Received 29 May 2025
Revised 10 August 2025
Accepted 26 August 2025

Plenty of natural resources, institutional quality, and sustainable total factors of production: the moderating role of green Islamic finance

Yun Li
College of Finance and Economics, Hainan Vocational University of Science and Technology, Haikou, China

Muhammad Naeem Shahid
Department of Business Administration, Government College University Faisalabad, Chiniot Campus, Pakistan

Urooj Anwar
School of Business, Monash University Malaysia, Bandar Sunway, Malaysia, and

Muhammad Umar Islam
School of Accounting and Finance, Asia Pacific University of Technology and Innovation, Federal Territory of Kuala Lumpur, Malaysia

Abstract

Purpose – The study aims to address the mechanism of the resource curse and achieve Sustainable Development Goals (SDGs) by exploring the connections between the abundance of natural resources (ANR), institutional quality (IQ) and green total factors of productivity (GTFOP) in the context of Islamic economies.

Design/methodology/approach – The study uses ordinary least squares, feasible generalized least squares and IV-GMM econometric models to uncover the proposed connectedness among 9 Islamic economies from 2017 to 2023. Moreover, the study examines the asymmetric linkages and moderating influence of green Islamic finance (GIF).

Findings – The study finds (a) ANR hinders the growth of GTFOP and verifies the resource curse hypothesis; (b) ANR has more depressive impacts on GTFOP in regions with higher GTFOP; (c) strong IQ enhances the systems of resource management with proper extraction and consumption of natural resources, hence IQ promotes GTFOP, especially in upper quantiles; (d) the replaced variables support the findings of benchmark regression; and (e) green Islamic finance reduces the inhibitory impacts of ANR on GTFOP while enhancing the favourable effects of IQ on GTFOP.

Originality/value – Finally, the study outcomes provide favourable suggestions for governments and policymakers.

Keywords Natural resources, GTFOP, Institutional quality, Green finance, Green economic sustainability

Paper type Research paper

International Journal of Islamic and Middle Eastern Finance and Management
Vol. 19 No. 3, 2026
pp. 740-766

1753-8394
DOI 10.1108/IMEFM-05-2025-0392

1. Introduction

The rapid industrial growth has shockingly consumed the natural resources and brought incredible economic growth. The World Bank reports a 7.96 times global increase in GDP [1] of all the countries between 1960 and 2021 (WDI, 2022) due to the depletion of natural resources. According to Rhodes (2020), the average annual growth rate of natural resource

consumption is 5.45%, reaching 100.6 billion tons in 2020 from 26.871 billion tons in 1970. This exploitation of natural resources has increased the vulnerability of the ecosystem, the loss of species' diversity and global warming (Pradel *et al.*, 2021; Wang *et al.*, 2022a; Zhao *et al.*, 2022). Therefore, industries and countries worldwide are now focusing on a zero-carbon society, which proposes the synchronised advancement of ecology, economy and resources. The United Nations Sustainable Development Summit officially endorsed the SDGs in 2015, harmonising environmental, social and economic advancements (European Commission, 2021). Therefore, the eternal purpose of an economy should only be to achieve sustainable green socio-economic advancements. Furthermore, Chang *et al.* (2023) recommend that the economies should establish green economic sustainability (hereafter GES) and improve the green total factor of production (hereafter GTFOP). Both GES and GTFOP are the primary strategies to cope with environmental hazards and to achieve sustainable advancements (Wang and Feng, 2021). According to Chen and Golley (2014), GTFOP integrates different environmental aspects, such as depletion of natural resources and pollution, thus offering a wide-ranging assessment of productivity to attain sustainability. Besides traditional inputs (labour, capital and technology), GTFOP uses natural resources to generate minimal waste and pollutants. The green total factor of productivity assumes how well a country converts inputs into outputs while minimising ecological damages (Tan *et al.*, 2022), where stringent policies can derive green advancements (Zheng *et al.*, 2023).

Islamic countries with abundant natural resources (hereafter ANR) may face significant complications in transitioning towards green advancements. Because regions with plenty of natural resources and most developing nations did not experience rapid economic development after World War II due to inefficient use of natural resources compared to those with scarcity (Cheng *et al.*, 2020). This phenomenon of less economic growth with plenty of natural resources is known as the "resource curse" phenomenon. Auty (2001) claims that the "resource curse" phenomenon exists due to the wasteful and inefficient use of natural resources; however, GTFOP reduces such inefficiencies. On the one hand, over-resource revenues, official corruption, civil wars and rent-seeking behaviour have exhausted the advantages of natural resource abundance (Angrist and Kugler, 2008). According to Pradel *et al.* (2021), the statistics show that politically unstable countries or countries with weak institutional quality (IQ) contribute to more than 60% of global resources. However, plenty of natural resources hinder manufacturing; for instance, the natural gas boom in the last century has adversely affected Dutch industrial and agricultural exports. Ideally, regional/national growth and sustainable local prosperity are based on natural resources, but the distribution of green resources is uneven in Islamic economies (see Figure 1). Many Islamic countries are a natural resource-rich continent, but Singh *et al.* (2024) argue that abundant natural resources do not contribute towards regional sustainable economic advancements. This supports the resource curse hypothesis, which states that countries with plenty of natural resources exhibit fewer green developments.

Moreover, the governments of various countries have paid great attention to green finance as a significant tool to link economic development and environmental protection. Recently, China has vigorously advanced towards a green financial system to encourage high-quality, low-carbon and green socio-economic developments. Zhang *et al.* (2023a) argue that green transformation purely depends on green finances, and the green financial system helps promote the sustainable evolution of the supply side and optimises green economic advancements (Xie *et al.*, 2020; Zhou *et al.*, 2020; Lee *et al.*, 2022). By taking advantage of green financing, enterprises can increase their investment in R&D to enhance research activities to stimulate green transformation via green technological inventions and green environmental awareness (Zhou *et al.*, 2020; Xu and Li, 2020; Hu *et al.*, 2021). Moreover,

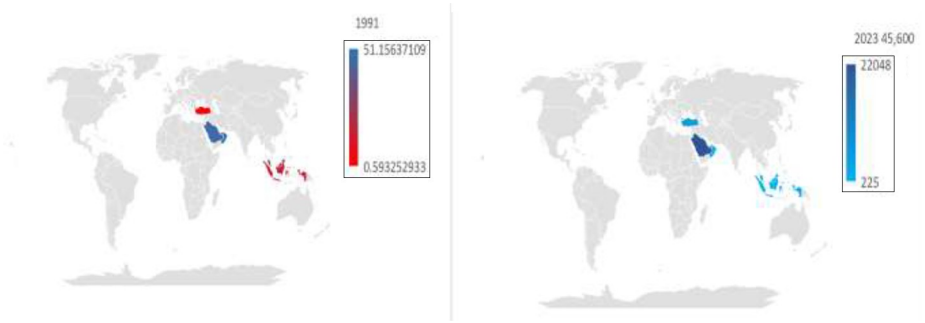

Figure 1. Abundance of natural resources (left-hand side) and issuance of green Islamic finance (right-hand side) over extended periods

Note(s): The map shows a few countries that issue green Islamic finance (Bonds and Sukuk)

Source: Figure by the author's elaboration of the data collected from WDI (abundance of natural resources) and Bloomberg (green Islamic finance)

the role of green financing cannot be ignored in attaining the SDGs because it is important to explore whether green financing intensifies or mitigates the curse for GTFOP. Similarly, solid institutional quality reduces frequent corruption (Danish and Ulucak, 2020), enhances GTFOP and nurtures the benefits of green financing (see Table 1 for Green Financing activities).

The composite association between regional sustainable green growth and natural resources has mystified governments and scholars. Scholars have investigated the abundance of natural resource rents (ANR), green total factor of productivity (GTFOP), Institutional Quality (IQ), many ecological (e.g., land, climate and energy) and other factors to explore the complex eco-environmental issues. For example, Algarini (2017) investigates the impact of human capital on GTFOP in GCC economies, and Majeed *et al.* (2021) explore the nexus of economic growth, energy consumption, natural resources and environmental quality in Islamic economies. Kahouli *et al.* (2022) examine the nexus of ICT technologies with ecological footprints and GTFOP in Saudi Arabia, and Amer *et al.* (2022) study the linkages of human capital, urbanisation and natural resources with sustainable ecology in the GCC. Similarly, Saqib *et al.* (2022) examine the impact of financial deepening and natural resources on climate sustainability in GCC economies. Sun (2024) investigates GULF countries and explores the role of inclusive finance and natural resources for green recovery. Alajmi (2024) examines GCC economies and uncovers the nexus of total factor productivity and carbon emissions. Similarly, from the perspective of other countries, Tan *et al.* (2022) investigate the impact of economic agglomeration and transportation infrastructure on GTFOP in China, Chang *et al.* (2023) explore the nexus of artificial intelligence and GTFOP in China and Ngo (2024) examines the influence of clean energy and natural resources on GTFOP in Vietnam using data from the pre- and post-COVID era. Furthermore, from a global perspective, Song *et al.* (2023) uncover the impact of institutional quality and climate risk on GTFOP in 88 countries, and Zhang *et al.* (2023b) inspect the connections of technology innovation and IQ with renewable energy development via the moderating role of green financing in 24 African nations. Moreover, Liu *et al.* (2023) provide global evidence on the nexus between the abundance of natural resources and GTFOP under the influence of green finance. However, these prevailing studies lack comprehensive evidence of how control of corruption and natural resource abundance influence the GTFOP in the presence of

Table 1. Description of green/sustainable finance in Islamic economies

Sustainable and green sukuk issuers in the GCC (Gulf Cooperation Council) from 2019 to 2022 (in million US dollars)	
Majid Al Futtaim (2019 / UAE)	1,200
Saudi Electricity (2020 / Saudi Arabia)	1,300
Etihad Airways (2020 / UAE)	600
Infracorp (2022 / Bahrain)	900
Riyad Bank (2022 Saudi Arabia)	750
Saudi National Bank (2022 Saudi Arabia)	750
DIB Sukuk Limited (2022 Saudi Arabia)	750
Islamic Finance (international sukuk bond)issued in Europe from 2001 to 2020 (in million US dollars)	
Turkey	16,917
United kingdom	1,769
Luxembourg	280
Germany	206
France	1
Islamic Finance Country Index (IFCI) scores for MENA (Middle East and North Africa region) in 2019	
Iran	79.03
Saudi Arabia	60.65
Sudan	55.71
United Arab Emirates	45.31
Kuwait	40.90
Bahrain	30.09
Qatar	29.88
Turkey	20.77
Oman	19.21
Jordan	18.33
Egypt	11
Morocco	5.30
Tunisia	4.09
Lebanon	3.30
Algeria	2.01
Yemen	1.99
Palestine	1.32
Syria	0.99

Source(s): Table by data collected from statista.com

renewable energy consumption and economic sustainability in Islamic economies. Moreover, none of the studies have investigated the moderating role of green Islamic finance, even though Green Islamic Bonds (Sukuk) are receiving attention for climate concerns (Billah and Adnan, 2024). Effective use of natural resources and better IQ enhance GTFOP, where green Islamic finance may boost this relationship. Such interactions may help Islamic economies succeed and increase overall green productivity. Hence, a connectedness between the ANR, IQ and GTFOP in the context of natural resource curse or blessing is more significant for economic aspirants, scholars and policymakers to attain sustainable advancements. Additionally, in the current era, it is necessary to develop natural resource-related hypotheses, explore how to alleviate the probable curse and assist governments in attaining green developments and zero-carbon emissions. Moreover, investigating such connectedness via the moderating role of green Islamic finance facilitates the Shariah-compliant and religiously sentimental investors to support various sustainable and environmentally friendly projects to enhance GTFOP. Therefore, the current study explores

the impact of ANR and IQ on GTFOP using the IV-GMM technique from 2017 to 2023. Furthermore, the study explores the relationship between ANR, IQ and GTFOP via the moderating role of green Islamic finance (bonds and sukuk). The current research contributes to the literature in the following way. First, the article is a pioneering attempt to explore the connection between ANR, IQ and GTFOP from Islamic Economies. This study is the first to link the relationship between ANR, IQ and GTFOP via the moderating role of green Islamic finance, which may provide a valuable strategy to the government to mitigate the local resource curse phenomenon. Such a linkage between the variables is valuable for governments to ensure strong institutional quality in using local natural resources. The results endorse valuable references for promoting green economic advancements by encouraging green exploration and development, empowering macroeconomic regulations and improving the green financial ecosystem.

We structure the remaining theme of the article as follows: Section 2 includes the relevant literature review. Section 3 exhibits the data, their sources and relevant econometric methods. Section 4 provides the empirical outcomes and discussion, using previous studies as a guide. Finally, the Section 5 offers conclusions, limitations, recommendations and policy implications.

2. Literature review

2.1 Resource curse hypothesis

Scholars have documented mixed evidence of the impact of the abundance of natural resources and economic advancement in terms of natural resources as blessings or curses for economies. Natural resources and labour are the vital components of production in a region, and they positively impact economic development. Cheng *et al.* (2020) recently found that resource-abundant regions are more prone to accumulate capital and faster economic development than regions with a scarcity of resources. However, the reality is different as the more classical and seminal work of Sachs and Warner (1995) on the resource curse infers that global resource-abundant countries experience less economic development than countries with a deficiency of resources. This phenomenon is attributed to a natural resource curse (Auty and Mikesell, 1998), which has attracted the attention of academicians and research scholars who postulated the resource curse hypothesis as a "significant adverse relationship exists between the abundance of natural resources and economic growth. Atkinson and Hamilton (2003) argue that the resource curse arises and prevails due to the incapability of governments to sustainably manage the abundance of natural resources and their vast revenues. Such government incapability is attributed to weak institutional quality (Danish and Ulucak, 2020). Satti *et al.* (2014) confirm the resource curse phenomenon by finding that Venezuela's abundance of natural resources hampers economic advancement. Using cross-country data, Arin and Braunfels (2018) deny the natural resource curse and infer that natural resource rents (mainly from oil) strongly drive economic growth. However, using a period from 2005 to 2018, Wang *et al.* (2019) investigate the connectedness between economic development and natural resources and find the prevalence of the resource curse in China, while Shahbaz *et al.* (2019) find the same in developed economies. The presence of the resource curse hypothesis is investigated by Asif *et al.* (2020) in the Pakistani context. The authors find depressive impacts of oil and coal rents on market capitalisation and money supply. The empirical negative connection between plenty of natural resources and financial advancement is reported by Tang *et al.* (2022) from 1984 to 2018 in ASEAN economies. Singh *et al.* (2024) argue that countries with abundant natural resources suffer less sustainable economic advancement, thus supporting the resource curse hypothesis. Most researchers have only documented the connection between ANR and economic

development, and the scope of previous research is relatively limited (Alajmi, 2024). Reviewing the prevailing studies provides a controversial resource blessing or curse phenomenon, motivating the authors to uncover the real marvel.

2.2 Nexus between institutional quality and green total factors of productivity

North's (1990) study is seminal on the institutional quality (IQ) framework. The author argues that institutional quality is not static but evolves, and different factors influence it, such as political change, technological advancements and social norms. North's IQ framework promotes sustainable economic advancement. Institutional quality expresses the governmental power to absorb external shocks like policy uncertainty (Su *et al.*, 2022). Politically involved constituencies, political openness and diffusion of power can facilitate addressing environmental issues (Burnell, 2012) and enhance factors of production in different sectors (Liu *et al.*, 2023). Few scholars believe that social inequality, corruption and poverty adversely affect the environmental quality-related policies (Sarkodie and Adams, 2018) and factors of production. Excellent political institutions and good discipline nurture the best impacts of climate quality and efficient productivity factors. Furthermore, robust political institutions assure a strong rule of law, discourage corruption, guard property rights and ensure the implementation of strict eco-friendly plans (Dasgupta and De Cian, 2018; Canh *et al.*, 2019). Moreover, better institutional quality ensures the availability of financial resources in an economy. Strong institutional quality enhances economic advancements by mobilising the economic resources of individual entities (Boudreaux *et al.*, 2019), reduces frequent corruption (Danish and Ulucak, 2020) and enhances GTFOP. Pradel *et al.* (2021) argue that countries with poor institutional quality and political stability contribute more towards global natural resources. According to Fang *et al.* (2023), a vague IQ reduces the flexibility of the labour market, while a strong IQ appeals more to FDI and gives rise to productivity factors. Song *et al.* (2023) uncover the impact of institutional quality and climate risk on GTFOP in 88 countries and find that good institutional quality mitigates the adverse impacts of climate risks on GTFOP. However, the impact of IQ on GTFOP in the presence of green Islamic finance has not yet been explored in any study. Thus, the current study intends to uncover such impacts. Wu and Lin (2025) state that the influence of IQ on GTFOP cannot be ignored. Using data from 4582 companies, the authors find that IQ improves GTFOP by reducing the financing constraints, improving the green innovations and environmental performance.

2.3 Nexus between ANR and green total factors of productivity

The scholars have documented in-depth and substantial evidence on components of the Total Factor Productivity (TFP). In the current study, we use a green total factor of production (GTFOP), which has evolved and differs from traditional TFP because GTFOP considers economic and environmental factors. For instance, some researchers have explored the economic and political hazards by documenting the effect of environmental policy uncertainty of global oil price volatility on TFOP (Ren *et al.*, 2022a, 2023), while scholars have also focused the influence of the political environment on financial decisions and organisational climate (Ren *et al.*, 2022b; Wang *et al.*, 2022b). GCC economies are highly dependent on natural resources (El-Agouz, 2022). Natural resources play a vital role in economic advancements and deteriorate environmental quality. The current study's significance lies in its use of GTFOP in the presence of green economic sustainability and renewable energy consumption. Literature neglects such variables in the context of GCC economies. Economic growth and renewable energy consumption have strongly impacted the GTFOP, while GCC economies suffered from substantial CO_2 emissions and a recent loss in

biocapacity per capita (Ansari *et al.*, 2020). Kahouli *et al.* (2022) find that Saudi Arabia's continuous rate of natural resource consumption will result in a decline in oil exports by the end of the current decade. However, Bin Amin and Rehman (2022) observe contradictory findings and argue that there is an increase in the consumption of natural resources in gas and oil-supplying nations, but the GCC exports remain constant. The authors observed that gas and oil are the GCC's cornerstone exports. Still, Bahrain and Oman are experiencing a decline in oil production because their oil reserves are declining due to limited natural resources. Similarly, Lee and He (2022) report that the nexus between natural resource abundance and the Green Total Factor Productivity is time-variant because it depends on different growth cycles due to changing environmental policies. Moreover, recent scholars are sure about the ambiguous impacts of natural resources on GTFOP. Therefore, the debate on the resource curse or blessing of natural resources is important to explore in the current era.

Green Financing enhances R&D culture in organisations, stimulates green techno-environmental innovations and improves environmental responsiveness to derive green transformation (Xu and Li, 2020; Zhang *et al.*, 2023a). Therefore, green financing may nurture SDG achievements. Sun (2024) finds that natural resources, financial inclusion and climate quality help to achieve balanced and sustainable advancements. It is important and necessary to explore whether green financing lessens or intensifies the "curse" for GTFOP. Therefore, the current study explores the connectedness of ANR and IQ with GTFOP via the moderating role of green Islamic finance because the previous studies have many limitations. First, the researchers are at two different strains, the resource curse or resource blessings, and they have not yet reached a consistent conclusion. Secondly, no traceable evidence exists on the footprints of the natural resource curse and green economic growth. Thirdly, the literature provides little evidence on the connection between institutional quality and the green total factor productivity. Moreover, previous studies use partial indicators of institutional quality i.e. rule of law and democracy (Kolstad, 2009), economic and political institution (Song *et al.*, 2023) and law and order (Zhang et al, 2023b), while the current study uses five most significant indicators of institutional quality introduced by World Bank. Finally, none of the previous studies have explored the impact of green Islamic financing on minimising the natural resource curse and strengthening the IQ under the umbrella of GTFOP. Green credit regarding policies also influences the GTFOP. Using the difference-in-differences model, Ge *et al.* (2024) uncover that "Green Credit Guidelines" significantly positively impact a firm's GTFOP. The authors further observe that corporate R&D and CSR indirectly enhance the impact of Green credit Guidelines on GTFOP. Ma and Li (2025) find that green credit policy alleviates financing constraints and improves GTFOP. The authors argue that enterprises with high real economic integration and state-owned enterprises reap more benefits from the green credit policy and GTFOP. Green finance supply is essential in resource allocation and improving productivity issues. Dong *et al.* (2025) use the data from 30 provinces from 2012 to 2022. Using the Slack-Based Measures, the authors observe that green finance supply reduces capital misallocation, enhances innovation-driven growth, and thus improves GTFOP.

3. Methodology and data description

To explore the resource-curse footprints of a green total factor of productivity (GTFOP), the study proposes a framework to examine the connection between plenty of natural resources, institutional quality and GTFOP. The study considers the impact of a few control variables to avoid the potential endogeneity problem arising from omitted variable bias. These control variables comprise a set of energy structure factors, trade factors and economic factors explored in the recent relevant literature. Hence, the proposed framework is presented through equation (1):

$$GTFOP_{it} = f(ANR_{it}, IQ_{it}, GES_{it}, CRE_{it}, TO_{it},) \quad (1)$$

The country effect is indicated in subscript with "*i*", and the time effect is presented with "*t*". $GTFOP_{it}$ represents the green total productivity factor, and ANR_{it} indicates abundant natural resources. Green economic sustainability is presented through GES_{it}, consumption of renewable energies is indicated with CRE_{it}, IQ_{it} indicates institutional quality and TO_{it} represents trade openness. All the variables are transformed into natural logarithmic form to avoid the heteroskedasticity effects. The standardised form of the leading independent variables is presented to eliminate the magnitude effect of variable variance (Shahid *et al.*, 2019a; Shahid, 2019b). The logarithmic impression of equation (1) is presented through the following Equation:

$$LnGTFP_{it} = \lambda_0 + \lambda_1 x\_ANR_{it} + \lambda_2 z\_IQ_{it} + \lambda_3 LnGES_{it} + \lambda_4 LnCRE_{it} + \lambda_5 LnTO_{it} + \varepsilon_{it} \quad (2)$$

where the coefficients of all variables are indicated with $\lambda_1 - \lambda_5$, and λ_0 presents a constant term, while a random disturbance is indicated withε_{it}. $\lambda_1 < 0$ is expected for the resource curse hypothesis. The outcome variable in the current study is green total factor of production (GTFOP), which is measured through a Global Malmquist–Luenberger (GML) index method. This technique is broadly used to quantify sustainable economic advancement (Lin and Chen, 2018; Liu and Xin, 2019). The data envelopment analysis (DEA) is the foundation for constructing the GML index in the current study, as suggested in the literature (see Oh, 2010a; Oh, 2010b). The current study assumes that the production processes of Islamic countries are comprised of multiple decision-making units (DMU), where each unit contains N input aspects"$(x = x_1, \ldots\ldots, x_n)\ \varepsilon R_N^+$" to attain M anticipated outputs "$(y = y_1 \ldots y_m)\varepsilon R_M^+$", and I unanticipated outputs "$(b = b_1 \ldots b_I)\ \varepsilon R_I^+$", and at period *t*, the input-output is (x_k^t, y_k^t, b_k^t) for *K* economies.

Capital, energy and labour are the input factors used in this article, which are computed as the number of people involved per million capital stock, final consumption of energy and labour, respectively. GDP represents the desirable outputs, and pollutants produced are the undesirable outputs, which include carbon emissions (CO_2). The following equation defines the possibility set for general production:

$$P^g(x) = \left\{ \left(y^t, b^t\right) : \sum_{t=1}^{T} \sum_{k=1}^{k} z_k^t y_{km}^t \geq y_{km}^t,\ vm;\ \sum_{t=1}^{T} \sum_{k=1}^{K} z_k^t b_{ki}^t \geq b_{ki}^t,\ \text{vi};\right.$$
$$\left. \sum_{t=1}^{t} \sum_{k=1}^{K} z_k^t x_{kn}^t \leq x_{kn}^t \quad ,\ \text{vn};\ \sum_{k=1}^{K} z_k^t = 1,\ z_k^t \geq 0,\ \text{vk} \right\} \quad (3)$$

where Z_k indicates the weight of each observation surface. The non-regular and non-radial (SBM) function of directional distance is a set described in the following equation:

$$\overrightarrow{D_G}(x, y, b, g) = max\left\{\beta | (y + \beta g_y, b - \beta g_b)\varepsilon\ P^G(x)\right\} \quad (4)$$

where the directional vector is $g = (g_y, g_b)$, and a distance function value for β is $g\ \varepsilon R_M^+ \times \varepsilon R_S^+$ To minimise the undesirable outputs and to maximise the desirable outputs. Hence, we set the GML index as follows:

$$GML_t^{t+1} = \frac{1 + \overrightarrow{D_G}(x_t, y_t, b_t, g)}{1 + \overrightarrow{D_G}(x_{t+1}, y_{t+1}, b_{t+1}, g)} \quad (5)$$

Since equation (5) presents the variation in production in two periods, e.g. if GML, if $\varepsilon R_t^{(t+1)} > 1$, indicating productivity at time *t* is greater than its lagged values or vice versa. Moreover, different methods are used to estimate the impact of ANR and IQ on GTFOP; a)

ordinary least squares (OLS) test is used to elaborate the basic relationship between the variables, feasible generalized least squares (FGLS) proposed by Wu *et al.* (2020) is applied to account for the potential issues of autocorrelation, heteroskedasticity and the study relaxes the assumptions of homogeneous and independent distribution of arbitrary error terms and IV-GMM model is applied for estimation and avoidance of potential endogeneity. The results for all three models are discussed in Table 3. We select the IV-GMM method as a standard estimation model and undergo successive estimations on instrumental variables to accurately improve the estimated outcomes (as suggested by Wang *et al.*, 2022a). The current study uses truly exogenous and strong external instruments, as the literature (Angrist and Krueger, 2001; Hall and Peixe, 2003) suggests using external instruments when internal instruments are not feasible and the lag values are not strongly correlated with endogenous variables. Moreover, the current study uses IV-GMM; the literature (Baum *et al.*, 2007; Angrist and Pischke, 2009; Wooldridge, 2010) argues that when a study has valid, relevant and robust external instruments, the study should prefer to use the IV-GMM model instead of the system and different GMM.

The key independent variable is (ANR), which is the availability of natural resources in a region or a country. The current study is motivated to incorporate ANR as an independent variable because these resources are vulnerable to different socio-political factors (Cheng *et al.*, 2020); hence, the volatility of natural resources is associated with institutional quality and Green TFP (Song *et al.*, 2023).To evade the errors associated with estimated parameters due to omitted variable bias, the current study incorporates a few control variables, namely, green economic sustainability (GES), trade openness (TO) and consumption of renewable energies (CRE). Moreover, the article uses the lens of green Islamic finance (GIF) to explore the possible footprints of institutional quality (IQ) and abundance of natural resources (ANR) on GTFOP. GIF is measured by green Islamic bonds and sukuk, which promote the production and utilisation of renewable/clean energy (including hybrid systems). Figures 2, 3 and 4 show how the current study measures the institutional quality with different indicators. On the other hand, Figure 5 presents economic sustainability (GDP) in sample economies. The study uses data from 2017 to 2023 from nine Islamic economies, generating 63 observations for each variable under study. The short sample period was used because we could obtain data on green Islamic bonds and sukuk from only nine Islamic economies over the period. However, except for green Islamic finance, the data is available for an extended period for all other variables; therefore, descriptive graphs are presented over a more extended period, but the statistical analysis comprises only nine years. Table 2 provides the details of the variables used in the current study.

4. Empirical findings

The section exhibits the empirical outcomes with the application of econometric models discussed in the methodology. Table 3 reveals that the "Kleibergen–Paap RK Lagrange Multiplier statistic" coefficient is significant at a 1% confidence interval, denying the under-identification of instrumental variables (Kleibergen& Paap, 2006). The model has no problem with weak instrumental variables because the "Kleibergen–Paaprk Wald F statistic" coefficient exceeds the critical values (Stock and Yogo, 2002). The over-identification problem of instrumental variables is also eliminated in our data set because the Hansen J statistic exhibits a value greater than 0.1. Table 3 also reveals that x_ANR is negative and significant, indicating depressive effects on GTFOP, as a 1% increase in ANR induces a 0.068% decrease in GTFOP. This finding implies that countries with abundant natural resources or excess natural resource rents suffer from a resource curse because ANR does not

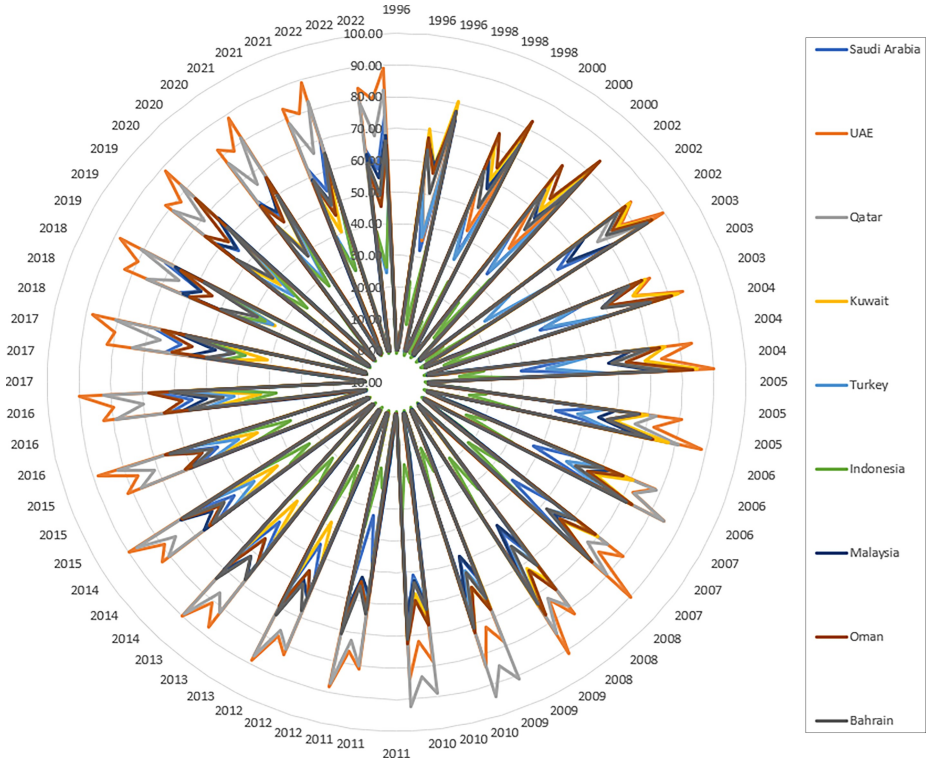

Figure 2. Institutional quality (z_IQ) measured through control of corruption in sample economies and presented over a more extended period

Source: Figure by the author's elaboration of the data collected from WDI and IMF

benefit these economies. Consistent with the outcomes of the current study, Cheng *et al.* (2020) find that ANR is not the autonomous stimulus of green economic advancements because resource-rich economies erect resource-dependent industries, which trigger the resource curse. From the Chinese economy, Wang *et al.* (2019a) find an inverse association between ANR and the efficiency of carbon emissions, while few other pieces of evidence confirm that ANR initiates climate hazards and leads to over-exploitation of natural resources (Ahmad *et al.*, 2020; Usman *et al.*, 2022). From the African continent, Amowine *et al.* (2021) find that sustainable development and environmental ecology are inversely affected by the overutilisation of natural resources. Recently, researchers have uncovered the connectedness of natural resource rents with carbon and ecological footprints (Agboola *et al.*, 2021; Erdogan *et al.*, 2021; Sun and Wang, 2021; He *et al.*, 2022; Jahanger *et al.*, 2022; Yang *et al.*, 2022), where Erdogan *et al.* (2021) find that countries with ANR are protected from ecological footprints or exhaustion. He *et al.* (2022) find that an excess of natural resources has both short- and long-term connections with emissions of greenhouse gases and deteriorates the climate quality. The reason behind these connections is that the mining and feasting of natural resources are untenable. Furthermore, undue dependence on natural resources negatively influences climate quality and sustainability (He *et al.*, 2022). On the

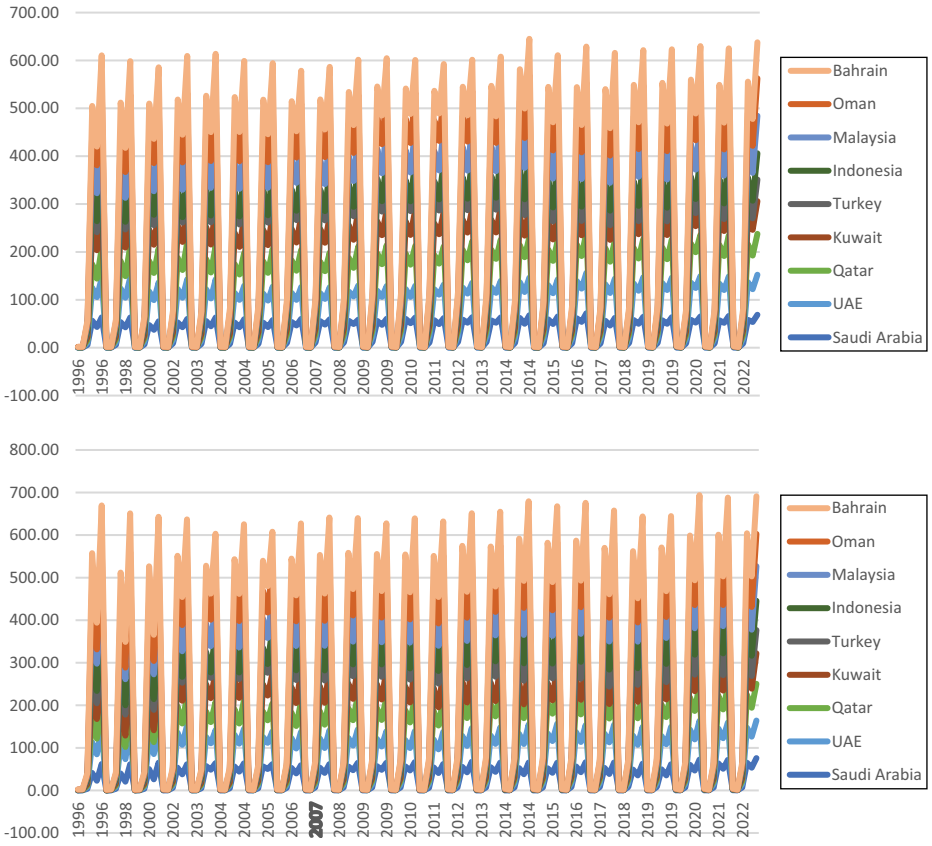

Figure 3. Institutional quality (IQR) is measured through the Rule of Law (upper graph) and regulatory quality (lower graph) in sample economies and is presented over a more extended period
Source: Figure by the author's elaboration of the data collected from WDI

other hand, the IV-GMM model exhibits a positive association between institutional quality (IQ is measured through control of corruption) and GTFOP, where poor institutional quality leads to worsening GTFOP. Poor state governance (IQ) (Niknamian, 2019), faulty ownership structure (Ulucak and Danish Ozcan, 2020) and inadequate systems of resource management are the main inefficiencies associated with the extraction and consumption of natural resources. The outcomes of the current study are similar to the results of previous studies (see Badeeb *et al.*, 2017; Mlachila and Ouedraogo, 2020), which find that the resource curse crucifies a few sub-Saharan economies because of poor institutional and weak management systems to handle natural resources. Table 3 further supports the results of IV-GMM via OLS and FGLS models because both confirm the adverse effect of ANR on GTFOP and the positive influence of IQ on GTFOP.

Table 3 also presents the impact of control variables on GTFOP, where empirically estimated outcomes show that green economic sustainability (GES) positively and significantly influences the GTFOP, indicating that economic sustainability is highly

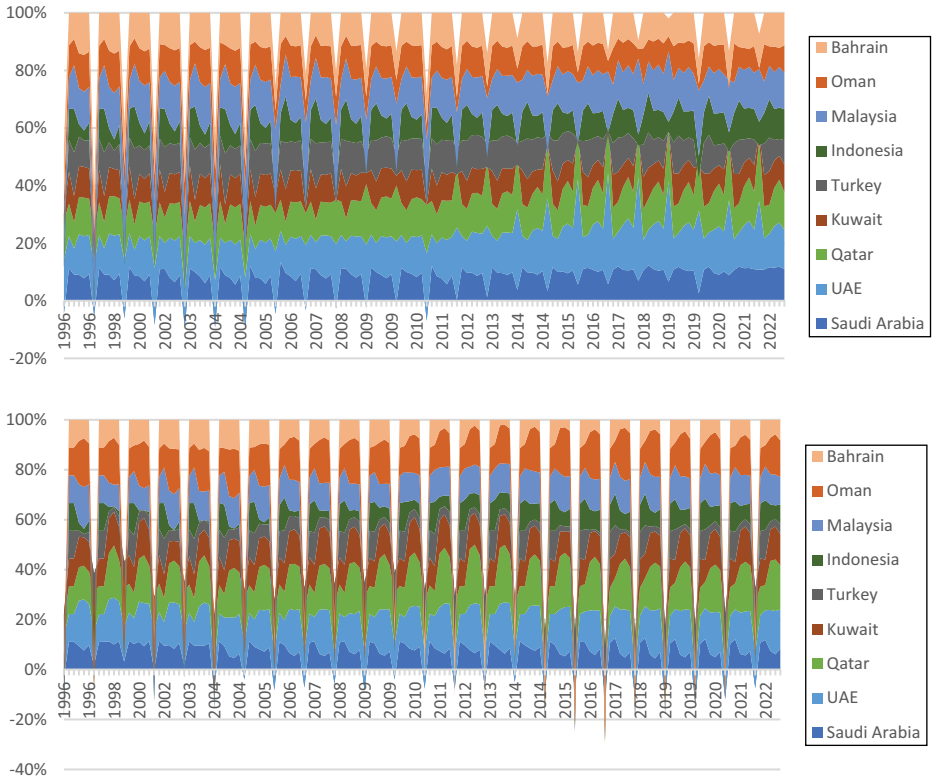

Figure 4. Institutional Quality (IQG&P) measured through government effectiveness (see upper graph) and political stability and absence of violence/terrorism (see lower graph) in sample economies and presented over a more extended period

Source: Figure by the author's elaboration of the data collected from WDI

conducive to the efficiency of GTFOP. The findings align with the study of Du and Li (2019), who find that higher GDP levels lead to investing more in resources to enhance climate quality. Furthermore, trade openness plays a significant and positive role in the efficiency of GTFOP, which shows that high trade openness enhances the trade flows, which are favourable for GTFOP. These findings are in favour of the argument proposed by Dou *et al.* (2020) and Shittu *et al.* (2021), who describe that globalised trade enables the transference of green, clean and low-carbon technology from developed to emerging economies, therefore, enhancing the green economic advancements. The Table also infers that the increased proportion of clean energy in the entire energy consumption benefits GTFOP (as the coefficient of CRE is positive and significant in all three models). These findings of the current study are supported by many recent research articles (e.g. Wang *et al.*, 2021; Mehmood, 2022), which find that CRE is beneficial in achieving social, economic and climate sustainability.

To support the robustness of empirical estimations achieved via three different regression estimators, the current study first winsorises the range of quantiles less than 0.5% and more significant than 99.5% of the outcome variables. The winsorised regression outcomes are

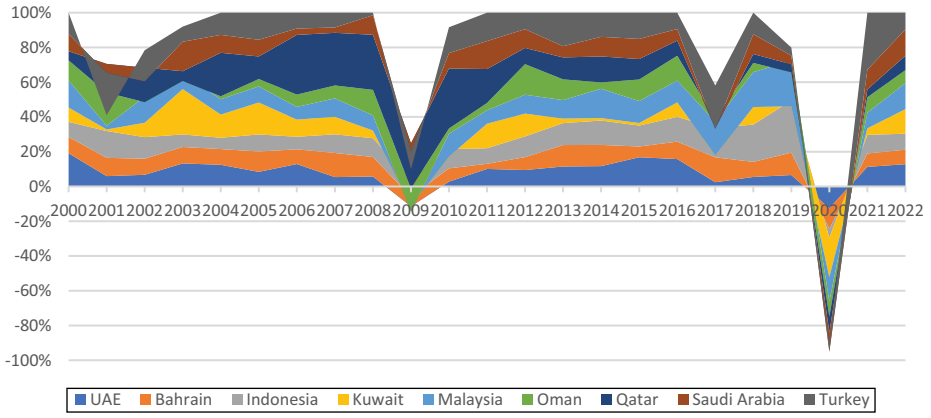

Figure 5. Economic sustainability in sample economies over a longer period
Source: Figure by the author's elaboration of the data collected from WDI

presented in the first column of Table 4. The effect of outliers is easily mitigated by winsorising the dependent variable at 1%. However, a winsorisation rule ranging from 0.5% to 2.5% yields similar outcomes (Chen *et al.*, 2008). Similarly, Frank and Goyal (2005) argue that when the data order or magnitude is too large, a level of winsorisation is expected to be used from 0.5% to 1%. More recently, Leone *et al.* (2019) argue that different approaches or a range of levels of winsorisation affect estimates, and *ad hoc* winsorisation levels often vary from study to study. All variables produce significant coefficients (see Table 4) with the same signs as exhibited by benchmark regression (see Table 3 for comparison).

To explore the robustness, the study replaces the main independent variables with other (instrument) variables. For instance, *x*_ANR is replaced with a dependency on the abundance of natural resources (DANR), computed as the share of natural resources rents in the total GDP of a respective sample country. It is clear from Table 4 (see Model 2) that all the variables produce significant coefficients with the same sign as benchmark regressions exhibit (in Table 3). Moreover, DANR produces significant and negative coefficients as ANR in the original model (Table 3) and Models 1, 3, 4 and 5, indicating the robustness of benchmark regression.

Table 4 reveals that better IQ (measured through Control of corruption) enhances GTFOP via models 1 and 2. The results support the findings of all three regression models presented in Table 3. These findings are further supported when the study replaces the institutional quality with its different aspects (instruments). The study first replaces IQ with IQR in Model 3, where higher values of IQR produce a significant and positive impact on GTFOP, which is the same as IQ exhibits in models 1 and 2. However, IQR's coefficient value (0.372***) is higher than IQ's (0.194*** and 0.237***) in Models 1 and 2. Similarly, a higher coefficient value (0.391***) is obtained when IQ is replaced with IQG&P in Model 4.

The findings indicate that better GTFOP can be obtained by replacing IQ with IQR and IQG&P. Moreover, the signs of the parameters of all control variables remain unchanged and significant. The five robustness models in Table 4 support the findings of benchmark regression outcomes exhibited in Table 3. In Model 5, the study replaces GES (GDP) with PGES (PGDP), where *x*_ANR is negative and significant. The study finds a significant positive coefficient for PGES, the same as GES exhibits in Models 1–4.

Table 2. Description of variables along with abbreviations, measurements and data sources

Variables	Abbreviations	Measurements	Source
Dependent variable			
Green total factor productivity	LnGTFOP	–	Computation is based on the technique discussed in the methodology section
Independent variables			
The abundance of natural resources	*x*_ANR	Natural resources rents (% age of GDP)	WDI
Institutional quality	*z*_IQ	Control of corruption	WDI and IMF
Control variables			
Green economic sustainability	LnGES	GDP per capita	WDI
Consumption of renewable energy	LnCRE	Renewable energy portion of total energy	WDI
Trade openness	LnTO	Export/import of goods and services	WDI
Instrumental or replaced variables			
Dependency on natural resources	LnDANR	Share of natural resource rents in GDP	WDI
Institutional quality (regulatory)	LnIQR	Rule of law + regulatory quality	WDI
Institutional quality (governance)	LnIQG&P	Governance (government effectiveness) + political stability and absence of violence/terrorism	WDI
Per-capita green economic sustainability	LnPGES	GDP per capita	WDI
Moderator			
Provision of green Islamic finance	LnGIFS	Green sukuk and green bonds for clean and renewable energy usage and green projects	Bloomberg

Source(s): Table by the author's elaboration of the existing gap in the prevailing literature

5. Further discussion

5.1 Asymmetry analysis

To explore the impact of ANR and IQ on GTFOP at various echelons of sustainable productivity, the article uses an asymmetric panel quantile regression model, which is presented in the following equation:

$$Q_{\tau}(LnGTFP_{it}) = \varphi_{o\tau} + \varphi_{1\tau}x\_ANR_{it} + \varphi_{2\tau}z\_LnIQ_{it} + \varphi_{3\tau}LnGES_{it} + \varphi_{4\tau}LnCRE_{it} + \varphi_{5\tau}LnTO_{it} + \mu_{it} \quad (6)$$

where the τ^{th} quantile of GTFOP is indicated with $Q_{\tau}(LnGTFP_{it})$. The estimated parameters of the independent and control variables are indicated with $\varphi_{1\tau}$ -$\varphi_{5\tau}$. The projected outcomes of the asymmetric test are exhibited in Table 5.

The table reveals a negative coefficient of ANR throughout the quantile ranges, indicating the adverse impact of x_ANR_{it} on GTFOP. The 90^{th} quantile shows a significantly larger value. It implies that x_ANR_{it} puts more depressive impacts on GTFOP in regions with higher GTFOP. The reason behind such findings is that Islamic economies with excessive

Table 3. The dependent variable GTFOP is influenced by the variables used in equation (2) using OLS, FGLS and IV-GMM

Variables	Constant	ANR	IQ	GES	CRE	TO	Kleibergen–Paap RK LM-statistic	Kleibergen–Paap RK Wald *F*-statistic	*P*-value of the Hansen *J*-statistic
OLS	0.082	−0.028***	0.035***	0.059***	0.029***	0.193***			
FGLS	0.174***	−0.050***	0.062***	0.068***	0.048***	0.201***			
IV-GMM	0.045*	−0.068***	0.087***	0.077***	0.064***	0.225**	59***	377	0.274

Note(s): ***, ** and * indicate 1, 5 and 10% confidence levels, respectively
Source(s): Table by the author’s elaboration of data analysis using econometric methods

Table 4. Checks for robustness

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
	Dependent variable: GTFOP				
Constant	0.254*** (0.000)	0.232*** (0.008)	0.347*** (0.001)	0.452** (0.019)	0.375** (0.089)
TO	0.051*** (0.001)	0.056*** (0.000)	0.062*** (0.000)	0.048*** (0.000)	0.129*** (0.000)
CRE	0.035*** (0.000)	0.024*** (0.000)	0.039** (0.013)	0.046** (0.029)	0.174*** (0.000)
GES	0.049*** (0.000)	0.035*** (0.000)	0.125*** (0.000)	0.187*** (0.000)	
ANR	−0.053*** (0.007)		−0.166*** (0.001)	−0.259*** (0.000)	−0.120*** (0.000)
IQ	0.194*** (0.002)	0.237*** (0.000)			0.341*** (0.000)
DANR		−0.362*** (0.001)			
IQR			0.372*** (0.000)		
IQG&P				0.391*** (0.000)	
PGES					0.052*** (0.000)
Kleibergen–Paap RK LM	64.69***	94.72***	85.01***	78.44***	82.70***
Kleibergen–Paap RK Wald	628.7	174.59	284.11	385.01	431.4
P-value of Hansen J	0.382	0.294	0.263	0.277	0.283

Note(s): ***, ** and * indicate 1, 5 and 10% confidence levels, respectively
Source(s): Table by the author's elaboration of data analysis using econometric methods

Table 5. Asymmetric analysis

Variables/Quartiles	10th	25th	50th	75th	90th
ANR	−0.047*** (0.000)	−0.038*** (0.000)	−0.056*** (0.000)	−0.071*** (0.000)	−0.077*** (0.000)
IQ	0.159*** (0.000)	0.126*** (0.000)	0.133*** (0.000)	0.160*** (0.000)	0.174*** (0.000)
GES	0.052*** (0.002)	0.031*** (0.001)	0.038*** (0.000)	0.059*** (0.001)	0.064*** (0.000)
CRE	0.015** (0.022)	0.026** (0.011)	0.037*** (0.002)	0.070** (0.001)	0.082*** (0.000)
TO	0.038*** (0.007)	0.023*** (0.006)	0.020*** (0.002)	0.029*** (0.001)	0.035** (0.019)
Constant	0.185* (0.095)	0.254** (0.028)	0.216*** (0.001)	0.366*** (0.006)	0.475*** (0.003)

Note(s): ***, ** and * indicate 1, 5 and 10% confidence levels, respectively
Source(s): Table by the author’s elaboration of data analysis using econometric methods

levels of sustainable economic development are incredibly dependent on renewable and clean energy sources (Copeland and Taylor, 1994), and these nations do not depend on local natural resources. Hence, Islamic economies are experiencing adverse footprints of resource abundance on GTFOP and green economic recovery. A positive and significant connection between IQ and GTFOP is observed throughout the quantile ranges, where a higher impact of IQ on GTFOP is observed in upper quantiles. Moreover, all the control variables have significant and positive effects on GTFOP. Figure 6 presents panel quantile regression coefficients (where graphs represent the direct and moderating impacts).

5.2 Moderating impressions

Governments around the globe are gradually promoting sustainable economic advancements for green development. Green financing has been important to bridge economic growth and environmental sustainability. For instance, China introduced a green finance policy in 2017 to encourage the evolution from essential economic growth to sustainable/green economic advancements. Many recent research articles have explored the footprints between green/sustainable financing and the attainment of SDGs and find that green finance facilitates green transition by supporting technological innovation and climate awareness (Xu and Li, 2020; Zhou *et al.*, 2020; Hu *et al.*, 2021). Recently, Liu *et al.* (2023) explored the moderating effects of green financing between plenty of natural resources and GTFOP. However, none of the recent articles have investigated the impressions of green Islamic finance (Bonds and Sukuk) to boost the connectedness between natural resources and the green productivity factor. The study first explores the role of green Islamic finance (GIF) in mitigating the repressive impacts of ANR on GTFOP. Therefore, the study introduces green Islamic finance (LnGIF) and an interaction term (i.e. LnGIF*x_ANR_{it}) between GIF and ANR. Similarly,

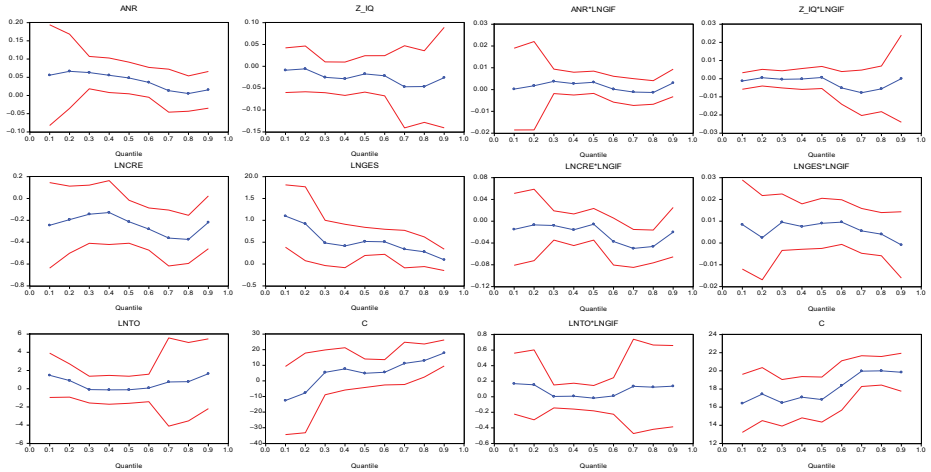

Figure 6. Panel quantile regression coefficient with a trend change, where different quartile levels for GTFOP are indicated on the X-axis, while the Y-axis exhibits each variable's regression parameters (blue line)

Note(s): The graph represents the direct and moderating impacts

Source: Figure by the author's elaboration of data analysis using econometric methods

another interaction term (i.e. LnGIF*z_IQ_{it}) is introduced between GIF and IQ. Thus, the moderating effect is evaluated via the following equations:

$$LnGTFP_{it} = \psi_o + \psi_1 x\_ANR_{it} + \psi_2 LnGES_{it} + \psi_3 LnCRE_{it} + \psi_4 LnTO_{it} + \psi_5 LnGIF_{it} + \psi_6 LnGIF_{it} * x\_ANR_{it} + \eta_{it} \quad (7)$$

$$LnGTFP_{it} = \psi_o + \psi_1 z\_IQ_{it} + \psi_2 LnGES_{it} + \psi_3 LnCRE_{it} + \psi_4 LnTO_{it} + \psi_5 LnGIF_{it} + \psi_6 LnGIF_{it} * z\_IQ_{it} + \eta_{it} \quad (8)$$

In both equations, the constant term and the random disturbance are indicated with ψ_o and η_{it} respectively, while the estimated coefficients are presented through $\psi_1 - \psi_6$. The moderating variable used in this study is $LnGIF_{it}$ and significant value of the term "ψ_6" will confirm the presence of moderating effects.

Models 1 and 2 in Table 6 present the connectedness between ANR and GTFOP after incorporating LnGIF and interactive terms i.e.$LnGIF_{it} * x\_ANR_{it}$. Green Islamic finance (GIF) favourably contribute to GTFOP (see Model 1). It is clear from Model 2 that x_ANR is still negative and significant, which is consistent with benchmark and robust regression models. However, the parameter of LnGIF$*x$_ANR is significant and positive, indicating that green Islamic finance can efficiently alleviate the repressive footprints of ANR on GTFOP. Recent studies confirm the favourable impact of green finance on climate sustainability (Majeed and Mazhar, 2020). Shahbaz *et al.* (2013) argue that green finance is a low-cost source of funding for green projects to enhance green technology innovations and production efficiency (Awan *et al.*, 2020), thus improving GTFOP and climate sustainability (Zhou *et al.*, 2020; Zheng *et al.*, 2021; Lee and Lee, 2022).

Similarly, models 3 and 4 in Table 6 indicate the footprints between IQ and GTFOP by incorporating LnGIF and interaction terms i.e. $LnGIF_{it} * z\_IQ_{it}$.Green Islamic finance (GIF) positively contributes to GTFOP (see Model 3 GIF is significant and positive). It is clear from Model 4 that z_IQ_{it} is still positive and significant, consistent with benchmark and robust regression models. However, the parameters of $LnGIF_{it} * z\_IQ_{it}$ are significantly positive and indicate that green Islamic finance can efficiently enhance the favourable

Table 6. Results for moderating impressions

	Dependent variable: LaGTFOP			
Variables	Model 1	Model 2	Model 3	Model 4
*x*_ANR	−0.054*** (0.000)	−0.031*** (0.000)		
z_IQ			0.033*** (0.000)	0.120*** (0.000)
LnGES	0.011*** (0.000)	0.009*** (0.000)	0.028*** (0.000)	0.046*** (0.000)
LnTO	0.045*** (0.000)	0.022*** (0.000)	0.056*** (0.000)	0.087*** (0.000)
LnCRE	−0.014*** (0.000)	−0.006*** (0.000)	−0.014*** (0.000)	−0.21*** (0.000)
LnGIF	0.012*** (0.000)	0.015*** (0.000)	0.009*** (0.000)	0.017*** (0.000)
LnGIF*x_ANR		0.008*** (0.000)		
LnGIF*z_IQ				0.016*** (0.000)
Constant	−0.215*** (0.000)	0.041*** (0.000)	0.134*** (0.000)	0.025*** (0.001)
AR(1)	0.0280	0.0265	0.0457	0.0410
AR(2)	0.339	0.321	0.419	0.392
Hansen	0.455	0.427	0.479	0.424

Note(s): ***, ** and * indicate 1, 5 and 10% confidence levels, respectively
Source(s): Table by the author's elaboration of data analysis using econometric methods

footprints of z_IQ_{it} on GTFOP. Such findings confirm the moderating role of green Islamic finance.

6. Conclusions, policy implications and recommendations

6.1 Conclusions

Encouraging the assessment of sustainable and green economic growth is a crucial strategy for assisting nations in achieving the SDGs. The current article investigates the causal connections and impression mechanics between ANR and GTFOP and IQ and GTFOP from the perspective of nine Islamic economies from 2017 to 2023. We also investigate the moderating effect of green Islamic finance to uncover the impression mechanics between ANR&GTFOP and IQ&GTFOP. The results support the resource curse theory by demonstrating that NRA has a negative impact on GTFOP, while IQ (control of corruption) enhances the efficiency of GTFOP. The asymmetry analysis demonstrates that nations with more abundant natural resources exhibit a more significant negative influence of the exploitation of ANR on sustainable/green economic advancements and GTFOP. However, nations with higher IQs are more efficient in the conduciveness of GTFOP. Moreover, the moderating effect results indicate that green Islamic finance is a powerful tool for reducing the inverse impressions of ANR on GTFOP. On the other hand, green Islamic finance enhances the positive footprints between IQ and GTFOP.

6.2 Policy suggestions and recommendations

The conclusions above deliver the following significant policy suggestions. First, practitioners and businesses should actively promote high-end talents, introduce cutting-edge technologies, implement and raise awareness of green practices in mining natural resources and diminish pollution and environmental damage. So that governments can enhance the favourable impacts of ANR and IQ on GTFOP. Secondly, Governments should implement severe penalties for violations of "laws and regulations (IQ)" about the discovery, mining, transportation and consumption of natural resources and rigorously regulate market access for resource-based enterprises. In addition, they ought to establish accountability and encourage sharing information regarding using and mining natural resources. Thirdly, governments should fully embrace their role as macro regulators and improve laws and regulations in those areas rich in natural resources. Finally, financial institutions in Islamic countries should actively promote the growth of green Islamic finance and enhance the sustainable financial system by issuing green sukuk, green funds, green credit, green insurance and green bonds.

Governments should be creative and supportive of upgrading an environmentally friendly Islamic financial system. They ought to progressively encourage environmental information disclosure, enhance the transparency of green financial markets and fortify financial institution administration. Moreover, Governments should enhance the system of rewards and penalties and aggressively direct financial resources towards accumulating low-carbon and green industries.

In the era of sustainable finance, this study helps to reduce the influence of the natural resource curse via strong institutional quality and green Islamic finance. However, future researchers should investigate the precise mechanism by which the resource curse effect spreads, as this could provide policymakers with more helpful information. Furthermore, exploring the possibility of nonlinear linkages between GTFOP, ANR, IQ and GIF is worthwhile. Future researchers can explore the time-varying impacts of IQ and ANR on GTFOP because countries are now implementing better IQ practices and developing strong

policies for mining and consuming abundant natural resources. Moreover, future researchers can explore the phenomenon using different market conditions.

Note

[1.] In constant 2015 prices.

References

Agboola, M.O., Bekun, F.V. and Joshua, U. (2021), "Pathway to environmental sustainability: nexus between economic growth, energy consumption, CO2 emission, oil rent and total natural resources rent in Saudi Arabia", *Resources Policy*, Vol. 74, p. 102380, doi: 10.1016/j.resourpol.2021.102380.

Ahmad, M., Jiang, P., Majeed, A., Umar, M., Khan, Z. and Muhammad, S. (2020), "The dynamic impact of natural resources, technological innovations and economic growth on ecological footprint: an advanced panel data estimation", *Resources Policy*, Vol. 69, p. 101817, doi: 10.1016/j.resourpol.2020.101817.

Alajmi, R.G. (2024), "Total-Factor energy efficiency (TFEE) and CO2 emissions for GCC countries", *Sustainability*, Vol. 16 No. 2, p. 878.

Algarini, A. (2017), "The effect of human capital on total factor productivity growth in the Arab Gulf cooperation council countries", (Doctoral dissertation, Colorado State University).

Amer, E.A.A.A., Meyad, E.M.A., Gao, Y., Niu, X., Chen, N., Xu, H. and Zhang, D. (2022), "Exploring the link between natural resources, urbanization, human capital, and ecological footprint: a case of GCC countries", *Ecological Indicators*, Vol. 144, p. 109556.

Amowine, N., Li, H., Boamah, K.B. and Zhou, Z. (2021), "Towards ecological sustainability: assessing dynamic total-factor ecology efficiency in Africa", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 17, p. 9323, doi: 10.3390/ijerph18179323.

Angrist, J.D. and Krueger, A.B. (2001), "Instrumental variables and the search for identification: from supply and demand to natural experiments", *Journal of Economic Perspectives*, Vol. 15 No. 4, pp. 69-85.

Angrist, J.D. and Kugler, A.D. (2008), "Rural windfall or a new resource curse? Coca, income, and civil conflict in Colombia", *Review of Economics and Statistics*, Vol. 90 No. 2, pp. 191-215, doi: 10.1162/rest.90.2.191.

Angrist, J.D. and Pischke, J.S. (2009), *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton university press.

Ansari, M.A., Ahmad, M.R., Siddique, S. and Mansoor, K. (2020), "An environment Kuznets curve for ecological footprint: evidence from GCC countries", *Carbon Management*, Vol. 11 No. 4, pp. 355-368.

Arin, K.P. and Braunfels, E. (2018), "The resource curse revisited: a Bayesian model averaging approach", *Energy Economics*, Vol. 70, pp. 170-178, doi: 10.1016/j.eneco.2017.12.033.

Asif, M., Khan, K.B., Anser, M.K., Nassani, A.A., Abro, M.M.Q. and Zaman, K. (2020), "Dynamic interaction between financial development and natural resources: evaluating the 'resource curse' hypothesis", *Resources Policy*, Vol. 65, p. 101566, doi: 10.1016/j.resourpol.2019.101566.

Atkinson, G. and Hamilton, K. (2003), "Savings, growth and the resource curse hypothesis", *World Development*, Vol. 31 No. 11, pp. 1793-1807.

Auty, R.M. (Ed.). (2001), *Resource Abundance and Economic Development*, Oxford university press.

Auty, R.M. and Mikesell, R.F. (1998), *Sustainable Development in Mineral Economies*, Clarendon Press.

Awan, A.M., Azam, M., Saeed, I.U. and Bakhtyar, B. (2020), "Does globalization and financial sector development affect environmental quality? A panel data investigation for the Middle east and

North African countries", *Environmental Science and Pollution Research*, Vol. 27 No. 36, pp. 45405-45418, doi: 10.1007/s11356-020-10445-4.

Badeeb, R.A., Lean, H.H. and Clark, J. (2017), "The evolution of the natural resource curse thesis: a critical literature survey", *Resources Policy*, Vol. 51, pp. 123-134, doi: 10.1016/j.resourpol.2016.10.015.

Baum, C.F., Schaffer, M.E. and Stillman, S. (2007), "Enhanced routines for instrumental variables/generalized method of moments estimation and testing", *The Stata Journal: Promoting Communications on Statistics and Stata*, Vol. 7 No. 4, pp. 465-506.

Billah, S.M. and Adnan, N. (2024), "Navigating environmental concerns and geopolitical risks: a study on green sukuk and Islamic equities amid climate crisis and the Russia-Ukraine conflict", *Energy Strategy Reviews*, Vol. 53, p. 101372.

Bin Amin, M.F. and Rehman, M.Z. (2022), "Asymmetric linkages of oil prices, money supply, and TASI on sectoral stock prices in Saudi Arabia: a non-linear ARDL approach", *Sage Open*, Vol. 12 No. 1, p. 21582440211071110.

Boudreaux, C.J., Nikolaev, B.N. and Klein, P. (2019), "Socio-cognitive traits and entrepreneurship: the moderating role of economic institutions", *Journal of Business Venturing*, Vol. 34 No. 1, pp. 178-196.

Burnell, P. (2012), "Democracy, democratization and climate change: complex relationships", *Democratization*, Vol. 19 No. 5, pp. 813-842.

Canh, N.P., Schinckus, C. and Thanh, S.D. (2019), "Do economic openness and institutional quality influence patents? Evidence from GMM systems estimates", *International Economics*, Vol. 157, pp. 134-169.

Chang, L., Taghizadeh-Hesary, F. and Mohsin, M. (2023), "Role of artificial intelligence on green economic development: joint determinates of natural resources and green total factor productivity", *Resources Policy*, Vol. 82, p. 103508.

Chen, S. and Golley, J. (2014), "'Green' productivity growth in China's industrial economy", *Energy Economics*, Vol. 44, pp. 89-98.

Chen, W., Liu, C. and Ryan, S. (2008), "Characteristics of securitizations that determine issuers' retention of the risks of the securitized assets", *The Accounting Review*, Vol. 83 No. 5, pp. 1181-1215.

Cheng, Z., Li, L. and Liu, J. (2020), "Natural resource abundance, resource industry dependence and economic green growth in China", *Resources Policy*, Vol. 68, p. 101734, doi: 10.1016/j.resourpol.2020.101734.

Copeland, B.R. and Taylor, M.S. (1994), "North-South trade and the environment", *The Quarterly Journal of Economics*, Vol. 109 No. 3, pp. 755-787, doi: 10.2307/2118421.

Danish, and Ulucak, R. (2020), "The pathway toward pollution mitigation: does institutional quality make a difference?", *Business Strategy and the Environment*, Vol. 29 No. 8, pp. 3571-3583.

Dasgupta, S. and De Cian, E. (2018), "The influence of institutions, governance, and public opinion on the environment: synthesized findings from applied econometrics studies", *Energy Research and Social Science*, Vol. 43, pp. 77-95.

Dong, B., Chen, L., Zhang, Y. and Xie, B. (2025), "How does green credit supply enhance the efficiency of forestry ecological development? Taking the perspective of ecological total factor productivity", *Journal of Cleaner Production*, Vol. 488, p. 144643.

Dou, Y., Dong, K., Jiang, Q. and Dong, X. (2020), "How does trade openness affect carbon emission? New international evidence", *Journal of Environmental Assessment Policy and Management*, Vol. 22 No. 03n04, p. 2250005, doi: 10.1142/S1464333222500053.

Du, K. and Li, J. (2019), "Towards a green world: how do green technology innovations affect total-factor carbon productivity", *Energy Policy*, Vol. 131, pp. 240-250, doi: 10.1016/j.enpol.2019.04.033.

El-Agouz, N. (2022), "The impact of economic growth on CO2 emissions and energy consumption (in the Gulf cooperation council countries)", Sustainable Energy-Water-Environment Nexus in

Deserts: Proceeding of the First International Conference on Sustainable Energy-Water-Environment Nexus in Desert Climates, *Springer International Publishing*, *Cham*, pp. 553-563.

Erdoğan, S., Çakar, N.D., Ulucak, R., Danish, and Kassouri, Y. (2021). "The role of natural resources abundance and dependence in achieving environmental sustainability: evidence from resource-based economies", *Sustainable Development*, Vol. 29 No. 1, pp. 143-154.

European Commission (2021), "Regulation establishing the just transition fund", European Commission, 2019, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=ELEX%3A32021R1056 (accessed 20 October 2022).

Fang, H., Zhang, X., Lei, T. and Houadi, B.L. (2023), "FDI quality, green technology innovation and urban carbon emissions: Empirical evidence from China", *Sustainability*, Vol. 15 No. 12, p. 9657.

Frank, M. and Goyal, V. (2005), "Trade-off and pecking order theories of debt", In Eckbo, B.E. (Ed.), *Handbook of Empirical Corporate Finance*, Elsevier Science B.V, Amsterdam, The Netherlands.

Ge, S., Luo, X., Li, Y. and Zheng, L. (2024), "The impact of green credit policy on total factor productivity of enterprises", *International Review of Economics and Finance*, Vol. 95, p. 103480.

Hall, A.R. and Peixe, F.P. (2003), "A consistent method for the selection of relevant instruments", *Econometric Reviews*, Vol. 22 No. 3, pp. 269-287.

He, Y., Li, X., Huang, P. and Wang, J. (2022), "Exploring the road toward environmental sustainability: natural resources, renewable energy consumption, economic growth, and greenhouse gas emissions", *Sustainability*, Vol. 14 No. 3, p. 1579, doi: 10.3390/su14031579.

Hu, G., Wang, X. and Wang, Y. (2021), "Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China", *Energy Economics*, Vol. 98, p. 105134, doi: 10.1016/j.eneco.2021.105134.

Jahanger, A., Usman, M., Murshed, M., Mahmood, H. and Balsalobre-Lorente, D. (2022), "The linkages between natural resources, human capital, globalization, economic growth, financial development, and ecological footprint: the moderating role of technological innovations", *Resources Policy*, Vol. 76, p. 102569, doi: 10.1016/j.resourpol.2022.102569.

Kahouli, B., Hamdi, B., Nafla, A. and Chabaane, N. (2022), "Investigating the relationship between ICT, green energy, total factor productivity, and ecological footprint: Empirical evidence from Saudi Arabia", *Energy Strategy Reviews*, Vol. 42, p. 100871.

Kolstad, I. (2009), "The resource curse: Which institutions matter?", *Applied Economics Letters*, Vol. 16 No. 4, pp. 439-442.

Lee, C.C. and He, Z.W. (2022), "Natural resources and green economic growth: an analysis based on heterogeneous growth paths", *Resources Policy*, Vol. 79, p. 103006, doi: 10.1016/j.resourpol.2022.103006.

Lee, C.C. and Lee, C.C. (2022), "How does green finance affect green total factor productivity? Evidence from China", *Energy Economics*, Vol. 107, p. 105863, doi: 10.1016/j.eneco.2022.105863.

Lee, C.C., Wang, C.W. and Ho, S.J. (2022). "Financial aid and financial inclusion: Does risk uncertainty matter?", *Pacific-Basin Finance Journal*, Vol. 71, p. 101700.

Leone, A.J., Minutti-Meza, M. and Wasley, C.E. (2019), "Influential observations and inference in accounting research", *The Accounting Review*, Vol. 94 No. 6, pp. 337-364.

Lin, B. and Chen, Z. (2018), "Does factor market distortion inhibit the green total factor productivity in China?", *Journal of Cleaner Production*, Vol. 197, pp. 25-33, doi: 10.1016/j.jclepro.2018.06.094.

Liu, Y., Wang, J., Dong, K. and Taghizadeh-Hesary, F. (2023), "How does natural resource abundance affect green total factor productivity in the era of green finance? Global evidence", *Resources Policy*, Vol. 81, p. 103315.

Liu, Z. and Xin, L. (2019), "Has China's belt and road initiative promoted its green total factor productivity?——evidence from primary provinces along the route", *Energy Policy*, Vol. 129, pp. 360-369, doi: 10.1016/j.enpol.2019.02.045.

Ma, T. and Li, J. (2025), "Green credit policy, financing constraints, and total factor productivity of enterprises", *Finance Research Letters*, Vol. 85, p. 108060.

Majeed, M. T. and Mazhar, M. (2020). "Reexamination of environmental Kuznets curve for ecological footprint: the role of biocapacity, human capital, and trade", *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, Vol. 14 No. 1, pp. 202-254.

Majeed, A., Wang, L., Zhang, X. and Kirikkaleli, D. (2021), "Modelling the dynamic links among natural resources, economic globalization, disaggregated energy consumption, and environmental quality: fresh evidence from GCC economies", *Resources Policy*, Vol. 73, p. 102204.

Mehmood, U. (2022), "Renewable energy and foreign direct investment: does the governance matter for CO2 emissions? Application of CS-ARDL", *Environmental Science and Pollution Research*, Vol. 29 No. 13, pp. 19816-19822, doi: 10.1007/s11356-021-17222-x.

Mlachila, M. and Ouedraogo, R. (2020), "Financial development curse in resource-rich countries: the role of commodity price shocks", *The Quarterly Review of Economics and Finance*, Vol. 76, pp. 84-96, doi: 10.1016/j.qref.2019.04.011.

Niknamian, S. (2019), "Resource–economic growth nexus, role of governance, financial development, globalization and war: Dynamic approach", Financial Development, Globalization and War: Dynamic Approach (April 4, 2019), doi: 10.2139/ssrn.3366655.

North, D.C. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University.

Oh, D.H. (2010a), "A global Malmquist-Luenberger productivity index", *Journal of Productivity Analysis*, Vol. 34 No. 3, pp. 183-197, doi: 10.1007/s11123-010-0178-y.

Oh, D.H. (2010b), "A metafrontier approach for measuring an environmentally sensitive productivity growth index", *Energy Economics*, Vol. 32 No. 1, pp. 146-157, doi: 10.1016/j.eneco.2009.07.006.

Pradel, M., Garcia, J. and Vaija, M.S. (2021), "A framework for good practices to assess abiotic mineral resource depletion in life cycle assessment", *Journal of Cleaner Production*, Vol. 279, p. 123296, doi: 10.1016/j.jclepro.2020.123296.

Ren, X., Yan, H. and Gozgor, G. (2023). "Climate policy uncertainty and idiosyncratic volatility: evidence from the non-financial listed Chinese firms", *Journal of Climate Finance*, Vol. 5, p. 100026.

Ren, X., Qin, J., Jin, C. and Yan, C. (2022b), "Global oil price uncertainty and excessive corporate debt in China", *Energy Economics*, Vol. 115, p. 106378.

Ren, X., Zhang, X., Yan, C. and Gozgor, G. (2022a), "Climate policy uncertainty and firm-level total factor productivity: Evidence from China", *Energy Economics*, Vol. 113, p. 106209.

Rhodes, C. (2020), "Human consumption of natural resources exceeds an annual 100 BillionTonnes", *Resilience website* (February 28, 2020), available at: www. resilience. org/stories/2020-02-28/human-consumption-of-natural-resources-exceeds-an-annual-100-billion-tonnes

Sachs, J.D. and Warner, A. (1995), "Natural resource abundance and economic growth".

Saqib, N., Duran, I. and Hashmi, N.I. (2022), "Impact of financial deepening, energy consumption and total natural resource rent on CO2 emission in the GCC countries: evidence from advanced panel data simulation", *International Journal of Energy Economics and Policy*, Vol. 12 No. 2, pp. 400-409.

Sarkodie, S.A. and Adams, S. (2018), "Renewable energy, nuclear energy, and environmental pollution: accounting for political institutional quality in South Africa", *Science of The Total Environment*, Vol. 643, pp. 1590-1601.

Satti, S.L., Farooq, A., Loganathan, N. and Shahbaz, M. (2014), "Empirical evidence on the resource curse hypothesis in oil abundant economy", *Economic Modelling*, Vol. 42, pp. 421-429.

Shahbaz, M., Ahmed, K., Tiwari, A.K. and Jiao, Z. (2019), "Resource curse hypothesis and role of oil prices in USA", *Resources Policy*, Vol. 64, p. 101514, doi: 10.1016/j.resourpol.2019.101514.

Shahbaz, M., Khan, S. and Tahir, M.I. (2013), "The dynamic links between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis", *Energy Economics*, Vol. 40, pp. 8-21, doi: 10.1016/j.eneco.2013.06.006.

Shahid, M.N. (2019b), "Behavior of stock return, calendar effects and adaptive market hypothesis (AHM): evidence from Pakistan by using historic data with special focus on Gregorian and Islamic calendar (doctoral dissertation", PhD Thesis).

Shahid, M.N., Coronado, S. and Sattar, A. (2019a), "Stock market behaviour: efficient or adaptive? Evidence from the Pakistan stock exchange", *Afro-Asian J. of Finance and Accounting*, Vol. 9 No. 2, pp. 167-192.

Shittu, W., Adedoyin, F.F., Shah, M.I. and Musibau, H.O. (2021), "An investigation of the nexus between natural resources, environmental performance, energy security and environmental degradation: evidence from Asia", *Resources Policy*, Vol. 73, p. 102227, doi: 10.1016/j.resourpol.2021.102227.

Singh, S., Sharma, G.D., Radulescu, M., Balsalobre-Lorente, D. and Bansal, P. (2024), "Do natural resources impact economic growth: an investigation of P5+ 1 countries under sustainable management", *Geoscience Frontiers*, Vol. 15 No. 3, p. 101595.

Song, Y., Wang, C. and Wang, Z. (2023), "Climate risk, institutional quality, and total factor productivity", *Technological Forecasting and Social Change*, Vol. 189, p. 122365.

Stock, J.H. and Yogo, M. (2002), "Testing for weak instruments in linear IV regression", doi: 10.3386/t0284.

Su, H., Geng, Y., Xia, X.Q. and Wang, Q.J. (2022), "Economic policy uncertainty, social development, political regimes and environmental quality", *International Journal of Environmental Research and Public Health*, Vol. 19 No. 4, p. 2450.

Sun, T. (2024), "Role of inclusive finance on oil resource production targets: how fiscal pressures influence natural resources policy and green recovery in Gulf countries?", *Resources Policy*, Vol. 88, p. 104337.

Sun, Z. and Wang, Q. (2021), "The asymmetric effect of natural resource abundance on economic growth and environmental pollution: Evidence from resource-rich economy", *Resources Policy*, Vol. 72, p. 102085, doi: 10.1016/j.resourpol.2021.102085.

Tan, R., Pan, L., Xu, M. and He, X. (2022), "Transportation infrastructure, economic agglomeration and non-linearities of green total factor productivity growth in China: evidence from partially linear functional coefficient model", *Transport Policy*, Vol. 129, pp. 1-13.

Tang, C., Irfan, M., Razzaq, A. and Dagar, V. (2022), "Natural resources and financial development: Role of business regulations in testing the resource-curse hypothesis in ASEAN countries", *Resources Policy*, Vol. 76, p. 102612, doi: 10.1016/j.resourpol.2022.102612.

Usman, M., Jahanger, A., Makhdum, M.S.A., Balsalobre-Lorente, D. and Bashir, A. (2022), "How do financial development, energy consumption, natural resources, and globalization affect arctic countries' economic growth and environmental quality? An advanced panel data simulation", *Energy*, Vol. 241, p. 122515, doi: 10.1016/j.energy.2021.122515.

Wang, M. and Feng, C. (2021), "Revealing the pattern and evolution of global green development between different income groups: a global meta-frontier by-production technology approach", *Environmental Impact Assessment Review*, Vol. 89, p. 106600, doi: 10.1016/j.eiar.2021.106600.

Wang, X., Li, J. and Ren, X. (2022a), "Asymmetric causality of economic policy uncertainty and oil volatility index on time-varying nexus of the clean energy, carbon and green bond", *International Review of Financial Analysis*, Vol. 83, p. 102306, doi: 10.1016/j.irfa.2022.102306.

Wang, J., Dong, X. and Dong, K. (2021), "How renewable energy reduces CO2 emissions? Decoupling and decomposition analysis for 25 countries along the belt and road", *Applied Economics*, Vol. 53 No. 40, pp. 4597-4613, doi: 10.1080/00036846.2021.1904126.

Wang, E., Gozgor, G., Mahalik, M.K., Patel, G. and Hu, G. (2022b), "Effects of institutional quality and political risk on the renewable energy consumption in the OECD countries", *Resources Policy*, Vol. 79, p. 103041.

Wang, K., Wu, M., Sun, Y., Shi, X., Sun, A. and Zhang, P. (2019), "Resource abundance, industrial structure, and regional carbon emissions efficiency in China", *Resources Policy*, Vol. 60, pp. 203-214, doi: 10.1016/j.resourpol.2019.01.001.

WDI, (2022), World Development Indicators, available at: https://databank.worldbank.org/source/world-development-indicators (accessed 20 October 2022).

Wooldridge, J.M. (2010), "Econometric analysis of cross section and panel data".

Wu, N. and Lin, B. (2025), "Institutional ownership drives a new strategy for green total factor productivity development of Chinese listed companies: effects, mechanisms, and implications", *Journal of Environmental Management*, Vol. 373, p. 123459.

Wu, H., Ren, S., Yan, G. and Hao, Y. (2020), "Does China's outward direct investment improve green total factor productivity in the "belt and road" countries? Evidence from dynamic threshold panel model analysis", *Journal of Environmental Management*, Vol. 275, p. 111295, doi: 10.1016/j.jenvman.2020.111295.

Xie, H., Ouyang, Z. and Choi, Y. (2020), "Characteristics and influencing factors of green finance development in the Yangtze river Delta of China: Analysis based on the spatial Durbin model", *Sustainability*, Vol. 12 No. 22, p. 9753, doi: 10.3390/su12229753.

Xu, X. and Li, J. (2020), "Asymmetric impacts of the policy and development of green credit on the debt financing cost and maturity of different types of enterprises in China", *Journal of Cleaner Production*, Vol. 264, p. 121574, doi: 10.1016/j.jclepro.2020.121574.

Yang, L., Bashiru Danwana, S. and Issahaku, F.L.Y. (2022), "Achieving environmental sustainability in Africa: the role of renewable energy consumption, natural resources, and government effectiveness—evidence from symmetric and asymmetric ARDL models", *International Journal of Environmental Research and Public Health*, Vol. 19 No. 13, p. 8038, doi: 10.3390/ijerph19138038.

Zheng, H., Wu, S., Zhang, Y. and He, Y. (2023), "Environmental regulation effect on green total factor productivity in the Yangtze river economic belt", *Journal of Environmental Management*, Vol. 325, p. 116465.

Zhang, H., Wang, Y., Li, R., Si, H. and Liu, W. (2023a), "Can green finance promote urban green development? Evidence from green finance reform and innovation pilot zone in China", *Environmental Science and Pollution Research*, Vol. 30 No. 5, pp. 12041-12058.

Zhang, P., Li, Z., Ghardallou, W., Xin, Y. and Cao, J. (2023b), "Nexus of institutional quality and technological innovation on renewable energy development: Moderating role of green finance", *Renewable Energy*, Vol. 214, pp. 233-241.

Zhao, J., Jiang, Q., Dong, X., Dong, K. and Jiang, H. (2022), "How does industrial structure adjustment reduce CO2 emissions? Spatial and mediation effects analysis for China", *Energy Economics*, Vol. 105, p. 105704, doi: 10.1016/j.eneco.2021.105704.

Zheng, M., Feng, G.F., Jang, C.L. and Chang, C.P. (2021), "Terrorism and green innovation in renewable energy", *Energy Economics*, Vol. 104, p. 105695, doi: 10.1016/j.eneco.2021.105695.

Zhou, X., Tang, X. and Zhang, R. (2020), "Impact of green finance on economic development and environmental quality: a study based on provincial panel data from China", *Environmental Science and Pollution Research*, Vol. 27 No. 16, pp. 19915-19932, doi: 10.1007/s11356-020-08383-2.

Further reading

BP statistical review of world energy (2019), available at: www.bp.com/en/global/co rporate/energy-economics/statistical-review-of-world-energy/downloads.html

Holloway, E. and Cowie, S. (2019), "Mine planning and the crucial role of geology", *SEG Discovery*, No. 118, pp. 16-27.

Kleibergen, F. and Paap, R. (2006), "Generalized reduced rank tests using the singular value decomposition", *Journal of Econometrics*, Vol. 133 No. 1, pp. 97-126, doi: 10.1016/j.jeconom.2005.02.011.

Majeed, M., Majeed, M.T. and Mazhar, M. (2020), "Reexamination of environmental Kuznets curve for ecological footprint: the role of biocapacity, human capital, and trade", *Reexamination of Environmental Kuznets Curve for Ecological Footprint: The Role of Biocapacity, Human Capital, and Trade. Pakistan Journal of Commerce and Social Sciences*, Vol. 14 No. 1, pp. 202-254.

Ngo, T.Q. (2024), "Natural resource rents, clean energy, and green total factor productivity. Evidence from Vietnam in pre-post covid era", *Resources Policy*, Vol. 88, p. 104401.

Rafindadi, A.A., Muye, I.M. and Kaita, R.A. (2018), "The effects of FDI and energy consumption on environmental pollution in predominantly resource-based economies of the GCC", *Sustainable Energy Technologies and Assessments*, Vol. 25, pp. 126-137.

Ulucak, R. and Ozcan, B. (2020), "Relationship between energy consumption and environmental sustainability in OECD countries: the role of natural resources rents", *Resources Policy*, Vol. 69, p. 101803, doi: 10.1016/j.resourpol.2020.101803.

Corresponding author
Muhammad Naeem Shahid can be contacted at: naeemtuf@yahoo.com