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Article

Does globalization matter for environmental sustainability? New evidence from the QARDL approach

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Does globalization matter for environmental sustainability? New evidence from the QARDL approach

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ABSTRACT

Many researches have been conducted to provide theoretical explanations and/or empirical evidence of how globalization affects environmental quality. However, theoretical explanations have not reached consensus, empirical research has not yet clarified the possible effects in developing countries particularly. For Saudi Arabia from 1981 to 2018, we tested the environmental Kuznets curve hypothesis (EKC). We studied the impact of globalization on the ecological footprint (ECP) relying on the QARDL approach. Four globalization indicators are used namely: social (GLOBS), economic (GLOBE), political (GLOBP), and total globalization (GLOBG). Based on QARDL results, it appears that all quantiles show a statistically significant and negative sign for error correction parameter. These results affirm that the related variables and ecological footprint in Saudi Arabia are reverting to a long-term equilibrium. In the long-run, the results of the study suggest that GLOBG, as well as GLOBE, will lead to increased ECP across all the quantiles. However, the fluctuations in GLOBP and GLOBS negatively affect ecological footprint in higher quantiles. Additionally, the QARDL results confirmed that the Saudi economy has an inverted U-Shaped curve. In the short-run, ECP is negatively affected by four globalization indicators in middle and upper quantiles. Sustainable development and environmental policy can be advanced using the guidelines found in this research. Based on the findings, the government and political system in Saudi Arabia should pay more attention to global and economic globalization to achieve sustainable environmental goals in the long run.

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1. Introduction

Given that climate change is the main concern of recent literature, academics, economists and policy makers are called upon to look beyond economic growth in the modern era, shifting their attention from optimizing countries' economic productivity to the well-being of society (Franzen & Mader, 2018; Adedoyin et al., 2021). At both the local and global levels, policymakers have become primarily concerned with sustainable development because of observable changes in ecosystems (Bilgili et al., 2020). Indeed, most of the previous works dealing with the issue of environmental quality focused on the link between GDP and CO2 emissions through the environmental Kuznets curve. The latter predicts that, in an initial stage, the country's growth is followed by an increased degradation of the environment, and when a threshold level of income is reached the association becomes negative (Grossman & Krueger, 1991). However, the impact of globalization remains negligible despite its complex and widespread impact on political and economic aspects (Leal & Marques, 2021). Therefore, the present study explores the nexus between economic growth, globalization, and Saudi Arabia's ecological footprint in order to contribute to the current literature.

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According to the discipline in which one seeks to explain globalization, empirical links could be identified between growth and the environment, (Figge et al., 2017). The divergence in existing studies on globalization is related to how it is defined and measured (Adedoyin et al., 2021). From this perspective, globalization is considered as the main stimulator of world economic growth through the geographical extension of trade, and the extension of that trade's scope. Thus, a country's exposure to a higher globalization level implies increased levels of foreign investment, skills and technologies exchange, and trade liberalization, which in turn brings many economic and social benefits during development (Sharif et al., 2019).

However, while globalization has some benefits, it also has negative environmental consequences (Xia et al., 2022). Indeed, since countries aim to achieve higher and higher income levels resulting from increased globalization, they are increasing their industrialization which is causing undesirable outcomes, such as environmental degradation due to an escalation of resources use and ecological footprint in key industrial processes (Shahbaz et al., 2015). Indeed, globalization has promoted deforestation and the enormous energy consumption and natural resources. Also, due to globalization and industrialization, various chemicals were introduced, resulting in many toxic wastes that caused significant damage (Shahzad et al., 2022; Song et al., 2022).

Therefore, and given the divergence of findings on the role of globalization in bringing about socio-economic and political changes as well as its questionable impacts on the environment, our work- based on exploring the link between these variables- appears to be essential. According to our knowledge, the data collected from the Globalization Index and Ecological Footprint is the first time this has been used in a study for Saudi Arabia as well as empirical strategies following the QARDL model. In the context of the above motivation, and driven by Saudi's ambitious carbon neutral 2030 goal, the objective of this paper is to examine the impact of globalization and the green economy on ecological footprint in the Saudi economy. Our study differs from previous studies in that the index used to measure globalization is based on the KOF indicator. Indeed, this indicator differs from traditional measures given that it takes into account social, political and economic dimensions. Similarly, our contribution lies in the indicator of environmental quality, which in our case will be the ecological footprint. This indicator is broader than the CO₂ emissions indicator used in most previous studies as it takes into account the effect of national demand for land and productive resources on the environment.

The rest of our paper will be organized as follows. Section 2 will be devoted to a review of the literature that analyzes the relationship between globalization, the green economy and environmental quality. Section 3 will explain the methodology used in our study. Section 4 will present the empirical results of our work. Finally, the last section will be devoted to the conclusion and appropriate policy recommendations.

2. Review of the literature

The potential link between country globalization and environmental degradation has been widely discussed in the literature. However, the results of previous studies did not reach a consensus regarding the specific relationship between globalization and CO₂ emissions. This has led to the initiation of two diverse ideologies that account for the positive or negative effect of globalization on CO₂ emissions. The first ideology asserts that integrated economic activities lead to healthier environmental conditions. Proponents of this belief support the idea that globalization is a source of technological exchange. Globalization thus reflects the green economy as it increases communication, promotes faster access to technology and innovation (Xia et al., 2022; Zhao et al., 2022; Alola & Adebayo, 2023a; Alola & Adebayo, 2023b; Adebayo et al., 2023a). Adebayo et al. (2023b) studied the relationship between renewable energy consumption (REC) and CO₂ emissions in BRICS countries. They reported unidirectional causality from REC to CO₂ emissions. The second ideology supports the idea that globalization is a source of increased consumption in many activities and hence a source of natural resource depletion (Song et al., 2022; Rao et al., 2023).

In the literature, several studies have confirmed the positive effect of globalization on environmental quality (Lee & Min, 2014; Lv & Xu, 2018; Guru et al., 2023). For example, in a study of 15 emerging countries during the 1970–2012 period, Lv and Xu (2018) analyzed the effect of economic globalization on

CO₂ emissions. Based on advanced panel econometric techniques that account for the heterogeneity of cross-sectional dependence, the authors concluded that in the long term, a 1% increase in economic globalization decreases CO₂ emissions by 0.12%. Farooq et al. (2022) analytically and empirically explored the links between globalization and CO₂ emissions for 180 countries over the 1980–2016 period. They showed that globalization contributes to improving environmental degradation. In addition, they confirmed the favorable role of globalization, mainly for economies with low carbon emission levels.

The positive impact of globalization on CO₂ emissions is also confirmed in the Kiviyro and Arminen (2014) study of six sub-Saharan African countries through ARDL models and causality tests. Yameogo et al. (2021) analyzed the relationship between economic globalization and environmental quality by including corruption control for a group of Sub-Saharan African countries over the 2002–2017 period. The authors used the GMM method and concluded that economic globalization and corruption control negatively affect environmental degradation. Zafar et al. (2019) analyzed the impacts of globalization and financial development on environmental quality through the environmental Kuznets curve and incorporating energy consumption. The study is conducted in OECD countries over the 1990–2014 period. Their results indicated that globalization and financial development increase environmental quality by reducing CO₂ emissions. Adebayo et al. (2023c) tested the relationship between hydroelectricity energy consumption, economic growth and CO₂ emissions for USA using a Wavelet coherence (WTC) approach. The authors found that GDP has a positive impact on CO₂ emissions, and hydroelectricity energy consumption has a negative impact. Adebayo and Ullah (2023) studied the relationship between economic growth, nuclear energy, government stability and environmental quality in China. They found that causality ran from nuclear energy and government stability to environmental quality. Adebayo et al. (2023d) found cointegration between nuclear energy, human capital, gas consumption, ecological footprint and economic growth. they showed that nuclear energy has a causal relationship with the ecological footprint in India.

In a second strand of the literature, several works did mention that globalization is strongly linked to environmental degradation by affecting environmental pollution through openness, increased massive energy consumption, and the circulation of goods and services. In a study for the case of Bangladesh over the period spanning from 1972 to 2015, Ahad and Khan (2016) used the ARDL technique to analyze the relationship between globalization, economic growth, energy consumption and environmental quality. The authors confirmed the existence of a positive relationship between globalization, energy consumption, and CO₂ emissions. In Sub-Saharan Africa, Twerefou et al. (2017) studied the relationship between globalization, GDP, environmental quality, and sustainability from 1990 to 2013. The results of the study confirmed that globalization tends to increase CO₂ emissions and has negative impact on economic sustainability. Li et al. (2017) investigated the impact of economic globalization and trade on forest ecosystems. According to the results, exports significantly decreased forest area and volume.

3. Data and methodology

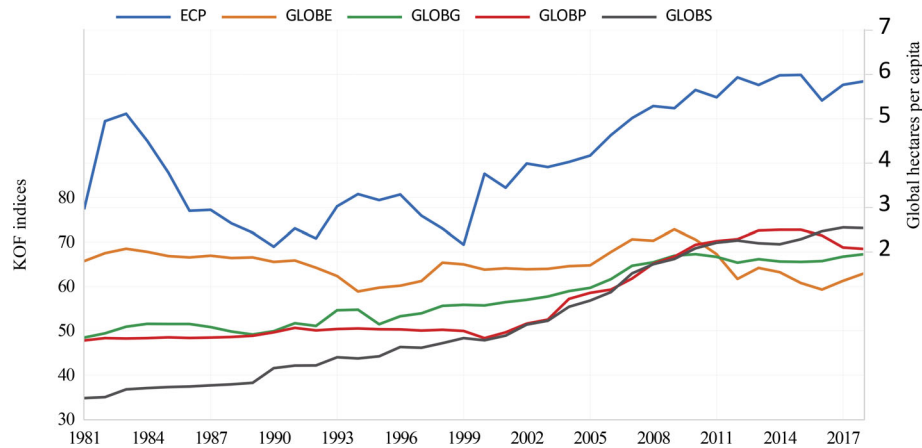
3.1. Data

In order to analyze empirically the effect of globalization on the environment quality, we based our present study on three variables: the ecological footprint (ECP), gross domestic product (GDP) and the globalization variable (GLOB) measured using four indicators of globalization (Economic Globalization (GLOBE), Social Globalization (GLOBS), Political Globalization (GLOBP) and Global Globalization (GLOBG)). The ecological footprint variable is used as a proxy for the quality of the environment and collected from Global Footprint Network, the gross domestic product per capita represents a proxy for economic growth and is collected from the global development indicator (WDI) managed by the World Bank; finally, data on all types of globalization are collected from Swiss Economic Institute. Our study used annual data from Saudi Arabia for the 1981–2018 period.

Table 1 presents the descriptive statistics of the variables, namely ecological footprint (per capita), economic growth (per capita), and globalization indices, namely GLOBG, GLOBE, GLOBS and GLOBP for the case of Saudi Arabia. The results indicate that all the variables have a positive mean value. The

Table 1. Descriptive statistics.

	ECP	GDP	GLOBGG	GLOBE	GLOBS	GLOBP
Mean	4.072	18934.33	57.521	64.963	52.129	56.457
Maximum	5.990	33898.25	67.264	72.815	73.279	72.739
Minimum	2.116	15129.57	48.478	58.863	34.793	47.817
Std. Dev.	1.286	3093.885	6.613	3.307	13.222	9.325
Jarque-Bera	3.253	325.172	3.999	0.333	3.772	5.570
Probability	0.000	0.000	0.002	0.014	0.000	0.005
Observations	38	38	38	38	38	38

**Figure 1.** The trends of ecological footprint and Globalization indices.

average value of ECP is 4.072, whereas the minimum value is 2.116 and the maximum value is 5.990. Moreover, the average value of GDP per capita is 18934.33 \$, with a minimum value of 15129.57 and a maximum value of 33898.25. Lastly, GLOBG, GLOBE, GLOBS and GLOBP have a mean value of 57.521, 64.963, 52.129 and 56.457, respectively, with a minimum value of 48.478, 58.863, 34.793 and 47.817 and a maximum value of 67.264, 72.815, 73.279 and 72.739. The results in Table 1 also illustrate the Jarque-Bera statistic for testing the presence of normality of the variables. We notice well that the probability associated with the test is below the 1% threshold for all the variables. This confirms the non-normality of the distributions and hence the non-linearity in the variables, which motivated our use of different quantile estimates that provide detailed information compared to the traditional linear model (Sharif et al., 2019).

Figure 1 shows the positive trends of ecological footprint and globalization in the majority of the years studied in Saudi Arabia. A positive relationship could be expected from the co-movements of ecological footprint and globalization.

Correlation coefficients between pairwise variables are provided in Table 2. There is almost no multicollinearity observed because the correlation coefficients are almost below 0.6. ECP is positively correlated with GDP and globalization at 1% level of significance, which suggests that improving economic growth and globalization are conducive to ECP. The following sections will provide a detailed analysis of the relationships between the variables.

The flow of the analysis is shown in Figure 2.

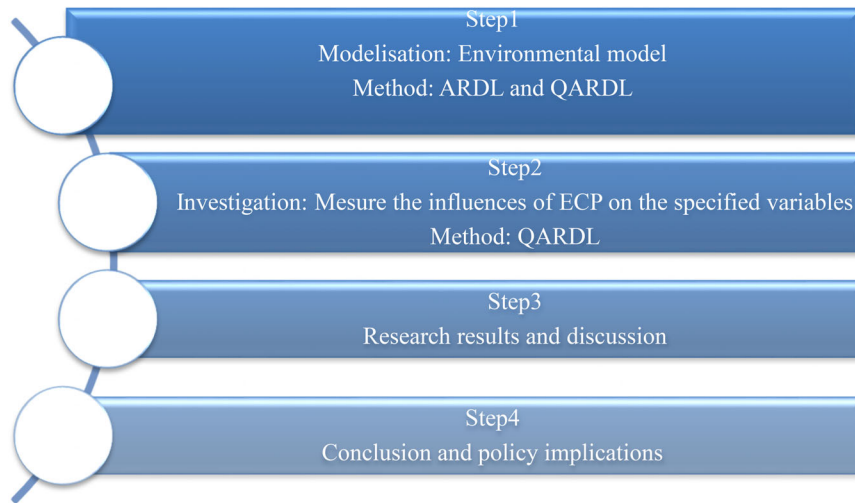
3.2. Methodology

The objective of our study is to analyze the nonlinear relationship between different types of globalization indices and ecological footprint. To do so, we will rely on an innovative procedure, namely the QARDL approach recently introduced by Cho et al. (2015). Thus, the QARDL method can be used to assess the long-term quantitative effect of globalization on Saudi Arabia's ecological footprint. Thus, applying the QARDL approach has various advantages over traditional methods. For example, relying on the QARDL approach helps to consider both long- and short-term estimates using a range of quantiles

Table 2. Correlation matrix.

	ECP
ECP	1
GLOBE	0.584*** (0.000)
GLOBG	0.617*** (0.000)
GLOBP	0.344*** (0.000)
GLOBS	0.591*** (0.000)
GDP	0.619*** (0.000)

Notes: *** and ** denote significance at the 1%, and 5% levels.

**Figure 2.** Analysis flowchart.

and to account for the conditional distribution of the exogenous variables (Ren et al., 2023; Dagar & Malik, 2023).

This equation can be used to represent the ARDL model:

$$ECP_t = \alpha + \sum_{i=1}^p \theta ECP_{t-i} + \sum_{i=0}^{q_1} \rho GDP_{t-i} + \sum_{i=0}^{q_2} \sigma GDP_{t-i}^2 + \sum_{i=0}^{q_3} v GLOB_{t-i} + \omega_t \quad (1)$$

Where ECP_t , GDP_t , GDP_t^2 and $GLOB_t$ represent the ecological footprint, the income per capita, the squared income per capita and the globalization index respectively. ω_t is the error term, p , q_1 , q_2 and q_3 are the respective delays of each variable set on the basis of the Schwarz Information Criterion (SIC). The context of the quantile ARDL model is then recommended by adjusting equation (1) to a framework of quantiles:

$$QECP_t = \alpha(\tau) + \sum_{i=1}^p \theta(\tau) ECP_{t-i} + \sum_{i=0}^{q_1} \rho(\tau) GDP_{t-i} + \sum_{i=0}^{q_2} \sigma(\tau) GDP_{t-i}^2 + \sum_{i=0}^{q_3} v(\tau) GLOB_{t-i} + \omega_t(\tau) \quad (2)$$

Where $\omega_t(\tau) = ECP_t - QECP_t(\tau/\omega_{t-1})$ and $0 < \tau < 1$ is the corresponding quantile. To estimate our data, this study uses the successive pair of quantiles τ pertaining to $\{0.25, 0.50 \text{ et } 0.75\}$. Furthermore, with respect to the probability of serial correlation in the residual, the ARDL quantile model in equation (2) is determined as follows:

$$\begin{aligned} Q\Delta ECP_t = & \alpha(\tau) + \delta(\tau) ECP_{t-1} + \phi(\tau) GDP_{t-1} + \varphi(\tau) GDP_{t-1}^2 + \gamma(\tau) GLOB_{t-1} + \\ & \sum_{i=1}^p \theta(\tau) \Delta ECP_{t-i} + \sum_{i=0}^{q_1} \rho(\tau) \Delta GDP_{t-i} + \sum_{i=0}^{q_2} \sigma(\tau) \Delta GDP_{t-i}^2 + \sum_{i=0}^{q_3} v(\tau) \Delta GLOB_{t-i} + \omega_t(\tau) \end{aligned} \quad (3)$$

From equation (3) presented above, we can derive the error correction model in a quantile ARDL context as follows (Cho et al., 2015):

$$Q\Delta ECP_t = \alpha(\tau) + \delta(\tau)(ECP_{t-1} - \phi(\tau)GDP_{t-1} - \varphi(\tau)GDP_{t-1}^2 - \gamma(\tau)GLOB_{t-1}) + \sum_{i=1}^{p-1} \theta(\tau)\Delta ECP_{t-i} + \sum_{i=0}^{q_1-1} \rho(\tau)\Delta GDP_{t-i} + \sum_{i=0}^{q_2-1} \sigma(\tau)\Delta GDP_{t-i}^2 + \sum_{i=0}^{q_3-1} v(\tau)\Delta GLOB_{t-i} + \omega_t(\tau) \quad (4)$$

From equation 4 we can deduce that the short-term impact of the previous ecological footprint on the current ecological footprint is determined by $\theta^* = \sum_{i=1}^{p-1} \theta_i$. Similarly, the short-term impact of GDP, GDP² and previous and current GLOB on the ecological footprint is measured by $\rho^* = \sum_{i=1}^{q_1-1} \rho_i$, $\sigma^* = \sum_{i=1}^{q_2-1} \sigma_i$ and $v^* = \sum_{i=1}^{q_3-1} v_i$. In addition, the long-term impact of GDP, GDP² and GLOB on the ecological footprint is measured by: $\phi^* = -\frac{\phi}{\delta}$, $\varphi^* = -\frac{\varphi}{\delta}$ and $\gamma^* = -\frac{\gamma}{\delta}$. Finally, the speed of adjustment represented by the parameter δ in equation (4) must be significant and negative.

4. Results and interpretation

Our QARDL analysis follows four steps: the first examines the stationary properties of each variable using the unit root test which allows us to define the variables' order of integration. The Augmented Dickey-Fuller (ADF, 1979) and Phillips Perron (PP, 1988) stationarity tests are used in this sense. The second step consists in verifying the existence of long-term relationships between the variables; the third step aims at estimating the short- and long-term parameters for the different quantiles; while the fourth step allows us to determine if a parameter is constant across the quantiles by relying on the Wald test. The results of the ADF and Phillips stationarity tests are presented in Table 3. This Table shows the results of the stationarity tests for the variables (the ADF and PP test). We can see that all the variables are not stationary at the level of the model. By moving to their first difference, the variables become stationary at the 1 and 5% thresholds. According to the results, each variable has a unique order of integration.

Table 4 is reserved for the results of the QARDL estimation of three main quantiles, namely (0.25, 0.50 and 0.75) of the ecological footprint. The main parameters selected in the table are the error correction term coefficient (δ^*), long-term coefficients (β_i), and short-term coefficients (φ , ω , γ et θ). The four models' results use different proxies of globalization, namely GLOBG, GLOBE, GLOBP, and GLOBS.

The results presented in Table 4 show that the coefficient associated with the error correction term (δ) is negative and significant at the 1% and 5% thresholds in the four models studied and for the different quantiles used, which confirms the existence of a long-term relationship between the variables. In other words, the results confirm that there is a long-term feedback effect between the ecological footprint and each globalization indicator. Similarly, the results of our estimations indicate that the GDP variable is associated with a positive and significant coefficient ($\beta_{GDP}(\tau)$) at the 1% and 5% thresholds in the four models used and for the different quantile levels; which confirms that economic growth stimulates the increase of the ecological footprint in Saudi Arabia. Also, we can notice that the coefficient associated to the GDP variable increases in a first step for the quantiles which are lower than 0.5 (indeed the value goes from 0.121 to 0.342 in the first model) then it will take a downward trend for the quantiles higher than 0.5 (the value goes from 0.342 to 0.284).

For the GDP² variable, the results show that it is only significant for quantiles greater than or equal to 0.5. Thus, the GDP² variable has no effect for low quantiles, and hence the relationship between growth and ecological footprint takes the form of an increasing linear line. However, for quantiles greater than 0.5, the coefficient associated with this variable becomes negative and significant at the 1%

Table 3. Unit root test.

Variables	ADF		PP	
	In level	In difference	In level	In difference
ECP	-0.719	-7.231***	-1.132	-7.281***
GLOBG	-0.419	-5.564***	-0.439	-5.557***
GLOBE	-2.455	-4.718***	-1.979	-4.680***
GLOBP	-2.025	-3.481**	-0.383	-3.594***
GLOBS	0.553	-4.933**	-0.345	-5.048***
lnGDP	-0.587	-5.199***	-0.348	-5.221***
lnGDP ²	-4.687	-5.121***	-4.434	-5.133***

Notes: p-values are in parentheses. *** and ** denote significance at the 1%, and 5% levels.

Table 4. Quantile autoregressive distributed lag (QARDL) results.

Quantiles	$\alpha(\tau)$	$\delta^*(\tau)$	$\beta_{GDP}(\tau)$	$\beta_{GDP}^2(\tau)$	$\beta_{GLOB}(\tau)$	$\varphi_1(\tau)$	$\omega_0(\tau)$	$\gamma_0(\tau)$	$\theta_0(\tau)$
Model A: GLOBG									
0.25	0.040 (0.142)	-0.228*** (0.002)	0.121** (0.016)	-0.042 (1.039)	0.173*** (0.007)	0.150 (0.355)	0.180 (0.214)	-0.190*** (0.009)	-0.107 (0.117)
0.50	0.103 (0.130)	-0.284** (0.014)	0.342*** (0.008)	-0.102*** (0.006)	0.137*** (0.008)	0.109 (0.207)	0.161 (0.257)	-0.182*** (0.002)	-0.109 (0.178)
0.75	0.110 (0.112)	-0.110** (0.011)	0.284** (0.017)	-0.084*** (0.009)	0.190** (0.040)	0.273* (0.073)	0.166** (0.016)	-0.157 (0.135)	-0.110 (0.121)
Model B: GLOBE									
0.25	0.011 (0.114)	-0.294*** (0.004)	0.150** (0.021)	-0.122 (0.302)	0.420** (0.021)	0.219*** (0.004)	0.159 (0.108)	-0.113*** (0.008)	-0.123 (0.658)
0.50	0.002 (0.201)	-0.221** (0.041)	0.290*** (0.009)	-0.175*** (0.007)	0.390** (0.033)	0.227*** (0.006)	0.138 (0.152)	-0.117** (0.012)	-0.125 (0.363)
0.75	0.075 (0.251)	-0.271* (0.070)	0.253*** (0.005)	-0.167*** (0.000)	0.310*** (0.008)	0.254*** (0.002)	0.145** (0.025)	-0.127 (0.319)	-0.121 (0.199)
Model C: GLOBP									
0.25	0.025 (0.159)	-0.194** (0.015)	0.217*** (0.008)	-0.204 (0.204)	-0.168 (0.148)	0.147*** (0.000)	0.121 (0.148)	-0.113** (0.038)	-0.129*** (0.008)
0.50	0.032 (0.146)	-0.253** (0.000)	0.328** (0.040)	-0.215*** (0.003)	-0.165 (0.403)	0.173*** (0.003)	0.132 (0.552)	-0.117** (0.012)	-0.124** (0.043)
0.75	0.059 (0.109)	-0.278*** (0.001)	0.315*** (0.001)	-0.243*** (0.009)	-0.132*** (0.008)	0.234*** (0.005)	0.145*** (0.001)	-0.127 (0.309)	-0.119** (0.039)
Model D: GLOBS									
0.25	0.015 (0.159)	-0.118** (0.012)	0.111** (0.022)	-0.230 (0.361)	-0.175 (0.118)	0.187** (0.036)	0.186 (0.135)	-0.108*** (0.002)	-0.122 (0.558)
0.50	0.035 (0.204)	-0.201** (0.033)	0.319*** (0.005)	-0.103*** (0.002)	-0.166 (0.523)	0.153*** (0.001)	0.108 (0.520)	-0.127* (0.087)	-0.104 (0.128)
0.75	0.022 (0.325)	-0.220*** (0.002)	0.165*** (0.003)	-0.215*** (0.000)	-0.142** (0.048)	0.203** (0.022)	0.217** (0.018)	-0.203 (0.214)	-0.155 (0.136)

Note: p -values are in parentheses. *** is the level of significance at 1%, ** is the level of significance at 5% and * is the level of significance at 10%.

threshold. This indicates that the relationship between economic growth and ecological footprint shifts from an increasing linear shape to an inverted U shape. Indeed, economic growth stimulates the increase of the ecological footprint in a first phase, hence environmental degradation is reinforced and a threshold level of growth (the turning point) is reached. Thus, the increase in growth will lead to a reduction in the ecological footprint, i.e. the quality of the environment improves. The results of our study therefore confirm that the environmental Kuznets curve is verified for the case of Saudi Arabia and that it takes an inverted U shape in all four models. These results can be explained by the new technologies adopted by Saudi Arabia to reduce CO₂ emissions as much as possible and preserve the ecological footprint through the establishment of smart cities. We can mention the 'The Line' project which should stretch over 170 kilometers in the northwest of the country and could eventually accommodate up to one million inhabitants in a carbon-neutral, state-of-the-art urban complex. In addition, Saudi Arabia has recently initiated a massive investment in clean energy generation projects. The existence of EKC for Saudi Arabia supports the findings of Charfeddine (2017); Mahmood and Alkhateeb (2017) and Mahmood et al. (2018), which contradicts the results of Egli (2002) and Egli (2004).

The impact of various globalization indices on the ecological footprint in Saudi Arabia is very interesting and exclusive. In the long-run, the effect of different proxies of political and social globalization are negatively and statistically significant at middle and upper quantiles. Contrarily to Ahmed et al. (2019), the results showed that the effect of social and political globalization are not significant across all the quantiles. These findings are consistent with the study of Ulucak et al. (2020). Nonetheless, Global and economic Globalization are responsible for increasing environmental degradation in Saudi Arabia. We can see that the coefficients associated with the two indicators (GLOBG and GLOBE) are positive and significant. A one-point increase in GLOBG leads to decrease in the ecological footprint of 0.190 points for the quantile (0.25). This coefficient is even lower when moving from one quantile to another. Thus, Global and economic globalization is considered as a source of degradation of the environment quality since any increase in globalization implies strengthening the process of internationalization of industrial and commercial transactions, which require more and more fossil fuels that represent a source of pollution. In addition, the increase in Global and economic Globalization leads to the extraction of more and more natural resources and in particular oil products in Saudi Arabia. This conclusion is not in line with

She and Mabrouk (2023) who concentrated on the BRICS countries and found that globalization contributes significantly to reducing the carbon footprint. The conclusion drawn by Shahbaz et al. (2015) in India demonstrates that the economic Globalization is negatively affected by EFP. More recently, Rehman et al. (2023) showed that an increase in Global and economic Globalization reduces the EFP in the emerging countries during the 1970–2020 period.

Regarding the short-term dynamics, the results show that the current ECP was statistically significant and positively affected by their former disturbances. Similarly, in Models (A), (B), (C) and (D), only the highest ECP quantiles are significant in the short term for GDP. Other models (such as GLOBE, GLOBS, and GLOBP) do not show any significant effect of GDP². Additionally, short-term dynamics indicate that Globalization changes have significant impacts on ECP in Saudi Arabia. Furthermore, the findings of short-term symmetries indicate a negative and significant effect of different proxies (GLOBE, GLOBS, GLOBG, and GLOBP) on ECP. These results are consistent with the study of Suki et al. (2020) and Farooq et al. (2022). According to the QARDL findings, GLOBG and GLOBE are sources of short-term increases of environmental degradation. This result can be explained by a Saudi economic structure based on the extractive industry. However, GLOBP and GLOBS help reduce ECP. This result is due to the implementation of an effective regulatory system and the enhancement of human capital. On the other hand, Saudi Arabia's environmental degradation is influenced by globalization, according to the study. Sustainable development and environmental policy can be advanced using the guidelines found in this research. Based on our findings, the government and political system in Saudi Arabia should pay more attention to global and economic globalization to achieve sustainable environment goals in the long run.

Table 5 shows the Wald test results. Using the Wald test, we can check if the parameters are constant across the three quantiles. The Wald test confirms that the parameters for estimating are nonlinear in both the short- and long- terms. There were no asymmetries and nonlinearities in the relationship since the null hypothesis was accepted. According to our results, this study rejects the null hypothesis of the speed of adjustment parameter at a 1% significance threshold. In other words, the cointegrating parameter between ECP and GLOB is dynamic for the Saudi economy when different quantiles are applied.

The Wald test confirms a symmetric relationship between GDP² and ECP in models A and B in the long term. They reject the null hypothesis that parameters depend on the GDP² impact on ECP at present values. At various quantiles, the Wald test rejects the null hypothesis of parameter dependability relating to the previous level of ECP, according to Table 5. Furthermore, the Wald test rejects the null hypothesis of parameter dependence for all quantiles in Models (A, B, C and D), which further confirms an asymmetric lagged and contemporaneous effect of GDP on ECP in the short term. This study finds that the short-term effects of GLOBG and GLOBP on ECP are asymmetric because the Wald statistics reject the null hypothesis. Meanwhile, the study confirms that GLOBE and GLOBS in Saudi Arabia has no asymmetric effects on environmental degradation.

Table 5. Results of the Wald test for parameter stability.

Variables	Model A: GLOBG	Model B: GLOBE	Model C: GLOBP	Model D: GLOBS
δ	5.648*** (0.000)	7.112*** (0.000)	4.978*** (0.000)	6.547*** (0.000)
β_{GDP}	2.088*** (0.000)	4.641*** (0.000)	3.291*** (0.000)	2.184*** (0.000)
β_{GDP^2}	2.254*** (0.000)	3.207*** (0.000)	2.057 (0.247)	0.120 (0.655)
β_{GLOB}	6.077*** (0.000)	4.881*** (0.000)	3.896*** (0.000)	5.377*** (0.000)
φ_1	1.032*** (0.000)	2.520*** (0.000)	1.554*** (0.000)	3.670*** (0.000)
ω_0	2.566*** (0.000)	0.108 (0.382)	0.654 (0.209)	1.511 (0.366)
γ_0	1.067 (0.361)	0.273 (0.808)	0.654 (0.117)	1.031 (0.204)
θ_0	2.320*** (0.001)	0.104 (0.152)	1.330 (0.816)	3.220*** (0.000)

Note: p -values are in parentheses. *** is the level of significance at 1%.

5. Conclusion and policy implications

This study has investigated how globalization affects ECP in Saudi Arabia for the period 1981–2018. Four globalization indicators are used. They are: GLOBS, GLOBE, GLOBP, and GLOBG. Using the QARDL model, empirical evidence is presented. In addition, based on Cho et al., (2015), we can take into consideration the asymmetric and nonlinear relationship between globalization and the ECP in order to analyze the long-term relationship and short-term dynamics instantaneously.

The QARDL results showed that, across all quantiles, the estimated parameter (δ) is statistically significant with a negative value. Our findings affirm that the related variables and ecological footprint in Saudi Arabia are reverting to a long-term equilibrium. In general, the results of the study suggest that GLOBG, as well as GLOBE, will lead to increased environmental degradation in the long term. On the other hand, GLOBP and GLOBS help reduce environmental degradation. Additionally, the QARDL results confirmed that Saudi Arabia's economy has an inverted U-Shaped curve. However, ECP is negatively affected by GLOBG and GLOBP in the short term. Finally, the QARDL results support the EKC hypothesis by showing a positive impact of GDP and a negative impact of GDP² on ecological footprint. It is, therefore, confirmed that GDP and ECP have an inverted U-shaped relationship.

This study also recommends that, since economic progress and globalization are constantly growing in Saudi Arabia, the ecological status of the country will further deteriorate. Consequently, the Saudi government should focus on adopting effective environmental policies and invest more in the research and development sector to reduce the negative effect of the country's increasing globalization on the environment. Moreover, the study suggests that Saudi Arabia's ecological status will worsen as economic development and globalization progress; hence, Saudi Arabia's government should adopt effective environmental policies and increase investment in the environment. Currently, the country relies heavily on fossil fuels such as oil and natural gas for its economic activities. Energy efficiency with technological progress, diversification of energy sources, and emissions reduction are important steps to achieve green growth. In order to avoid damaging economic growth patterns in the future, renewable energy solutions should be implemented phase-wise, instead of replacing fossil fuels in a single phase.

Finally, a successful implementation of sustainable development policies requires citizens' involvement, and therefore, in order to achieve sustainable development goals, the people-public-private partnership should be encouraged.

As a result of the positive impact of GLOBS and GLOBP on environmental stability, the government should take measures to increase the participation of local trading partners in economic processes, particularly by reducing or eliminating trade barriers, especially for local trading partners. In turn, this can lead to a greater degree of social globalization in the economy as it improves regional integration and boosts consumer and business confidence. In addition, the policymakers have to implement policies to analyze the environmental viability of foreign investments, and businesses using outdated dirty technologies should be penalized. In addition, foreign investors should be provided with incentives to use cleaner technology and invest in cleaner energy projects.

There are some limitations to this study that can also provide opportunities for future research.

The validity of these hypotheses can therefore be tested simultaneously for a group of countries by taking advantage of a panel data analysis, since this study only examines the impact of GLOB on ECP and EKC hypotheses for Saudi Arabia. Future studies can also examine similar countries. Additionally, future research avenues can consider factors like renewable energy and energy intensity, which were not considered in this study. Numerous new econometric techniques have been developed recently, including CS-ARDL, and CS- quantile approach, can also be applied to future studies to enhance the understanding of the current situation. Consequently, new studies can improve environmental assessments.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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