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Impact of institutional quality on ecological footprint: New insights from G20 countries

Mohammad Naim Azimi *, Mohammad Mafizur Rahman

School of Business, University of Southern Queensland, Toowoomba, QLD, 4350, Australia

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ABSTRACT

The complex relationship between institutional quality and ecological footprint (ECF) has been verified in prior literature; however, the subject is still inadequately explored and often disregarded to highlight areas where specific policy tensions exist. Therefore, this study aims to delve into the significance of institutional quality on ECF through a limited information maximum likelihood (LIML) panel analysis in the G20 countries from 2000 to 2022. For a precise evaluation, the study innovatively constructs a composite institutional quality index (IQI) and three indices under the accountability, transparency, and participation dimensions. Additionally, the study develops an economic uncertainty predictor to capture the effects of external economic shocks on the subject. The results obtained from the LIML estimation demonstrate that IQI is substantive in reducing ECF in the recipient panel. Further, the findings highlight that all three dimensions of IQI are significant in abating ECF, while the transparency index yields a higher influence on abating ECF. It is also observed that IQI plays an effective role in modulating the relationships between ECF, financial development, human development, growth, and energy consumption, while it is found to be insignificant in reducing the negative effects of globalization on ECF. Finally, the results indicate that IQI is highly influential in eliminating the adverse impact of external shocks on ECF. The results are robust and have specific policy implications.

1. Introduction

The global ecosystem has been negatively affected by increasing human interaction, such as soil erosion, air pollution, acidification of the oceans, and habitat destruction (Santo et al., 2022). It resulted in long-term tendencies toward rapidly rising environmental degradation and a significant shortage of natural resources. These trends are intricately linked and will present formidable obstacles over the coming decades (Shrinkhal, 2019). In a bid to prevent the worst-possible situation, global actions were called for. One such global action was the emergence of the Sustainable Development Goals (SDGs) of the United Nations, in particular SDG7, SDG12, and SDG13, which imply affordable and clean energy, responsible production and consumption, and climate action, respectively (United Nations, 2019). They represent an international plea for action with specific goals that must be accomplished by the end of 2030, specifically to direct the available resources towards sustainable environmental quality. However, while awareness of reducing the effects of atmospheric changes has grown across all spheres of society (Saqib et al., 2023), the deterioration of global ecosystems has not yet received the necessary attention. Recent estimates show that nearly 99% of the world's population is exposed to environmental pollution, which is worse than the level recommended by the World Health Organization (WHO, 2022). Indeed, since decades ago, people have been in an ecological overshoot where demand for resources exceeds Earth's periodic regrowth (Borucke et al., 2013). Overfishing, overharvesting forests, and releasing more carbon dioxide into the atmosphere than nature can absorb cause a significant loss in biodiversity by utilizing more natural resources than nature can replenish.

Specifically, the G20 countries are the primary engine of the world's development and growth, governing more than 84% of the international economy and 65% of the world's population (Chodor, 2021). Undoubtedly, these are advantageous, but the bloc also contributes to more than 75% of the world's ecological footprint (ECF). Despite the variety and divergent routes for development among the members of the G20 countries, the bloc's influence and power also make it extremely accountable for a majority of the environmental problems that the world is currently facing. Rapid globalization, swift urbanization, higher energy consumption to boost further economic output, unrestricted trade,

* Corresponding author.
E-mail address: naeem.azimi@gmail.com (M.N. Azimi).

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and highly unmaintainable consumption of resources have driven three key challenges, among all others, including loss of biodiversity, climate change, and substantial air pollution (Codal et al., 2021). Fig. 1 shows the ECF across the G20 countries in 2022. It indicates an increase in ecological deficit compared to 2010, as shown in Fig. 2. It is apparent that Canada and the USA have the highest ECF, while India, Indonesia, and Mexico have the lowest one in 2010 and 2022. Nevertheless, all other G20 nations indicate varying ECF with a general increasing trend, alarming the sustainable environmental quality trajectory.

The G20 countries must now decide whether it is worthwhile to make a trade-off between leading nations down an identical resource-hungry and high-carbon route that threatens to undo the benefits it has gained and thwart the SDGs or to forge a new and effective decision to ease urgent actions that ties humanity and nature back together and preserves its long-standing prosperity.

The above discussion encourages further empirical investigations and the provision of more precise solutions through more scientific research to assist relevant policymakers from different perspectives. Indeed, institutional studies present environmental quality as a pressing issue for societies and governments to address relevant policies and actions (Gupta et al., 2022). Therefore, the present study primarily aims to delve into the effects of institutional quality on ECF in the G20 countries by addressing three contemporary questions: First, what is the direct impact of institutional quality and its dimensional effects on the ECF? Second, can institutional quality effectively modulate the nexus between key socioeconomic indicators and the ECF? Third, can institutional quality account for the recent unexpected external shocks to the global economy that influence environmental quality? Answering these questions will help us offer precise evaluations and highlight specific areas where policy tensions exist in the recipient panel.

Meanwhile, compared to other exogenous factors, the impact of institutional quality on economic growth, financial development, financial inclusion, health outcomes, income inequality, and many other indicators has been acknowledged in prior studies (Fredriksson and Gaston, 2000; Neumayer, 2002; Fredriksson et al., 2004; Castiglione et al., 2012; Azam et al., 2021; Espinosa-González et al., 2019; Li et al., 2021; Nansai et al., 2021; Khan et al., 2022; Li et al., 2022; Ashraf et al., 2022; Rahman et al., 2023; Sibanda et al., 2023); but the available literature reports rare cases examining the direct, moderating, and multidimensional effects of institutional quality on ECF. However, studies like Goel et al. (2013) for the Middle East and North Africa, Lau et al. (2014) for Malaysia, Uzar (2021) for the E−7 group, and Hussain et al. (2023) for Pakistan have examined the effects of institutional quality on ECF and valuably contributed to the existing literature, but to the best of our knowledge, the G20 has not been attended by scholars to delve into the subject. Thus, in addition to directing our focus toward achieving the primary objectives of the study, the resulting gaps in the literature motivates us to carry out this piece of investigation.

This paper is a novel piece and contributes to literature in four aspects: First, it builds a foundational analytical framework for approaching the role of institutional quality spillovers on ECF in the G20 countries. Second, it innovatively constructs a composite institutional quality index and three-dimensional indices of accountability, transparency, and participation using a distance-based technique to capture the extensive and precise effects of institutional quality on ECF. Third, it highlights critical policy areas by establishing the interaction of institutional quality index with major macroeconomic and pollutant predictors to capture the extent to which both environmental endogenous and exogenous predictors are moderated by institutional quality. This approach reveals unique underlying relationships between ECF and other socioeconomic variables. For example, it reveals how human development, economic growth, energy consumption, or globalization are influenced by effective institutional quality to explain ECF. Fourth, this study uses the generalized autoregressive conditional heteroskedasticity method to construct a predictor of economic uncertainty to capture the effects of recent global economic uncertainties on environmental quality. However, Ayad et al. (2023), in their study, implicitly attempted to define how economic uncertainty influences CO_2 emissions in India, but the present study extends the literature and constructs a novel predictor using the trend of economic growth in the G20 to explicitly explore both its direct impact and its interactional effects with institutional quality on the subject. The inferences that can be drawn from this study drastically alter policymakers' perspectives and evidentially assist them in reorienting their subject policies. Therefore, this study highlights major strategic policy implications for players in the G20 countries, aside from assumed contributions to current literature grounded in the approach and style of interaction pursued in this inquiry. Furthermore, the study adopts an evaluation strategy that identifies the variability of key socioeconomic indicators impacting ECF through the increasing complexity and multidimensionality of institutional quality. This approach may influence current policy debates among the G20 nations to advance sustainable environmental quality by targeting a zero-carbon atmosphere by the end of 2050.

The remaining parts of the study are structured as follows: Section 2 conceptualizes the study and reviews the relevant and empirical literature. Section 3 explains the methodology. Section 4 presents the results. Section 5 provides a brief discussion about the findings. Section 6 concludes the article and highlights specific policy implications.

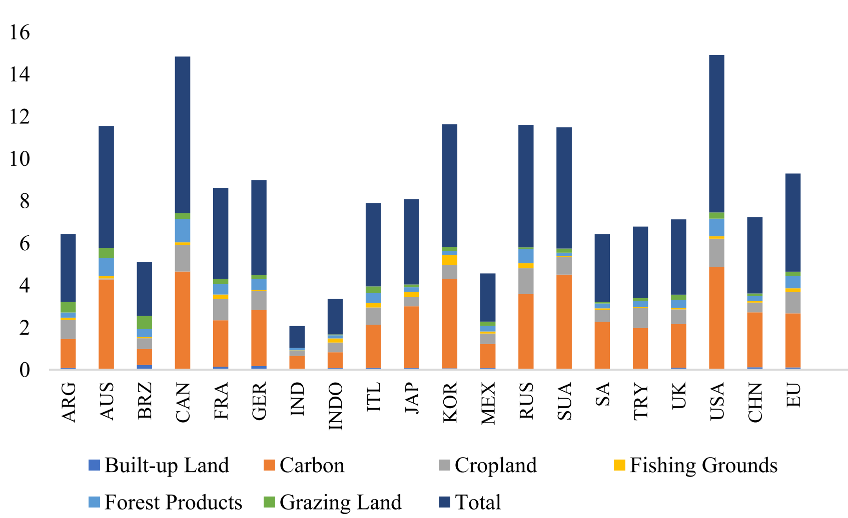

Fig. 1. Ecological footprint per person; G20-2022. Notes: ARG: Argentina, AUS: Australia, BRZ: Brazil, CAN: Canada, FRA: France, GER: Germany, IND: India, INDO: Indonesia, ITL: Italy, JAP: Japan, KOR: Korea, MEX: Mexico, RUS: Russian Federation, SUA: Saudia Arabia, SA: South Africa, TRY: Turkiye, UK: United Kingdom, USA: United States of America, CHN: China, EU: Europe.
Source: Global Footprint Network (G F N, 2023).

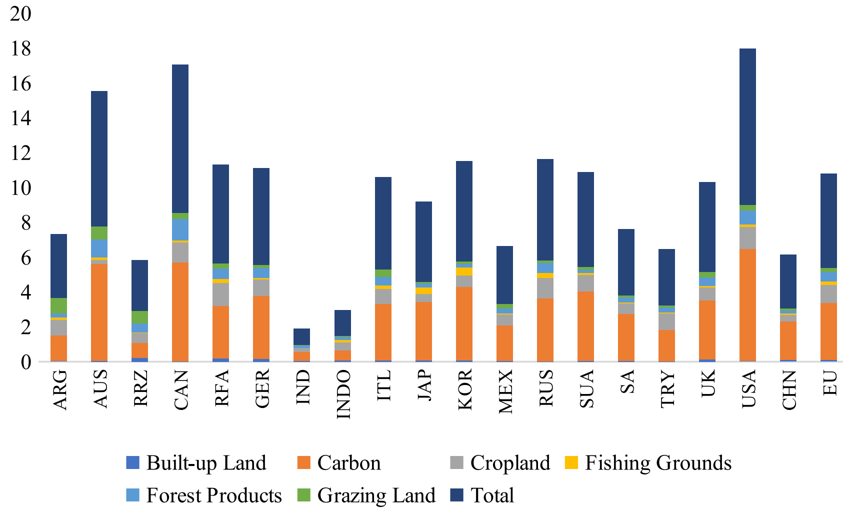

Fig. 2. Ecological footprint per person; G20-2010.
Source: Global Footprint Network (G F N, 2023).

2. Literature review

2.1. Concept

The impact of institutional quality on ECF either directly or as a moderating instrument has not been extensively studied. It might be due to the multidimensional and complex nature associated with predictors of institutional quality, ECF, and the multifaceted nature of socioeconomic indicators linked to each other, as discussed by Abid et al. (2022), Rafei et al. (2022), and Homer (2022). Hussain and Dogan (2021), for instance, observed an adverse impact of economic growth on ECF. Indeed, it was through the secondary association of institutional quality as a mediating policy predictor in their recipient panel. Studies suggested that a more diverse and comprehensive view is required to determine the complexity of linkages between institutional quality and environmental degradation (Azam et al., 2021; Abd Razak et al., 2021; Omri et al., 2022). Contrary to this background, we conceptualize the study to draw on the multidimensional and complex link between institutional quality and ECF in the presence of major socioeconomic predictors. Fig. 3 illustrates that L1 (line-1) alters the direct impact of socioeconomic and pollutant indicators on the subject, and thus L3 is an altered impact. L2 assumes a direct link between institutional quality and the ECF, while L4–6 indicates the dimensional impact of institutional quality on the ECF. Importantly, L7 presents the interaction effects of institutional quality and L8 indicates the impact of external shocks, i.e., economic uncertainty on the subject.

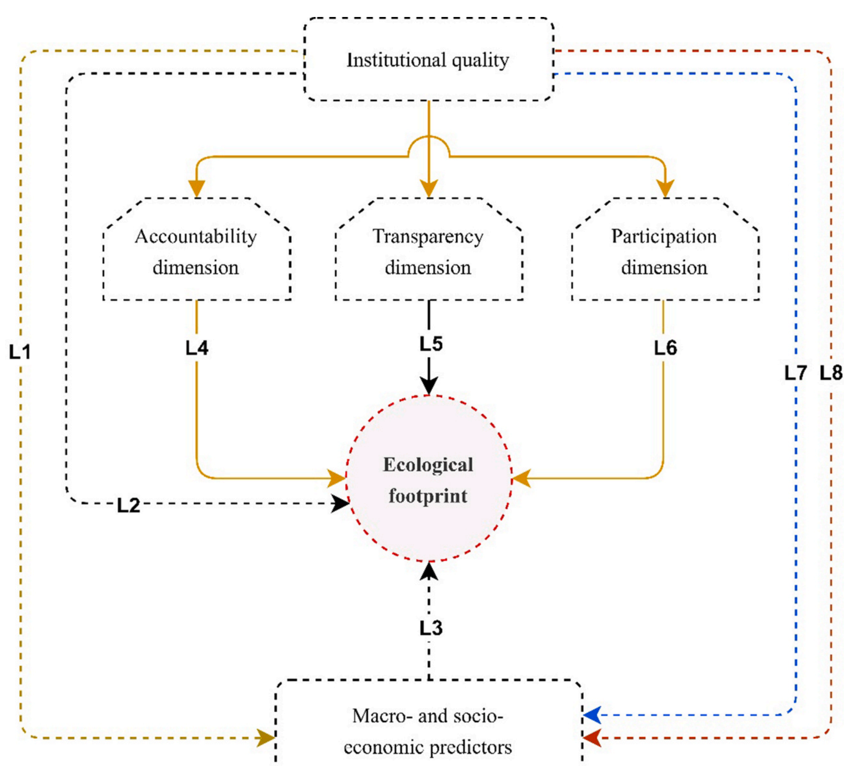

Fig. 3. Conceptual framework.

2.2. Links

In an empirical sense, the ECF is affected by major demographic, macro-, and socio-economic indicators, including urbanization (Gupta et al., 2022; Sahoo and Sethi, 2022), human capital (Ahmed et al., 2020; Chen et al., 2022), globalization (Sabir and Gorus, 2019; Apaydin et al., 2021; Sun et al., 2023), financial development (Omoke et al., 2020; Ashraf et al., 2022; Gill et al., 2023), economic growth (Baz et al., 2020; Kazemzadeh et al., 2022a,b,c; Lee et al., 2023), and population growth (Wu, 2014; Weber and Sciubba, 2019). Most importantly, the available literature also reveals some studies focusing on the effects of institutional quality on ECF (L1) that are briefly reported in the proceeding parts of this section.

2.2.1. Urbanization-ECF

Recent studies revealed that urbanization can significantly influence the ECF, though their presented results are mixed. For instance, Ahmed et al. (2020) investigated the effects of urbanization on ECF over the period from 1971 to 2014 in the G-7 nations and found that urbanization is effective in reducing ECF. Similarly, Nathaniel et al. (2020) and Liang et al. (2019) found that urbanization exerts negative effects on ECF. Danish et al. (2018) used a set of time-series data from 1970 to 2011 in Pakistan and showed that urbanization negatively impacts environmental degradation. In contrast, Salman et al. (2022) evaluated the effects of urbanization on ECF in Indonesia, Thailand, Malaysia, and the Philippines from 1980 to 2017. The authors failed to document an inverted U-shaped curve among the predictors and stated that urbanization is positively associated with the ECF, with a higher impact in Indonesia and Thailand. Balsalobre-Lorente et al. (2021) delved into the effects of urbanization on ECF in Italy, Portugal, Spain, and Greece from 1995 to 2015 using generalized and fully modified ordinary least squares methods. Their findings indicate that urbanization is a key source of environmental degradation in their recipient countries. Likewise, many other studies revealed that urbanization upsurges environmental degradation (Hashmi et al., 2021; Shahbaz et al., 2017a,b; Wang et al., 2016; Liddle and Lung, 2010). In a similar vein, Kazemzadeh et al. (2023a,b) have also noticed the influence of urbanization on the ECF and suggested that due to the complex nature of urbanization's link with the ECF, more extensive empirical investigations are required to observe their true nexus.

2.2.2. Economic-ECF

The effects of growth on environmental degradation are mostly studied under the environmental Kuznets curve (EKC) hypothesis, and undisputedly, the literature hosts a large number of such studies. Lee et al. (2023) examined the effects of economic growth on ECF in Economic Cooperation and Development countries from 1995 to 2017. They observed a nonlinear relationship between growth and the ECF, confirming an inverted U-shaped curve in their recipient panel. Further, Pata and Hizarci (2022) assessed the effects of economic complexity on ECF and CO_2 emissions under the EKC hypothesis in Germany, Switzerland, and Sweden. In the presence of other control variables, the authors found an inverted U-shaped curve only for Germany and Sweden. Likewise, Adebayo et al. (2022) tested the pollution haven hypothesis using foreign direct investment, ECF, CO_2 emissions, and load capacity in Thailand. Their findings confirm the validity of the hypotheses for load capacity and CO_2 emissions while invalidating the ECF. Ali et al. (2021) examined the effects of growth on ECF in three sets of panels classified as high-, upper-middle-, and lower-middle-income countries. Their results validated the EKC hypothesis across all panels, indicating that growth deteriorates environmental quality up to a certain level of income, after which it improves it. Contrary to that, there are a large number of studies that significantly rejected the validity of the EKC hypothesis (Markandya et al., 2006; Niu and Li, 2014; Wang et al., 2018; Erdoğan et al., 2020). The presentation of mixed results is caused by at least one of three common reasons, such as the economic status of the host country, the duration of the datasets used in the studies (which might be in a transitional state), or the results sensitivity to empirical models employed by the authors.

2.2.3. Finance-ECF

Compared to other predictors, the literature reports a limited number of studies that delve into the finance-ECF nexus. Although financial development is assumed to suppress ECF by encouraging and supporting sound financial projects, some studies offer counter-examples. Shahbaz et al. (2023) examined the impact of financial development on ECF in the USA, China, Japan, India, Brazil, Indonesia, Korea, Mexico, the UK, and Turkey. Their findings show that financial development has a positive impact ECF. Likewise, Kihombo et al. (2021) probed the effects of financial development and economic growth on ECF in West Asia and Middle Eastern countries from 1990 to 2017. The authors observed, in particular, that financial development stimulates ECF. Baloch et al. (2019) examined the effects of financial development on ECF in Belt and Road Initiative countries from 1990 to 2016. They also found that financial development is significant for increasing the ECF across their recipient panel.

Moreover, Ashraf et al. (2022) evaluated the effects of financial development dimensions on ECF in a sample of 124 countries. They found that financial institutions, including depth, access, and efficiency, are significant indicators of decreasing ECF, while the financial market has the opposite effect. In the same vein, Usman and Hammar (2021) analyzed the effects of financial development and innovations on ECF in Asia-Pacific Economic Cooperation countries from 1990 to 2017. The authors found that financial development accelerates environmental quality by reducing the ECF. Omoke et al. (2020) examined the effects of financial development on ECF in Nigeria and they also found that an increase in financial development significantly causes ECF to decrease. An in-depth analysis reveals that the indication of mixed results is attributed to the compositional scale effect of financial development in transforming the market economy across countries; that is, the ECF exhibits a positive response to financial development in some countries and a negative response in others.

2.2.4. Human development-ECF

With respect to the human capital and ECF nexus, there is no general consensus on the effects of human development on ECF in the existing literature. For example, Ahmed and Wang (2019) analyzed the effects of human capital on ECF in India from 1971 to 2014. They observed that human capital negatively contributes to ECF, while also showing that human capital has a causal link with ECF. Pata et al. (2021) employed the human development index and ECF to examine their nexus in the top ten countries with the highest ECF from 1992 to 2016. Their findings reject the validity of the human capital Kuznets curve; however, they found that the human development index negatively effects ECF. Furthermore, Saleem et al. (2019) investigated the effects of human capital and biocapacity on environmental degradation in Brazil, the Russian Federation, India, China, and South Africa from 1991 to 2014. Their findings revealed that human capital significantly increases environmental degradation. Meanwhile Ünal and Aktuğ (2022) investigated the impact of human capital and other control variables on ECF in G20 countries from 1970 to 2016, using the dynamic common correlated effects technique. Their findings indicated that human capital decreases ECF in developed economies while becoming insignificant in developing economies. Chen et al. (2022) probed the effects of human capital on ECF from a global perspective using a sample of 110 countries from 1990 to 2016. They noticed that human capital initially boosts ECF and then suppresses it. The authors also indicated that human capital is significant for reducing ECF in high-income countries, whereas it turns positive in the low-income group.

2.2.5. Globalization-ECF

Recent studies have greatly contributed to enhancing familiarity with the nexus between globalization and ECF across various countries. For instance, Pata (2021) delved into the effects of globalization, renewable energy, and agricultural activities on ECF and CO_2 emissions in Brazil, the Russian Federation, India, and China from 1971 to 2016. In particular, the author found that globalization is statistically significant in pressurizing the pollutant predictors. Likewise, Sabir and Gorus (2019) investigated the effects of globalization on environmental degradation in South Asia from 1975 to 2017. Their empirical findings suggested globalization indicators such as trade openness, foreign direct investment, and the KOF index are significant for increasing ECF. Figge et al. (2017) examined the effects of the globalization index on ECF in a panel of 171 countries using multivariate regression analysis. The authors found that the globalization index significantly increases ECF. Usman et al. (2020) probed the impact of globalization on ECF in the USA from 1985 to 2014 using the autoregressive distributed lag approach. Their empirical evidence suggested that globalization positively pressurizes ECF in the long run. The literature also reveals studies that found counter results. Shahbaz et al. (2017a,b) investigated the EKC hypothesis in the presence of globalization in China from 1970 to 2012 using the vector error correction method causality technique. It was discovered that the EKC is valid in China, while globalization is significant in reducing environmental degradation. Further, Rafindadi and Usman (2021) delved into the asymmetric effects of growth and globalization on ECF in Brazil from 1971 to 2014. They also found that the nexus between the variables is asymmetric. Specifically, their results indicated that the negative partial sum from globalization highly reduces the ECF compared to its positive shocks.

2.2.6. Energy-ECF

Comparatively, the existing literature is immense with studies concerning the effects of energy consumption on ECF. Kazemzadeh et al. (2023) probed the effects of energy consumption structure on ECF in a panel of countries classified as high- and middle-income from 1990 to 2017. The authors innovatively employed the club convergence approach to verify similar ECF patterns over time. They found that, in general, energy consumption structure in various quantiles up to the 50th, positively pressurizes the ECF, while above that, it has a negative impact on the ECF. Similarly, Sun et al. (2023) explored the effects of energy consumption on ECF in Brazil, the Russian Federation, India, China, and South Africa using quantile regression approach. Their findings indicate that energy consumption increases ECF in China and India while decreasing it in South Africa. Moreover, Majeed et al. (2021) investigated the non-linear effects of energy consumption on ECF in Pakistan from 1971 to 2014. Using the asymmetric autoregressive distributed lags model, the author discovered that the negative shocks from aggregate energy consumption have negative effects, while the positive shocks increase ECF. Likewise, Baz et al. (2020) have also examined the effects of energy consumption on ECF in Pakistan from 1971 to 2014 using similar methods and found that energy consumption is asymmetrically cointegrated with ECF and that it asymmetrically increases ECF in Pakistan. Contrary to that, Rehman et al. (2021) analyzed the nexus between energy consumption, ECF, and other relevant control variables in Pakistan from 1974 to 2017. They employed an autoregressive distributed lag model and found that energy usage, growth, and trade have productive interactions with ECF, implying that energy consumption increases ECF. Further, Nathaniel et al. (2019) explored the effects of energy consumption and urbanization on ECF in South Africa from 1965 to 2014. Although they found that economic growth and financial development decreased the ECF, energy consumption was found to positively contribute to the ECF. Although prior literature is vast, results are conflicting and require extensive and complex investigations to highlight their contextual nexus.

2.2.7. Institutions-ECF

The recent contribution of studies to the literature on the effects of institutional quality on environmental degradation is valuable, though the precision of the presented results is still debatable. Farzin and Bond (2006), Li and Reuveny (2006), Bernauer and Koubi (2009), Arvin and Lew (2011), and Satrovic et al. (2021) utilized democracy as a proxy for institutional quality to test whether it affected air pollution. They found that democracy is substantive in reducing environmental degradation. Goel et al. (2013), Lau et al. (2014), Akhbari and Nejati (2019), Uzar (2021), and Fatima et al. (2022) employed corruption, law, and order as a substitute for institutional quality predictors and observed their significant effects on mitigating carbon emissions. Furthermore, Adedoyin et al. (2022) tested the link between regulator quality, CO_2 emissions, and financial development in Sub-Saharan Africa. The authors showed that growth highly influences CO_2 emissions, while regulatory quality and institutional indicators are significant in reducing carbon emissions. Differently, Abid (2016) investigated the moderating effects of political stability, democracy, government effectiveness, and control of corruption on CO_2 emissions in Sub-Saharan Africa. The author found that institutional quality significantly reduces CO_2 emissions. Hunjra et al. (2020) assessed the moderating role of institutional quality on environmental quality and financial development in South Asia. They observed that institutional quality effectively moderates the impact of financial development on the environment.

Finally, the literature reveals that Salman et al. (2019) examined the effects of government effectiveness on environmental degradation in a panel of three Asian countries from 1990 to 2016. They observed several results, among which they concluded that institutional quality increases carbon emissions, but efficient institutions are impartial to increase growth and decrease carbon emissions. Somewhat consistent with this, Azam et al. (2021) used administrative capacity, political stability, and democratic accountability as proxies for institutional quality. Their results also concluded that institutional quality has a positive impact on energy consumption and environmental degradation.

2.3. Gaps

The contribution of recent studies focusing on numerous indicators influencing ECF is valuable to enhancing the existing knowledge of the field with respect to the effects of growth, globalization, urbanization, finance, and energy consumption on ECF. However, based on the subject of present interest, the review of the above-cited studies reveals several gaps. First, institutional quality is a broad and multifaceted concept, and its extensive effects may not be well explored by using single or inconclusive proxies. For instance, different studies employed different proxies, such as corruption, democracy, and government effectiveness. These indicators may not correspond to the comprehensive concept of institutional quality. Therefore, to address this issue, the following hypothesis is developed:

***Hyp*$_1$**: The distance-based institutional quality index that accounts for the variability of institutional quality from the worst to an ideal point can capture its exact effects on ECF.

Second, the absence of a precise evaluation of institutional quality on the ECF is another irrationality found in prior literature. Aggregate indexing, or surprisingly, augmenting individual proxies, may not capture the true effects of institutional quality on the subject; rather, it may lead to perplexing conclusions. Thus, the following hypothesis will address this issue:

***Hyp*$_2$**: Institutional quality has a multidimensional impact on ECF including accountability, transparency, and participation that verifies specific policy implications.

Third, although the existing literature reports the exceptional work of Uzar (2021) for E−7 with respect to the deployment of ECF in the analytical framework of environmental degradation and institutional quality linkages, the present inquiry failed to find any such empirical studies focusing on the most comprehensive context, the G20, to delve into the effects of institutional quality on ECF. To account for this issue, the following hypothesis is developed:

***Hyp*$_3$**: IQI and its dimensions have a significant impact on ECF in the

G20 countries.

Fourth, although studies have accounted for the effects of globalization on ECF, almost all have ignored the effects of external economic shocks raised by recent political divisions, trade tensions, and global pandemics on ECF. The following hypothesis will address this problem:

Hyp_4: Economic uncertainties impose an unfavorable impact on ECF across the G20 nations.

Finally, the spillover effects of institutional quality are acknowledged by recent studies. It is imperative to explore how it modulates the relationship between ECF and other indicators. The hypothesis below will address this issue:

Hyp_5: Institutional quality is effective in moderating the relationship between ECF and macro- and socioeconomic indicators in the G20 nations.

3. Methodology

In a bid to offer empirical replicability, Fig. 4 presents the key stages of the methodological framework adopted in the study. This framework ensures a systematic approach to testing the developed research hypotheses and achieving the primary objectives of the study. Similar methodological approach has been largely used in prior literature (see, *inter alia*, Kazemzadeh et al., 2022a,b,c; Ansari et al., 2022). In stage 1, the G20 countries have been selected as the geographical context of the study. The choice of the G20 is based on the verification of its holistic scope. It represents two-thirds of the world's population, more than 84% of the global GDP, and 75% of international trade (Bilgili and Ulucak, 2018). Additionally, it is one of the premier international forums for economic cooperation and has a considerable impact on the architecture and global governance of key economic and environmental issues. Importantly, the G20 represents more than 80% of global emissions and is therefore a crucial domain for key policy initiatives beneficial to other nations (Ansari et al., 2022). In stage 2, key explanatory variables are selected. In stage 3, reliable sources are verified for collecting the required datasets for the variables of interest. In stage 4, the IQI and economic uncertainty predictor are constructed. In stage 5, the study specifies key empirical models to explore the effects of IQI on ECF, while in stage 6, the estimation techniques are presented to examine the direct, dimensional, and moderating effects of IQI on ECF, using the limited information maximum likelihood (LIML) method.

3.1. Selection of variables

The variables used in the study are consistent with prior empirical literature. ECF has been selected as the dependent variable. However, some prior studies (Saboori and Sulaiman, 2013; Salahuddin and Khan, 2013; Abbasi and Riaz, 2016; Chen et al., 2019; Ragoubi and Mighri, 2021; Jiang et al., 2022; Shabir et al., 2023) employed CO_2 emissions as a proxy for environmental degradation; ECF is a more comprehensive predictor that captures the total affected areas used by human interaction (Hussain et al., 2023; Kazemzadeh et al., 2022a,b,c; Pata and Isik, 2021). The ECF used is based on consumption and expressed in terms of constant per capita. From Section 2 (literature review), we noticed that economic growth, urbanization, globalization, financial development, human development, energy consumption, and population growth are the key determinants of ECF. For instance, Pata (2018) noticed that urbanization has a positive impact on environmental degradation, whereas Wei and Zhang (2017) observed a mixed result. This suggests probing its effects on ECF. Thus, urbanization (URB), expressed as a percentage of the total population, has been added to the analysis. The study accounts for the complex links between financial development and the ECF and therefore uses the financial development index (FDI), which includes both the elements of financial markets and financial institutions like depth, access, and efficiency. FDI is measured in terms of numbers ranging from 0 to 1 (perfect). Recent studies are also conducive to employing FDI (Satyanarayana Murthy et al., 2014; Ito and Kawai, 2018) instead of using proxies such as credit to the private sector or gross fixed capital formation. Regardless of its magnitude, the effect of economic growth on environmental quality is undeniable Okonkwo and Ifeanyi (2021); Lorente and Álvarez-Herranz (2016). The study employs the GDP growth as a proxy for economic growth (EG), which is expressed as an annual percentage. Moreover, prior literature (Anand and Sen, 1994; Khan et al., 2019) suggests that human capital is a key determinant of environmental degradation. To that end, the study uses the human development index (HDI), which is a relatively comprehensive measure of human capital elements such as health, education, knowledge, and well-being. HDI is measured in terms of numbers from 0 (lower) to 1 (higher). In order to observe the social, economic, and political aspects of globalization on the subject, the study follows Bilgili et al. (2020) and Cervantes et al. (2020) and employs the globalization index (GI), measured in terms of numbers spanning from 1 (lower) to 100 (higher). Consistent with studies by Dong et al. (2018) and Ray and Ray (2011), who observed the significance of population growth on

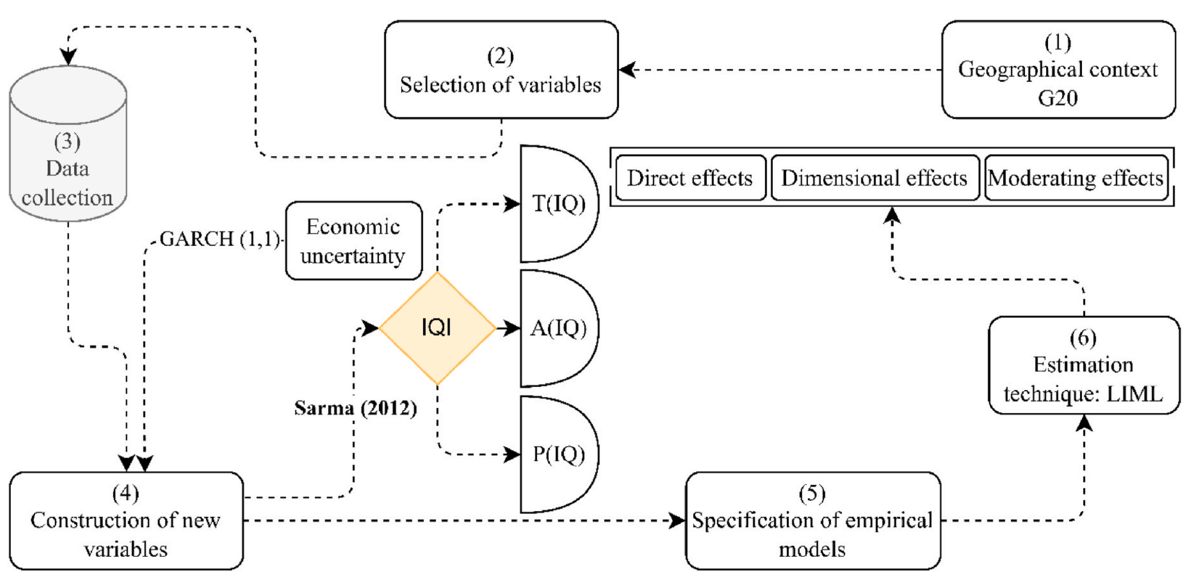

Fig. 4. Methodological framework.
Source: Authors' conception.

environmental quality, the present study employs the population growth rate (PGR) as a control variable, which is expressed as an annual percentage of the total population. Finally, ignoring the influence of energy consumption (EGY) on ECF may cause bias. Thus, following Rahman and Vu (2020), Salahuddin and Gow (2019), and many other relevant studies, we control for the effects of EGY, measured in terms of metric tons per capita.

3.2. Data collection

The datasets employed range from 2000 to 2022. The time period was conditioned on the availability of the required datasets for the variables of interest; however, it represents two global events that are crucial for the present inquiry: first, the global financial crisis from mid-2007 to early 2009; and second, the COVID-19 pandemic from early 2020 to early 2022. Both of these events had significant impacts on major economic, environmental, social, and health outcomes (Stuckler et al., 2009; Prawoto et al., 2020). To acquire data for the selected variables, various reliable sources have been identified. The dataset for ECF was collected from the Global Footprint Network (G F N, 2023). The datasets for EG, EGY, URB, and PGR were compiled from the World Development Indicators (WDI, 2023), and data for FDI was accessed from the International Monetary Fund (IMF, 2023). Furthermore, sources relevant to the United Nations Development Program (UNDP, 2023) and the KOF Swiss Economic Institute (KOF, 2023) offered the required datasets for HDI and GI, respectively.

3.3. Construction of new variables

3.3.1. IQI construction

As indicated, in order to allow precision in assessing the extensive effects of institutional quality on ECF, the study constructs a composite institutional quality index (*IQI*) using six measures of the Worldwide Governance Indicators developed by Kaufmann and Kraay (2020). They include control of corruption (*CoC*), rule of law (*RoL*), government effectiveness (*GoE*), regulatory quality (*ReQ*), political stability (*PoS*), and voice and accountability (*VoA*). These variables are expressed on the same scale, ranging from 0 to 100 percentile ranks, where a higher value indicates a higher quality of institutions and vice versa. To construct the index, the study adopts the methodology proposed by Sarma (2012). This methodology is based on a distance-point approach from a worst to an ideal point rather than simply allocating equal average weights to indicators. It has recently gained prominence in literature due to its preference over common techniques. Based on notable works by Lenka and Sharma (2017), Park and Mercado (2018), and Omar and Inaba (2020), the study begins the construction of *IQI* with the allocation of weights using the coefficient of variations of each WGI measure using equation (1), and then each indicator will be normalized through the use of equation (2) as:

$$W_{it} = \frac{\upsilon_{it}}{\sum_{i=1}^{N} \upsilon_{it}} \tag{1}$$

$$N_{it} = \sum_{i=1}^{N} \left(\frac{T_{it} - L_{it}}{U_{it} - L_{it}} \right) W_{it} \tag{2}$$

where W refers to the allocated weight, υ is the coefficient of variation, $\mathbb{N}$ is the normalized value of an indicator, T is the true value of the indicator, L refers to lower limit fixed by 0, and U is the upper limit fixed by 90th percentile rank for an indicator i at time t. The upper value is set to remove any excessively high benchmarks across the indicators (Omar and Inaba, 2020). Table 1 displays the estimated mean, standard deviation, coefficient of variation, allocated weight, and normalized values. The normalized value (N) indicates the extent to which the panel (G20) achieved quality at each institutional indicator. The higher the normalized value, the higher the achievement will be. Next, the distance of datapoints ($d = d_1, \ldots, d_n$) from a worst situation (0) to an ideal one ($I = I_1, \ldots, I_n$) are computed using equations (3) and (4):

$$d_{it} = \sqrt{\left(\sum_{i=1}^{n} N_{it}^2 \right)} \Big/ \sqrt{\left(\sum_{i=1}^{n} w_{it}^2 \right)} \tag{3}$$

$$I_{it} = 1 - \left(\sqrt{\left(\sum_{i=1}^{n} (w_{it} - N_{it})^2 \right)} \Big/ \sqrt{\left(\sum_{i=1}^{n} w_{it}^2 \right)} \right) \tag{4}$$

where all other variables are defined before, d_{it} is the normalized Euclidian distance achieved from the point (d) to the worst point (O) for the nth-dimensional distance (Sarma, 2012) and (I_{it}) refers to the inverse Euclidian distance normalized value achieved from point (d) to an ideal point (I).

Finally, the study takes the ratio of (3) over (4) and constructs the IQI as:

$$IQI_{it} = 0.50\left(x_{it}^{nor} + x_{it}^{inv} \right) \tag{5}$$

Here, the constructed *IQI* ranges from 0 (imperfect) to 1 (perfect) institutional quality in country ($i = 1, 2, \ldots, = 20$) at time ($t = 1, 2, \ldots, = 2022$). Fig. 5 shows the *IQI*'s box plot distribution across the G20 panel.

For the construction of the IQI dimensional indices, the study follows the same procedure as defined in equations (1)–(5). Thus, accountability index (*A(IQ)*) includes *CoC* and *RoL* variables, transparency index (*T (IQ)*) includes *GoE* and *ReQ* indicators, and participation index (*P(IQ)*) includes *PoS* and *VoA* indicators. Fig. 6 displays a boxplot of the constructed *IQI* dimensional indices. It also notes that *A(IQ)*, *T(IQ)*, and *P (IQ)* are expressed in numbers ranging from 0 (lower) to 1 (higher).

3.3.2. Economic uncertainty

Political divisions and international trade rigidities between some nations—for instance, Brexit, the US-China trade relationships, and recent global pandemic (COVID-19)—have ushered in significant turbulence and resulted in a high level of economic uncertainty (Ahir et al., 2022). Therefore, it is important to explore the extent to which global economic uncertainty influences ECF. To that end, the study develops an economic uncertainty variable using the generalized autoregressive

Table 1
IQI's basic estimations.

Dimensions	Indicators	Mean	Std. Dev.	Coefficient of variation ($\sigma_i \div \bar{x}_i$)	Allocated wight $\upsilon_{it} \div \sum_{i=1}^{N} \upsilon_{it}$	Normalized values $\sum_{i=1}^{N} (T_{it} \div U_{it}) W_{it}$
Accountability	*CoC*	73.1406	21.7686	0.29762	0.505246	0.761385
	RoL	74.8031	21.8011	0.29144	0.494754	0.749726
Transparency	*ReQ*	77.2622	18.6339	0.24117	0.520765	0.778628
	GoE	77.5049	17.2017	0.22194	0.479235	0.732483
Participation	*PoS*	64.8711	24.6790	0.38043	0.553976	0.715529
	VoA	75.5529	23.1417	0.30629	0.446024	0.695582

Notes: *CoC*: Control of corruption, *RoL*: Rule of law, *GoE*: Government effectiveness, *ReQ*: Regulatory quality, *PoS*: Political stability, *VoA*: Voice and accountability. All these indicators were originally expressed in percentile ranks ranging from 0 to 100.
Source: Authors' computations.

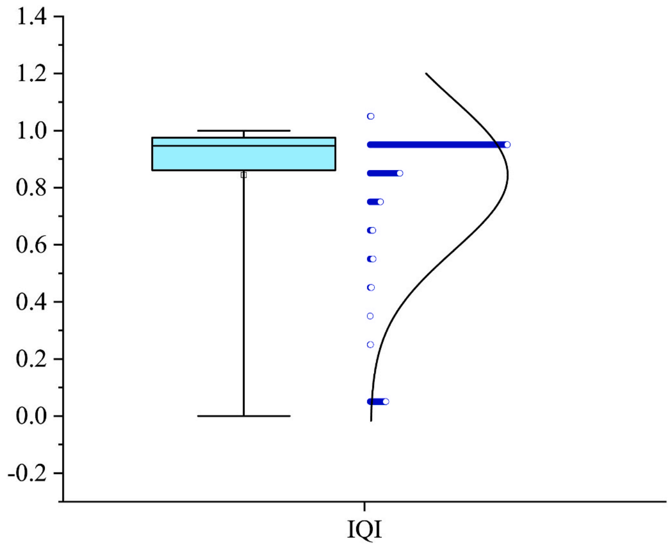

Fig. 5. IQI's distribution box plot; G20.
Source: Authors' estimations.

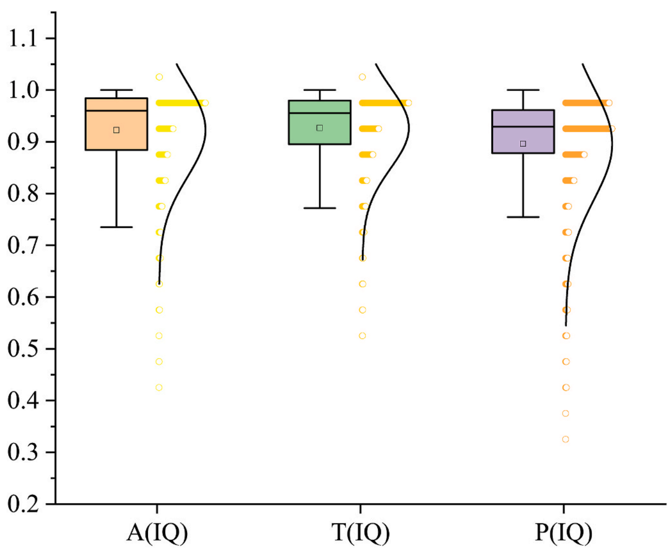

Fig. 6. IQ dimensions' boxplot.
Source: Authors' estimations.

conditional heteroskedasticity (GARCH) approach to produce data-points from the GDP annual growth rate for each G20 countries under review. It is a notable procedure and is extensively employed in prior literature (see, for example, Asteriou and Price, 2005; Gokbulut and Pekkaya, 2014; Abaidoo and Agyapong, 2022b). Additionally, the GARCH model is employed to estimate the volatility of the variable under review as an indicator of uncertainty. The GARCH model used is specified as:

$$\sigma_{GDPG,t} = \vartheta + \theta\lambda^2_{GDPG,t-1} + \xi\sigma_{GDPG,t-1} \tag{6}$$

where σ is the conditional volatility of GDP growth rate at time ($t = 2000$ to 2022), ϑ presents the model intercept, θ is the autoregressive conditional heteroskedasticity (ARCH) parameter, and λ is the parameter of the GARCH model. Fig. 7 displays the estimated economic uncertainties for the G20 countries.

3.4. Model specification

The key objective of this inquiry, which is translated into the key research questions and the hypotheses, is to determine the direct, moderating, and multidimensional effects of IQI on ECF. In doing so, the study begins with the specification of the following long-run multivariate dynamic equation to test the direct effects of IQI on ECF as:

$$\begin{aligned} ECF_{it} = \theta + \vartheta_1 IQI_{it} + \vartheta_2 FDI_{it} + \vartheta_3 HDI_{it} + \vartheta_4 EGY_{it} \\ + \vartheta_5 EG_{it} + \vartheta_6 GI_{it} + \vartheta_7 URB_{it} + \vartheta_8 PGR_{it} \\ + \vartheta_9 ECU_{it} + n_t + \varepsilon_{it} \end{aligned} \tag{7}$$

where *FDI* refers the financial development index, *HDI* is the human development index, *EGY* refers to energy consumption, *EG* presents the GDP growth, *GI* presents the globalization index, *URB* is the urbanization, PGR refers to population growth, *ECU* is the economic uncertainty, and ε_{it} is the error-term. Additionally, θ is the intercept, ϑ_1 to ϑ_8 are the long-run coefficients of the variables, and n_t refers the country-specific effect. Our second focus is to delve into the moderating impact of the IQI on relationship between ECF and major macro- and socio-economic indicators. To that end, the study specifies the following model:

$$\begin{aligned} ECF_{it} = \theta + \vartheta_1 IQI_{it} + \vartheta_2 FDI_{it} + \vartheta_3 HDI_{it} + \vartheta_4 EGY_{it} \\ + \vartheta_5 EG_{it} + \vartheta_6 GI_{it} + \vartheta_7 URB_{it} + \vartheta_8 PGR_{it} \\ + \vartheta_9 ECU_{it} + \psi(MSI_{it} \times IQI_{it}) + n_t + \varepsilon_{it} \end{aligned} \tag{8}$$

where all other variables are explained before, ψ is the coefficient of the interaction term, and *MSI* refers to the macro- and socio-economic indicators, say, the control variables. To augment ($MSI_{it} \times IQI_{it}$) into equation (8), the study takes its differentiation as:

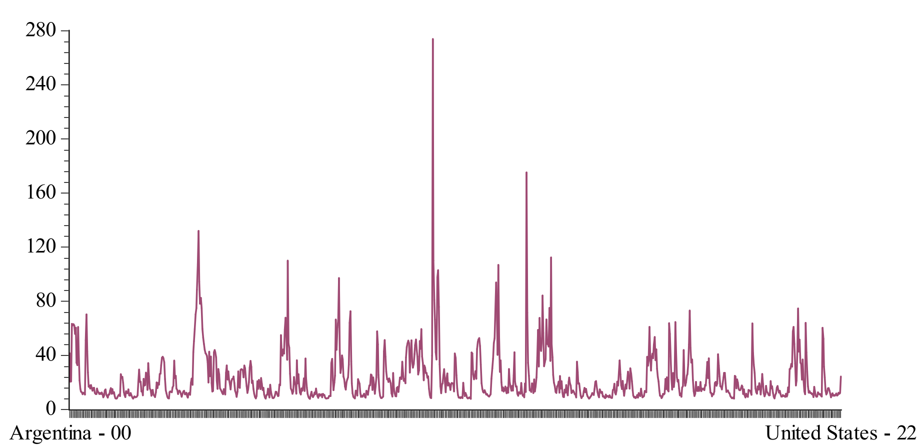

Fig. 7. Economic uncertainty plot from 2000 to 2022. Notes: Countries are arranged in alphabetical order; that is, Argentina is the first and the United States is the last one in the G20 panel. 00 indicates the year 2000 and 22 denotes the year 2022.

$$\frac{\partial ECF_{it}}{\partial MSI_{it}} = \vartheta_1 + \psi IQI_{it} \tag{9}$$

where ϑ_1 and ψ capture the extent to which the *IQI* advances the efficiency of the macro- and socio-economic indicators (*MSI*), such as *FDI*, *HDI*, *EGY*, *EG*, *GI*, *URB*, *PGR*, and *ECU* on *ECF*. Furthermore, the study investigates the effects of key institutional quality dimensions, such as accountability, transparency, and participation on ECF. To this faith, it specifies the following model:

$$\begin{aligned} ECF_{it} = \theta + \eta A_{IQ,it} + \lambda T_{IQ,it} + \varphi P_{IQ,it} + \vartheta_1 FDI_{it} + \vartheta_1 HDI_{it} \\ + \vartheta_3 EGY_{it} + \vartheta_4 EG_{it} + \vartheta_5 GI_{it} + \vartheta_6 URB_{it} + \vartheta_7 PGR_{it} \\ + \vartheta_8 ECU_{it} + n_t + \varepsilon_{it} \end{aligned} \tag{10}$$

where $\eta, \lambda,$ and φ refer to the long-run coefficients of accountability index (*A*), transparency index (*T*), and participation index (*P*) of institutional quality (IQ), respectively, and all other variables carry the same meaning as explained before.

3.5. Estimation technique

Prior literature about the direct and spillover effects of *IQI* on environmental degradation is somewhat opaque. There are empirical criticisms about the inconclusive outcomes caused by methodological deployment that ignores endogeneity issues in panel data analysis (Barros et al., 2020). Customarily, the most evident source of endogeneity is the omission of predictors correlated with the dependent variable. From Section 2, we observed that, for dynamic panel estimations, the existing literature reports various methods such as pooled ordinary least squares, random effects (RE), fixed effects (FE), the generalized method of moment (GMM), two-stage least squares (2 S LS), and panel autoregressive distributed lags (ARDL) models with both mean group and pooled mean group estimators. In the presence of heterogeneity and inverse causality, both RE and FE methods are proven to be inconsistent and inefficient (Phillips and Sul, 2007; Hahn and Kuersteiner, 2011). Weak instrumentation is detrimental to GMM estimators (Stock et al., 2002), and differencing the GMM equation would be affected by sample distortion. The panel ARDL model of Pesaran et al. (1999) has been widely used in relevant studies. However, it might be biased in the presence of cross-sectional dependence among the predictors. While the cross-sectionally augmented ARDL model of Chudik and Pesaran (2015) accounts for cross-sectional dependence, its accurate outcome heavily depends on a large number of observations to allow sufficient lags of both the dependent and independent variables. It also restricts estimations to a single long-run relationship between variables. Thus, in light of the above-cited issues, the present study employs the limited information maximum likelihood (LIML) method of Anderson and Rubin (1949), which was initially suggested by Girshick and Haavelmo (1947). The study initiates fitting the following single structural equation for the observation (i), which refers to as "limited information" as:

$$y_i = Y_{-i}\omega_i + X_i\xi_i + \varepsilon_i \equiv Z_i\lambda_i + \varepsilon_i^{'} \tag{11}$$

where y_i presents the dependent variable (say, ECF), X_i is the vector of explanatory variables included in the model, and Y_{-i} is the unspecified endogenous variables defined in a reduced form as:

$$Y_{-i} = X\Psi + U_{-i} \tag{12}$$

where $Y_{-i}, X_{-i},$ and X refer to the endogenous, exogenous, and instrumental variables (*IVs*), respectively (Harvey and Amemiya, 1987). Thus, the LIML model can be expressed as:

$$\widehat{\lambda}_i = \left(Z_i^{'}(I - \vartheta M)Z_i\right)Z_i^{'}(I - \vartheta M)y_i \tag{13}$$

where M denotes $I - X(X^{'}X)^{-1}X^{'}$ and ϑ refers to $\left(\begin{bmatrix} y_i \\ Y_{-i} \end{bmatrix} M_i [y_i \quad Y_{-i}]\right)\left(\begin{bmatrix} y_i \\ Y_{-i} \end{bmatrix} M [y_i \quad Y_{-i}]\right)^{-1}$ that is the smallest root matrix. In other words, as stated by Young and Theil (1973) and explained by Hill and William (2019), ϑ solves for the smallest generalized eigenvalue issues as $|[y_i \quad Y_{-i}]' M_i [y_i \quad Y_{-i}] - \vartheta [y_i \quad Y_{-i}]' M [y_i \quad Y_{-i}] = 0|$. Consequently, $\widehat{\lambda}_{LIML}$ is estimated as a simple *IV*-regression (*ivregress*) form (Akashi and Kunitomo, 2015). The LIML has several advantages over common dynamic panel data techniques. First, it captures panel endogeneity and estimates consistent and robust coefficients in panels, whether or not they are balanced. Second, it is asymptomatically normal in terms of country-specific fixed effects and does not remove it from estimation (Stock and Yogo, 2005). According to Akashi and Kunitomo (2015), the LIML is efficient in the presence of endogeneity and maintains dynamic individuality effects in the panel. Third, it does not suffer from weak instrumentation due to the small sample size. Fourth, it achieves an asymptotic bound where there are a large number of orthogonal settings (Abaidoo and Agyapong, 2022b). Fifth, compared to 2 S LS, the LMIL has been proven to be more robust (Stock and Yogo, 2005; Akashi and Kunitomo, 2012). Sixth, because panel data is generally subject to cross-sectional dependence issues, the LIML, which is an *IV*-regression method, imposes restrictions so that cross-sectional dependence does not cause $y_{i,t-1}$ to be endogenous (Sarafidis and Wansbeek, 2012; Verdier, 2016). The LIML is an empirical competitor to the CS-ARDL model in overcoming cross-sectional dependence in a sample with a small number of observations (De Hoyos and Sarafidis, 2006). Finally, "the LIML estimators are consistent and asymptotically normal when the factor loadings in the reduced form explanatory variables and the reduced form errors are uncorrelated conditional on the common shocks" (Forchini et al., 2018). Based on these advantages, the LIML method has recently gained prominence in the literature and is widely used in studies of a sophisticated nature concerned with institutional quality predictors (Federici et al., 2023; Abaidoo and Agyapong, 2022a; Lu et al., 2020; Lin and Liscow, 2013; Dmitriev, 2013). However, great caution is sought when augmenting *IVs* into the model. Thus, as an integral part of the LIML estimation, the study estimates and reports the robustness of the model using the under-, over-, and weak-identification tests, respectively, to ensure that the endogenous predictors are greater than the *IVs*, that the *IVs* and ε_{it} do not correlate, and that the *IVs* are sufficient to explain the endogenous variables in our estimations. All estimations are carried out using Oximetric 6.0, Stata/BE 17.0, and OriginLab 2022 software packages. Specifically, the *sum*, *corr*, *xtreg*, *vif*, *xtcd*, *ivregress liml*, and *estat* commands were used in STATA, while the GARCH (1,1) under multivariate analysis-ARCH modeling has been used in Oximetric for preliminary analysis and key estimations.

4. Results and discussions

4.1. Preliminary tests

The analysis begins with some important descriptive statistics reported in Table 2. It demonstrates that the mean value for *ECF* stands at 5.204, with a minimum of 0.745 and a maximum of 17.283 units per capita. It is observed that a similar pattern exists for *ECF* across the panel, while *IQI*, with a mean value of 0.844 and minimum and maximum values of 0.265 and 0.944, respectively, shows a non-monotonic behavior during the period. This is mostly based on the indicators of three countries, such as India, Indonesia, and the Russian Federation.

Once *IQI* is split into three dimensional indices [*A(IQ), T(IQ),* and *P (IQ)*], many similarities are found between them across all G20 countries that might be due to the similarities in their institutional structures. The statistics indicate that *GI* is at its peak, with a mean of 76.798 and a maximum of 91.141 in the G20 panel. Though one can read through, interestingly, the study observes that *EUC* shows an average of 23% with the highest volatile peak of 273.81%. Nonetheless, as it is delved into its effects later, it suggests the harmfulness of *EUC* to environmental

Table 2
Summary statistics.

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum
Ecological footprint	460	5.204	2.319	0.745	17.283
Institutional quality index	460	0.844	0.265	0.264	0.964
Accountability index	460	0.923	0.091	0.430	0.905
Transparency index	460	0.927	0.078	0.522	0.899
Participation index	460	0.896	0.108	0.313	0.961
Financial development index	460	0.518	0.237	0.005	0.967
Energy consumption	460	9.553	1.494	4.663	12.019
GDP growth	460	2.836	3.809	−14.839	24.37
Human development index	460	0.833	0.114	0.027	0.962
Urbanization	460	72.908	15.237	21.637	98.153
Population growth	460	1.137	1.924	−4950	21.260
Global index	460	76.798	9.711	43.582	91.141
Economic uncertainty	460	23.000	19.579	7.871	273.81

Source: Authors' computations.

quality. To explore the relationship between the variables, the study estimates the pairwise correlation. However, the results shown in Table 3 fail to report any significant correlation between variables, but two methods are used to detect multicollinearity: first, a threshold level of ≥0.85 as proposed by Elith et al. (2006); and second, the VIF (variance inflation factor) derived as a post-estimation of a pooled OLS regression. The former suggests that, with no exception, all variables indicate coefficients of <0.85, while the latter supports the estimated VIF showing fairly low inflated predictors (O'Brien, 2007). Thus, the outcomes do not favor any extreme collinearity among the variables.

Furthermore, the study proceeds to estimate the cross-sectional dependence test of Pesaran and Hashem (2004) and reports the results in Table 4. The results indicate that except for the accountability index, transparency index, participation index, and energy consumption, the remaining variables are statistically significant to reject the null of cross-sectional independence at a 1% level. The existence of cross-sectional dependence is common among countries that exhibit identical economic, social, and infrastructural characteristics (Fuinhas et al., 2021).

4.2. LIML estimates

Based on the primary objectives, the study proceeds to estimate the direct effects of *IQI* on the *ECF* using LIML method. Additionally, the estimations include the dimensional effects of institutional quality indices, such as *A(IQ)*, *T(IQ)*, and *P(IQ)* on *ECF*. In Table 4, the results of the direct effects of *IQI* on *ECF* are shown in the first column, while the dimensional effects are reported in the second, third, and fourth columns. The results indicate that *IQI* is statistically significant in reducing

Table 4
Cross-sectional dependence test results.

Variables	CD-test	*p-value*	Corr	Abs (corr)
Ecological footprint	32.67***	0.000	0.221	0.548
Institutional quality index	90.24***	0.000	0.612	0.661
Accountability index	1.58	0.113	0.011	0.375
Transparency index	1.67	0.110	0.018	0.354
Participation index	1.51	0.115	0.058	0.332
Financial development index	18.04***	0.000	0.122	0.401
Energy consumption	1.36	0.174	0.009	0.495
GDP growth	85.72***	0.000	0.581	0.583
Human development index	28.67***	0.000	0.372	0.477
Urbanization	88.96***	0.000	0.603	0.630
Population growth	22.19***	0.000	0.150	0.352
Global index	134.26***	0.000	0.710	0.710
Economic uncertainty	37.92***	0.000	0.257	0.335

Note: *** indicates significance at 1% level.
Source: Authors' computations.

the *ECF* during the period under review by 0.257 units per capita, while a more precise impact is achieved using the dimensional approach by splitting the *IQI* into three indices. It shows that a 1% increase in *A(IQ)*, *T(IQ)*, and *P(IQ)* reduces *ECF* by 0.144, 0.607, and 0.194 units per capita, respectively. The transparency index, among all others, has higher effects on *ECF* and is significantly conducive to existing policy reorientations. It is consistent with the conceptual framework of beneficial ownership transparency in G20 countries (Bagheri and Zhou, 2021), emphasizing the rearrangement of the concept to reduce the abuse of transparency, which outweighs social and economic benefits. Empirically, it supports the findings of Wawrzyniak and Doryń (2020) and Rahman et al. (2022), who also document that the control of corruption and transparency are profoundly beneficial to improving environmental quality. However, the magnitudes remain unchanged; the *A (IQ)* and *P(IQ)* indices are yet less influential than the transparency index. Recent studies by Pour (2012), Goel et al. (2013), Abid (2016), Ibrahim and Law (2016), Dhrifi (2019), Egbetokun et al. (2020), Le et al. (2020), Mehmood et al. (2021), Jiang et al. (2022), Fatima et al. (2022), and Borgi et al. (2023) have also found that institutional quality is substantive to improve environmental quality across various economic geographies, but there are few studies that have focused on specific indicator effects of institutional quality on environmental quality. They include Welsch (2004), Farzin and Bond (2006), Li and Reuveny (2006), Bernauer and Koubi (2009); Arvin and Lew (2011), Satrovic et al. (2021), Wu (2017), Akhbari and Nejati (2019), Montes et al. (2019), and Jahanger et al. (2022). In all four estimations (columns 1–4; Table 4), the results show that financial and human development indices are significant at a 1% level to reduce the *ECF*. Though the expected signs are achieved, the size of their impact varies across the estimations. Prior literature is contradictory with respect to the effects of financial development on environmental quality. These results are consistent with

Table 3
Pairwise correlation matrix.

Variables	ECF	IQI	A (IQ)	T (IQ)	P(IQ)	FDI	EGY	EG	HDI	URB	PGR	GI	EUC	VIF
ECF	1													
IQI	−0.12	1												3.36
A (IQ)	−0.43	0.19	1											3.25
T (IQ)	−0.37	0.24	0.79	1										3.11
P(IQ)	−0.24	0.15	0.53	0.74	1									2.88
FDI	−0.37	0.15	0.32	0.30	−0.21	1								1.85
EGY	−0.47	0.22	0.31	0.32	0.29	0.54	1							1.62
EG	0.05	−0.00	−0.21	0.17	0.24	0.16	0.11	1						1.48
HDI	0.08	0.15	−0.14	−0.11	−0.06	−0.22	−0.31	−0.02	1					1.31
URB	0.32	0.09	0.05	0.02	0.09	0.39	0.42	0.04	−0.23	1				1.22
PGR	0.38	0.17	0.29	0.45	0.25	0.08	0.36	0.22	−0.19	−0.05	1			1.19
GI	0.49	−0.27	0.55	0.51	0.36	0.56	0.72	0.11	−0.30	0.33	−0.21	1		1.14
EUC	0.17	−0.24	−0.25	−0.23	−0.18	−0.25	−0.36	−0.10	0.34	−0.28	−0.17	−0.33	1	1.08

Source: Authors' computations.

Table 5
IQI and its dimensional direct effects on *ECF*.

Variables	[1] Effects of *IQI* on *ECF*	[2] Effects of *A(IQ)* on *ECF*	[3] Effects of *T(IQ)* on *ECF*	[4] Effects of *P(IQ)* on *ECF*
Institutional quality index	−0.25716*** (−5.37)			
Accountability index		−0.144091*** (−6.25)		
Transparency index			−0.607189*** (−4.67)	
Participation index				−0.194201*** (−4.36)
Financial development index	−0.898*** (−4.41)	−0.406*** (−7.13)	−0.332*** (−4.92)	−0.460*** (−5.02)
Human development index	−0.806*** (−5.87)	−0.787*** (−5.31)	−0.385*** (−5.22)	−0.681*** (−4.99)
Energy consumption	0.386* (2.23)	0.414*** (4.68)	0.303*** (6.17)	0.559*** (−10.33)
GDP growth	0.170 (0.69)	0.110*** (5.04)	0.199*** (4.56)	0.118*** (6.47)
Urbanization	0.192** (2.94)	0.188** (3.05)	0.1015*** (4.77)	0.101 (0.77)
Population growth	0.009718*** (4.33)	0.00088 (1.45)	0.00022 (1.15)	0.0065 (1.08)
Globalization index	0.047*** (6.05)	0.067 (1.57)	0.084*** (3.79)	0.051*** (4.59)
Economic uncertainty	0.508*** (5.32)	0.622*** (9.34)	0.701* (1.89)	0.433*** (3.92)
Intercept	17.344*** (9.03)	−10.057*** (−7.19)	−9.551*** (−11.00)	−14.329*** (−7.09)
Diagnostics				
Observations	437	437	437	437
Groups	20	20	20	20
F-statistics	190.02	188.25	191.17	185.67
Wald-Chi-squared	43.03	66.01	48.12	59.59
R-squared	0.802	0.918	0.888	0.849
Under-identification	16.48	20.67	17.35	16.77
Over-identification	0.69	0.93	1.08	0.63
Weak identification	10.42	14.27	11.46	16.02

Notes: ***, **, and × indicate significance at 1%, 5%, and 10%, respectively. Values in brackets denote z-statistics.
Source: Authors' computations.

recent studies. For instance, Nasreen and Anwar (2015), Al-Mulali et al. (2015), and Charfeddine and Ben Khediri (2016) also found that financial development is instrumental in reducing environmental degradation, though they employed the EKC framework. Contrary to this, Shahbaz et al. (2016) employed a bank-based financial development index (*FDI*) and found that FDI impedes environmental quality. Likewise, Esmaeilpour and Dehbashi (2018) and Jiang and Ma (2019) noticed that financial development has a negative impact on environmental quality. With respect to the human development index, the findings are consistent with those of Ahmed and Wang (2019), Ahmed et al. (2020), Iorember et al. (2021), and Chen et al. (2022). Further, the findings reveal that economic growth, energy consumption, urbanization, and population growth impede *ECF* across all estimated models. Prior studies by Apergis and Payne (2009) and Fávero et al. (2022) verified that economic growth has a negative effect on environment, while Ang (2007) and Jalil and Mahmud (2009) documented that energy consumption increases the level of emissions. Moreover, similar to our results, studies by Liang et al. (2019) and Nathaniel et al. (2020) also found that urbanization negatively impacts environmental quality.

Innovatively, the study estimated and incorporated economic uncertainty into estimations. It shows that economic uncertainty increases *ECF* across the G20 countries. Again, the results indicate that when splitting *IQI* into dimensional indices, the negativity of economic uncertainty appears to be higher than the aggregate *IQI*, *A(IQ)*, and *P(IQ)* model estimations. Although studies by Tee et al. (2023), Shouchang et al. (2023), and Williams et al. (2022) implicitly delved into the impact of economic policy uncertainty on environmental quality, the present study explicitly adds to the literature that economic uncertainty caused by geopolitical tensions negatively impacts the sustainable environmental landscape. Other variables being constant, it is also found that the globalization index deteriorates environmental quality; that is, it increases *ECF* in G20 member countries. The established finding would alternatively be the consequence of a corresponding rise in globalization in the wake of rising trade turnover brought in by an economy's expanding manufacturing industries, which would then result in a considerable increase in the deployment of machinery production wastages and human capital, thus resulting in a higher *ECF*. Furthermore, when we split the *IQI* into dimensional aspects of accountability, transparency, and participation, we still achieve a similar magnitude of the effects of globalization on ECF. Studies by Sihan Zhang et al. (2022), Wu et al. (2022), Farooq et al. (2020), and Tausch and Heshmati (2018) have also enriched the literature with similar findings. In a bid to offer more empirical insights, the study augments the interaction terms of *IQI* and the control variables into estimations and report the results in Table 6 from columns 1–8. There are, additionally, five major results to report. First, when augmenting the interaction of *IQI* with financial and human development indices, their impacts on improving environmental degradation significantly increase. This implies that strong institutional quality in financial and human capital sectors contributes to sustainable environmental quality. Second, surprisingly, the findings show that the effect size of the interaction terms is higher than the direct one (see Tables 4 and 5). This also suggests that sector-specific institutional quality is more effective than an overall one. Similar statistical supports are achieved throughout the other interaction terms of *IQI* with the remaining predictors. For instance, when incorporating an overall *IQI* (Table 4), the results indicate that energy consumption increases *ECF* by 0.386; however, when the interaction term of $IQI \times EGY$ is used, the negative impact reduces by 0.168.

The findings are consistent with prior studies by Xiao et al. (2022), Ouedraogo et al. (2022), Kamalu and Wan Ibrahim (2022), Azam et al. (2021), Hunjra et al. (2020), Emara (2020), Le et al. (2016), Adams-Kane and Lim (2016), Acemoglu et al. (2014), and Yartey (2010), who also lend statistical support to the effects of institutional quality on human capital, financial development, and energy consumption. Third, interestingly, though aggregate IQI is effective in improving environmental quality to an extent, it is found that the interaction of *IQI* with GDP growth, say, $IQI \times EG$, turns its magnitude to a negative scale. Fourth, however, the interaction term of *IQI* with urbanization does not seem to be effective, but the effect of population growth tends to be zero. Fifth, the results indicate that the interaction of *IQI* with the *GI* is significant at a 1% and still positive. Finally, it shows that when the interaction of IQI × ECU is applied, it does not remain significant any more (column 8; coefficient = 0.000709). In order to capture the key findings obtained from a series of estimations, the study depicts them in Fig. 8.

The results presented in Tables 4 and 5 are statistically robust. The *F-statistics* are significant at a 1% level, showing that the explanatory variables are jointly sufficient to explain the movement of *ECF* across G20 countries. The *R-squared* value across all estimations (Table 4; columns 1–4 and Table 5; columns 1–8) is also significant to support the

Table 6
Moderating effects of *IQI* and *SEI* on *ECF*.

Variables	[1] Moderating role of *FDI*	[2] Moderating role of *HDI*	[3] Moderating role of *EGY*	[4] Moderating role of *EG*	[5] Moderating role of *URB*	[6] Moderating role of *PGR*	[7] Moderating role of *GI*	[8] Moderating role of *EUC*
Institutional quality index	−0.297*** (−4.18)	−0.310*** (−3.94)	−0.291*** (−4.02)	−0.305*** (−3.94)	−0.416*** (−6.13)	−0.338*** (−3.77)	−0.284*** (4.11)	−0.319*** (−5.01)
Financial development index	−0.391*** (5.07)	−0.448*** (−4.05)	−0.741*** (−3.84)	−0.365*** (−3.92)	−0.397*** (−4.00)	−0.319* (−2.55)	−0.444* (−2.49)	−0.710** (−2.87)
Human development index	−1.00098*** (−3.99)	−0.882*** (−6.07)	−0.914* (−2.18)	−0.715** (−2.77)	−0.910*** (−3.86)	−1.025*** (−5.13)	−0.926*** (4.44)	−0.846*** (4.36)
Energy consumption	0.168*** (6.34)	0.095* (2.29)	0.106*** (3.87)	0.08409*** (4.31)	0.227* (2.14)	0.149*** (5.63)	0.20079*** (5.25)	0.194*** (5.43)
GDP growth	0.104*** (3.91)	0.129*** (4.11)	0.110* (2.61)	0.122* (2.54)	0.169*** (4.32)	0.125*** (3.78)	0.187*** (5.00)	0.10009*** (3.80)
Urbanization	0.171** (2.47)	0.128*** (3.91)	0.146*** (4.08)	0.165*** (3.94)	0.1700069*** (4.28)	0.158*** (3.67)	0.160507*** (3.95)	0.144*** (3.87)
Population growth rate	0.111*** (5.11)	0.103*** (3.88)	0.142* (2.61)	0.137*** (4.00)	0.092** (2.69)	0.103*** (6.07)	0.125*** (3.89)	0.108*** (4.10)
Globalization index	0.233*** (3.82)	0.10991 (1.27)	0.208005** (2.88)	0.000056 (0.59)	0.129*** (3.91)	0.00041 (1.04)	0.00705 (0.87)	0.000108 (0.47)
Economic uncertainty	0.067*** (3.71)	0.009*** (8.46)	0.015*** (3.99)	0.078*** (4.15)	0.093*** (5.18)	0.01704*** (6.14)	0.01502*** (7.03)	0.066*** (3.67)
IQI × *FDI*	−0.917*** (−3.92)							
IQI × *HDI*		−0.844*** (−4.01)						
IQI × *EGY*			0.227*** (3.99)					
IQI × *EG*				−0.10015*** (−3.84)				
IQI × *URB*					0.10088*** (4.13)			
IQI × *PGR*						0.0035*** (3.77)		
IQI × *GI*							0.049*** (4.12)	
IQI × *EUC*								0.000709 (1.19)
Intercept	24.733*** (6.18)	−13.258*** (−3.99)	−19.138*** (−8.22)	−21.004*** (−5.09)	14.602*** (10.14)	−11.055*** (−6.06)	−18.001*** (−9.37)	−9.3098*** (−7.12)
Observations	437	437	437	437	437	437	437	437
F-statistics	133.45	140.16	137.29	131.01	141.27	130.99	135.44	181.04
Wald-Chi-squared	29.88	37.15	29.46	41.09	40.28	38.29	40.13	29.26
R-squared	0.825	0.817	0.805	0.899	0.765	0.911	0.792	0.801
Under-identification	17.47	15.99	19.07	28.12	16.44	16.89	21.57	14.86
Over-identification	0.66	0.91	1.17	0.86	1.12	0.54	0.99	1.04
Weak identification	16.32	11.98	15.39	17.01	28.45	15.33	17.91	15.82

Notes: ***, **, and × indicate significance at 1%, 5%, and 10%, respectively. Values in brackets denote z-statistics.
Source: Authors' computations.

fitness of the estimated models. The test statistics reported for the under-identification authenticate that the instruments used are significantly less than those of the endogenous predictors at a 1% level. In terms of the correlation of the error term with the instruments, the test statistic for over-identification is insignificant enough to reject the null, and thus it confirms the healthy estimation of our models. As a final robustness check, the test statistic for the null of weak instrumentation is rejected at the 1% significant level, implying that the augmented endogenous variables are sufficiently defined by the instruments.

5. Discussion

The present study hypothesized multidimensional and moderating effects of institutional quality index (*IQI*) on ecological footprint (*ECF*), with an emphasis on the G20 nations. From Section 4, we observed several interesting findings that are discussed herein. For brevity, the findings are classified into direct, dimensional, and moderating impacts of *IQI* on *ECF*. The results highlight that *IQI* is instrumental to reduce *ECF* in the G20 countries (Table 4). This is supported by both the theoretical assumption and recent empirical findings. For instance, institutional quality, through its effective conduits, imposes pressure on the public and private sectors and society to advance constructive behavior towards environmental sustainability (Neumayer, 2002; Munger and North, 1991). He et al. (2007) developed a model of public choice and introduced environmental regulation as a moderating factor to wealth and income that drive environmental quality. They observed that a corrupt bureaucracy is detrimental to the quality of environment in developing countries. This finding is, however, not as precise as to draw a comprehensive image of the overall effects of institutional quality, but Borgi et al. (2023) highlighted a relatively closer link between environment and institutional quality. They argued that an increase in the practice of institutional quality indicators would improve environmental quality in G-7 nations. The results are also consistent with those of Bernauer and Koubi (2009) Egbetokun et al. (2020), Le et al. (2020), and Mehmood et al. (2021), who found that institutional quality is effective in reducing environmental degradation. Of this, at least two intuitions can be drawn: first, institutional quality should be regarded as endogenous to *ECF*; and second, regardless of economic status of

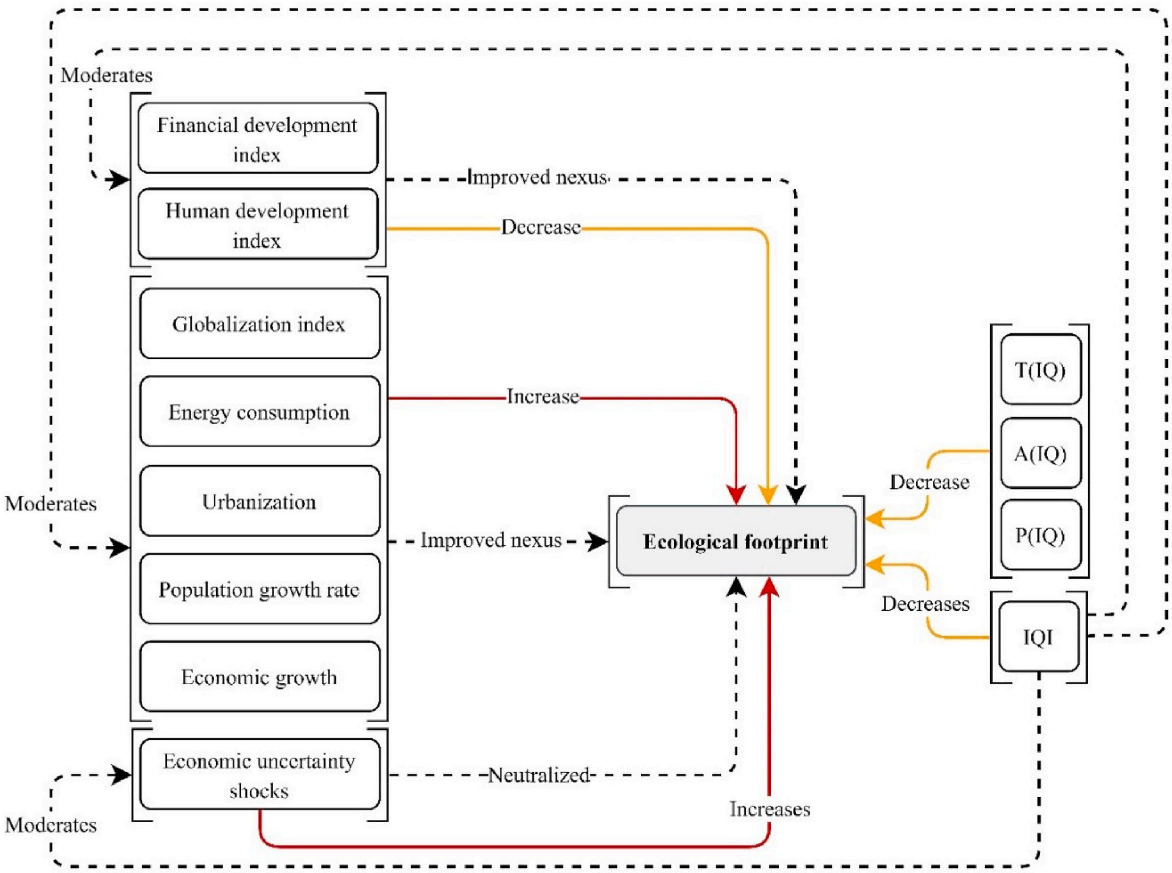

Fig. 8. Results' summary. Notes: IQI: Institutional quality index, *A(IQ)* = Accountability index; *T(IQ)* = Transparency index; *P(IQ)* = Participation index. Source: Authors' creation.

countries, institutional quality is effective in reducing environmental degradation.

Besides drawing a general image of the *IQI-ECF* nexus, it was important to delve into specific areas where the *IQI-ECF* nexus can highlight more specific policy implications. To this faith, the study developed new institutional quality dimensional indices (see, subsection 3.3) and tested their effects on *ECF* (Table 4). The results verified that higher achievement by governments in accountability, transparency, and participation indices of institutional quality is positively influential in improving environmental quality by reducing *ECF* in the G20; however, among them, the transparency index ranked higher. With respect to accountability, the results are consistent with the empirical assumption of Gök and Sodhi (2021), who postulated that when accountable governance comes into real practice, environmental outcomes improve. Yu et al. (2022) also confirmed that the accountability aspect of institutions is significant to reducing emissions. From the perspective of transparency, its magnitude and higher influence on *ECF* are linked to the emerging idea of "governance by disclosure", which is a conceptual backup to our results. According to Gupta and Mason (2014) governance transparency is seen as an integral part of solutions to complex arrays of political, ethical, and economic issues in global environmental governance. Particularly, it forms the basis of public-private partnership agreements and voluntary disclosure initiatives. Indeed, it is a transformative force in environmental institutional quality. Regulatory quality and government effectiveness (transparency indicators) are profound in three aspects: access to environmental information, awareness about the environment, and behavioral adjustments towards the environment (Zhang et al., 2022). An empirical study by Zhang and Wang (2020) quantified the effects of institutional transparency on environmental quality. Similar to our findings, they noticed that institutional transparency improves environmental quality. Consistent to the results we obtained for the effects of participation index on *ECF*, recent studies by Wu et al. (2020), Tu et al. (2019), and Ngo et al. (2017) have also found that participation is significant for environmental quality. For example, Wu et al. (2020) used spatial econometrics across 30 provinces in China and found that participatory governance has a significantly positive impact on regional environmental quality. From these results, two specific intuitions can be drawn: first, all dimensions of institutional quality are instrumental to controlling and reducing *ECF* in the G20 countries; and second, it is found that the transparency index, which includes government effectiveness and regulatory quality indicators, has been comparatively higher than accountability and participation indices and invites urgent policy intervention.

Finally, the present study explored whether *IQI* is effective in modulating the impact of macro- and socio-economic indicators on *ECF* (Table 5). It was important to verify how *IQI* can improve sectoral relationships that could affect environmental quality. It is found that *IQI* improves the impact of *FDI* on *ECF*. Likewise, Hunjra et al. (2020) also noticed that institutional quality effectively moderates the negative effects of *FD* on environmental quality in South Asia. Similar results were found by Abaidoo and Agyapong (2022b) for Sub-Saharan African countries. Furthermore, *IQI* is found to have a significant moderating role in improving the effects of *HDI* on *ECF*. This suggests that *IQI* plays an essential role in improving the performance of sectors engaged with the development of human capital, such as health, education, and habitats, that contribute to reducing *ECF*. The results verified that *IQI* moderates the negative effect of growth on *ECF*. This implies that economic-sector-specific *IQI* leads to safe growth without being harmful to environmental quality. Studies by Dada and Ajide (2021) and Salman et al. (2019) have also contributed to the literature on the moderating effects of institutional quality on economic growth. The result show that specific sectors engaged in promoting higher globalization, such as trade, tourism, education, health, technology, and so on, may greatly benefit from reducing the negative impact of globalization on local environmental quality. This is supported by the interaction of *IQI* with the *GI*. Although initial estimations confirmed the negative effects of economic uncertainty on *ECF*, when *IQI* interacts with economic uncertainty, it does not remain significant any more, while the size of its effects also tends to be zero. These findings highlight the necessity of a serious shift in relevant policies, giving higher importance to focusing on sector-specific institutional quality rather than relying on an overall and general approach to promote it.

In sum, the outcomes of the present study contribute to the existing body of knowledge on the relationship between institutional quality and ecological footprint from a different perspective. The results highlight specific policy areas where prompt attention is sought to reorient existing policies to support macro-level environmental issues. Since contemporary environmental quality deterioration is the consequence of the unmaintainable environmental behavior of various public and private institutions at different societal layers, more studies are required on the subject to better understand how microlayers contribute to environmental degradation and how institutional quality helps mitigate it.

6. Conclusions

The present study explored the effects of institutional quality on ecological footprint (*ECF*) in the G20 countries from 2000 to 2022. The primary objectives were to examine the direct, multidimensional, and moderating impact of institutional quality on *ECF*. For this purpose, the study constructed a composite institutional quality index (*IQI*) and three-dimensional indices under the accountability, transparency, and participation dimensions. To control for recent global economic shocks on ECF, the study developed a predictor of economic uncertainty. It has been developed using generalized autoregressive conditional heteroskedasticity and data points obtained from GDP growth. The required datasets were compiled from various reliable sources and the main analysis was performed using the limited information maximum likelihood (LIML) method.

The results of preliminary tests verified that there was no multicollinearity among variables. Further, due to common economic, trade, and cultural characteristics among the G0 nations, the existence of cross-sectional dependence was confirmed. The main results obtained from the LIML method highlight several key findings. First, the results confirmed that *IQI* is significantly instrumental in reducing *ECF* in the recipient panel. Second, the study observed more precise results by splitting the *IQI* into accountability, transparency, and participation dimensional indices. Although all institutional quality dimensional indices were found to be statistically significant in reducing *ECF*, the transparency index had a higher negative impact on *ECF*. Third, by augmenting the interaction term of *IQI* with major macro- and socio-economic variables, the results showed that *IQI* plays an effective moderating role in improving the relationships between *ECF* and the stated variables. Compared to the conventional approach, the results verified that the effects of the interaction of the *IQI* with the financial development index and the human development index were higher in reducing *ECF*. Further, the *IQI* was found to effectively reduce the positive effects of energy consumption on *ECF,* while the moderating role of the *IQI* has not been substantive to affect the positive effects of the globalization index on the subject. This might be due to the impracticality of local institutional quality and its power to influence key negative factors of globalization like the exploitation of cheap labor markets (India, China, and Indonesia for the US, UK, and other developed countries) and higher job displacement across the G20 countries. However, the conventional model results revealed that economic growth positively affects *ECF*, but the interaction of IQI with economic growth reversed the sign of the growth coefficient. Moreover, the results confirmed that the *IQI* was effective in moderating the impact of economic uncertainty on *ECF*. Although existing literature hosts studies that build on basic knowledge about the effects of *IQI* on environmental quality, the results of the present study conclude that effective institutional quality is essential for controlling and reducing the ecological footprint of countries in the G20. Notably, splitting institutional quality into its constituent dimensions like accountability, transparency, and participation further revealed that improved quality in the institutional accountability and participation dimensions is critical to the improvement of environmental quality in the G20 nations. However, institutional transparency remains as important as it is reflected. Additionally, the results also conclude that institutional quality instrumentally moderates the magnitude and direction of the effects of macroeconomic variables and, importantly, economic uncertainty on the sustainable development of environmental quality in the G20 countries.

6.1. Policy implications

The outcomes of the present study suggest some specific policy implications that are outlined as follows.

1) Institutional arrangement: The governments of the G20 countries need to ensure that the existing environmental protection policies articulate institutional arrangements, that is, to measure environmental monitoring and risk management indicators on a timely basis. It could be possible to develop or advance the contemporary e-environmental institution to allow governments to measure the effectiveness of institutional quality in mitigating spatial environmental risks.
2) Sector-specific arrangement: The findings revealed that the performance of various sectors, still at a macro-level, contributes to environmental degradation. Policymakers may focus on developing sector-specific policies based on the institutional quality framework to control and minimize environmental risks. That could be possible through three conduits, such as environmental awareness, environmental behavior adaptation, and constituent institutional regulations and supervision at sectoral levels.
3) Social engagement: Findings showed that human capital massification (say, urbanization) by any reason (employment, business, economic shift, or social factors) and growth in population positively contribute to the ecological footprint in the G20. Thus, social engagement comes into play. Environmental consumers, landowners, and citizens at large participating in almost all policy discourses may play an influential role in environmental sustainability. On the other hand, institutional quality would be effectively realized by the parallel engagement of the public, private, and social sectors (Acemoglu et al., 2014).
4) External shock management: As shown, external economic shocks due to global factors could be severely harmful to environmental quality. Governments need to ensure that they have policies to mitigate the negative impact of external shocks on environmental quality. This could be achieved by trading off between short-run pain and long-run gain, implying a reduction in public investments rather than a reduction in contemporary spending levels that support environmental policies. This prescription, however, is a short-term environmental economic policy for external shock management but could be beneficial to block the extensive impact of sudden shocks on environmental quality.
5) Exported risk management: Globalization, which is at its peak across the G20, was found to have a negative contribution to environmental quality, and the existing institutional quality measures fall short of improving the effects of globalization on ECF. Thus, it requires the G20 nations to collectively act on the subject. This could be possible to bring attention to the content and practice of the adopted Kunming-Montreal Global Biodiversity (KMGB) framework (UNEP, 2023) and emphasize stronger global environmental governance.

6.2. Limitations and future recommendations

Although this piece of inquiry illuminated the link between institutional quality and environmental degradation, it should still be regarded in the context of its limitations. Due to data constraints, the analysis and then the conclusions depend on annual aggregate data that can be disaggregated by sector-specific context. Nevertheless, most of the G20 nations lack access to such disaggregated data. This flaw does not, however, invalidate or lessen the significance of this work or the conclusions obtained. Future studies may adopt the same methodology and conceptual framework with disaggregated datasets for both sector-specific endogenous and institutional quality variables to overcome the limitations of this study. The present study offers an analytical framework for a particular economic-cooperation bloc (the G20) and highlights how the existing institutional quality structure of the G20 explains its link with environmental and macroeconomic predictors. Future studies on different blocs may uncover dissimilar nexuses that remained undetected in this inquiry.

Data and materials

Datasets relevant to ecological footprint, governance indicators, financial development index, human development index, and globalization index were compiled from the Global Footprint Network, Worldwide Governance Indicators, IMF, UNDP, and KOF Swiss Economic Institute, respectively. The data for remaining variables such as energy consumption, GDP growth, urbanization, and population growth rate were collected from World Development Indicator sources.

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CRediT authorship contribution statement

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Declaration of competing interest

The authors do not have any competing interest to declare.

Data availability

Data will be made available on request.

References

Abaidoo, R., Agyapong, E.K., 2022a. Environmental Sustainability Risk, Institutional Effectiveness and Urbanization. Energy and Environment. https://doi.org/10.1177/0958305X221118876.

Abaidoo, R., Agyapong, E.K., 2022b. Financial development and institutional quality among emerging economies. J. Econ. Dev. 24 (3), 198–216. https://doi.org/10.1108/jed-08-2021-0135.

Abbasi, F., Riaz, K., 2016. CO2 emissions and financial development in an emerging economy: an augmented VAR approach. Energy Pol. 90, 102–114. https://doi.org/10.1016/j.enpol.2015.12.017.

Abd Razak, F.D., Khalid, N., Ali, M.H., 2021. Asymmetric impact of institutional quality on environmental degradation: evidence of the environmental kuznets curve. Sustainability 13 (22). https://doi.org/10.3390/su132212507.

Abid, M., 2016. Impact of economic, financial, and institutional factors on CO2 emissions: evidence from Sub-Saharan Africa economies. Util. Pol. 41, 85–94. https://doi.org/10.1016/j.jup.2016.06.009.

Abid, N., Marchesani, F., Ceci, F., Masciarelli, F., Ahmad, F., 2022. Cities trajectories in the digital era: exploring the impact of technological advancement and institutional quality on environmental and social sustainability. J. Clean. Prod. 377 https://doi.org/10.1016/j.jclepro.2022.134378.

Acemoglu, D., Gallego, F.A., Robinson, J.A., 2014. Institutions, human capital, and development. Annual Rev. Econ. 6, 875–912. https://doi.org/10.1146/annurev-economics-080213-041119.

Adams-Kane, J., Lim, J.J., 2016. Institutional quality mediates the effect of human capital on economic performance. Rev. Dev. Econ. 20 (2), 426–442. https://doi.org/10.1111/rode.12236.

Adebayo, T.S., Pata, U.K., Akadiri, S. Saint, 2022. A Comparison of CO2 Emissions, Load Capacity Factor, and Ecological Footprint for Thailand's Environmental Sustainability. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-022-02810-9.

Adedoyin, F.F., Bekun, F.V., Eluwole, K.K., Adams, S., 2022. Modelling the nexus between financial development, FDI, and CO2 emission: does institutional quality matter? Energies 15 (20). https://doi.org/10.3390/en15207464.

Ahir, H., Bloom, N., Furceri, D., 2022. The world uncertainty index. SSRN Electron. J. https://doi.org/10.2139/ssrn.4039482.

Ahmed, Z., Wang, Z., 2019. Investigating the impact of human capital on the ecological footprint in India: an empirical analysis. Environ. Sci. Pollut. Control Ser. 26 (26), 26782–26796. https://doi.org/10.1007/s11356-019-05911-7.

Ahmed, Z., Zafar, M.W., Ali, S., Danish, 2020. Linking urbanization, human capital, and the ecological footprint in G7 countries: an empirical analysis. Sustain. Cities Soc. 55 https://doi.org/10.1016/j.scs.2020.102064.

Akashi, K., Kunitomo, N., 2012. Some properties of the LIML estimator in a dynamic panel structural equation. J. Econom. 166 (2), 167–183. https://doi.org/10.1016/j.jeconom.2011.08.005.

Akashi, K., Kunitomo, N., 2015. The limited information maximum likelihood approach to dynamic panel structural equation models. Ann. Inst. Stat. Math. 67 (1), 39–73. https://doi.org/10.1007/s10463-013-0438-5.

Akhbari, R., Nejati, M., 2019. The effect of corruption on carbon emissions in developed and developing countries: empirical investigation of a claim. Heliyon 5 (9), e02516. https://doi.org/10.1016/j.heliyon.2019.e02516.

Al-Mulali, U., Ozturk, I., Lean, H.H., 2015. The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Nat. Hazards 79 (1), 621–644. https://doi.org/10.1007/s11069-015-1865-9.

Ali, Q., Yaseen, M.R., Anwar, S., Makhdum, M.S.A., Khan, M.T.I., 2021. The impact of tourism, renewable energy, and economic growth on ecological footprint and natural resources: a panel data analysis. Resour. Pol. 74 https://doi.org/10.1016/j.resourpol.2021.102365.

Anand, S., Sen, A.K., 1994. Human development index: methodology and measurement. In: Human Development Report Office. UNDP. http://hdr.undp.org/en/media/HDI_methodology.pdf.

Anderson, T.W., Rubin, H., 1949. Estimation of the parameters of a single equation in a complete system of stochastic equations. Ann. Math. Stat. 20 (1), 46–63. https://doi.org/10.1214/aoms/1177730090.

Ang, J.B., 2007. CO2 emissions, energy consumption, and output in France. Energy Pol. 35 (10), 4772–4778. https://doi.org/10.1016/j.enpol.2007.03.032.

Ansari, M.A., Haider, S., Kumar, P., Kumar, S., Akram, V., 2022. Main determinants for ecological footprint: an econometric perspective from G20 countries. Energy, Ecol. Environ. 7 (3), 250–267. https://doi.org/10.1007/s40974-022-00240-x.

Apergis, N., Payne, J.E., 2009. CO2 emissions, energy usage, and output in Central America. Energy Pol. 37 (8), 3282–3286. https://doi.org/10.1016/j.enpol.2009.03.048.

Apaydin, Şükrü, Ursavaş, Uğur, Koç, Ümit, 2021. The impact of globalization on the ecological footprint: do convergence clubs matter? Environ. Sci. Pollut. Res. 28 (38), 53379–53393. https://doi.org/10.1007/s11356-021-14300-y.

Arvin, M.B., Lew, B., 2011. Does democracy affect environmental quality in developing countries? Appl. Econ. 43, 1151–1160. https://doi.org/10.1080/00036840802600277.

Ashraf, A., Nguyen, C.P., Doytch, N., 2022. The impact of financial development on ecological footprints of nations. J. Environ. Manag. 322 https://doi.org/10.1016/j.jenvman.2022.116062.

Ashraf, J., Luo, L., Khan, M.A., 2022. The spillover effects of institutional quality and economic openness on economic growth for the belt and road initiative (BRI) countries. Spatial Stat. 47, 100566 https://doi.org/10.1016/j.spasta.2021.100566.

Asteriou, D., Price, S., 2005. Uncertainty, investment and economic growth: evidence from a dynamic panel. Rev. Dev. Econ. 9 (2), 277–288. https://doi.org/10.1111/j.1467-9361.2005.00276.x.

Azam, M., Liu, L., Ahmad, N., 2021. Impact of institutional quality on environment and energy consumption: evidence from developing world. Environ. Dev. Sustain. 23, 1646–1667. https://doi.org/10.1007/s10668-020-00644-x.

Ayad, Hicham, Mishra, Pradeep, Kumari, Binita, Ray, Soumik, Nuţă, Florian Marcel, Gautam, Rajani, Balsalobre-Lorente, Daniel, Nuţă, Alina Cristina, Zamfir, Cristina Gabriela, 2023. The spillover effects of uncertainty and globalization on environmental quality in India: Evidence from combined cointegration test and augmented ARDL model. Front. Environ. Sci. 11, 1–11. https://doi.org/10.3389/fenvs.2023.1144201.

Bagheri, M., Zhou, J., 2021. Beneficial ownership transparency: the viability of global implementation of G20 high-level principles. Eur. Bus. Law Rev. 32 (6), 1021–1038. https://doi.org/10.54648/eulr2021037.

Baloch, M.A., Zhang, J., Iqbal, K., Iqbal, Z., 2019. The effect of financial development on ecological footprint in BRI countries: evidence from panel data estimation. Environ. Sci. Pollut. Control Ser. 26 (6), 6199–6208. https://doi.org/10.1007/s11356-018-3992-9.

Balsalobre-Lorente, D., Leitão, N.C., Bekun, F.V., 2021. Fresh validation of the low carbon development hypothesis under the ekc scheme in Portugal, Italy, Greece and Spain. Energies 14 (1). https://doi.org/10.3390/en14010250.

Barros, L.A.B.C., Bergmann, D.R., Henrique Castro, F., da Silveira, A.D.M., 2020. Endogeneity in panel data regressions: methodological guidance for corporate

finance researchers. Revista Brasileira de Gestao de Negocios 22 (Special Issue), 437–461. https://doi.org/10.7819/rbgn.v22i0.4059.
Baz, K., Xu, D., Ali, H., Ali, I., Khan, I., Khan, M.M., Cheng, J., 2020. Asymmetric Impact of Energy Consumption and Economic Growth on Ecological Footprint: Using Asymmetric and Nonlinear Approach, vol. 718. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2020.137364.
Bernauer, T., Koubi, V., 2009. Effects of political institutions on air quality. Ecol. Econ. 68 (5), 1355–1365. https://doi.org/10.1016/j.ecolecon.2008.09.003.
Bilgili, F., Ulucak, R., 2018. Is there deterministic, stochastic, and/or club convergence in ecological footprint indicator among G20 countries? Environ. Sci. Pollut. Control Ser. 25 (35), 35404–35419. https://doi.org/10.1007/s11356-018-3457-1.
Bilgili, F., Ulucak, R., Koçak, E., İlkay, S.Ç., 2020. Does globalization matter for environmental sustainability? Empirical investigation for Turkey by Markov regime switching models. Environ. Sci. Pollut. Control Ser. 27 (1), 1087–1100. https://doi.org/10.1007/s11356-019-06996-w.
Borgi, H., Mabrouk, F., Bousrih, J., Mekni, M.M., 2023. Environmental change and inclusive finance: does governance quality matter for african countries? Sustainability 15 (4), 1–15. https://doi.org/10.3390/su15043533.
Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., Lazarus, E., Morales, J.C., Wackernagel, M., Galli, A., 2013. Accounting for demand and supply of the biosphere's regenerative capacity: the National Footprint Accounts' underlying methodology and framework. Ecol. Indicat. 24, 518–533. https://doi.org/10.1016/j.ecolind.2012.08.005.
Castiglione, C., Infante, D., Smirnova, J., 2012. Rule of law and the environmental Kuznets curve: evidence for carbon emissions. Int. J. Sustain. Econ. 4 (3), 254. https://doi.org/10.1504/ijse.2012.047932.
Cervantes, P.A.M., López, N.R., Rambaud, S.C., 2020. The effect of globalization on economic development indicators: an inter-regional approach. Sustainability 12, 2–18. https://doi.org/10.3390/su12051942, 1942.
Charfeddine, L., Ben Khediri, K., 2016. Financial development and environmental quality in UAE: cointegration with structural breaks. Renew. Sustain. Energy Rev. 55, 1322–1335. https://doi.org/10.1016/j.rser.2015.07.059.
Chen, Yang, Lee, C.C., Chen, M., 2022. Ecological footprint, human capital, and urbanization. Energy Environ. 33 (3), 487–510. https://doi.org/10.1177/0958305X211008610.
Chen, Yulong, Wang, Z., Zhong, Z., 2019. CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. Renew. Energy 131, 208–216. https://doi.org/10.1016/j.renene.2018.07.047.
Chodor, T., 2021. The G-20 since the global financial crisis: neither hegemony nor collectivism. Global Govern. 23 (2), 205–223. https://doi.org/10.1163/19426720-02302005.
Chudik, A., Pesaran, M.H., 2015. Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. J. Econom. 188 (2), 393–420. https://doi.org/10.1016/j.jeconom.2015.03.007.
Codal, K.S., Ari, I., Codal, A., 2021. Multidimensional Perspective for Performance Assessment on Climate Change Actions of G20 Countries, vol. 39. Environmental Development. https://doi.org/10.1016/j.envdev.2021.100639.
Dada, J.T., Ajide, F.M., 2021. The moderating role of institutional quality in shadow economy–pollution nexus in Nigeria. Manag. Environ. Qual. Int. J. 32 (3), 506–523. https://doi.org/10.1108/MEQ-10-2020-0238.
Danish, Zhang, B., Wang, Z., Wang, B., 2018. Energy production, economic growth and CO2 emission: evidence from Pakistan. Nat. Hazards 90 (1), 27–50. https://doi.org/10.1007/s11069-017-3031-z.
De Hoyos, R.E., Sarafidis, V., 2006. Testing for cross-sectional dependence in panel-data models. STATA J. https://doi.org/10.1177/1536867x0600600403.
Dhrifi, Abdelhafidh., 2019. Does environmental degradation, institutional quality, and economic development matter for health? Evidence from African Countries. J. Knowl. Econ. 10 (3), 1098–1113. https://doi.org/10.1007/s13132-018-0525-1.
Dmitriev, A., 2013. Institutions and growth: evidence from estimation methods robust to weak instruments. Appl. Econ. 45 (13), 1625–1635. https://doi.org/10.1080/00036846.2011.633892.
Dong, K., Hochman, G., Zhang, Y., Sun, R., Li, H., Liao, H., 2018. CO2 emissions, economic and population growth, and renewable energy: empirical evidence across regions. Energy Econ. 75, 180–192. https://doi.org/10.1016/j.eneco.2018.08.017.
Egbetokun, S., Osabuohien, E., Akinbobola, T., Onanuga, O.T., Gershon, O., Okafor, V., 2020. Environmental pollution, economic growth and institutional quality: exploring the nexus in Nigeria. Manag. Environ. Qual. Int. J. 31 (1), 18–31. https://doi.org/10.1108/MEQ-02-2019-0050.
Elith, J., Graham, C.H., Anderson, R.P., Dudík, M., Ferrier, S., Guisan, A., Hijmans, R.J., Huettmann, F., Leathwick, J.R., Lehmann, A., Li, J., Lohmann, L.G., Loiselle, B.A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., McC, J., Overton, M., Townsend Peterson, A., Phillips, S.J., Richardson, K., Scachetti-Pereira, R., Schapire, R.E., Soberón, J., Williams, S., Wisz, M.S., Zimmermann, N.E., 2006. Novel methods improve prediction of species? distributions from occurrence data. Ecography 29 (2), 129–151. https://doi.org/10.1111/j.2006.0906-7590.04596.x.
Emara, A.M., 2020. The impact of corruption on human development in Egypt. Asian Econ. Financ. Rev. 10 (Issue 5), 574–589. https://doi.org/10.18488/journal.aefr.2020.105.574.589.
Erdoğan, S., Yıldırım, S., Yıldırım, D.Ç., Gedikli, A., 2020. The effects of innovation on sectoral carbon emissions: evidence from G20 countries. J. Environ. Manag. 267 https://doi.org/10.1016/j.jenvman.2020.110637.
Esmaeilpour Moghadam, H., Dehbashi, V., 2018. The impact of financial development and trade on environmental quality in Iran. Empir. Econ. 54, 1777–1799. https://doi.org/10.1007/s00181-017-1266-x.
Espinosa-González, A.B., Delaney, B.C., Marti, J., Darzi, A., 2019. The impact of governance in primary health care delivery: a systems thinking approach with a European panel. Health Res. Pol. Syst. 17 (65) https://doi.org/10.1186/s12961-019-0456-8.
Farooq, F., Faheem, M., Usman, M.Z., 2020. Does globalization asymmetrically affect CO2 emissions in Pakistan? A new evidence through nardl approach. Rev. Educ. Adm. & LAW 3 (3), 511–522. https://doi.org/10.47067/real.v3i3.96.
Farzin, Y.H., Bond, C.A., 2006. Democracy and environmental quality. J. Dev. Econ. 81 (1), 213–235. https://doi.org/10.1016/j.jdeveco.2005.04.003.
Fatima, N., Zheng, Y., Guohua, N., 2022. Globalization, institutional quality, economic growth and CO2 emission in OECD countries: an analysis with GMM and quantile regression. Front. Environ. Sci. 10, 1–14. https://doi.org/10.3389/fenvs.2022.967050.
Fávero, L.P., de Freitas Souza, R., Belfiore, P., Luppe, M.R., Severo, M., 2022. Global relationship between economic growth and CO2 emissions across time: a multilevel approach. Int. J. Glob. Warming 26 (1), 38–63. https://doi.org/10.1504/IJGW.2022.120067.
Federici, D., Ferrante, F., Parisi, V., 2023. The educational roots of persistent territorial disparities: the case of Italy. Geojournal 88 (2), 2063–2082. https://doi.org/10.1007/s10708-022-10740-2.
Figge, L., Oebels, K., Offermans, A., 2017. The effects of globalization on Ecological Footprints: an empirical analysis. Environ. Dev. Sustain. 19 (3), 863–876. https://doi.org/10.1007/s10668-016-9769-8.
Forchini, G., Jiang, B., Peng, B., 2018. TSLS and LIML estimators in panels with unobserved shocks. Econometrics 6 (2). https://doi.org/10.3390/econometrics6020019.
Fredriksson, P.G., Gaston, N., 2000. Environmental governance in federal systems: the effects of capital competition and lobby groups. Econ. Inq. 38 (3), 501–514. https://doi.org/10.1111/j.1465-7295.2000.tb00032.x.
Fredriksson, P.G., Vollebergh, H.R.J., Dijkgraaf, E., 2004. Corruption and energy efficiency in OECD countries: theory and evidence. J. Environ. Econ. Manag. 47 (2), 207–231. https://doi.org/10.1016/j.jeem.2003.08.001.
Fuinhas, J.A., Koengkan, M., Leitão, N.C., Nwani, C., Uzuner, G., Dehdar, F., Relva, S., Peyerl, D., 2021. Effect of battery electric vehicles on greenhouse gas emissions in 29 European Union countries. Sustainability 13 (24). https://doi.org/10.3390/su132413611.
G F N, 2023. Global Footprint Network. https://api.footprintnetwork.org/v1/data/all/2019/EFCpc.
Gill, A.R., Riaz, R., Ali, M., 2023. The asymmetric impact of financial development on ecological footprint in Pakistan. Environ. Sci. Pollut. Control Ser. 30 (11), 30755–30765. https://doi.org/10.1007/s11356-022-24384-9.
Girshick, M.A., Haavelmo, T., 1947. Statistical analysis of the demand for food: examples of simultaneous estimation of structural equations. Econometrica 15 (2), 79. https://doi.org/10.2307/1907066.
Goel, R.K., Herrala, R., Mazhar, U., 2013. Institutional quality and environmental pollution: MENA countries versus the rest of the world. Econ. Syst. 37 (4), 508–521. https://doi.org/10.1016/j.ecosys.2013.04.002.
Gök, A., Sodhi, N., 2021. The environmental impact of governance: a system-generalized method of moments analysis. Environ. Sci. Pollut. Control Ser. 28, 32995–33008. https://doi.org/10.1007/s11356-021-12903-z.
Gokbulut, R.I., Pekkaya, M., 2014. Estimating and forecasting volatility of financial markets using asymmetric GARCH models: an application on Turkish financial markets. Int. J. Econ. Finance 6 (4). https://doi.org/10.5539/ijef.v6n4p23.
Gupta, A., Mason, M., 2014. Transparency in global environmental governance: critical perspectives. In: Transparency in Global Environmental Governance: Critical Perspectives.
Gupta, M., Saini, S., Sahoo, M., 2022. Determinants of ecological footprint and PM2.5: role of urbanization, natural resources and technological innovation. Environ. Chall. 7 https://doi.org/10.1016/j.envc.2022.100467.
Hahn, J., Kuersteiner, G., 2011. Bias reduction for dynamic nonlinear panel models with fixed effects. Econom. Theor. 27 (6), 1152–1191. https://doi.org/10.1017/S0266466611000028.
Harvey, A.C., Amemiya, T., 1987. Advanced econometrics. Economica 54 (215), 409. https://doi.org/10.2307/2554459.
Hashmi, S.H., Fan, H., Habib, Y., Riaz, A., 2021. Non-linear relationship between urbanization paths and CO2 emissions: a case of South, South-East and East Asian economies. Urban Clim. 37 https://doi.org/10.1016/j.uclim.2021.100814.
He, J., Makdissi, P., Wodon, Q., 2007. Corruption , Inequality , and Environmental Regulation. World.
Hill, R. Carter, Griffiths, William E., C.Lim, Guay, 2019. Principle of Econometrics. Angewandte Chemie Int. Ed. 6 (11), 951–952.
Homer, J., 2022. Can good government save us? Extending a climate-population model to include governance and its effects. Systems 10 (2). https://doi.org/10.3390/systems10020037.
Hunjra, A.I., Tayachi, T., Chani, M.I., Verhoeven, P., Mehmood, A., 2020. The moderating effect of institutional quality on the financial development and environmental quality nexus. Sustainability 12 (9). https://doi.org/10.3390/su12093805.
Hussain, M., Dogan, E., 2021. The role of institutional quality and environment-related technologies in environmental degradation for BRICS. J. Clean. Prod. 304 https://doi.org/10.1016/j.jclepro.2021.127059.
Hussain, M.M., Pal, S., Villanthenkodath, M.A., 2023. Towards sustainable development: the impact of transport infrastructure expenditure on the ecological footprint in India. Innov. Green Dev. 2 (2), 100037 https://doi.org/10.1016/j.igd.2023.100037.
Ibrahim, M.H., Law, S.H., 2016. Institutional quality and CO2 emission–trade relations: evidence from Sub-Saharan Africa. S. Afr. J. Econ. 84 (2), 323–340. https://doi.org/10.1111/saje.12095.

IMF, 2023. *Financial Development Index Database*. International Monetary Fund. https://data.imf.org/?sk=388dfa60-1d26-4ade-b505-a05a558d9a42.
Iorember, P.T., Jelilov, G., Usman, O., Işık, A., Celik, B., 2021. The influence of renewable energy use, human capital, and trade on environmental quality in South Africa: multiple structural breaks cointegration approach. Environ. Sci. Pollut. Control Ser. 28 (11), 13162–13174. https://doi.org/10.1007/s11356-020-11370-2.
Ito, H., Kawai, M., 2018. Quantity and quality measures of financial development: implications for macroeconomic performance. Publ. Pol. Rev. 14 (5), 803–834.
Jahanger, Atif, Usman, Muhammad, Daniel, Balsalobre-Lorente, 2022. Linking institutional quality to environmental sustainability. Sustain. Develop. 30, 1749–1765. https://doi.org/10.1002/sd.2345.
Jalil, A., Mahmud, S.F., 2009. Environment Kuznets curve for CO2 emissions: a cointegration analysis for China. Energy Pol. 37 (12), 5167–5172. https://doi.org/10.1016/j.enpol.2009.07.044.
Jiang, C., Ma, X., 2019. The impact of financial development on carbon emissions: a global perspective. Sustainability 11 (5241), 1–22. https://doi.org/10.3390/su11195241.
Jiang, Q., Rahman, Z.U., Zhang, X., Guo, Z., Xie, Q., 2022. An assessment of the impact of natural resources, energy, institutional quality, and financial development on CO2 emissions: evidence from the B&R nations. Resour. Pol. 76, 102716 https://doi.org/10.1016/j.resourpol.2022.102716.
Kamalu, K., Wan Ibrahim, W.H., 2022. The influence of institutional quality on human development: evidence from developing countries. J. Econ. Malaysia 56 (1), 93–105. https://doi.org/10.17576/JEM-2022-5601-07.
Kaufmann, D., Kraay, A., 2020. World Governance Indicators. World bank publication. https://info.worldbank.org/governance/wgi/Home/Documents.
Kazemzadeh, E., Fuinhas, J.A., Koengkan, M., 2022a. The impact of income inequality and economic complexity on ecological footprint: an analysis covering a long-time span. J. Environ. Econ. Pol. 11 (2), 133–153. https://doi.org/10.1080/21606544.2021.1930188.
Kazemzadeh, E., Fuinhas, J.A., Koengkan, M., Osmani, F., 2022b. The heterogeneous effect of economic complexity and export quality on the ecological footprint: a two-step club convergence and panel quantile regression approach. Sustainability 14 (18). https://doi.org/10.3390/su141811153.
Kazemzadeh, E., Fuinhas, J.A., Koengkan, M., Osmani, F., Silva, N., 2022c. Do energy efficiency and export quality affect the ecological footprint in emerging countries? A two-step approach using the SBM–DEA model and panel quantile regression. Environ. Syst. Decis. 42 (4), 608–625. https://doi.org/10.1007/s10669-022-09846-2.
Kazemzadeh, E., Fuinhas, J.A., Salehnia, N., Koengkan, M., Silva, N., 2023a. Assessing influential factors for ecological footprints: a complex solution approach. J. Clean. Prod. 414 https://doi.org/10.1016/j.jclepro.2023.137574.
Kazemzadeh, E., Lotfalipour, M.R., Shirazi, M., Sargolzaie, A., 2023b. Heterogeneous effects of energy consumption structure on ecological footprint. Environmental Science and Pollution Research 30 (19), 55884–55904. https://doi.org/10.1007/s11356-023-26118-x.
Khan, H., Weili, L., Khan, I., 2022. The role of institutional quality in FDI inflows and carbon emission reduction: evidence from the global developing and belt road initiative countries. Environmental Science and Pollution Research 29 (20), 30594–30621. https://doi.org/10.1007/s11356-021-17958-6.
Khan, N.H., Ju, Y., Hassan, S.T., 2019. Investigating the determinants of human development index in Pakistan: an empirical analysis. Environmental Science and Pollution Research 26 (19), 19294–19304. https://doi.org/10.1007/s11356-019-05271-2.
Kihombo, S., Ahmed, Z., Chen, S., Adebayo, T.S., Kirikkaleli, D., 2021. Linking financial development, economic growth, and ecological footprint: what is the role of technological innovation? Environmental Science and Pollution Research 28 (43), 61235–61245. https://doi.org/10.1007/s11356-021-14993-1.
KOF, 2023. Globalization Index. KOF Swiss Economic Institute. https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html.
Lau, L.S., Choong, C.K., Eng, Y.K., 2014. Carbon dioxide emission, institutional quality, and economic growth: empirical evidence in Malaysia. Renewable Energy 68, 276–281. https://doi.org/10.1016/j.renene.2014.02.013.
Le, T.H., Chang, Y., Park, D., 2020. Governance, environmental vulnerability, and PM2.5 concentrations: international evidence. Energy Journal 42 (6), 147–169. https://doi.org/10.5547/01956574.42.6.THLE.
Le, T.H., Kim, J., Lee, M., 2016. Institutional quality, trade openness, and financial sector development in Asia: an empirical investigation. Emerging Markets Finance and Trade 52 (5), 1047–1059. https://doi.org/10.1080/1540496X.2015.1103138.
Lee, H.S., Chia, C.J., Liew, P.X., Lee, S.Y., Har, W.M., 2023. The heterogeneous effect of economic growth on the ecological footprint in OECD countries. IOP Conference Series: Earth and Environmental Science 1135 (1). https://doi.org/10.1088/1755-1315/1135/1/012032.
Lenka, S.K., Sharma, R., 2017. Does financial inclusion Spur economic growth in India? The Journal of Developing Areas 51 (1), 215–228. https://doi.org/10.1353/jda.2017.0069.
Li, D.D., Rishi, M., Bae, J.H., 2021. Green official development Aid and carbon emissions: do institutions matter? Environment and Development Economics 26 (1), 88–107. https://doi.org/10.1017/S1355770X20000170.
Li, P., Akhter, M.J., Aljarba, A., Akeel, H., Khoj, H., 2022. G-20 economies and their environmental commitments: fresh analysis based on energy consumption and economic growth. Frontiers in Environmental Science 10. https://doi.org/10.3389/fenvs.2022.983136.
Li, Q., Reuveny, R., 2006. Democracy and environmental degradation. International Studies Quarterly 50 (4), 935–956. https://doi.org/10.1111/j.1468-2478.2006.00432.x.
Liang, L., Wang, Z., Li, J., 2019. The effect of urbanization on environmental pollution in rapidly developing urban agglomerations. Journal of Cleaner Production 237. https://doi.org/10.1016/j.jclepro.2019.117649.
Liddle, B., Lung, S., 2010. Age-structure, urbanization, and climate change in developed countries: Revisiting STIRPAT for disaggregated population and consumption-related environmental impacts. Population and Environment 31 (5), 317–343. https://doi.org/10.1007/s11111-010-0101-5.
Lin, C.Y.C., Liscow, Z.D., 2013. Endogeneity in the environmental kuznets curve: an instrumental variables approach. American Journal of Agricultural Economics 95 (2), 268–274. https://doi.org/10.1093/ajae/aas050.
Lorente, D.B., Álvarez-Herranz, A., 2016. Economic growth and energy regulation in the environmental Kuznets curve. Environmental Science and Pollution Research 23 (16), 16478–16494. https://doi.org/10.1007/s11356-016-6773-3.
Lu, W., Kasimov, I., Karimov, I., Abdullaev, Y., 2020. Foreign direct investment, natural resources, economic freedom, and sea-access: evidence from the commonwealth of independent states. Sustainability (Switzerland) 12 (8). https://doi.org/10.3390/SU12083135.
Majeed, M.T., Tauqir, A., Mazhar, M., Samreen, I., 2021. Asymmetric effects of energy consumption and economic growth on ecological footprint: new evidence from Pakistan. Environmental Science and Pollution Research 28 (25), 32945–32961. https://doi.org/10.1007/s11356-021-13130-2.
Markandya, A., Golub, A., Pedroso-Galinato, S., 2006. Empirical analysis of national income and SO2 emissions in selected European countries. Environmental and Resource Economics 35 (3), 221–257. https://doi.org/10.1007/s10640-006-9014-2.
Mehmood, U., Tariq, S., Ul-Haq, Z., Meo, M.S., 2021. Does the modifying role of institutional quality remains homogeneous in GDP-CO2 emission nexus? New evidence from ARDL approach. Environmental Science and Pollution Research 28 (8), 10167–10174. https://doi.org/10.1007/s11356-020-11293-y.
Montes, G.C., Bastos, J.C.A., de Oliveira, A.J., 2019. Fiscal transparency, government effectiveness and government spending efficiency: some international evidence based on panel data approach. Economic Modelling 79, 211–225. https://doi.org/10.1016/j.econmod.2018.10.013.
Munger, M.C., North, D.C., 1991. Institutions, institutional change and economic performance. South. Econ. J. https://doi.org/10.2307/1060065.
Nansai, K., Tohno, S., Chatani, S., Kanemoto, K., Kagawa, S., Kondo, Y., Takayanagi, W., Lenzen, M., 2021. Consumption in the G20 nations causes particulate air pollution resulting in two million premature deaths annually. Nat. Commun. 12 (1) https://doi.org/10.1038/s41467-021-26348-y.
Nasreen, S., Anwar, S., 2015. The impact of economic and financial development on environmental degradation: an empirical assessment of EKC hypothesis. Stud. Econ. Finance 32 (4), 485–502. https://doi.org/10.1108/SEF-07-2013-0105.
Nathaniel, S., Nwodo, O., Adediran, A., Sharma, G., Shah, M., Adeleye, N., 2019. Ecological footprint, urbanization, and energy consumption in South Africa: including the excluded. Environ. Sci. Pollut. Control Ser. 26 (26), 27168–27179. https://doi.org/10.1007/s11356-019-05924-2.
Nathaniel, S., Nwodo, O., Sharma, G., Shah, M., 2020. Renewable energy, urbanization, and ecological footprint linkage in CIVETS. Environ. Sci. Pollut. Control Ser. 27 (16), 19616–19629. https://doi.org/10.1007/s11356-020-08466-0.
Neumayer, E., 2002. Do democracies exhibit stronger international environmental commitment? A cross-country analysis. J. Peace Res. 39 (2), 139–164. https://doi.org/10.1177/0022343302039002001.
Ngo, N.S., Kokoyo, S., Klopp, J., 2017. Why Participation Matters for Air Quality Studies: Risk Perceptions, Understandings of Air Pollution and Mobilization in a Poor Neighborhood in Nairobi. Kenya. Public Health. https://doi.org/10.1016/j.puhe.2015.07.014.
Niu, H., Li, H., 2014. An empirical study on economic growth and carbon emissions of G20 group. Proc. 2014 Int. Conf. Educ. Reform and Mod. Manag. 75 https://doi.org/10.2991/ermm-14.2014.86.
O'Brien, R.M., 2007. A caution regarding rules of thumb for variance inflation factors. Qual. Quantity 41 (5), 673–690. https://doi.org/10.1007/s11135-006-9018-6.
Okonkwo, J.J., Ifeanyi, O.N., 2021. Financial inclusion and economic growth in Nigeria: an empirical study. Int. J. Res. Innov. Soc. Sci. 5 (1), 323–330. https://doi.org/10.47772/ijriss.2021.5113.
Omar, M.A., Inaba, K., 2020. Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. J. Econ. Struct. 9 (37), 1–25. https://doi.org/10.1186/s40008-020-00214-4.
Omoke, P.C., Nwani, C., Effiong, E.L., Evbuomwan, O.O., Emenekwe, C.C., 2020. The impact of financial development on carbon, non-carbon, and total ecological footprint in Nigeria: new evidence from asymmetric dynamic analysis. Environ. Sci. Pollut. Control Ser. 27 (17), 21628–21646. https://doi.org/10.1007/s11356-020-08382-3.
Omri, A., Omri, H., Slimani, S., Belaid, F., 2022. Environmental degradation and life satisfaction: do governance and renewable energy matter? Technol. Forecast. Soc. Change 175. https://doi.org/10.1016/j.techfore.2021.121375.
Ouedraogo, Idrissa, Tabi, Henri Ngoa, Atangana Ondoa, Henri, Nester, Jiya, 2022. Institutional quality and human capital development in Africa. Econ. Syst. 41 (6), 100937 https://doi.org/10.1016/j.ecosys.2021.100937.
Park, Cyn Young, Mercado, Rogelio V, 2018. Financial inclusion: New measurement and cross-country impact assessment. ADB Economics Working Paper Series 539. Manila, Philippines, pp. 1–36 url: https://www.adb.org/sites/default/files/publication/408621/ewp-539-financial-inclusion.pdf.
Pata, U.K., 2018. Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: testing EKC hypothesis with structural breaks. J. Clean. Prod. 187, 770–779. https://doi.org/10.1016/j.jclepro.2018.03.236.

Pata, U.K., 2021. Linking renewable energy, globalization, agriculture, CO2 emissions and ecological footprint in BRIC countries: a sustainability perspective. Renew. Energy 173, 197–208. https://doi.org/10.1016/j.renene.2021.03.125.
Pata, U.K., Aydin, M., Haouas, I., 2021. Are natural resources abundance and human development a solution for environmental pressure? Evidence from top ten countries with the largest ecological footprint. Resour. Pol. 70 https://doi.org/10.1016/j.resourpol.2020.101923.
Pata, U.K., Hizarci, A.E., 2022. Investigating the Environmental Kuznets Curve in the Five Most Complex Countries: Insights from a Modified Ecological Footprint Model. Energy and Environment. https://doi.org/10.1177/0958305X221120255.
Pata, U.K., Isik, C., 2021. Determinants of the load capacity factor in China: a novel dynamic ARDL approach for ecological footprint accounting. Resour. Pol. 74 https://doi.org/10.1016/j.resourpol.2021.102313.
Pesaran, Hashem, M., 2004. General Diagnostic Tests for Cross Section Dependence in Panels, pp. 1–42. Discussion Paper No. 1240. https://docs.iza.org/dp1240.pdf.
Pesaran, M.H., Pesaran, M.H., Shin, Y., Smith, R.P., 1999. Pooled mean group estimation of dynamic heterogeneous panels. J. Am. Stat. Assoc. 94 (446), 621–634. https://doi.org/10.1080/01621459.1999.10474156.
Phillips, P.C.B., Sul, D., 2007. Bias in dynamic panel estimation with fixed effects, incidental trends and cross section dependence. J. Econom. 137 (1), 162–188. https://doi.org/10.1016/j.jeconom.2006.03.009.
Pour, M.A.A., 2012. The effects of good governance on environmental quality. Australian J. Basic and Appl. Sci. 6 (8), 437–443.
Prawoto, N., Purnomo, E.P., Zahra, A.A., 2020. The impacts of Covid-19 pandemic on socio-economic mobility in Indonesia. Int. J. Econ. Bus. Adm. 8 (3), 57–71. https://doi.org/10.35808/ijeba/486.
Rafei, M., Esmaeili, P., Balsalobre-Lorente, D., 2022. A step towards environmental mitigation: how do economic complexity and natural resources matter? Focusing on different institutional quality level countries. Resour. Pol. 78 https://doi.org/10.1016/j.resourpol.2022.102848.
Rafindadi, A.A., Usman, O., 2021. Toward sustainable electricity consumption in Brazil: the role of economic growth, globalization and ecological footprint using a nonlinear ARDL approach. J. Environ. Plann. Manag. 64 (5), 905–929. https://doi.org/10.1080/09640568.2020.1791058.
Ragoubi, H., Mighri, Z., 2021. Spillover effects of trade openness on CO2 emissions in middle-income countries: a spatial panel data approach. Regional Sci. Pol. Practice 13 (3), 835–877. https://doi.org/10.1111/rsp3.12360.
Rahman, Mafizur, Mohammad, Alam, K., 2022. Effects of corruption, technological innovation, globalisation, and renewable energy on carbon emissions in Asian countries. Util. Pol. 79, 101448 https://doi.org/10.1016/j.jup.2022.101448.
Rahman, M.M., Rayhan, I., Sultana, N., 2023. How does electricity affect economic growth? Examining the role of government policy to selected four South asian countries. Energies 16, 1417. https://doi.org/10.3390/en16031417.
Rahman, M.M., Vu, X.B., 2020. The nexus between renewable energy, economic growth, trade, urbanisation and environmental quality: a comparative study for Australia and Canada. Renew. Energy 155, 617–627. https://doi.org/10.1016/j.renene.2020.03.135.
Ray, S., Ray, I.A., 2011. Impact of population growth on environmental degradation: case of India. J. Econ. Sustain. Dev. 2 (8), 72–77. www.iiste.org.
Rehman, A., Radulescu, M., Ma, H., Dagar, V., Hussain, I., Khan, M.K., 2021. The impact of globalization, energy use, and trade on ecological footprint in Pakistan: does environmental sustainability exist? Energies 14 (17). https://doi.org/10.3390/en14175234.
Sabir, S., Gorus, M.S., 2019. The impact of globalization on ecological footprint: empirical evidence from the South Asian countries. Environ. Sci. Pollut. Control Ser. 26 (32), 33387–33398. https://doi.org/10.1007/s11356-019-06458-3.
Saboori, B., Sulaiman, J., 2013. CO2 emissions, energy consumption and economic growth in association of Southeast Asian Nations (ASEAN) countries: acointegration approach. Energy 55, 813–822. https://doi.org/10.1016/j.energy.2013.04.038.
Sahoo, M., Sethi, N., 2022. The dynamic impact of urbanization, structural transformation, and technological innovation on ecological footprint and PM2.5: evidence from newly industrialized countries. Environ. Dev. Sustain. 24 (3), 4244–4277. https://doi.org/10.1007/s10668-021-01614-7.
Salahuddin, M., Gow, J., 2019. Effects of energy consumption and economic growth on environmental quality: evidence from Qatar. Environ. Sci. Pollut. Control Ser. 26, 18124–18142. https://doi.org/10.1007/s11356-019-05188-w.
Salahuddin, M., Khan, S., 2013. Empirical link between economic growth, energy consumption and CO2 emission in Australia. J. Develop. Area. 47 (2), 81–92. https://doi.org/10.1353/jda.2013.0038.
Saleem, N., Shujah-ur-Rahman, S.-R., Jun, Z., 2019. The impact of human capital and biocapacity on environment: environmental quality measure through ecological footprint and greenhouse gases. J. Pollut. Effects & Control 7 (2), 12. https://doi.org/10.35248/2375-4397.19.7.237.
Salman, M., Long, X., Dauda, L., Mensah, C.N., 2019. The impact of institutional quality on economic growth and carbon emissions: evidence from Indonesia, South Korea and Thailand. J. Clean. Prod. 241, 118331 https://doi.org/10.1016/j.jclepro.2019.118331.
Salman, M., Zha, D., Wang, G., 2022. Interplay between urbanization and ecological footprints: differential roles of indigenous and foreign innovations in ASEAN-4. Environ. Sci. Pol. 127, 161–180. https://doi.org/10.1016/j.envsci.2021.10.016.
Santo, di Naomi, Russo, Ilaria, Sisto, Roberta, 2022. Climate change and natural resource scarcity: a literature review on dry farming. Land 11 (22). https://doi.org/10.3390/land11122102.
Saqib, Najia, Ilhan, Ozturk, Usman, M., 2023. Investigating the implications of technological innovations, financial inclusion, and renewable energy in diminishing ecological footprints levels in emerging economies. Geosci. Front. 14 (6), 101667 https://doi.org/10.1016/j.gsf.2023.101667.
Sarafidis, V., Wansbeek, T., 2012. Cross-sectional dependence in panel data analysis. Econom. Rev. 31 (5), 483–531. https://doi.org/10.1080/07474938.2011.611458.
Sarma, M., 2012. Index of financial inclusion – a measure of financial sector inclusiveness. Berlin Work. Pap. Money, Fin. Trade Dev. 24 (8), 472–476. https://finance-and-trade.htw-berlin.de/fileadmin/HTW/Forschung/Money_Finance_Trade_Development/working_paper_series/wp_07_2012_Sarma_Index-of-Financial-Inclusion.pdf.
Satrovic, E., Ahmad, M., Muslija, A., 2021. Does democracy improve environmental quality of GCC region? Analysis robust to cross-section dependence and slope heterogeneity. Environ. Sci. Pollut. Control Ser. 28 (44), 62927–62942. https://doi.org/10.1007/s11356-021-15020-z.
Satyanarayana Murthy, D., Kumar Patra, S., Samantaraya, A., 2014. Trade openness, financial development index and economic growth: evidence from India (1971-2012). J. Fin. Econ. Pol. 6 (4), 362–375. https://doi.org/10.1108/JFEP-10-2013-0056.
Shabir, Mohsen, Hussain, Iftikhar, Işık, Özcan, Razzaq, Kamran, Mehroush, I., 2023. The role of innovation in environmental-related technologies and institutional quality to drive environmental sustainability. Front. Environ. Sci. 11, 1–14. https://doi.org/10.3389/fenvs.2023.1174827.
Shahbaz, M., Chaudhary, A.R., Ozturk, I., 2017a. Does urbanization cause increasing energy demand in Pakistan? Empirical evidence from STIRPAT model. Energy 122, 83–93. https://doi.org/10.1016/j.energy.2017.01.080.
Shahbaz, M., Dogan, M., Akkus, H.T., Gursoy, S., 2023. The effect of financial development and economic growth on ecological footprint: evidence from top 10 emitter countries. Environ. Sci. Pollut. Control Ser. 30 (29), 73518–73533. https://doi.org/10.1007/s11356-023-27573-2.
Shahbaz, M., Khan, S., Ali, A., Bhattacharya, M., 2017b. The impact of globalization on Co2 emissions in China. Singapore Econ. Rev. 62 (4), 929–957. https://doi.org/10.1142/S0217590817400331.
Shahbaz, M., Shahzad, S.J.H., Ahmad, N., Alam, S., 2016. Financial development and environmental quality: the way forward. Energy Pol. 98, 353–364. https://doi.org/10.1016/j.enpol.2016.09.002.
Shouchang, Y., Zhonghua, L., Jintian, W., 2023. Exploring the impacts of economic policy uncertainty, natural resources, and energy structure on ecological footprints: evidence from G-10 nations. Environ. Sci. Pollut. Control Ser. 30 (16), 45701–45710. https://doi.org/10.1007/s11356-023-25392-z.
Shrinkhal, R., 2019. Economics, technology, and environmental protection. In: Phytomanagement of Polluted Sites: Market Opportunities in Sustainable Phytoremediation, pp. 569–580. https://doi.org/10.1016/B978-0-12-813912-7.00022-3.
Sibanda, K., Garidzirai, R., Mushonga, F., Gonese, D., 2023. Natural resource rents, institutional quality, and environmental degradation in resource-rich sub-saharan african countries. Sustainability 15 (2), 1–11. https://doi.org/10.3390/su15021141.
Stock, J.H., Wright, J., Yogo, M., 2002. GMM , weak instruments , and weak identification. J. Bus. Econ. Stat. 4 (20), 518–529.
Stock, J.H., Yogo, M., 2005. Testing for weak instruments in Linear Iv regression. In: Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg, pp. 80–108. https://doi.org/10.1017/CBO9780511614491.006.
Stuckler, David, Basu, Sanjay, Suhrcke, Marc, McKee, Martin, 2009. The health implications of financial crisis: A review of the evidence. Ulster Med. J. 78 (3), 142–145 url: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2773609/.
Sun, Q., Ma, R., Xi, Z., Wang, H., Jiang, C., Chen, H., 2023. Nonlinear impacts of energy consumption and globalization on ecological footprint: empirical research from BRICS countries. J. Clean. Prod. 396 https://doi.org/10.1016/j.jclepro.2023.136488.
Tausch, A., Heshmati, A., 2018. The effects of globalization on the environment. UKH J. Soc. Sci. 2 (1), 25–40. https://doi.org/10.25079/ukhjss.v2n1y2018.pp25-40.
Tee, C.M., Wong, W.Y., Hooy, C.W., 2023. Economic policy uncertainty and carbon footprint: international evidence. J. Multinatl. Financ. Manag. 67 https://doi.org/10.1016/j.mulfin.2023.100785.
Tu, Z., Hu, T., Shen, R., 2019. Evaluating public participation impact on environmental protection and ecological efficiency in China: evidence from PITI disclosure. China Econ. Rev. https://doi.org/10.1016/j.chieco.2019.03.010.
Ünal, H., Aktuğ, M., 2022. The impact of human capital and bio-capacity on the environmental quality: evidence from G20 countries. Environ. Sci. Pollut. Control Ser. 29 (30), 45635–45645. https://doi.org/10.1007/s11356-022-19122-0.
UNDP, 2023. Human Development Index. United Nations Development Programme. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI.
UNEP, 2023. Kunming-Montreal Global Biodiversity Framework. United Nations Environment Programme. https://www.unep.org/resources/kunming-montreal-global-biodiversity-framework.
United Nations, 2019. What Are the Sustainable Development Goals?, vols. 1–3. United Nations Development Programme (UNDP).
Usman, M., Hammar, N., 2021. Dynamic relationship between technological innovations, financial development, renewable energy, and ecological footprint: fresh insights based on the STIRPAT model for Asia Pacific Economic Cooperation countries. Environ. Sci. Pollut. Control Ser. 28 (12), 15519–15536. https://doi.org/10.1007/s11356-020-11640-z.
Usman, O., Akadiri, S. Saint, Adeshola, I., 2020. Role of renewable energy and globalization on ecological footprint in the USA: implications for environmental sustainability. Environ. Sci. Pollut. Control Ser. 27 (24), 30681–30693. https://doi.org/10.1007/s11356-020-09170-9.

Uzar, U., 2021. The relationship between institutional quality and ecological footprint: is there a connection? Nat. Resour. Forum 45 (4), 380–396. https://doi.org/10.1111/1477-8947.12235.
Verdier, V., 2016. Estimation of dynamic panel data models with cross-sectional dependence: using cluster dependence for efficiency. J. Appl. Econom. 31 (1), 85–105. https://doi.org/10.1002/jae.2486.
Wang, N., Zhu, H., Guo, Y., Peng, C., 2018. The heterogeneous effect of democracy, political globalization, and urbanization on PM2.5 concentrations in G20 countries: evidence from panel quantile regression. J. Clean. Prod. 194, 54–68. https://doi.org/10.1016/j.jclepro.2018.05.092.
Wang, Y., Chen, L., Kubota, J., 2016. The relationship between urbanization, energy use and carbon emissions: evidence from a panel of Association of Southeast Asian Nations (ASEAN) countries. J. Clean. Prod. 112, 1368–1374. https://doi.org/10.1016/j.jclepro.2015.06.041.
Wawrzyniak, D., Doryń, W., 2020. Does the quality of institutions modify the economic growth-carbon dioxide emissions nexus? Evidence from a group of emerging and developing countries. Econ. Res.-Ekon. Istrazivanja 33 (1), 124–144. https://doi.org/10.1080/1331677X.2019.1708770.
WDI, 2023. National Accounts Data, and OECD National Accounts Data Files. The World Bank. https://data.worldbank.org/indicator/Ny.Gdp.Mktp.Cd?most_recent_value_desc=true.
Weber, H., Sciubba, J.D., 2019. The effect of population growth on the environment: evidence from European regions. Eur. J. Popul. 35, 379–402. https://doi.org/10.1007/s10680-018-9486-0.
Wei, H., Zhang, Y., 2017. Analysis of impact of urbanization on environmental quality in China. China World Econ. 25 (2), 85–106. https://doi.org/10.1111/cwe.12195.
Welsch, H., 2004. Corruption, growth, and the environment: a cross-country analysis. Environ. Dev. Econ. 9 (5), 663–693. https://doi.org/10.1017/S1355770X04001500.
WHO, 2022. Ambient (Outdoor) Air Pollution. World Health Organisation Geneva. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.
Williams, M., Abu Alrub, A., Aga, M., 2022. Ecological footprint, economic uncertainty and foreign direct investment in South Africa: evidence from asymmetric cointegration and dynamic multipliers in a nonlinear ARDL approach. Sage Open 12 (2). https://doi.org/10.1177/21582440221094607.
Wu, C.F., Chang, T., Wu, T.P., Leng, K.J., Lin, M.C., Huang, S.C., 2022. Impact of globalization on the environment in major CO2-emitting countries: evidence using bootstrap ARDL with a Fourier function. Front. Public Health 10. https://doi.org/10.3389/fpubh.2022.907403.
Wu, J., 2014. Urban ecology and sustainability: the state-of-the-science and future directions. Landsc. Urban Plann. 125, 209–221. https://doi.org/10.1016/j.landurbplan.2014.01.018.
WU, L., Ma, T., Bian, Y., Li, S., Yi, Z., 2020. Improvement of regional environmental quality: government environmental governance and public participation. Sci. Total Environ. 717, 137265 https://doi.org/10.1016/j.scitotenv.2020.137265.
Wu, W.-L., 2017. Institutional quality and air pollution: international evidence. Int. J. Bus. Econ. 16 (1), 49–74.
Xiao, P., Zhang, H., Sun, X., Zhang, F., Du, X., Liu, G., 2022. International ambidexterity and innovation performance: the moderating role of the host country's institutional quality. J. Innov. Knowl. 7 (3) https://doi.org/10.1016/j.jik.2022.100218.
Yartey, C.A., 2010. The institutional and macroeconomic determinants of stock market development in emerging economies. Appl. Financ. Econ. 20 (21), 1615–1625. https://doi.org/10.1080/09603107.2010.522519.
Young, K.H., Theil, H., 1973. Principles of econometrics. J. Am. Stat. Assoc. 68 (342), 498. https://doi.org/10.2307/2284120.
Yu, H., Xu, J., Shen, F., Fang, D., Shi, D., 2022. The effects of an environmental accountability system on local environmental governance and firms' emissions. Econ. Syst. https://doi.org/10.1016/j.ecosys.2022.100987.
Zhang, L., Xu, M., Chen, H., Li, Y., Chen, S., 2022. Globalization, green economy and environmental challenges: state of the art review for practical implications. Front. Environ. Sci. 10 https://doi.org/10.3389/fenvs.2022.870271.
Zhang, Shujian, Wang, L., 2020. The influence of government transparency on governance efficiency in information age: the environmental governance behavior of Guangdong, China. J. Enterprise Inf. Manag. https://doi.org/10.1108/JEIM-01-2020-0017.
Zhang, Sihan, Zhang, M. ang, Qiao, Y., Li, X., Li, S., 2022. Does improvement of environmental information transparency boost firms' green innovation? Evidence from the air quality monitoring and disclosure program in China. J. Clean. Prod. 357 https://doi.org/10.1016/j.jclepro.2022.131921.