

Ecological Footprint Dynamics in Developing Islamic Economies: Is There Convergence?

(*Dinamika Jejak Ekologi dalam Membangunkan Ekonomi Islam: Adakah Wujud Konvergensi?*)

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ABSTRACT

Climate change and environmental degradation increasingly shape development policy, and reducing ecological footprints has become a central objective. This study uses the Factor PANIC LM test to assess whether per capita ecological footprints converge among member states of the Organization of Islamic Cooperation (OIC) over 1981–2022, accounting for cross-sectional dependence and heterogeneous dynamics. Yet the pattern is not universal. The estimates indicate statistically significant convergence for most OIC countries; however, Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia fall outside this convergence. An analysis of convergence breaks also identifies periods associated with United Nations-led environmental initiatives, which are consistent with substantial shifts in national environmental policies. Consequently, international environmental protocols and targeted sustainability regulations are confirmed as influential in promoting ecological convergence. This underscores the necessity for tailored policy actions and collaborative international governance to enhance environmental sustainability across developing countries.

Keywords: Ecological footprint; green development; convergence analysis; organization of Islamic cooperation; sustainability policies

ABSTRAK

Perubahan iklim dan kemerosotan alam sekitar merupakan cabaran penting dalam strategi pembangunan semasa, menjadikan pengurangan jejak ekologi sebagai objektif dasar yang utama. Kajian ini meneliti sama ada jejak ekologi per kapita sedang menunjukkan konvergensi dalam kalangan negara anggota Pertubuhan Kerjasama Islam (OIC) bagi tempoh 1981–2022 dengan menggunakan ujian Faktor PANIC LM, iaitu pendekatan data panel lanjutan yang mengambil kira pergantungan rentas-seksyen serta dinamik yang heterogen. Dapatan empirikal menunjukkan berlakunya konvergensi jejak ekologi dalam kebanyakan negara anggota OIC, kecuali Algeria, Chad, Niger, Nigeria, Sierra Leone dan Tunisia. Analisis lanjut terhadap titik patah konvergensi menonjolkan kesan ketara inisiatif alam sekitar yang diterajui Pertubuhan Bangsa-Bangsa Bersatu, yang mencerminkan perubahan signifikan dalam dasar alam sekitar negara. Sehubungan itu, protokol alam sekitar antarabangsa dan peraturan kelestarian yang disasarkan didapati berperanan dalam menggalakkan konvergensi ekologi. Hal ini menekankan keperluan tindakan dasar yang disesuaikan serta tadbir urus antarabangsa yang kolaboratif bagi memperkuatkan kelestarian alam sekitar di negara-negara membangun.

Kata kunci: Jejak Ekologi; Pembangunan hijau; analisis konvergensi; negara anggota pertubuhan Kerjasama Islam; dasar kelestarian.

JEL: Q56, Q01, C23, O13, O57

Received 21 April 2025; Revised 7 February 2026; Accepted 30 April 2026; Available online 13 May 2026

INTRODUCTION

When individual needs are met using limited natural resources, it is important to manage and balance those resources correctly to ensure a livable environment for future generations. The relationship of the individual with nature and natural resources is commonly emphasized today in the context of ecosystem balance. The concept of footprint has been brought to the literature by efforts to make sense of the effects on nature and natural resources, which arise indirectly within the scope of the direct activities or existence of the individual (Wiedmann & Allen 2021). The concept of footprint describes an individual's impact on the nature and natural resources (Matušík & Kočí 2021). In other words, it is a quantitative measure of individuals' use of natural resources, expressed in units of area (Laurent & Owsianiak 2017); i.e., an indicator of individual pressure on the environment (Matušík & Kočí 2021). Footprints are commonly discussed in terms of three core dimensions of sustainable development: social outcomes, economic welfare, and environmental protection (Čuček et al. 2012). A widely used typology treats ecological, carbon, and water footprints as key members of the broader footprint family (Fang 2015). In practice, this family has expanded. Fang et al. (2014) note that ecological, energy, carbon, and water footprints appear most often in the literature and function as broadly accepted indicators. The ecological footprint is often used to capture human demand on nature. It is defined as the total area of productive land and water ecosystems required to reflect nature's renewable capacity to meet basic and other vital needs and to absorb waste (Dada et al. 2022; Galli et al. 2014). It also serves as a practical indicator of environmental resource use. Scholars rely on it to assess the sustainability of ecosystems that support human life and to make visible the ecological pressures generated by human activities (Solarin et al. 2019; Srovátka 2020; Ulucak & Lin 2017; Yilanci & Korkut Pata 2020). In this sense, the productive land and water areas used both to generate resources consumed by human activities and to process the resulting wastes can be understood as individual-induced ecological pressure (Wackernagel et al. 2002; Borucke et al. 2013). Pressure has become harder to ignore. As ecological pressure intensifies, whether directly or indirectly, it can contribute significantly to environmental problems (Koseoglu et al. 2022).

Within the sustainability framework and with explicit attention to environmental pressures, the ecological footprint serves as a comprehensive measure of sustainability performance because it reflects both human demand on nature and the capacity of ecosystems to renew resources and absorb waste. It brings these pressures together in one measure. It does so by capturing the use of productive surface areas, including agricultural, fishing, residential, and forest areas, and carbon demand (Costanza 2000; Keßler et al. 2020). Several contemporary dynamics make such measurements necessary. These include the release of greenhouse gases due to fossil fuel use (Santos et al. 2022), the emergence of climate change (Pan et al. 2023), the acceleration of global warming (Cesaretti et al. 2014), the industrial activities that cause water pollution (Lei et al. 2018), and the increase in soil erosion associated with the destruction of forest areas (Francesconi et al. 2022). These pressures accumulate over time.

It is assumed that poorer, developing regions can attain the income levels of wealthier, developed regions through trade relations and converge in terms of income averages (Gökhan et al. 2019; Tian et al. 2016). It is important to consider the convergent features of the ecological footprint in environmental and sustainable development policies to be implemented to eliminate environmental damage that may occur due to climate change and global warming (Azmat et al. 2023; Ulucak & Lin 2017). The assumption that developed countries have higher and more balanced growth trends than less developed countries is unlikely to hold. This is because a high growth rate is a necessary but not sufficient condition for an increase in average per capita income (Young et al. 2008). In the convergence-oriented literature, researchers discuss the desire to go beyond the focus topics and standard convergence processes within the framework of research methodologies; the increasing number of studies on convergence; and the structural differences in policies and technologies among countries. The literature has introduced different types of convergence, such as micro-macro, intra-country and inter-country, income-level and growth-rate, conditional-unconditional, deterministic-statistical, global-club, and beta-sigma convergence (Acemoglu & Molina 2021; Akkoç & Şahin 2019; Islam 2003). In a bibliometric study by Klarin et al. (2023) on 857 convergence-oriented studies, six main convergence categories were identified. These categories are: “red category - industrial convergence cluster: industrial convergence, information convergence, applied convergence and digital convergence concept; green category - media and communication convergence cluster: media convergence and communication convergence concept; blue category - market, club and cluster convergence cluster: market convergence, convergence theory or convergence hypotheses, classical convergence and club/cluster convergence concept; yellow category - convergence impact on education and development cluster: telematic convergence concept; magenta category - industrial convergence cluster: industrial convergence, technological convergence and industrial divergence concept; light blue category - regulatory oversight and user adoption cluster: regulatory convergence and convergence product concept” (Klarin et al. 2023).

In studies in the literature, the ecological footprint, which represents sustainability and environmental pollution, is included in the convergence analysis, and the convergence of pollution indicators can affect international climate agreements (Bayraktar et al. 2023). The economic costs of climate change are increasing for all countries in other categories, particularly in developed countries (Kremer et al. 2022). Therefore, ecological footprint convergence plays an important role in understanding the effects of human activities on nature and in helping countries achieve successful outcomes in mitigating these impacts, such as pollution, global warming, climate change, and carbon emissions. The results of the studies in the literature vary according to the methods used, the country groups analyzed, and the time intervals

considered (Yilanci & Korkut Pata 2020). In this context, various convergence trends emerging at different time scales reveal the factors that should be considered in implementing and determining factors environmental policies (Ursavaş & Yilanci 2023). Ecological footprint convergence analyses play an important role in determining which policies to prioritize for the productive surface areas (pasture, agriculture, forest, construction, and carbon footprint) of countries with different structural characteristics in terms of ecological footprint components (Ulucak & Lin 2017). When it is revealed that there is convergence in ecological footprint between countries, common environmental policies can be implemented instead of each country adopting different policies (Yilanci et al. 2022).

Currently, the Organization of Islamic Cooperation (OIC) countries constitute a distinct group characterized by differences in economic capacity, natural resources, and diverse institutional cultures. Although this group of countries shares some common socio-cultural and religious values, it consists of countries with a heterogeneous structure in terms of their historical backgrounds, industrialization processes, energy dependencies, political systems, and environmental governance. This diversity means that countries with shared features can still diverge in meaningful ways. Therefore, it is essential to ask whether environmental sustainability indicators, especially ecological footprints, move toward a common path across OIC members. This question has direct policy consequences. Clear evidence on convergence, and on which convergence model best fits the group, helps to determine whether collective environmental strategies can be applied across group members and whether policy harmonization is realistic. This study tests for ecological footprint convergence among OIC member countries using data from 1981–2022. The main motivation of this research is to contribute to raising awareness about environmental sustainability and resource utilization for policy makers, understanding the environmental impacts of countries, and establishing regional strategic cooperation and common environmental policies by revealing and comparing the ecological footprint convergence values of OIC member countries. Although ecological footprint dynamics have attracted considerable attention in the literature, previous studies have mainly examined panels of developed and large developing economies, while the Islamic developing countries within the OIC have received relatively little attention. Furthermore, while existing studies focus primarily on the determinants of the ecological footprint, it remains to be investigated whether OIC countries show convergence in terms of their sustainability performance. Filling this gap, the present study makes an important contribution to the literature by focusing on the OIC and evaluating convergence models that provide information on region-specific environmental coordination. The findings of this study have important policy implications for OIC member countries in the context of ecological footprint convergence and in discussions aimed at reducing the environmental pollution gap among them. Policy makers can gain valuable insights by examining the results of this study to inform regional strategic cooperation and joint environmental policies among member countries. To the best of our knowledge, this is the first study to analyze and compare the ecological footprint convergence of OIC member countries it makes a significant contribution to existing literature.

The rest of this paper is organized as follows. Section 2 reviews previous studies. Section 3 discusses the methodology and presents the data and descriptive statistics. Section 4 presents the empirical results. Finally, Section 5 presents the conclusions and policy implications.

LITERATURE REVIEW

The number of studies examining cross-country convergence in ecological footprints and their components has increased in recent years. Some research on ecological footprint and ecological footprint convergence has focused on the socio-economic impacts of environmental performance and convergence through various measures such as greenhouse gas emissions, including carbon dioxide (Solarin et al. 2019). The literature presented here reviews previous studies on the ecological footprint and factors affecting ecological footprint convergence among OIC member countries (economic development, environmental policies, technological developments, and demographic trends).

The differences in development levels among the 54 member countries of the Organization of Islamic Cooperation due to their structural characteristics, stand as a barrier to the Organization's convergence with organizations of similar development levels (Sey 2020). In the short term, the coherence of economic, trade, and environmental policies among OIC member countries appears to be consistent. There has been no effort to converge with other OIC member countries at similar levels of development through the formation of common policies (Andreano et al. 2013). Although studies on the ecological footprints of OIC member countries are limited in the literature (Ali et al. 2020, 2021; Majeed 2021; Khan et al. 2023), there is no study on ecological footprint convergence. This gap strengthens the case for the present analysis, especially given the OIC's strategic vision that links economic cooperation with sustainable development among its members. The institutional context matters for how findings are translated. Assessing whether member countries' ecological footprints converge can extend the environmental economics literature and simultaneously inform regional policy integration aligned with the OIC's environmental action framework. Because OIC member countries are unlikely to reach absolute convergence in growth, development, and per capita income, it is necessary to determine whether ecological footprint convergence nonetheless holds among the relevant countries in discussions of OIC restructuring (Gunduz et al. 2021). Absolute convergence remains implausible across these members. As Nugroho & Herianingrum (2023) emphasize, the OIC is meant to deepen cooperation among member countries and support economic development; in that setting, ecological footprint convergence becomes consequential for fully realizing the group's economic potential,

for advancing common policies that narrow the environmental pollution gap (Ulucak et al. 2020; Yilanci & Korkut Pata 2020), and for tracking progress toward sustainable development goals.

This section examines the literature on ecological footprints and convergence studies, with a particular focus on research related to the OIC, dividing it into subgroups.

ECOLOGICAL FOOTPRINT STUDIES

Ulucak and Apergis (2018) examined the convergence of the per capita ecological footprint of EU member states using the club clustering method for the period 1961–2013. According to the findings of this study, some convergence clubs were identified. Producers and consumers, who are ecosystem stakeholders, should adopt new awareness strategies to maintain environmental quality standards in a sustainable growth process. The study emphasized the need to recognize the importance of ecological footprints for ecosystems and to develop strategies to benefit from the positive effects of globalization while simultaneously protecting against the risks of energy and environmental problems that threaten human life.

Similarly, Solarin et al. (2019) took a broader view and examined whether the ecological footprint converges not only as a whole but also through its six components: residential area, carbon, crop area, fishing area, forest area, and pasture. Their study uses data from 92 OECD countries from 1961 to 2014 and applies a combined club-convergence approach. The picture is not uniform. They identify distinct footprint clubs for each component. In the study, different convergence clubs were determined for each component using the Phillips and Sul (2007) methodology. The findings presented in this study are consistent with the work of Haider and Akram (2019), who conducted an inter-country club convergence analysis of the ecological and carbon footprints of 93 countries for the period 1980–2013, revealing strong heterogeneity in convergence behavior. To optimize carbon footprint reduction, the use of alternative renewable energy sources and the implementation of carbon taxation are proposed as viable solutions. The study emphasizes that, to overcome environmental problems, less developed economies should follow the example of developed countries in the same cluster, within the context of convergence pathways specific to those clusters.

In another regional context, Yilanci and Korkut Pata (2020) investigated the ecological footprint which is used as a reliable indicator of whether environmental pollution and biological capacity are exceeded within the scope of content components. This was analyzed using convergence tests, and the stationarity properties of ecological footprint per capita in ASEAN-5 countries were examined using TAR panel unit root tests. In the study's findings in which two regime groupings were made, absolute convergence was determined for regime 2, which represents 80.77% of the sample. This suggests that differences between countries in environmental pollution are decreasing over time. In the context of ASEAN-5 countries, it is assessed that the ecological footprint rate can be reduced through common policies to be implemented in general, information to raise awareness, the use of alternative resources to fossil fuels and renewable energy sources, technological progress, and control of population growth.

Extending the analysis to income groups, Erdogan and Okumus (2021) explored the convergence of countries' per capita ecological footprint across income groups using stochastic and club convergence panel stationarity tests on data for the relevant countries from 1961 to 2016. In the study, it was revealed that the per capita ecological footprint is cross-sectionally dependent across countries, and there are several convergent clubs in different income groups. It is emphasized that convergence clubs, as a common theme, depend on countries' economic structures and environmental conditions, and that there may be compromises among different convergence clubs. The assertion that environmental pollution stems from both industrial and individual activities underscores the significance of regulatory oversight in curtailing those activities.

Ursavaş and Yilanci (2023) examined the convergence of per capita ecological footprint in the Southern Common Market countries over different time scales based on the environmental convergence hypothesis, using data for the period 1961–2016. According to the study data, countries exhibit varying convergence trends at different time scales. The environmental convergence hypothesis is supported for all countries in the short run, while it is valid only for a subset of countries in the medium and long run. The environmental convergence hypothesis is valid for four countries in the medium term and three countries in the long term, with Uruguay being the only country where it is valid for all periods. In a study complementing these findings, Rahman et al. (2025) revealed that material footprint dynamics in G7 countries are also shaped by their economic and energy structures. This finding significantly shows that convergence in environmental indicators may be associated with similar structural characteristics among countries.

ECOLOGICAL FOOTPRINT AND CONVERGENCE IN OIC COUNTRIES

In his study, Majeed (2021) examined, using panel-data estimators, the relationship between ecological footprints and financial development for 38 OIC member countries over the period 1971–2017. He revealed that financial development contributes to improving environmental quality, and paradoxically, it is a key component of environmental degradation for member countries in the high-income group. The study emphasized that the policy-making executive power of the relevant member countries should pursue a balance between environmental policies and development.

Dada et al. (2022) examined the relationship between financial development and environmental quality (ecological footprint) and the impact of institutional quality on this relationship in the case of Malaysia from 1984 to 2017. The findings

of the study reveal that, in the short run, financial development and some other variables (foreign direct investment, economic growth, and institutional quality) improve environmental quality, whereas trade openness and natural resources worsen environmental quality. In the long run, they found that variables that appear to have positive effects on the environment in the short run also have negative effects.

Khan et al. (2023) used data from the period 2000-2020 for the middle and lower-income OIC countries, included in the study, and the effects of foreign direct investment, institutional performance, and scientific innovation on the ecological footprint were analyzed through the PMG method. Although the FDI variable has a negative effect on the ecological footprint overall, it has a decreasing role in the member countries within the scope of the study; the institutional performance variable exhibits an ecological footprint-increasing function; and the scientific innovation variable has a positive contribution to reducing the ecological footprint. The ecological footprint-reducing aspect of trade openness was emphasized. Since FDI, institutional performance, and scientific innovation can play a supportive role in the deterioration of environmental quality in OIC member countries in the middle and lower-income groups, together with negative practices such as bad governance and corruption, the policies to be followed should be compatible with the rule of law and political stability. In this context, another study by Kazak et al. (2025) revealed that green finance plays an important role in reducing the ecological footprint in OIC economies and emphasized the importance of harmonizing financial and environmental policies within the framework of the Sustainable Development Goals (SDGs).

INTRA-INDUSTRY TRADE (OIC) AND CONVERGENCE FINDINGS

Another group of studies examined in the literature investigates convergence in the context of intra-industry trade among OIC countries, emphasizing how economic integration among Islamic countries can affect environmental and income convergence. Gunduz et al. (2021) examined the per capita income convergence clubs of 57 OIC member countries from 1990 to 2017. In an empirical study of GDP per capita convergence across OIC countries, the authors situate their analysis within the OIC's stated ambition of moving toward an Islamic common market. Institutional quality sits at the center of their argument. They stress that income convergence matters for strengthening political and economic institutions during economic integration and development. The 2008 mortgage crisis has been identified as a key factor accelerating income convergence among OIC members; however, the number of convergence clubs subsequently declined. Fixed capital accumulation and human capital emerge as the main determinants of club membership. The paper finds evidence of two convergence clubs and one diverging unit, even though it does not confirm full income convergence. Differences in productivity growth between the clubs are substantial. The richer club also appears to have diverged from the poorer club more rapidly in recent periods. On this basis, the study calls for common policy measures to narrow the gap between clubs and underscores the importance of human and physical capital investment, particularly in lower-income member countries.

When the existing literature is read as a whole, countries do not converge in a uniform way; they follow heterogeneous convergence models shaped by economic structures, policy frameworks, and levels of environmental awareness. Convergence rarely occurs by default across countries. Studies of OECD and ASEAN samples generally report partial convergence or club convergence, whereas studies focusing on the OIC, consistent with evidence from both developing and advanced economies, report mixed and often incomplete convergence patterns. These differences indicate that convergence behavior is not universal and instead hinges on institutional quality, technological development, economic and financial development, and the degree of policy coordination across countries. Research on OIC members, in particular, underscores the joint influence of financial development and institutional quality on ecological footprint dynamics. It also reinforces the importance of economic integration for environmental convergence.

Taken together, these findings indicate that convergence is feasible under specific structural and institutional conditions, yet divergence can persist where governance is weak, financial depth differs sharply, resource distribution is uneven, or environmental policies are inconsistent. Institutions and finance shape environmental outcomes. The mixed evidence, therefore, calls for context-sensitive comparative work that treats economic and financial conditions and environmental interactions as intertwined, rather than as separate domains, and that uses this linkage to sharpen the agenda for future research.

Despite these contributions, the literature still lacks a comprehensive assessment of ecological footprint convergence that integrates environmental and economic-financial dimensions, particularly in the OIC setting. Cross-country linkages are important in the OIC sample. Prior studies often understate the interdependencies and cross-sectional linkages that characterize OIC economies, which narrows what can be inferred about shared environmental behavior among member countries. To address this gap, the present study offers an expanded convergence analysis of OIC members for the period 1981–2022, using updated data and a methodological approach that incorporates inter-country interdependence and heterogeneous dynamics.

This research provides empirical evidence of ecological footprint convergence and focuses on its implications for policy coordination and collective environmental governance among OIC members. It is not only an academic exercise. By examining environmental outcomes together with the economic factors that shape ecological pressures, the study moves beyond the mainly descriptive comparisons common in earlier work and puts forward a more integrated framework. It also takes cross-country heterogeneity seriously, including differences in development and income levels, production and industrial structure, energy intensity and energy mix, and institutional capacity to implement and enforce environmental

regulation. These differences shape both pressures and responses. Within this setup, shared regional commitments, such as the Kyoto Protocol, are treated as part of the empirical context, and interaction patterns associated with the Kyoto period offer additional evidence on how international environmental initiatives may coincide with changes in national ecological trajectories. Consistent with this perspective, the empirical results indicate convergence for most OIC members, while a small group of countries, Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia, departs from the common path, which plausibly reflects country-specific structural and institutional constraints. The departures are not random. In this way, the study makes a methodological contribution through its use of advanced convergence techniques and a contextual contribution by foregrounding the heterogeneous institutional and developmental features of OIC economies.

DATA AND METHODOLOGY

DATA SOURCE

This study uses annual panel data for OIC member countries over the period 1981–2022. The ecological indicator is the Ecological Footprint of consumption per person (EFPP), expressed in global hectares (gha), which provides a comprehensive measure of the biologically productive area required to support a population’s consumption and to absorb associated waste, especially carbon emissions. EFPP data were obtained from the Global Footprint Network Open Data Platform (<https://data.footprintnetwork.org>).

EFPP is calculated as a country’s total Ecological Footprint of consumption divided by its total population and reported in global hectares (gha) per person.

Data availability for OIC members is most consistent from 1981 onward. Based on dataset coverage, countries with missing observations were excluded: Azerbaijan, Kazakhstan, Kuwait, Kyrgyzstan, Palestine, Sudan, Suriname, Tajikistan, Turkmenistan, and Uzbekistan. The final sample, therefore, includes 47 OIC countries. The full list of countries included in the sample is provided in Appendix A for transparency.

MODEL SPECIFICATION

This analysis aims to test whether ecological footprints among OIC members exhibit stochastic convergence. The convergence concept adopted here implies that cross-country deviations from a common benchmark do not grow without bound over time; empirically, this is assessed by testing whether the relative ecological footprint indicator is stationary.

Following the transformation used in the convergence literature, the EFPP series is organized as:

$$\hat{C}_{it} = \ln(I_{it}) / \ln(I_t), \quad I \equiv EFPP \quad (1)$$

where (I_{it}) denotes ecological footprint per person in country (i) at time (t), and (I_t) denotes the cross-sectional benchmark in year (t) (computed from the sample).

To model cross-sectional dependence and heterogeneous dynamics, we rely on the Factor PANIC LM framework of Payne et al. (2022), which specifies the panel series using the following data generating process (DGP):

$$y_{it} = \delta_i Z_{it} + \pi_i F_t + e_{it}, e_{it} = \beta_i e_{i,t-1} + e_{it} \quad (2)$$

$$i = 1, 2, \dots, M; t = 1, 2, \dots, H$$

where (y_{it}) represents the transformed series used in the convergence test, (Z_{it}) collects deterministic components and (one or two) structural-break terms, (F_t) is a vector of unobservable common factors, and (π_i) captures country-specific factor loadings.

H₀ The ecological footprints of OIC member countries are converging, indicating a common stochastic trend.

H₁ The ecological footprints of OIC member countries are not converging, indicating differences between countries.

If the calculated p-value is lower than traditional significance levels (1%, 5%, or 10%), the convergence hypothesis (H₀) is rejected; however, if $p > 0.10$, it cannot be rejected, thus failing to provide evidence for the existence of convergence (Nazlioglu & Lee 2020; Payne et al. 2022).

METHODOLOGY

In this study, cross-sectional dependence tests were conducted first. The tests developed by Breusch and Pagan (1980), Pesaran (2004), and Pesaran et al. (2008) are used to test for cross-sectional dependence [Equations (3)–(5)]. Here, (p_{ij}) denotes the pairwise correlation of the residuals across cross-sectional units (i) and (j), (N) is the number of countries, (T) is the time dimension, and (k) is the number of regressors used in the auxiliary regressions.

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N (\hat{p}_{ij}^2) X^2 \frac{N(N-1)}{2} \quad (3)$$

$$CD_{LM} = \left(\frac{1}{N(N-1)} \right)^{\frac{1}{2}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N (T \hat{p}_{ij}^2 - 1) \quad (4)$$

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \frac{(T-k) \hat{p}_{ij}^2 - \hat{\mu}_{Tij}}{VT_{ij}} \quad (5)$$

In the next step, the stochastic convergence of OIC member countries with respect to per capita ecological footprint is calculated. For this purpose, the data to be analyzed have been organized using Equation 1. The method used for convergence analysis in this study was developed by Payne et al. (2022). By adopting the PANIC procedure developed by Lee & Strazicich (2003) and Bai & Ng (2004), and by extending the two-breakpoint tests developed by Lee and Strazicich (2003), they developed a new method that, unlike other unit root tests that do not account for cross-correlations, allows for cross-correlations in the factor structure.

Payne et al. (2022) first defined a panel model with an alternative DGP (Equation 2). In the model defined in Equation 2, (F_t) is the " $r \times 1$ " vector of unobservable common factors, and (π_i) are the factor loadings capturing the responses of each cross-sectional unit to the common factors. Again, (Z_{it}) includes deterministic components and one or two structural break terms, and (ε_{it}) denotes the unique innovation term (Payne et al. 2022). Importantly, the "one or two structural breaks" are not imposed based on pre-selected historical events; instead, the procedure determines the break locations endogenously (i.e., "optimal break locations") for each country, yielding estimated structural break dates that can be interpreted ex post.

While the LM approach developed by Lee and Strazicich (2003) involves a two-stage testing process, the Factor PANIC method proposed by Payne et al. (2022) was preferred in this study. Payne et al. (2022) applied a similar iterative method, following the approaches of Bai and Carrion-I-Silvestre (2009) and Nazlioglu et al. (2022). Accordingly, for each horizontal section unit (i), Equation 6 was first estimated.

$$\Delta y_{it} = \delta_i' \Delta Z_{it} + w_{it}^* \quad (6)$$

In the subsequent step, Equation 7 is determined by specifying " ΔZ_{it} " utilizing the optimal break locations.

$$q_{it} = \Delta y_{it} - \delta_i' \Delta Z_{it} \quad (7)$$

In the next step of the testing process, the test statistics for each section unit are calculated using the established regression model.

$$\Delta y_{it} = y_i + \beta_i \tilde{S}_{i,t-1}^* + \delta_i' \Delta Z_{it} + \hat{\pi}_i' \hat{f}_t + \sum_{s=1}^{k_i} C_{is} \Delta \tilde{S}_{i,t-s} + v_{it} \quad (8)$$

Where, the term " $\tilde{S}_{i,t-1}^*$ " represents the series transformed by taking into account the estimated structural break dates. To eliminate the autocorrelation problem, the lagged value of the series " $\tilde{S}_{i,t}$ " along with the estimated frequencies " \hat{f}_t " and the difference component " $\Delta \tilde{S}_{i,t}$ " have also been included in the model. Thus, within the scope of this newly developed analysis method, all breakpoints, factors, and extended components can be estimated simultaneously.

Notation and abbreviations. DGP denotes the "data generating process." Δ is the first-difference operator. y_{it} denotes the transformed ecological footprint series used in the convergence analysis for country (i) at time (t). F_t is the vector of common factors, π_i is the associated factor loading vector, e_{it} is the idiosyncratic component, and ε_{it} is the idiosyncratic innovation term.

The primary reason we chose the PANIC procedure in our study is that the proposed test statistic shares the asymptotic distribution properties of the broken LM statistic defined by Meng et al. (2013). This important methodological similarity, which influenced our choice to use this test, has enabled the critical values and p-values obtained from the response surface estimates developed by Nazlioglu and Lee (2020) to be used directly in this study.

EMPIRICAL RESULTS

Before presenting the convergence results, we report descriptive statistics for the main variable used in the analysis namely, the ecological footprint of consumption per person (EFPP) for the 47 OIC countries from 1981 to 2022. Because of the

large size of the country-by-country table, the full descriptive statistics (mean, median, minimum, maximum, standard deviation, and normality statistics) are provided in Appendix B. Overall, the highest average EFPP values are observed for Qatar, the United Arab Emirates, and Bahrain, whereas the lowest average values are recorded for Bangladesh, Pakistan, and Yemen.

Having reported the descriptive statistics, we proceed with the preliminary diagnostics by examining whether the panel exhibits cross-sectional dependence. To this end, we apply the Breusch and Pagan (1980) LM test, the Pesaran (2004) CDLM and CD tests, and the Pesaran et al. (2008) bias-adjusted LM (LMadj) test. Establishing the presence or absence of cross-sectional dependence is important because it guides the choice of appropriate panel procedures for the subsequent convergence analysis.

TABLE 1. Cross-section dependence tests

Tests	Statistics	Prob
Breusch and Pagan 1980 LM Test	11,875.33	0.000
Pesaran (2004) CDLM Test	232.15	0.000
Pesaran (2004) CD Test	-2.209	0.014
Pesaran et al. (2008) CDLMadj Test	88.281	0.000

The cross-sectional dependence test analyzes whether the error terms in the datasets of the countries included in the panel data analysis affect each other. If the probability values are less than 0.05, it is concluded that there is a relationship between the error terms of the countries. When the results in Table 1 are analyzed, it is determined that the probability value is less than 0.05 in all test results used for the analysis of cross-section dependence. Therefore, it is concluded that there is cross-sectional dependence among the countries used in the panel data.

The FACTOR PANIC LM analysis developed by Payne et al. (2022) was conducted. Table 2 shows the results of the FACTOR PANIC LM test, which was developed by Payne et al. in 2022 by adding factor values to the PANIC LM test.

TABLE 2. Result of the Factor Panic LM Test (Payne et al. 2022)

Country	Two Level Breaks				Two Trend Breaks					
	LM	P. Val	Break1	Break2	LM	P. Val	Break1	Break2		
Afghanistan	-5.01	***	0.00	1999	2003	-5.39	***	0.01	1997	2005
Albania	-3.20	**	0.04	1993	2002	-4.41	*	0.07	2006	2009
Algeria	-2.07		0.38	1996	2006	-2.93		0.65	1993	2009
Bahrain	-2.24		0.25	2002	2006	-7.16	***	0.00	1995	2009
Bangladesh	-3.82	***	0.01	1993	1995	-3.84		0.20	1998	2006
Benin	-3.82	***	0.01	1995	2009	-4.20	*	0.10	1994	2009
Brunei Darussalam	-4.23	***	0.00	1995	2009	-6.30	***	0.00	1999	2003
Burkina Faso	-3.81	***	0.01	2004	2006	-7.35	***	0.00	1997	2006
Côte d'Ivoire	-3.27	**	0.03	1997	2004	-4.53	**	0.05	1995	2007
Cameroon	-4.26	***	0.00	2001	2003	-4.60	**	0.05	1997	2001
Chad	-2.30		0.26	1996	2000	-3.57		0.30	1996	2002
Comoros	-4.37	***	0.00	1997	2002	-4.06		0.14	2004	2009
Djibouti	-3.78	***	0.01	2005	2007	-6.40	***	0.00	1998	2009
Egypt	-2.52		0.16	1999	2004	-4.77	**	0.03	1998	2009
Gabon	-2.98	*	0.07	1997	1999	-5.24	***	0.01	1999	2008
Gambia	-3.79	***	0.01	2000	2009	-5.80	***	0.00	1998	2001
Guinea	-2.37		0.23	1996	2000	-4.88	**	0.02	1994	1999
Guinea-Bissau	-2.20		0.31	1995	2009	-4.57	**	0.05	1993	1998
Guyana	-4.08	***	0.00	1995	1998	-5.58	***	0.01	1994	2006
Indonesia	-3.11	**	0.05	1993	1996	-6.05	***	0.00	2001	2009
Iran	-3.00	*	0.06	2003	2006	-5.25	***	0.01	2006	2009
Iraq	-4.06	***	0.00	1994	1996	-4.81	**	0.03	1993	1997
Jordan	-4.89	***	0.00	1993	2002	-3.47		0.38	1994	2007
Lebanon	-5.61	***	0.00	2004	2006	-6.09	***	0.00	1999	2009
Libya	-4.02	***	0.00	2004	2006	-4.41	*	0.07	2006	2009
Malaysia	-1.91		0.48	2005	2008	-4.23	*	0.09	1998	2007
Maldives	-7.80	***	0.00	1999	2001	-4.76	**	0.03	2002	2009
Mali	-2.39		0.22	1994	2008	-4.51	**	0.05	1994	2006
Mauritania	-3.93	***	0.01	1994	1998	-5.40	***	0.01	1998	2002
Morocco	-6.56	***	0.00	1996	2006	-9.79	***	0.00	1994	2005
Mozambique	-3.82	***	0.01	2001	2005	-5.93	***	0.00	2000	2007
Niger	-2.53		0.15	1995	1997	-3.88		0.19	1995	1998
Nigeria	-2.45		0.17	1993	2009	-3.84		0.21	1995	2006
Oman	-6.01	***	0.00	2002	2007	-6.20	***	0.00	2001	2004
Pakistan	-4.89	***	0.00	1997	2008	-5.05	**	0.02	2000	2009
Qatar	-4.70	***	0.00	1994	2004	-5.24	***	0.01	1994	2000
Saudi Arabia	-7.05	***	0.00	1995	1998	-7.01	***	0.00	1995	1998
Senegal	-3.16	**	0.03	2004	2006	-4.18		0.11	1998	2004
Sierra Leone	-2.58		0.15	2006	2009	-3.30		0.48	1993	2006
Somalia	-4.45	***	0.00	1995	2009	-5.43	***	0.01	1995	2003
Syria	-3.41	**	0.02	2003	2008	-6.06	***	0.00	1994	2007
Togo	-4.33	***	0.00	2005	2007	-3.40		0.38	1993	2002
Tunisia	-2.76		0.11	1995	2007	-3.88		0.18	1996	2002
Türkiye	-4.82	***	0.00	1996	1999	-4.11		0.12	1997	2001
Uganda	-2.85	*	0.08	1995	2009	-5.46	***	0.01	1993	1999
United Arab Emirates	-2.53		0.17	2001	2008	-7.22	***	0.00	1994	2008
Yemen	-4.46	***	0.00	2007	2009	-4.77	**	0.03	1998	2008

Note: In the table, the significance levels for the rejection of the null hypothesis are depicted as follows: "*** (1%), ** (5%) and * (10%)".

When the results in Table 2 are analyzed, it is seen that most of the countries have convergence in two different models: level breaks and trend breaks. In the Two-Level Breaks model, convergence was not detected for “Algeria, Bahrain, Chad, Egypt, Guinea, Guinea-Bissau, Malaysia, Mali, Niger, Nigeria, Sierra Leone, Tunisia, and the United Arab Emirates”. In the Two Trend Breaks model, no convergence was found for “Algeria, Bangladesh, Chad, Comoros, Jordan, Niger, Nigeria, Senegal, Sierra Leone, Togo, Tunisia, and Türkiye”. Six countries (Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia) did not converge in any of the models.

In the Factor Panic LM test results reported by Payne et al. (2022), when both level and trend models are evaluated, the first break period is predominantly seen as the 1988-1994 period in countries experiencing convergence. The second break period is predominantly determined as the 2002-2008 period. One of the developments that may have affected the first break period was the establishment of the Intergovernmental Panel on Climate Change in 1988 by two United Nations organizations, the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), to assess the risks of climate change caused by human activities (Reinman 2012; Venturini et al. 2023). The second important development was the organization of the first and second global environmental conferences, namely the United Nations Conference on the Human Environment in Stockholm in 1972 (June 5-16) and “the United Nations Conference on Environment and Development (UNCED)” in Rio de Janeiro in 1992 (June 3-14), and the resulting Stockholm and Rio Declarations (Handl, 2012). The third important development was the United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992 and entered into force in 1994, which initiated the process of taking the necessary steps to reverse climate change trends and limit anthropogenic sources of greenhouse gas emissions (Schipper, 2006). The most important trigger of the second breakthrough period was the Kyoto Protocol, which was adopted in Kyoto, Japan, in 1997 and entered into force in 2005. Countries that signed this protocol made commitments to reduce anthropogenic CO2 emissions. On the one hand, the Protocol called for a significant commitment to reduce global greenhouse gas (GHG) emissions by 5% compared to 1990 levels while continuing the economic growth and development processes of countries (Lau et al. 2009). Table 3 presents the dates on which member countries of the Organization of Islamic Cooperation signed and acceded to the Kyoto Protocol.

TABLE 3. Participation and signature dates of the OIC countries in the Kyoto protocol

Country	Signature	Ratification, Accession(a)	Country	Signature	Ratification, Accession(a)
Afghanistan		25 Mar 2013 a	Libya		24 Aug 2006 a
Albania		1 Apr 2005 a	Malaysia	12 Mar 1999	4 Sep 2002
Algeria		16 Feb 2005 a	Maldives	16 Mar 1998	30 Dec 1998
Bahrain		31 Jan 2006 a	Mali	27 Jan 1999	28 Mart 2002
Bangladesh		22 Oct 2001 a	Mauritania		22 Jul 2005 a
Benin		25 Feb 2002 a	Morocco		25 Jan 2002 a
Brunei Darussalam		20 Aug 2009 a	Mozambique		18 Jan 2005 a
Burkina Faso		31 Mar 2005 a	Niger	23 Oct 1998	30 Sep 2004
Cameroon		28 Aug 2002 a	Nigeria		10 Dec 2004 a
Chad		18 Aug 2009 a	Oman		19 Jan 2005 a
Comoros		10 Apr 2008 a	Pakistan		11 Jan 2005 a
Côte d'Ivoire		23 Apr 2007 a	Qatar		11 Jan 2005 a
Djibouti		12 Mar 2002 a	Saudi Arabia		31 Jan 2005 a
Egypt	15 Mar 1999	12 Jan 2005	Senegal		20 Jul 2001 a
Gabon		12 Dec 2006 a	Sierra Leone		10 Nov 2006 a
Gambia		1 Jun 2001 a	Somalia		26 Jul 2010 a
Guinea		7 Sep 2000 a	Syria		27 Jan 2006 a
Guinea-Bissau		18 Nov 2005 a	Togo		2 Jul 2004 a
Guyana		5 Aug 2003 a	Tunisia		22 Jan 2003 a
Indonesia	13 Jul 1998	3 Dec 2004	Türkiye		28 May 2009 a
Iran		22 Aug 2005 a	Uganda		25 Mar 2002 a
Iraq		28 Jul 2009 a	United Arab Emirates		26 Jan 2005 a
Jordan		17 Jan 2003 a	Yemen		15 Sep 2004 a
Lebanon		13 Nov 2006 a			

Source: UN (2005)

The Kyoto Protocol has increased the sensitivity of not only the participating, signatory, and committed countries but also all countries of the world to the environment. In this context, the member countries of the Organization of Islamic Cooperation have been closely affected by this protocol. As the last and most important impact, the Millennium Development Goals (MDGs), announced by the United Nations (UN) in September 2001 (UN, 2000, 2012), and the Sustainable Development Goals (UN, 2015) created afterwards have shaped and continue to shape the steps to be taken by countries on the environment.

All these developments have apparently paved the way for a change in policy among the member countries of the Organization of Islamic Cooperation. According to the results of the Payne et al. (2022) Factor Panic LM Test, only six countries (Algeria, Chad, Niger, Nigeria, Sierra Leone and Tunisia) were excluded from this process. These countries are among those that have joined the Kyoto Protocol. However, the main reason for their exclusion from convergence is their level of economic development. At the outset of the economic growth and development process, a country's priorities are economic growth, industrialization, and development goals rather than environmental concerns.

Within the scope of this study, and consistent with the hypotheses tested using the Factor PANIC LM framework (Payne et al. 2022), the convergence hypothesis (H_0) could not be rejected for most OIC member countries. This finding confirms the existence of a common stochastic trend in the ecological footprints of OIC member countries. However, a

deviation was also identified in a small group of economies, such as Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia, particularly during the periods 1988–1994 and 2002–2008, which coincided with important global environmental agreements, including the UNFCCC and the Kyoto Protocol. These findings are consistent with the partial or club-level convergence models observed for the EU by Ulucak and Apergis (2018) and for OECD countries by Solarin et al. (2019), as well as with the heterogeneous convergence behaviors identified by Haider and Akram (2019) and Ursavaş and Yilanci (2023). Similarly, the finding that convergence is shaped by income levels and institutional structures is parallel to the study by Erdogan and Okumus (2021), which identified club formation among income groups. Specifically, for OIC member countries, our results are consistent with Majeed (2021), which shows that financial development can both enhance and hinder environmental quality, and with Khan et al. (2023), which emphasizes institutional quality and innovation as key drivers of ecological performance. However, our findings differ from those of Dada et al. (2022), who report that financial development leads to short-term improvements in environmental quality. This is because our long-term evidence, as examined in this study, indicates a more persistent divergence for certain OIC economies. This is an important finding because of its contribution to the literature. From another perspective, our study is also consistent with results that highlight the importance of economic integration for environmental coordination in the context of intra-industry trade, as emphasized by Gündüz et al. (2021), which reveal convergence clusters partly driven by common economic structures.

In conclusion, while the findings presented in this study generally show that most OIC countries exhibit ecological footprint convergence, they also indicate that the continuing divergence in others may stem from unequal institutional capacity, governance quality, the depth of economic and financial development, and policy implementation. Therefore, the results integrate the environmental, economic, and financial dimensions of convergence within a single analytical framework focused on OIC member countries, thereby both supporting and expanding previous studies by offering a new perspective.

CONCLUSION AND POLICY IMPLICATIONS

The ecological footprint is an important measure of anthropogenic (human-induced) pressure on the environment and is widely used in sustainability assessments. Increasing production capacity worldwide makes it imperative to control greenhouse gas emissions and reduce anthropogenic environmental impacts to ensure sustainable production. The UN Sustainable Development Goals include steps to ensure this process of change. The Kyoto Protocol and the subsequent Paris Agreement contain important regulations and commitments, especially for reducing carbon emissions. All these developments have made achieving a low ecological footprint an important goal for countries. In the process of all these developments, the main purpose of this study is to reveal the per capita ecological footprint converges over time among Organization of Islamic Cooperation countries. Data for the period 1981–2022 were analyzed using the Factor Panic LM test.

In the empirical analyses, according to the results of the Factor Panic LM Test (Payne et al. 2022), no convergence was detected for Algeria, Bahrain, Chad, Egypt, Guinea, Guinea-Bissau, Malaysia, Mali, Niger, Nigeria, Sierra Leone, Tunisia, and the United Arab Emirates in the model with a level break. In the level-trend break model, in which the trend effect was also analyzed, no convergence was found for Algeria, Bangladesh, Chad, Comoros, Jordan, Niger, Nigeria, Senegal, Sierra Leone, Togo, Tunisia, and Türkiye. In both models, convergence was not achieved for six countries (Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia). When the results of the Factor Panic LM Test (Payne et al. 2022) are evaluated, the first break is predominantly 1988–1994 period, and the second break is predominantly 2002–2008 period. One of the most important developments that may affect the first break period is the establishment of the Intergovernmental Panel on Climate Change in 1988 by two United Nations organizations, World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP), to assess the risks of climate change caused by human activities. Other important developments included United Nations Conference on Environment and Development (UNCED) and the Stockholm and Rio Declarations. The United Nations Framework Convention on Climate Change (UNFCCC) also contributed positively to this process. The most important trigger for the second breakthrough period is the Kyoto Protocol. Other influencing factors include the Millennium Development Goals (MDGs), announced by the United Nations (UN), and the Sustainable Development Goals, established afterward. All these developments paved the way for a change of action in the member countries of the Organization of Islamic Cooperation. According to the results of the Factor Panic LM Test of Payne et al. (2022), only six countries (Algeria, Chad, Niger, Nigeria, Sierra Leone, and Tunisia) were excluded from this process. Although these countries participate in the Kyoto Protocol, their levels of economic development and economic priorities have slowed down the convergence process with other countries.

These findings, in contrast to earlier studies, validate the heterogeneous and partial convergence findings of Ulucak and Apergis (2018), Solarin et al. (2019), and Haider and Akram (2019), as well as the work of Majeed (2021) and Khan et al. (2023), who emphasized that financial development and institutional quality significantly shape environmental outcomes. The non-convergence of certain countries validates the argument that convergence is a function of institutional capacity, environmental regulation, and policy harmonization intervention, as proposed by Erdogan and Okumus (2021). Thus, this study contributes to earlier evidence by presenting fresh regional evidence for the OIC that integrates environmental, economic, and financial dynamics within a holistic framework.

When convergence breaks are considered, the study clearly shows that the United Nations' environmental initiatives lead to policy changes within countries. These results show that conference protocols and environmental policy arrangements contribute to countries' goals of achieving lower ecological footprints. Therefore, steps to be taken by countries and organizations in this regard are essential. These steps are essential to livable and sustainable development models and to the future of humanity and the world. The most urgent problem here concerns underdeveloped countries in the early stages of economic growth. Since the priorities of these countries are different, it will be an important achievement for developed countries to contribute to their development process to increase their environmental sensitivity. Another important factor is that measures should be taken to ensure that developed countries transition to renewable energy sources in the production race, and ongoing positive efforts should be supported.

Like any empirical study, this one has a few boundaries that readers should consider. We work with a single headline indicator, EFPP, from the Global Footprint Network. EFPP is broad and informative, but it cannot fully represent every facet of environmental stress, such as production-based emissions, local air and water pollution, or biodiversity loss. Our sample covers 47 OIC members for the period 1981–2022; however, some countries were excluded because of missing observations, which means the results do not reflect the full OIC membership. From an econometric perspective, the Factor PANIC LM approach is well suited to panels with cross-sectional dependence and structural change, yet its outcomes may still vary with modelling choices such as the factor structure or the way deterministic components and breaks are specified. Finally, our analysis is designed to assess convergence patterns rather than to identify causal effects. For that reason, when we relate the estimated break periods to major international environmental initiatives, this should be read as a contextual interpretation rather than as a definitive claim that these initiatives caused the breaks.

In light of the findings of this study, OIC member countries should prioritize regional cooperation mechanisms, including harmonized environmental regulations, common carbon pricing strategies, and joint investment in clean energy technologies. Cooperation will determine whether convergence holds. Improvements in institutional quality, technological convergence, and stronger governance frameworks can further accelerate ecological footprint convergence. Establishing a “Green Development Fund” within the OIC or developing joint innovation programs in renewable energy could also strengthen this process by providing targeted financial and technological support to lower-income member countries.

Finally, convergence in ecological performance is not only an environmental issue. It also reflects the economic choices and institutional capacity of member states and will not advance without both. For that reason, the implications of this study reach beyond environmental management and speak to the broader governance of sustainable development, with lessons that should matter to scholars and policy makers alike.

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APPENDICES

APPENDIX A. OIC countries included in the sample (47)

COUNTRIES

Afghanistan; Albania; Algeria; Bahrain; Bangladesh; Benin; Brunei Darussalam; Burkina Faso; Côte d'Ivoire; Cameroon; Chad; Comoros; Djibouti; Egypt; Gabon; Gambia; Guinea; Guinea-Bissau; Guyana; Indonesia; Iran; Iraq; Jordan; Lebanon; Libya; Malaysia; Maldives; Mali; Mauritania; Morocco; Mozambique; Niger; Nigeria; Oman; Pakistan; Qatar; Saudi Arabia; Senegal; Sierra Leone; Somalia; Syria; Togo; Tunisia; Türkiye; Uganda; United Arab Emirates; Yemen.

APPENDIX B. Descriptive Statistics (EFPP, 1981–2022)

Country	Afghanistan	Albania	Algeria	Bahrain	Bangladesh	Benin
Mean	1.065504	1.80901	1.85468	9.123396	0.497203	1.294561
Median	0.942555	1.795108	1.693693	9.093613	0.460508	1.241802
Maximum	1.660487	2.44891	2.814009	11.75419	0.730998	1.69174
Minimum	0.797938	1.031224	1.307408	6.204372	0.353802	1.074173
Std. Dev.	0.268389	0.365025	0.411102	1.257584	0.128213	0.164151
Skewness	1.038364	-0.51137	0.508473	-0.19601	0.526652	0.923055
Kurtosis	2.507108	2.514482	1.974309	2.741269	1.751033	2.806561
Jarque-Bera	7.972544	2.243027	3.650885	0.386092	4.671395	6.029695
Probability	0.018569	0.325786	0.161146	0.824444	0.096743	0.049053
Sum	44.75118	75.97841	77.89657	383.1827	20.88252	54.37156
Sum Sq. Dev.	2.953339	5.462974	6.929206	64.84225	0.673985	1.104768
Observations	42	42	42	42	42	42
Country	Brunei Darussalam	Burkina Faso	Côte d'Ivoire	Cameroon	Chad	Comoros
Mean	5.554876	1.041381	1.066339	1.232913	1.924728	1.452784
Median	5.875367	1.051248	1.037642	1.219806	1.844497	1.304361
Maximum	7.908623	1.22181	1.544503	1.500379	2.500548	2.680779
Minimum	3.072709	0.845703	0.884764	1.044024	1.374624	1.097807
Std. Dev.	1.427828	0.095995	0.1407	0.105358	0.338454	0.392652
Skewness	-0.18713	-0.23635	1.111822	0.590408	0.245069	1.743055
Kurtosis	1.922619	2.120858	4.494115	2.844273	1.696385	5.299428
Jarque-Bera	2.276431	1.743573	12.55971	2.482509	3.394382	30.52058
Probability	0.32039	0.418204	0.001874	0.289021	0.183197	0
Sum	233.3048	43.73801	44.78623	51.78236	80.83859	61.01693
Sum Sq. Dev.	83.58637	0.377814	0.811657	0.45511	4.69659	6.321186
Observations	42	42	42	42	42	42
Country	Djibouti	Egypt	Gabon	Gambia	Guinea	Guinea-Bissau
Mean	1.639992	1.466685	2.15227	0.989273	1.533393	1.387831
Median	1.416514	1.434617	2.160947	0.962301	1.545629	1.273497
Maximum	2.749323	1.773453	2.767838	1.315406	1.818814	1.980232
Minimum	1.056077	1.156991	1.448734	0.778236	1.236043	1.043158
Std. Dev.	0.505	0.196745	0.333444	0.120698	0.118306	0.24579
Skewness	0.860887	0.236019	-0.16465	0.971047	-0.18611	0.805093
Kurtosis	2.337795	1.68583	2.227894	3.431231	3.373618	2.44762
Jarque-Bera	5.955292	3.412258	1.23302	6.925958	0.486736	5.071195
Probability	0.050913	0.181567	0.539825	0.031336	0.783983	0.079214
Sum	68.87967	61.60079	90.39534	41.54948	64.4025	58.28888
Sum Sq. Dev.	10.45603	1.587046	4.558575	0.597288	0.573845	2.476923
Observations	42	42	42	42	42	42
Country	Guyana	Indonesia	Iran	Iraq	Jordan	Lebanon
Mean	2.823705	1.35298	2.483318	1.551373	2.024575	2.94929
Median	2.589101	1.313493	2.719956	1.551465	1.960101	3.045934
Maximum	5.327468	1.683977	3.260136	1.956731	3.276643	3.490041
Minimum	2.069633	1.127975	1.314169	1.135126	1.303853	2.272598
Std. Dev.	0.660208	0.175178	0.729854	0.213871	0.427107	0.357854
Skewness	1.916051	0.444343	-0.40049	-0.00794	1.009353	-0.41119
Kurtosis	7.021452	1.907393	1.492884	2.141693	4.129853	1.933707
Jarque-Bera	53.99991	3.471217	5.097695	1.289651	9.365556	3.173243
Probability	0	0.176293	0.078172	0.524754	0.009253	0.204616
Sum	118.5956	56.82515	104.2994	65.15766	85.03216	123.8702
Sum Sq. Dev.	17.87084	1.258178	21.84017	1.875365	7.479247	5.25043
Observations	42	42	42	42	42	42
Country	Libya	Malaysia	Maldives	Mali	Mauritania	Morocco
Mean	3.361052	3.710459	6.901749	1.147361	2.454832	1.443583
Median	3.224281	3.926729	7.211155	1.14727	2.44416	1.472723
Maximum	5.318737	5.046304	10.37158	1.479491	2.925963	1.805331
Minimum	2.495501	2.408282	3.755608	0.857073	1.956101	1.010475
Std. Dev.	0.628909	0.635084	1.402463	0.15719	0.194622	0.225421
Skewness	1.405698	-0.49559	-0.14343	0.069502	0.316299	-0.18017
Kurtosis	4.770011	2.433932	3.017381	1.933291	3.899058	1.93908
Jarque-Bera	19.31455	2.280044	0.144537	2.025082	2.114851	2.196948
Probability	0.000064	0.319812	0.930281	0.363295	0.347349	0.333379
Sum	141.1642	155.8393	289.8735	48.18917	103.1029	60.63047
Sum Sq. Dev.	16.2166	16.53661	80.64303	1.013056	1.552994	2.083394
Observations	42	42	42	42	42	42
Country	Mozambique	Niger	Nigeria	Oman	Pakistan	Qatar
Mean	0.821657	1.473451	1.021038	4.430231	0.764259	11.35489
Median	0.821662	1.451223	1.027718	4.0593	0.761341	11.70739
Maximum	0.932975	2.002298	1.237043	7.281467	0.846183	15.97643
Minimum	0.739424	1.101739	0.801335	1.811627	0.677321	7.336538

Std. Dev.	0.04113	0.175029	0.107743	1.917121	0.037363	2.491012
Skewness	0.197135	1.286899	-0.27259	0.137904	0.225142	-0.00409
Kurtosis	3.032727	5.599002	2.761665	1.317362	2.962331	1.743948
Jarque-Bera	0.273908	23.41368	0.619556	5.087849	0.357306	2.761032
Probability	0.87201	0.000008	0.73361	0.078558	0.836396	0.251449
Sum	34.5096	61.88495	42.88359	186.0697	32.09886	476.9053
Sum Sq. Dev.	0.069359	1.256034	0.475951	150.6895	0.057235	254.4108
Observations	42	42	42	42	42	42
Country	Saudi Arabia	Senegal	Sierra Leone	Somalia	Syria	Togo
Mean	4.387863	1.428567	1.028614	1.220717	1.571139	1.152647
Median	4.305835	1.407379	1.033383	1.213778	1.605124	1.133639
Maximum	6.853075	1.8704	1.249683	1.570117	2.131513	1.874292
Minimum	2.358018	1.125529	0.919113	0.89139	0.997263	0.893112
Std. Dev.	1.292164	0.158369	0.05679	0.209901	0.287576	0.212333
Skewness	0.062984	0.768372	0.989058	0.202734	-0.30901	1.113386
Kurtosis	1.81526	3.45047	6.931677	1.688754	2.378954	4.67031
Jarque-Bera	2.484086	4.487885	33.89931	3.296598	1.34336	13.55979
Probability	0.288794	0.10604	0	0.192377	0.51085	0.001136
Sum	184.2902	59.99982	43.2018	51.27013	65.98782	48.41119
Sum Sq. Dev.	68.45717	1.028306	0.13223	1.806399	3.390696	1.848497
Observations	42	42	42	42	42	42
Country	Tunisia	Türkiye	Uganda	United Arab Emirates	Yemen	
Mean	1.528833	2.834849	1.45912	10.80793	0.791951	
Median	1.548678	2.784577	1.469792	11.4286	0.765224	
Maximum	1.962922	3.476258	1.854082	13.85859	1.020374	
Minimum	0.92741	2.069885	0.97796	7.359525	0.599582	
Std. Dev.	0.291023	0.435152	0.244552	1.857519	0.112702	
Skewness	-0.25126	-0.08196	-0.20069	-0.26083	0.214462	
Kurtosis	2.025095	1.588604	2.19933	1.631951	2.124422	
Jarque-Bera	2.105178	3.533092	1.403808	3.751438	1.663573	
Probability	0.349033	0.170922	0.495641	0.153245	0.435271	
Sum	64.21099	119.0637	61.28304	453.9332	33.26196	
Sum Sq. Dev.	3.472463	7.763647	2.452041	141.4654	0.520772	
Observations	42	42	42	42	42	