these countries. For example, although Indonesia (80%), Kazakhstan (88%), Pakistan (70%), Jordan (92%), Qatar (90%), Iran (92%), Turkey (58%) as well as Kuwait and Sudan are trying to develop green financing strategies, energy projects supported through Islamic finance may increase emissions since energy production is largely based on fossil fuels such as coal. Similarly, although Saudi Arabia is quite active in the field of Islamic finance, its economy's dependence on fossil fuel revenues causes the environmental impacts of financing to be negatively shaped. Malaysia is a country with a developed institutional infrastructure for Islamic finance, but due to its industrial and export-oriented economic structure, environmental sustainability cannot always be a priority. In addition, the weak environmental regulations in many OIC member countries, limited renewable energy investments, and the insufficient prevalence of environmentally friendly financial instruments also pave the way for this effect to emerge. In this context, although the ethical and environmental principles of Islamic finance are theoretically strong, in practice, the environmental consequences of these principles may be limited due to the development priorities and structural conditions of the countries. In this context, green sukuk, environmentally friendly projects, and green finance should be developed in the OIC member countries in order to reduce the environmental damage caused by Islamic financial development and to turn its effects into positive ones. Sustainable Islamic finance products should be popularized, and investments that will harm the environment should be prevented. To mitigate the environmental pollution caused by economic growth in high-emission areas, green

growth policies should be promoted in these countries, and stringent environmental regulations should be implemented in high-emission regions. In addition, political decisions in these countries should be integrated with environmental policies. Political stability should be strengthened, especially in high-emission regions, and environmentally sustainable policies should be developed. To improve the environmental impacts of urbanization, low-carbon urbanization should be supported by sustainable infrastructure projects.

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