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RESEARCH ARTICLE

Idolization and ramification between globalization and ecological footprints: evidence from quantile-on-quantile approach

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Abstract

Globalization persists the tendency to alter numerous aspects of today's world including religion, transport, language, living styles, and international relations; however, its potential to influence quality of environment is the prime concern for trade and environmental policies guidelines (Audi and Ali 2018). In response to the growing interest for identifying the dynamic relationship between globalization and environmental performance, the present study seeks to investigate the critical link between globalization and ecological footprints in top 15 globalized countries between 1970 and 2016. Applying the novel methods of quantile-on-quantile regression (QQ) and Granger causality in quantiles, the findings examine the manners in which quantiles of globalization affect the quantiles of ecological footprints and vice versa. The empirical results suggest that globalization has a long-term positive effect on ecological footprint and vice versa in case of Belgium, the Netherlands, Sweden, Switzerland, Denmark, Norway, Canada, and Portugal. On the other hand, the estimated results indicate a negative effect between globalization and ecological footprint in the case of France, Germany, the UK, and Hungary. These results extend the recent findings on the globalization–environment nexus implying that the magnitude of relationship among both variables varies with countries demanding individual focus and cautions for postulating environmental and trade policies.

Keywords Globalization · Ecological footprints · Quantile-on-quantile approach · Granger causality in quantiles

Introduction

The world, at present, is rapidly phasing towards the era of technological advancements by continuously shaping itself from the conventional economic and financial systems towards a more integrated, innovative, and concurrent economies (Sharif et al. 2017). There is no denying on the positive paybacks of globalization in the form of altering business dynamics, evolving economies of scales and enhancing the level of innovation. The modern world of enhanced globalization brings numerous changes in economic activities and thus leads to enhance its dependence on the prosperity of the country leading to development. However, the fast-paced inclination of international corporate cohesions, cost minimization, and trade liberties in the form of economic and financial globalization has also raised the people's concern of investigating their influence on the environment (You and Lv 2018). The modern economies have now shifted their focus towards the modes of sustainable development. In this regard, the role of globalization has started to question for promoting environmental degradation (Antweiler et al. 2001; Figge et al. 2017).

The search for a relationship between environment and development is initiated from Environment Kuznets Curve (EKC). It established the inverted U-shape association between output development and deterioration in the natural environment. The adherents of EKC approach believe that

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development in the economy is initially accompanied by the adverse effects on environment that tend to improve at the threshold level (Jaunky 2011; Saboori et al. 2012) but happen to conclude the inverse association between the variables at the end (Grossman and Krueger 1991). Considering globalization as an inevitable part of modern economies, the role of globalization in effecting environmental degradation is also substantial (Audi and Ali 2018). The existing literature investigating the nexus of globalization and environmental degradation is filled with the contentious debate on the specific relationship between globalization and its effects on the environment (Borghesi and Vercelli 2003; Rudolph and Figge 2017) and tends to reflect both positive and negative association between the variables. The adherents of the positive nexus between globalization and environmental degradation stress that globalization leads to ecologically intensive production and consumption. This puts pressure on the environment and decreases its quality. On the other hand, the believers of the negative link between globalization and environmental degradation argue that globalization has the potential to encourage clean technologies and leapfrogging through foreign direct investment, augment operational, and productive efficiencies and improves the overall environmental governance, which brings positive effect on the environment (Rudolph and Figge 2017). In line with the ridden debate, more recently, the emerging emphasis on the eco-friendly corporate practices in order to ensure sustainable development is also evolved as a counteractive phenomenon. The emphasis on sustainable development is aimed to evaluate how countries are using their natural capacity in the way of its national and international development. The aim is to help the economies to mitigate any adverse effect of the globalization on the environment.

Figge et al. (2017) asserted that the consequences of globalization are recognized in several ways by many scholars, conditional to their discipline and worldview, making it hard to form a cohesive assessment of its effects on the environment. The major contribution of this ambiguity is ascribed to the way these phenomena are defined. For instance, globalization cannot be entirely reflected from the level of country's trade openness as it lacks the ability to incorporate certain levels of technology spread, skills beyond geographical borders, and the extent of capital controls (You and Lv 2018). Nonetheless, the literature is filled with the studies that focus on trade freedom and the related trade essentials to describe the effects of globalization on the environment (Jorgenson and Givens 2014; Twerefou et al. 2017; Le et al. 2016). Similar piecemeal approaches are witnessed in defining environmental degradation in the form of carbon-di-oxide emissions (Shahbaz et al. 2013; Shahbaz et al. 2017b; Twerefou et al. 2017; You and Lv 2018) by ignoring the other essential dynamics of land exploitation and resource deterioration. Thus, the measurement and quantitative valuation of both variables are significant in investigating the empirical outcomes for the existing contentious debate that is ridden by opacity, indecisive causal claims, and contradictory worldviews related to globalization and its effect on the environment.

Modern economies reliant on reliable and sustainable access to numerous natural resources including freshwater, energy carriers, minerals, arable land, and core metals (Vivanco et al. 2017). However, the physical availability of these resources is emerged as a severe challenge and is predicted to increase in coming future. At present, humans are utilizing more than the generable capacity of world's resources. According to the Global Footprint Network (2017), human civilization at present is in a state of overshoot as it is utilizing the renewable resources of one and a half Earth every year. This overshoot is a result of the excessive consumption of the planet resources, compared to the time it takes to regenerate them and alters eco-systems by instigating the ecological pressure in performing the business activities causing land degradation, resource extractions, deforestation, overfishing, emission of hazardous gases, as well as waste pollution (Rudolph and Figge 2017). Therefore, the current study utilized Ecological Footprint as an indicator of environmental degradation for providing an inclusive perspective of environmental deterioration as it tends to reveal the impact of countries on environment in the form of soil, air, and water (Al-Mulali et al. 2015). Similarly, the phenomenon of globalization accentuates numerous scales and domains and poses methodological challenges in measurement (Figge et al. 2017). Therefore, the present study utilized the KOF index of globalization to investigate its role in effecting environmental degradation. The selection of the KOF index is based on its uniqueness in reflecting the phenomenon in the form of economic, political, and social dimensions.

Numerous empirical examinations attempt to educate the connection between globalization and its effect on the environment. However, the outcomes are commonly confined to conventional empirical methodologies with simplified measures (Audi and Ali 2018; Fuinhas et al. 2017; Dreher et al. 2008; Leit 2014). Recognizing the similar issue, Katircioglu (2009) identified that methodologies are crucial in resulting unbiased research outcomes and insisted on the significance of utilizing the innovative econometric methods. The failure of prevailing time series-driven findings might indulge the policymakers in adopting the eco-friendly policies of global economic and socio-political integrations.

In compliance, the present study employed the advanced quantile-on-quantile (Q-Q) approach to assess the link between globalization and environmental degradation in top 15 globalized economies. The prime motivation for the current study in contributing to the existing literature lies in three ways. (i) This study examines the conventional globalization-ecological footprints nexus by applying the advance quantile-on-quantile approach introduced by Sim and Zhou (2015). The uniqueness of Q-Q methodology lies in its

capability to merge the basics of quantile regression and non-parametric estimation analysis. In doing so, the approach tends to regress the quantile of one variable into another and the findings have the potential to respond the queries enquiring the relationship between globalization and ecological footprints at both lower and higher quantiles of the time series data. (ii) This paper also studies the time-series dependence of the top globalized countries individually with such an extensive approach. We believe that the outcomes derived from our research will provide an inclusive depiction of the crucial globalization–environment nexus which would not be otherwise possible from the conventional methods. (iii) This paper also uses the Granger-causality in quantiles test suggested by Troster (2018) that examine the causal connection in all quantiles of the conditional distribution. Another objective of the current study is to investigate a causal relationship on quantiles of conditional distribution. By applying this methodology, we can differentiate among the causality influencing the tails of distribution and the median. Also, it gives an adequate situation for Granger-causality when all quantiles are focused. Moreover, the methodology of Troster (2018) is reliable over a range of quantiles, and it focuses on the non-linear condition in a quantile regression model. The rest of the paper is organized as follows: "Literature review" provides a thorough analysis of the existing literature. "Methodology" presents the methodology of the quantile-on-quantile framework, Granger causality in quantiles, and the detail description of the data. "Empirical results and analysis" presents empirical results and their discussion. "Conclusion and policy recommendation" concludes the study with policy implications.

Literature review

The long-run association of globalization with the environment is adequately supported in the literature; however, the direction of their effects is always debatable. This is due to the fact that the relationship between globalization and environmental degradation is entangled with corporate practices, level of innovation, and use of renewables and country's capacities of natural resources (Sharif et al. 2019). On the other hand, the combative debate on whether the growth in international business integrations in the form of globalization is connected with improved environmental quality or high level of globalization has resulted in the deterioration of the natural environment, makes the investigation worthy of detailed analysis.

The remarkable explanation regarding the theoretical link between globalization and environmental degradation has been given by Grossman and Krueger (1991) establishing that globalization in the form of trade openness happens to produce both the negative and positive effects on the environment. The positive association, also known as the *income effect*, is found as a result of the enhanced economic activity that is emerged from international trade and spread the harmful carbon emissions worldwide and, thus, carries negative effects to the environment (Cole et al. 2006; Jena and Grote 2008). Contrarily, globalization can also bring the positive change in the environment through the *technique effect.* It is achieved as a result of the globalization-induced energy efficient technologies around the world that underlies the potential to augment the domestic production and decline the carbon emissions without controlling the energy consumption (Copeland 2005; Copeland and Taylor 2004; Dasgupta et al. 2006). Therefore, in the context of causal associations between globalization–environment nexus, empirical investigations are filled with both positive and negative (Antweiler et al. 2001 and Liddle 2001) causal claims and therefore lack the cohesion in determining the specific link between the variables providing room to investigate the association by using refined measurements and advanced econometrics.

Focusing on the time series analysis, Shahbaz et al. (2015) examined the association of globalization with carbon-dioxide emission between the years of 1970 to 2012 in India. The findings of the study conclude that globalization plays a positive significant impact in degrading the environmental quality using the overall KOF index of globalization. However, studying the individual effects of globalization index, the results of economic globalization revealed the negative relationship with carbon emission of the country. Utilizing the similar measurement for China, Shahbaz et al. (2017a) explored the relationship between globalization and carbon emission employing the Bayer and Hanck combined cointegration analysis along with ARDL bounds testing approach. The findings of the study confirm the presence of a long-run association between globalization and environmental degradation suggesting the negative association of globalization, across every level of KOF index, with the emission of carbon dioxide in the Chinese economy. Furthermore, the results of causality established the uni-directional causality from globalization to carbon emissions in the country. On the other hand, when Leit (2014) investigate the relationship between globalization and CO_2 emission, the causal claims in Portugal are dissimilar to Shahbaz et al. (2017a). The study utilizes 41 year's data from 1970 to 2010, and the outcomes of Granger causality establish the presence of uni-directional causality between the variable suggesting that the direction of causality runs from CO_2 emission to globalization in the Portuguese economy.

In a panel of 30 OECD countries, Dreher et al. (2008) studied the contribution of globalization to enhanced environmental degradation from 1970 to 2000. The authors utilized the KOF index to examine the impact of globalization on numerous ecological pressures including oxygen demand, carbon dioxide, round wood production, and sulfur dioxide. The results from panel regression suggest that globalization

decreases the levels of sulfur dioxide along with oxygen demand but failed to find the effects of overall globalization index with carbon emission and round wood production. Interestingly, when breaking down the globalization index into its sub-parts of social, political, and economic, the results presented quite contrasting evidence. It is revealed that economic globalization has a weak positive impact on the production of round wood and carbon emission is increased with enhanced level of social globalization. Using the similar measure of globalization, Rudolph and Figge (2017) studied the role of globalization in determining ecological footprint in 146 countries over the period of 1981 to 2009. Unlike Dreher et al. (2008), the findings of the study established that overall globalization has a significant positive impact on ecological footprints. Furthermore, the outcomes highlight the negative influence of social globalization on the production and consumption while positive on the import and exports of the ecological footprints. In addition, economic globalization tends to drives the overall ecological consumption, production, exports, and imports. The study, however, failed to find any contribution of political globalization in determining ecological footprint across the countries.

Analyzing the investigation between globalization in the form of trade openness and hazardous emissions, Lee et al. (2016) distributed the panel into a group of high-, low-, and middle-income countries. The findings of the analysis suggest that trade liberalization has a positive effect on the environment of high-income economies while the influence tends to reflect adverse effects on the environment of low and middle-income countries. Conversely, in a panel of top 10 new globalized economies, Zhang et al. (2017) established that globalization in the form of trade openness is negatively related to the emission of hazardous gasses in the countries. Overall, the association between globalization and environmental degradation is inconclusive in the literature. The lack of conclusive findings demands the additional scholarly inquiry possibly with a refined methodological approach. The understanding of the direction of association might result in additional insight for the policymakers to craft suitable environmental policy in a globalized world.

Methodology

Quantile-on-quantile approach

The current study explains the simple significance and characteristics of quantile-on-quantile (QQ) approach following Sim and Zhou (2015) with the portrayal of the model to investigate the association between globalization (ecological footprints) and ecological footprints (globalization) in top globalized countries. The QQ approach can be supposed as being inclusive for the typical quantile regression model, which defines firstly to examine how the quantiles of an independent variable affect the provisional quantiles of the dependent variable. The QQ approach is applying on the combination of non-parametric estimation and quantile regression. Primarily, orthodox quantile regression is used to inspect the result of an independent variable on various quantiles of the dependent variable. Moreover, conventional linear regression is performed to estimates the conventional effect of a particular quantile of a predictor variable on criterion variable. The main idea behind this data reduction analysis is to correct a liner regression traditionally about a quarter of every part of data in the sample, assigning a high weight to nearer quarters. Therefore, combining these two approaches allows modeling the relationship among the quantiles of dependent variable and quantiles of the independent variables, giving a large amount of evidence as compared to another assessment methods for example ordinary quantile regression or the OLS. The QQ method is proposed to investigate the outcome of the quantiles of globalization (ecological footprints) and quantiles of ecological footprints (globalization). The method has its original fact in the following non-parametric quantile regression model:

$$ECO_t = \gamma^{\sigma}\left(GLO_t\right) + \mu_t^{\sigma} \tag{1}$$

$$GLO_t = \gamma^{\sigma}\left(ECO_t\right) + \mu_t^{\sigma} \tag{2}$$

where ECO_t explains ecological footprints of a country in period t, GLO_t is globalization index in period t, σ is the σth quantile of the provisional scattering of transportation services, and μ_t^{σ} is a quantile error term whose provisional σth quantile is equivalent to 0. $\alpha^{\sigma}(.)$ is an unidentified function since we had no previous knowledge connecting globalization and ecological footprints. This quantile regression approaches the outcome of globalization on the distribution of the ecological footprints for top globalized countries of the world, whereas explaining the result of globalization to contrast through various quantiles of an ecological footprints. The main benefit of this description is its elasticity for no hypothesis was established about the efficient procedure of relationship between globalization and ecological footprints.

Finally, the selection of bandwidth is important when applying non-parametric investigation. The bandwidth clarifies the scope of the quarter backgrounds, the goal point, and consequently, the bandwidth gearshifts the pace of the outcome. A greater bandwidth identifies a larger possibility for bias in outcomes while a lesser bandwidth that hits an equal and balance variance and bias must be chosen. Resulting (Sim and Zhou 2015), a bandwidth parameter $h = 0.05$ was used in the current research.[1]

[1] Different values of the bandwidth have also been selected in order to check the outcome. Nonetheless, the outcome of the calculation remains qualitatively same.

Granger causality in mean and in quantiles approach

As per Granger (1969), a time series Y_i does not Granger-cause another series X_i if earlier Y_i does not help to forecast X_i, providing the former X_i. Let assume there is a describing vector $\left(M_i = M_i^X, M_i^y\right)' \in \mathbb{R}^e, e = o + q$, where M_i^y is the former evidence set of $Y_i M_i^y := \left(Y_{i-1}, \ldots, Y_{i-q}\right)' \in \mathbb{R}^q$. We explain the null hypothesis of Granger non-causality from Y_i to X_i as follows:

$$H_o^{Y \nrightarrow X} : F_X\left(x|M_i^X, M_i^y\right) = F_X\left(x|M_i^X\right), \text{for all } x \in \mathbb{R}, \quad (3)$$

where $F_X(.|M_i^X, M_i^Y)$ is the conditional scattering function of X_i provided $\left(M_i^X, M_i^Y\right)$ under the null hypothesis from Eq. 3.

Following Troster (2018), the current study performs the D_T test by identifying the QAR framework $m(\cdot)$ for entire $\pi \in \Gamma \subset [0, 1]$, upon the null hypothesis of non-Granger causal relationship as follows:

$$QAR(1) : m^1\left(M_i^X, \partial(\pi)\right) = \lambda_1(\pi) + \lambda_2(\pi) X_{i-1} + \mu_t \Omega_\Upsilon^{-1}(\pi), \quad (4)$$

where the values $\partial(\pi) = \lambda_1(\pi)$, $\lambda_2(\pi)$, and μ_t are calculated by supreme probability in an identical space of grid of quantiles, and $\Omega_\Upsilon^{-1}(.)$ is the converse of a traditional ordinary scattering function. In order to rectify the sign of causality among the variables, we calculate the quantile autoregressive frameworks in Eq. 4 with lagged variable to another variable. Finally, the equation of QAR(1) model with the help of Eq. 4 is written as follows:

$$Q_\pi^X\left(X_i|M_i^X, M_i^Y\right) = \lambda_1(\pi) + \lambda_2(\pi) X_{i-1} + \eta(\pi) Y_{i-1} + \mu_t \Omega_\Upsilon^{-1}(\pi). \quad (5)$$

Data

The dataset in the current study comprises two variables, i.e., overall globalization (includes political globalization, social globalization, and economic globalization) and ecological footprints are used as a proxy for environmental degradation. The data of globalization index (GLO) are gathered from the website of KOF Globalization index,[2] whereas the data for ecological footprints (ECO) are collected from the website of Global Footprint network.[3] The annual data is transformed into quarter frequency using a quadratic match-sum method following Shahbaz et al. (2018). This process also performs amendments for seasonal deviations as data is transformed from low to high frequency by dropping the point-to-point data deviations (Cheng et al. 2012; Sbia et al. 2014; Shahbaz et al. 2017a). For empirical analysis, we used quarterly data of top 15 globalized economies[4] over the period of 1970Q1-2016Q4. Table 1 provides descriptive statistics analysis of globalization and ecological footprints. The average value for globalization and ecological footprints is positive for all countries.

Belgium is top in the list of developed countries due to its highest mean value for real GLO (83.949) which varies from 76.241 to 91.159. The Netherlandss is in the second position with the maximum mean value of (82.653) which varies from 72.560 to 91.036. Switzerland is in the third place with the maximum mean value of (81.872) which varies from 72.347 to 89.926. Similarly, Sweden, Austria, Denmark, France, and the UK also have huge globalization index with highest mean values of 81.659, 81.498, 81.207, 81.176, and 81.069 respectively. In comparison, Portugal has the lowest mean value of (69.552) which varies from 52.398 to 82.267. Also, Spain has the lowest mean value of 70.033 and 50.216 to 83.522. In addition, Germany, Norway, Hungary, Iceland, and Canada have also high globalization index with the average value of 80.766, 79.842, 77.512, 76.683, and 76.529 respectively.

On the other hand, in ecological footprints, Germany is on top of the list with its highest value of ecological footprints (493.000) which varies from 423.000 to 582.000. The UK is in the second position with the maximum value of (342.000) which fluctuates from 294.000 to 392.000. France is in the third place with a mean value of 322.000 which changes from 278.000 to 364.000. Likewise, Canada and Spain also have huge ecological footprints with a maximum mean value of 260.000 and 181.000. In contrast, Iceland and Norway have the lowest mean value of (21.511 and 34.150) which varies from 15.103 to 28.245 and 27.482 to 45.370 respectively. Besides, Portugal, Switzerland, Hungary, Denmark, and Austria have also low ecological footprints with the average value of 38.801, 39,928, 42.238, 42.834, and 44.553 respectively.

The results of the Jarque-Bera test are significant at 1% level of significance, which displays that ecological footprints and globalization are not normally distributed in any of the countries. This simplifies the rationality of the quantile regression analysis that is robust to not normally distribute in estimation. Along with this, Augmented Dickey-Fuller (ADF) unit root test was utilized to identify the stationarity of a time series variables. The outcomes of ADF test determine that both

[2] https://www.kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html

[3] https://www.footprintnetwork.org/licenses/public-data-package-free-2018/

[4] (Belgium, the Netherlands, Switzerland, Sweden, Austria, Denmark, France, the UK, Germany, Norway, Hungary, Ireland, Canada, Spain, and Portugal.)

Table 1 Descriptive statistics for globalization and ecological footprints

Variables	Mean	Min.	Max.	Std. dev.	J-B stats	ΔADF	ΔPP	Break year
Panel A: globalization								
Belgium	83.949	76.241	91.159	4.643	16.667***	− 6.624***	− 6.497***	1990 Q4
Netherlands	82.653	72.560	91.036	5.171	14.355***	− 6.797***	− 6.667***	1990 Q3
Switzerland	81.872	72.347	89.926	5.671	19.236***	− 8.434***	− 8.412***	1995 Q2
Sweden	81.659	69.496	88.603	5.982	14.117***	− 6.974***	− 6.867***	2016 Q2
Austria	81.498	65.571	88.254	7.285	16.568***	− 6.839***	− 6.729***	1990 Q1
Denmark	81.207	70.505	88.041	5.699	16.123***	− 7.183***	− 7.097***	1989 Q1
France	81.176	64.389	87.797	7.286	14.636***	− 7.634***	− 7.696***	1990 Q2
UK	81.069	67.197	87.753	5.843	11.226***	− 7.071***	− 6.954***	1992 Q1
Germany	80.766	64.723	87.656	7.576	19.175***	− 7.377***	− 7.292***	1990 Q1
Norway	79.842	69.446	85.918	4.770	15.148***	− 6.916***	− 6.996***	1990 Q1
Hungary	77.512	49.091	84.804	13.236	21.996***	− 5.237***	− 6.427***	1986 Q2
Ireland	76.683	64.484	83.554	5.703	14.949***	− 4.600***	− 5.537***	1990 Q1
Canada	76.529	65.567	83.581	5.876	19.243***	− 5.017***	− 6.143***	1989 Q1
Spain	70.033	50.216	83.522	11.230	20.217***	− 8.067***	− 8.016***	1988 Q1
Portugal	69.552	52.398	82.267	10.594	20.332***	− 4.626***	− 5.632***	1990 Q1
Panel B: ecological footprints								
Belgium	72.734	57.448	82.624	6.023	17.570***	− 8.178***	− 8.12***	1983 Q1
Netherlands	93.247	73.888	121.000	11.252	17.582***	− 8.174***	− 8.143***	2008 Q1
Switzerland	39.928	32.178	45.833	3.029	15.354***	− 7.418***	− 7.339***	1975 Q1
Sweden	60.042	50.934	81.504	6.012	23.205***	− 8.456***	− 8.346***	2010 Q3
Austria	44.553	36.539	55.503	5.457	16.348***	− 7.986***	− 7.944***	2009 Q1
Denmark	42.834	33.173	48.750	3.901	50.004***	− 8.533***	− 8.517***	1975 Q4
France	322.000	278.000	364.000	20.564	16.682***	− 8.262***	− 8.233***	2008 Q2
UK	342.000	294.000	392.000	25.468	19.207***	− 7.269***	− 7.179***	2007 Q4
Germany	493.000	423.000	582.000	42.698	12.510***	− 7.615***	− 7.555***	1990 Q2
Norway	34.150	27.482	45.370	5.248	17.190***	− 7.798***	− 7.742***	1981 Q4
Hungary	42.238	29.199	54.686	7.103	12.563***	− 8.642***	− 8.628***	1992 Q3
Ireland	21.511	15.103	28.245	3.297	16.189***	− 8.092***	− 8.128***	2006 Q4
Canada	260.000	201.000	309.000	27.882	16.516***	− 7.275***	− 7.196***	2005 Q1
Spain	181.000	116.000	268.000	40.711	11.807***	− 6.856***	− 6.975***	2007 Q2
Portugal	38.801	23.113	51.942	9.629	20.459***	− 7.114***	− 7.012***	1985 Q1

Source: Authors Estimation

***1% level of significance

globalization and ecological footprints are found non-stationary at level, but they are stationary at first differences. In simple words, both variables are integrated at 1st difference, i.e., *I*(1). For capturing the structural break, we used Kim and Perron (2009) unit root test. The results are shown in Table 1 which indicates that both variables are non-stationary at a level in the existence of structural breaks. However, all the variables are stationary with the presence of structural break at first differential series. The empirical results also confirm that the variables have a unique order of integration, i.e., I(1). Therefore, globalization and ecological footprints are used in their difference series for empirical analysis.

The empirical results in Table 2 explain the coefficients of correlation between globalization and ecological footprints. The sign of the correlation coefficient shows that globalization and ecological footprints are positively associated in all countries. The highest correlation coefficient is found in Austria (0.991), followed by Sweden (0.986), Germany (0.985), Norway (0.981), and Belgium (0.969). The coefficient is also high in the UK (0.962), the Netherlands (0.939), and Switzerland (0.932). For Portugal, Canada, Ireland, Denmark, France, Hungary, and Spain, the value of correlation is also relatively high, i.e., (0.933), (0.913), (0.894), (0.883), (0.880), (0.834), and (0.813) respectively. This high value of correlation ratifies that globalization and ecological

Table 2 Correlation analysis between globalization and ecological footprints

Countries	Correlation	*t*-stats	*p* value
Belgium	0.969	316.743***	0.000
Netherlands	0.939	41.193***	0.000
Switzerland	0.939	41.173***	0.000
Sweden	0.986	90.3930***	0.000
Austria	0.991	109.459***	0.000
Denmark	0.883	28.334***	0.000
France	0.880	27.881***	0.000
UK	0.962	53.189***	0.000
Germany	0.985	86.938***	0.000
Norway	0.981	84.991***	0.000
Hungary	0.834	58.456***	0.000
Ireland	0.894	46.239***	0.000
Canada	0.913	72.344***	0.000
Spain	0.813	41.394***	0.000
Portugal	0.933	88.382***	0.000

***The value is statistically significant at the 1% level of significance

footprints are highly connected in all countries. The *p* value of the correlation coefficient is highly significant as the value is less than 1%, which explains that these *p* values are statistically significant at 1% significance level.

Empirical results and analysis

Estimates of the quantile-on-quantile approach

The current study discusses the association between globalization and ecological footprints for top 15 most globalized countries focusing on the QQ approach. Figure 1 displays the slope estimates $b_1(\sigma, \pi)$ which holds πth quantile effect of globalization on σth quantile of ecological footprints, by various values of σ and π for to the p-15 most globalized economy. Figures 1 and 2 reveal some critical outcomes. The empirical outcomes of QQ estimation ratify that the association between globalization and ecological footprints is not similar for all the countries. Comparatively, there is considerable heterogeneity present between all countries about globalization–environment connection.

In Belgium, the overall positive and strong effect is observed from globalization to ecological footprints. The globalization and ecological footprint relations provide strong and positive value for the significant number of groupings of quantiles, signifying that there is a positive effect of globalization on ecological footprints. In fact, a comparatively noticeable effect with the positive sign was detected in the region that combines the lower quantiles of globalization (i.e., 0.15–0.30) with the link across all quantiles of ecological footprints (i.e., 0.30–0.95). Overall, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. However, the positive impact gets weaker on middle quantiles of globalization. This outcome recommends that sharp boost in ecological footprints by globalization which is represented by the lowest quantiles of globalization. On the other hand, the effect of ecological footprints is not only weak but also positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is very high quantiles of ecological footprints (0.70–0.95) and upper quantiles of globalization (0.70–0.95). Overall, these results conclude that both variables have a positive effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. Though, the power of this effect is different. The effect of ecological footprints is strong only at high quantiles of ecological footprints, whereas the effect of globalization is strong only at low quantiles of globalization. In general, the results reveal a feedback effect of globalization and ecological footprints.

In the case of the Netherlands, the overall positive and huge effect is detected from globalization to ecological footprints. The globalization and ecological footprints associations provide positive value for the various numbers of groupings of quantiles, indicating that there is a positive effect of globalization on ecological footprints. In fact, a relatively noteworthy effect with the positive sign was noticed in the area that syndicates the upper quantiles of globalization (i.e., 0.80–0.95) with the link across all quantiles of ecological footprints (i.e., 0.10–0.95). In general, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. However, the positive impact gets weaker on low quantiles of globalization. This result acclaims that sharp boost in ecological footprints by globalization which is signified by the high quantiles of globalization. On the other hand, the effect of ecological footprints is not only very weak but also positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is very relatively strong at high quantiles of ecological footprints (0.85–0.95) and upper quantiles of globalization (0.70–0.95). Generally, these results conclude that both variables have a positive effect on each other. However, the power of this effect is different. In summary, the results reveal a feedback effect of globalization and ecological footprints in the Netherlands.

In Sweden and Austria, the results on the relationship between globalization and ecological footprints are quite similar. Overall strong and positive effect is identified from globalization to ecological footprints. The globalization and ecological footprints connections confirm a strong and positive value for the significant number of group of quantiles, representing that there is a positive effect of globalization on ecological footprints. In fact, a comparatively obvious effect with the positive sign was detected in

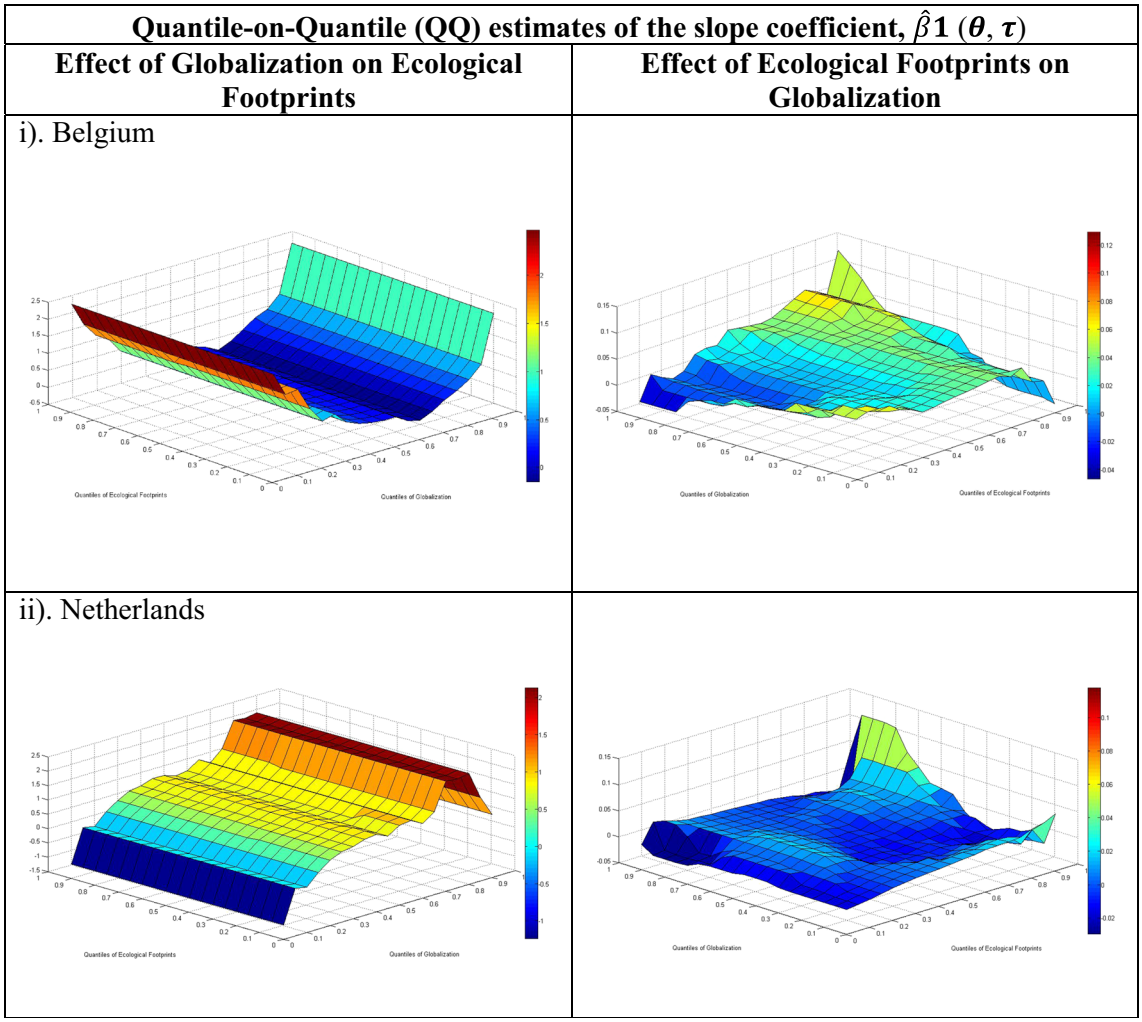


Fig. 1 Quantile-on-quantile (QQ) estimates of the slope coefficient, $\hat{\beta}\ 1\ (\theta, \tau)$. Note: The graphs show the estimates of the slope coefficient $\beta 1\ (\theta, \tau)$ on the z-axis against the quantiles of ecological footprints (globalization) on the y-axis and the quantiles of globalization (ecological footprints) on the x-axis

the area that pools the lower quantiles of globalization (i.e., 0.15–0.30 for both countries) with the link across all quantiles of ecological footprints (i.e., 0.15–0.95 for Sweden and 0.30–0.95 for Austria). Overall, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. Though, the positive impact gets weaker on middle to upper quantiles of globalization. This consequence suggested that rapidly enhance ecological footprints by globalization which is represented by the lowest quantiles of globalization. In contrast, the effect of ecological footprints is not only weak but also positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is high at upper quantiles of ecological footprints (i.e., 0.80–0.95 for Sweden and 0.90–0.95 for Austria) and upper quantiles of globalization (i.e., 0.60–0.90 for Sweden and 0.70–095 for Austria). Overall, these results conclude that both variables have a positive effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. Though, the power of this effect is different. The effect of ecological footprints is strong only at high quantiles of ecological footprints with the coefficient of 0.04 for Sweden and 0.06 for Austria, whereas the effect of globalization is strong only at low quantiles of globalization with the coefficient value of 4.00 for Sweden and 3.50 for Austria. Overall, the outcomes disclose a feedback effect of globalization and ecological footprints.

In the case of Switzerland, the overall weak negative and positive effect is seen from globalization to ecological footprints. The globalization and ecological footprints associations provide weak negative value for the various numbers of groupings of quantiles, indicating that there is actually a negative but weak effect of globalization on ecological footprints. In fact, a relatively notable effect with the negative sign was identified in the region that syndicates the middle quantiles of globalization (i.e., 0.30–0.75) with the link across all quantiles of ecological footprints (i.e., 0.10–0.95). Overall,

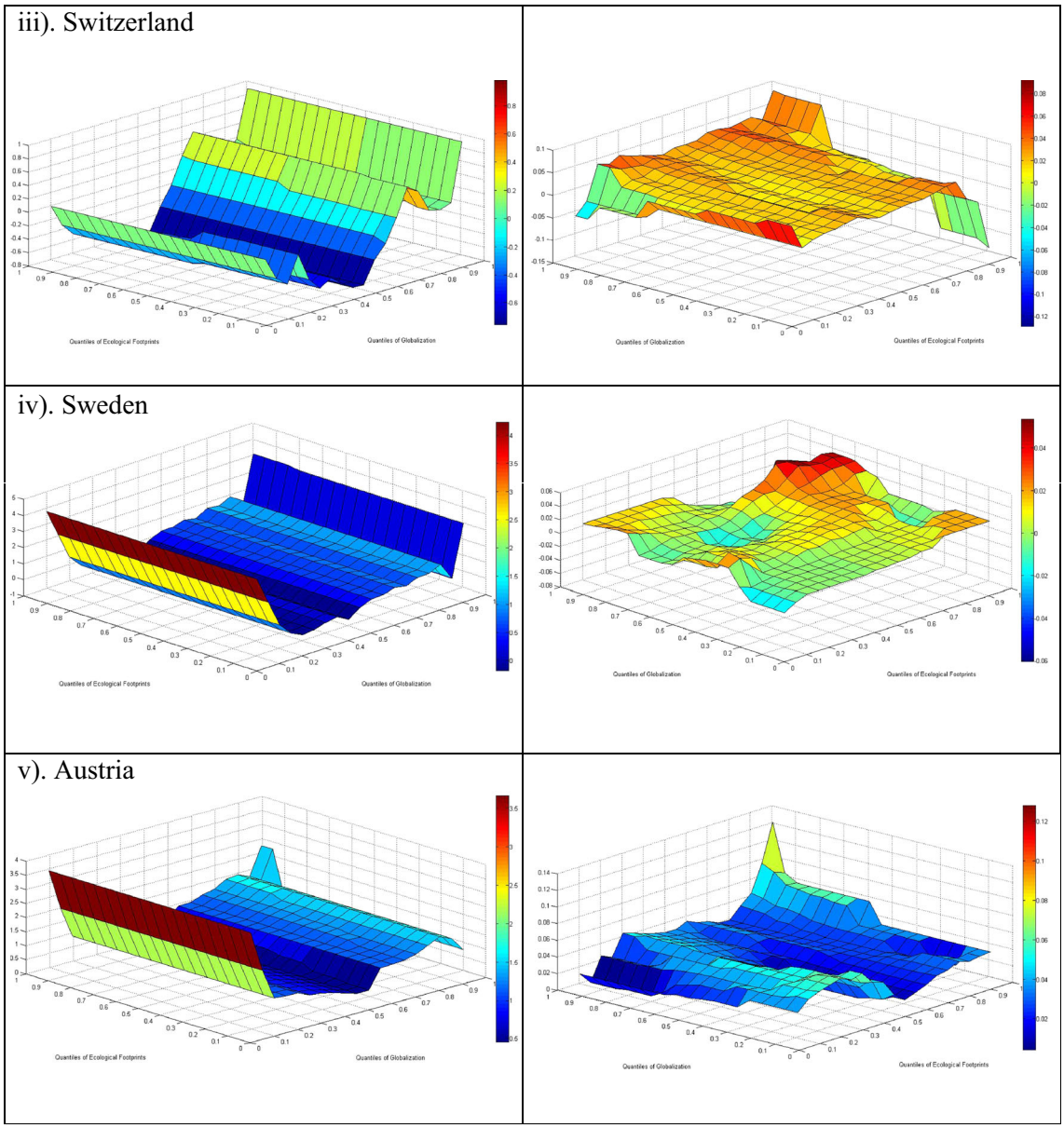


Fig. 1 continued.

the effect of globalization on ecological is negative and weak across all the quantiles of ecological footprints. However, the positive is also detected in both low and high tails of globalization. On the other hand, the effect of ecological footprints is very weak but positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is very relatively strong at lower middle quantiles of ecological footprints (0.45–0.55) and middle quantiles of globalization (0.50–0.65). Mostly, these results conclude that both variables have an inverse effect on each other.

The results of reflecting the effect of globalization on ecological footprint are quite similar to the case of Denmark and Norway. Overall strong and positive effect is identified from globalization to ecological footprints. The globalization and ecological footprints linkages ratify a strong and positive value for the significant number of group of quantiles, suggesting that there is a positive effect of globalization on ecological footprints. In fact, a relatively clear effect with the positive sign was observed in the area that merging the high and middle quantiles of globalization (i.e., 0.85–0.95 for Denmark and 0.45–0.65 for Norway) with the link across all quantiles of ecological footprints (i.e., 0.15–0.95 for Denmark and 0.40–0.95 for Norway). Overall, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. Though, the positive impact gets weaker on middle and upper quantiles of globalization in the case of Denmark and Norway respectively. This consequence suggested that

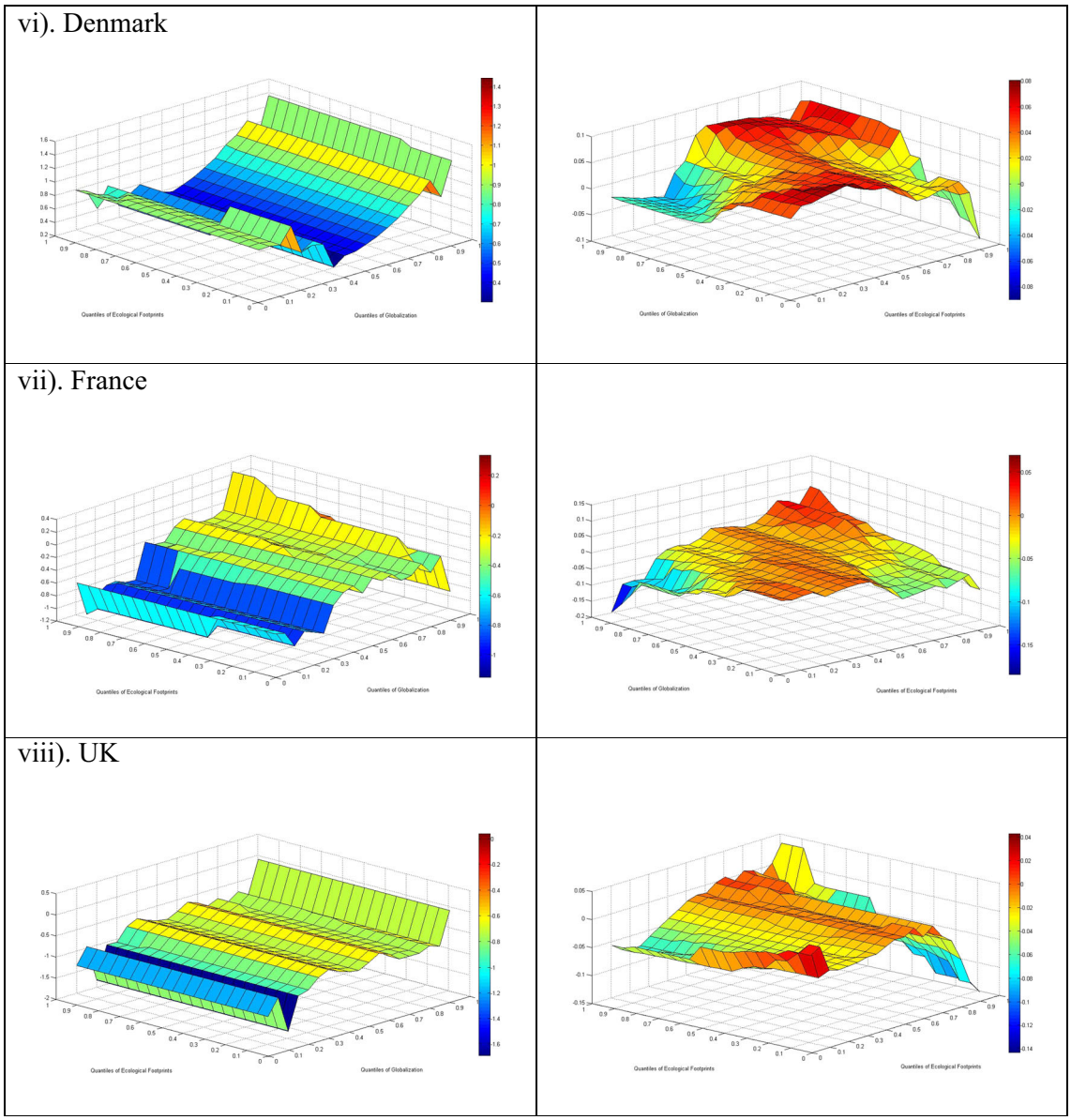


Fig. 1 continued.

rapidly enhancing ecological footprints by globalization is represented by the middle to upper quantiles of globalization for both countries. Conversely, the effect of ecological footprints is strong and positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is high at middle quantiles of ecological footprints (i.e., 0.40–0.65 for Denmark and 0.35–0.55 for Norway) and upper middle quantiles of globalization (i.e., 0.55–0.70 for Denmark and 0.50–075 for Norway). To summarize, these results determine that both variables have a positive effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. However, the coefficient of this effect is different. The effect of ecological footprints is strong only at middle quantiles of ecological footprints with the coefficient of 0.08 for Denmark and 0.10 for Norway, whereas the effect of globalization is strong at middle and high quantiles of globalization with the coefficient value of 1.10 for Denmark and 1.60 for Norway. Generally, the results confirm a feedback effect between globalization and ecological footprints in Denmark and Norway.

In France and the UK, the results on the relationship between globalization and ecological footprints are quite interesting and similar. Inclusively, a strong and negative effect is identified from globalization to ecological footprints. The globalization and ecological footprints linkages provide a strong and negative value for the significant number of group of quantiles, representing that there is a negative effect of

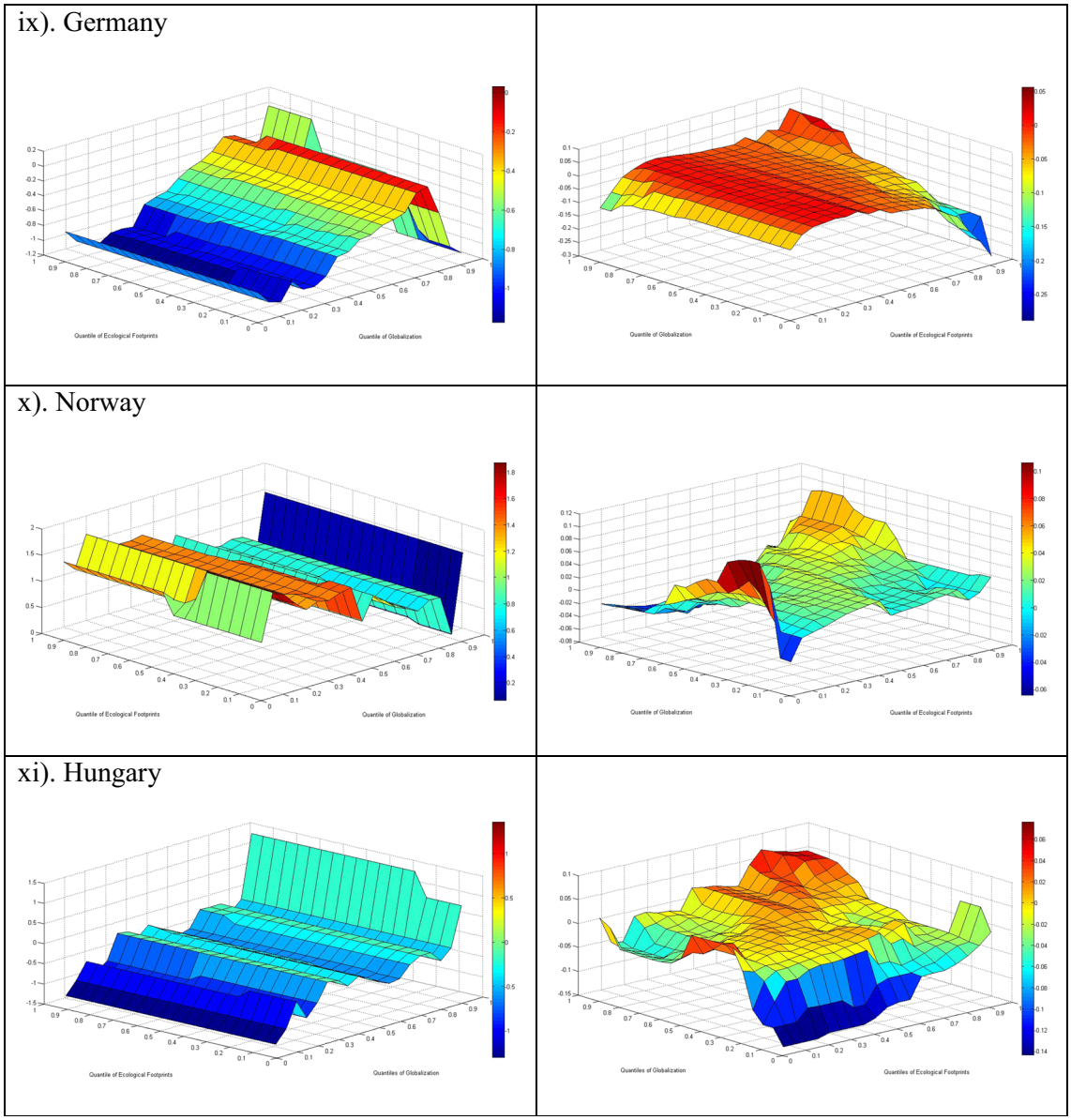


Fig. 1 continued.

globalization on ecological footprints. In connection, a relatively clear effect with the negative sign was noticed in the area that combines the lower middle quantiles of globalization (i.e., 0.30–0.50 for France and 0.25–0.60 for the UK) with the link across all quantiles of ecological footprints (i.e., 0.20–0.95 for France and 0.15–0.95 for the UK). Overall, the effect of globalization on ecological is found strong and negative across all the quantiles of ecological footprints. Though, the negative impact gets weaker on upper quantiles of globalization. This consequence suggested that sharp decrease in ecological footprints by globalization which is represented by the lowest quantiles of globalization. Alternatively, the effect of ecological footprints is very weak but also negative for all quantiles of ecological footprints and globalization. The negative effect of ecological footprints on globalization is high at lower and upper quantiles of ecological footprints (i.e., 0.10–0.25 for France and 0.85–0.95 for the UK) and upper quantiles of globalization (i.e., 0.80–0.95 for France and 0.05–0.30 for the UK). In general, the results conclude that both variables have a negative effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. Though, the power of this effect is not same. The effect of ecological footprints is strongly negative only at high quantiles of ecological footprints with the coefficient of − 0.15 for France and − 0.08 for the UK, whereas the effect of globalization is strongly negative only at low quantiles of globalization with the coefficient value of − 1 for France and − 1.6 for the UK. Overall, the

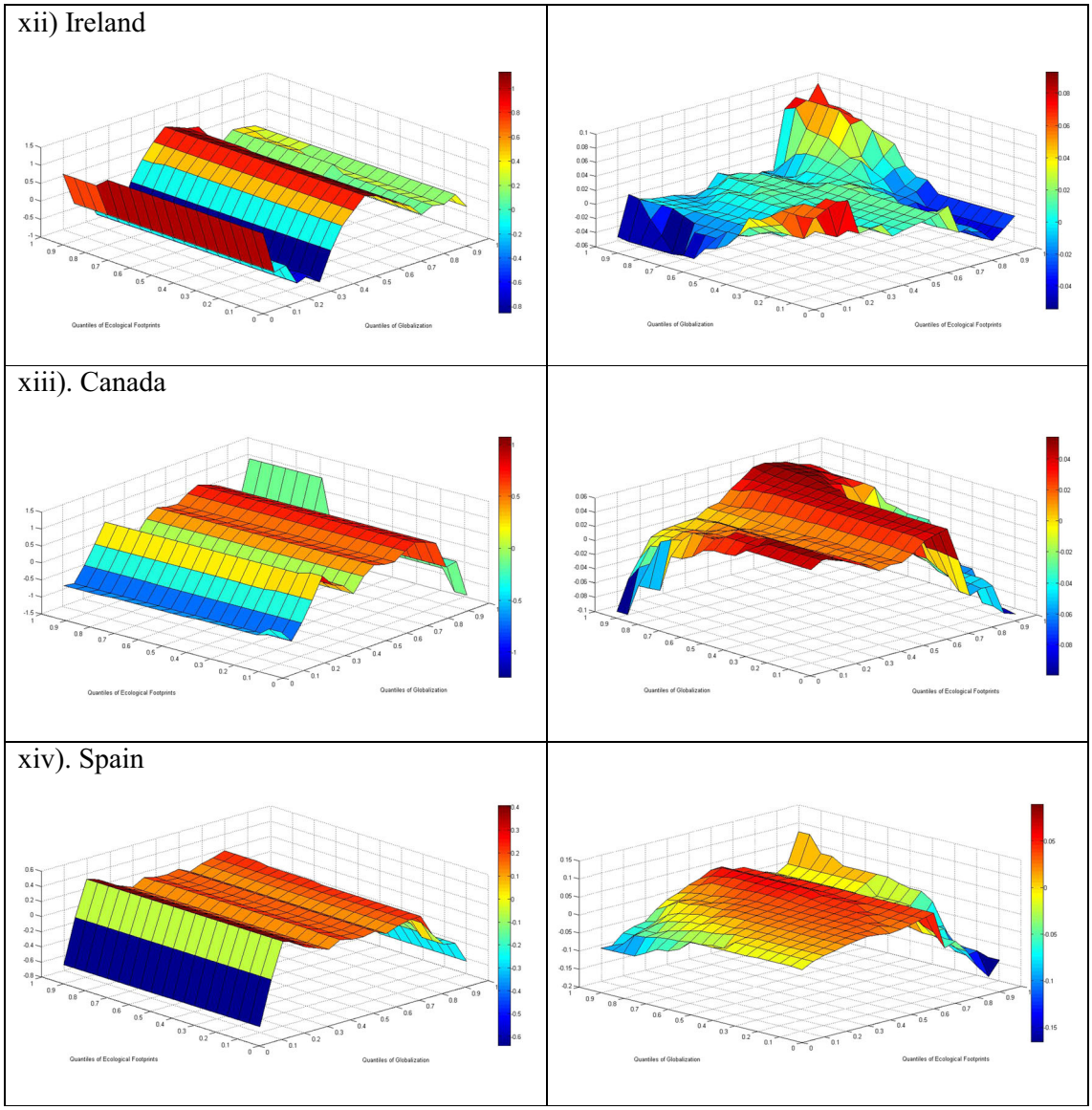
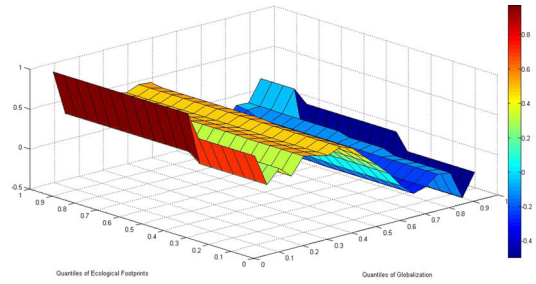


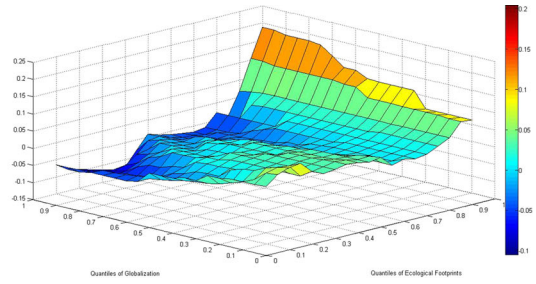
Fig. 1 continued.

outcomes disclose a feedback effect of globalization and ecological footprints in France and the UK.

The results of reflecting the effect of globalization on ecological footprint are quite similar to the case of Canada and Spain. Overall strong and positive effect is identified from globalization to ecological footprints. The globalization and ecological footprints connections confirm a strong and positive value for the significant number of group of quantiles, proposing that there is a positive effect of globalization on ecological footprints. In fact, a relatively clear effect with the positive sign was observed in the area that combines the upper-middle quantiles of globalization (i.e., 0.50–0.85 for Canada and 0.45–0.85 for Spain) with the link across all quantiles of ecological footprints (i.e., 0.20–0.90 for Canada and 0.15–0.95 for Spain). Generally, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. Though, the results also found a negative impact of globalization on ecological footprints only in both high and low tails for the case of Canada and Spain. Contrariwise, the effect of ecological footprints is strong and positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is high at middle quantiles of ecological footprints (i.e., 0.55–0.75 for Canada and 0.65–0.75 for Spain) and upper middle quantiles of globalization (i.e., 0.85–0.95 for Canada and 0.70–0.95 for the case of Spain). To summarize, these results determine that both variables have a positive effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. However, the coefficient of this effect is different. In

xv). Portugal





Note: The graphs show the estimates of the slope coefficient $\beta 1(\theta, \tau)$ on the z-axis against the quantiles of ecological footprints (globalization) on the y-axis and the quantiles of globalization (ecological footprints) on the x-axis.

Fig. 1 continued.

summary, the results confirm a feedback effect of globalization and ecological footprints.

In Germany and Hungary, the results on the relationship between globalization and ecological footprints are quite curious and alike. Overall, a strong and negative effect is detected from globalization to ecological footprints. The globalization and ecological footprints connections offer a strong and negative value for the significant number of groupings of quantiles, proposing that there is a negative effect of globalization on ecological footprints. In addition, a comparatively vibrant effect with the negative sign was noticed in the region that combines the lower middle quantiles of globalization (i.e., 0.15–0.55 for Germany and 0.10–0.30 for Hungary) with the link across all quantiles of ecological footprints (i.e., 0.10–0.95 for both Germany and Hungary). Conclusively, the effect of globalization on ecological is found strong and negative across all the quantiles of ecological footprints. Though, the negative impact gets weaker on upper quantiles of globalization. This result suggested that sharp decrease in ecological footprints by globalization which is represented by the lowest

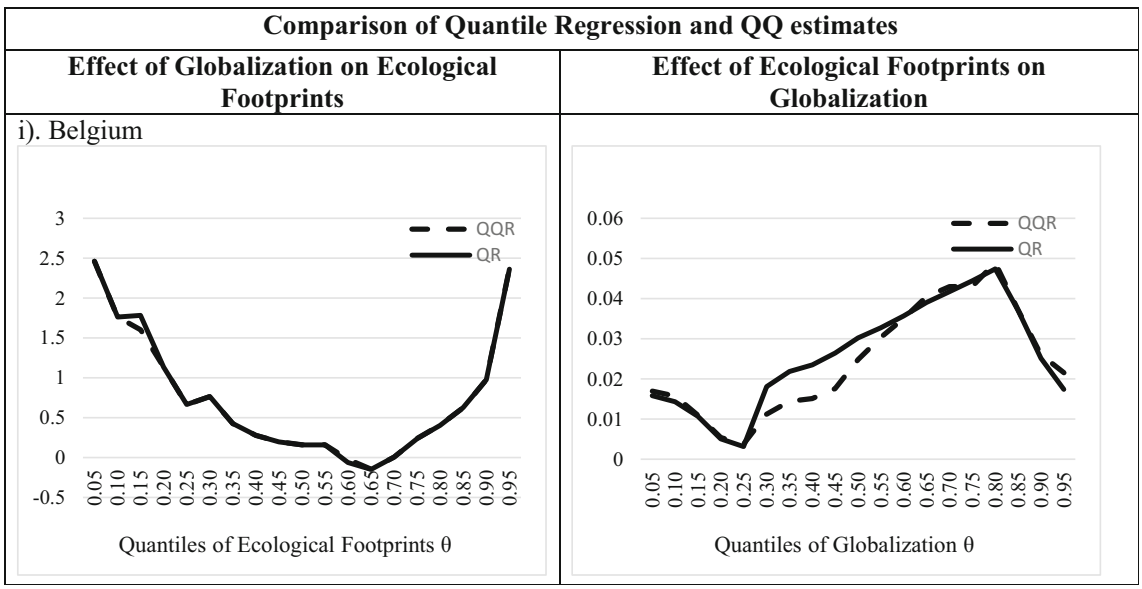


Fig. 2 Comparison of quantile regression and QQ estimates. Note: The graphs display the estimates of the standard quantile regression parameters, denoted by QR (continuous black line), and the averaged QQR parameters, denoted by QQR (dashed black line), in the different quantiles of ecological footprints and globalization for all selected countries

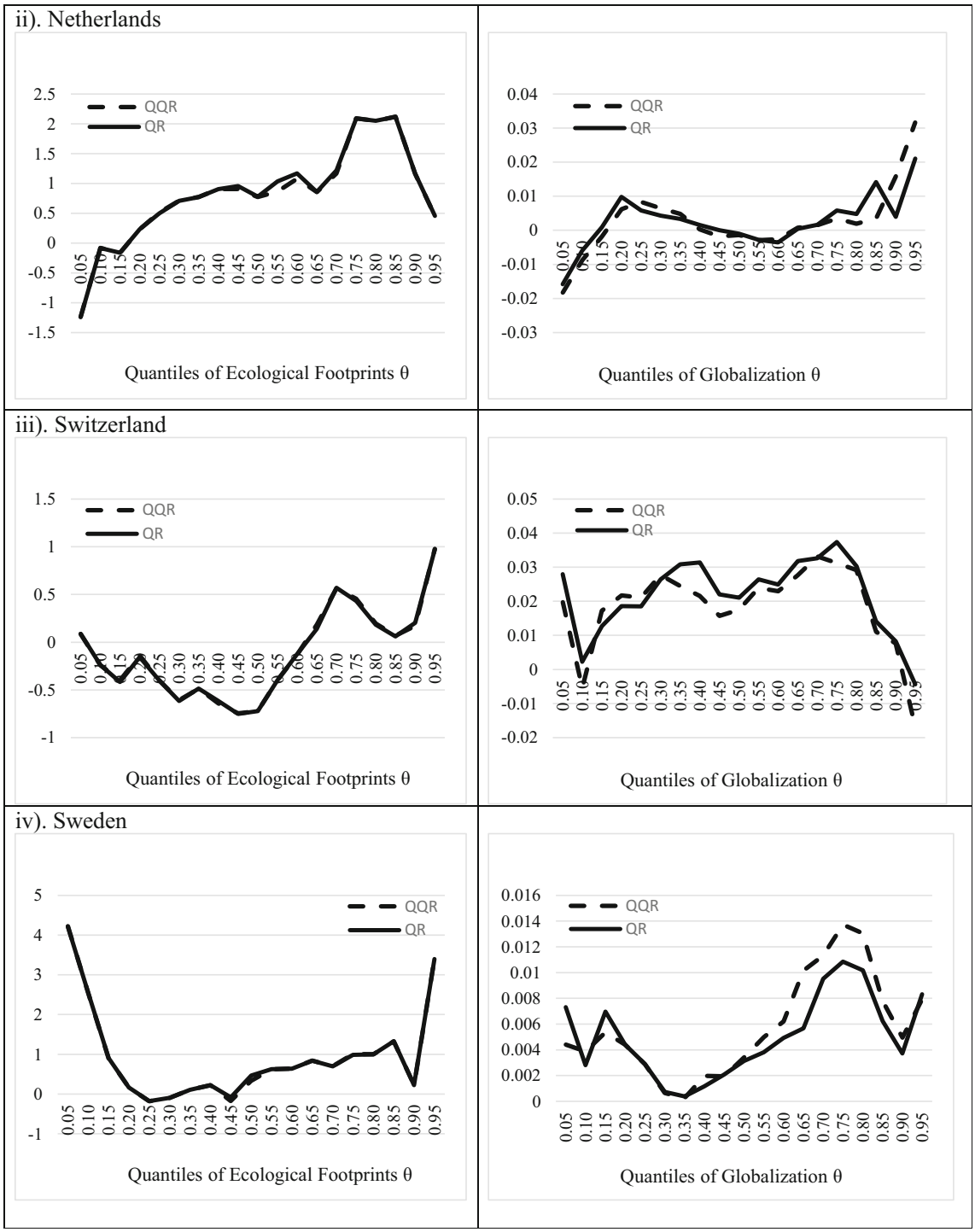


Fig. 2 continued.

quantiles of globalization in the case of Germany and Hungary. Instead, the effect of ecological footprints is not only very weak but also negative for almost all quantiles of ecological footprints and globalization. The negative effect of ecological footprints on globalization is high at lower to upper quantiles of ecological footprints (i.e., 0.80–0.95 for Germany and 0.05–0.75 for Hungary) and lower quantiles of globalization (i.e., 0.05–0.20 for Germany and 0.05–0.25 for Hungary). In general, the results conclude that both variables have a negative effect on each other. The effect of globalization on ecological footprint is parallel to the effect of ecological footprints on globalization. However, the power of this effect is not the same. The effect of ecological footprints is strongly negative only at high quantiles of ecological

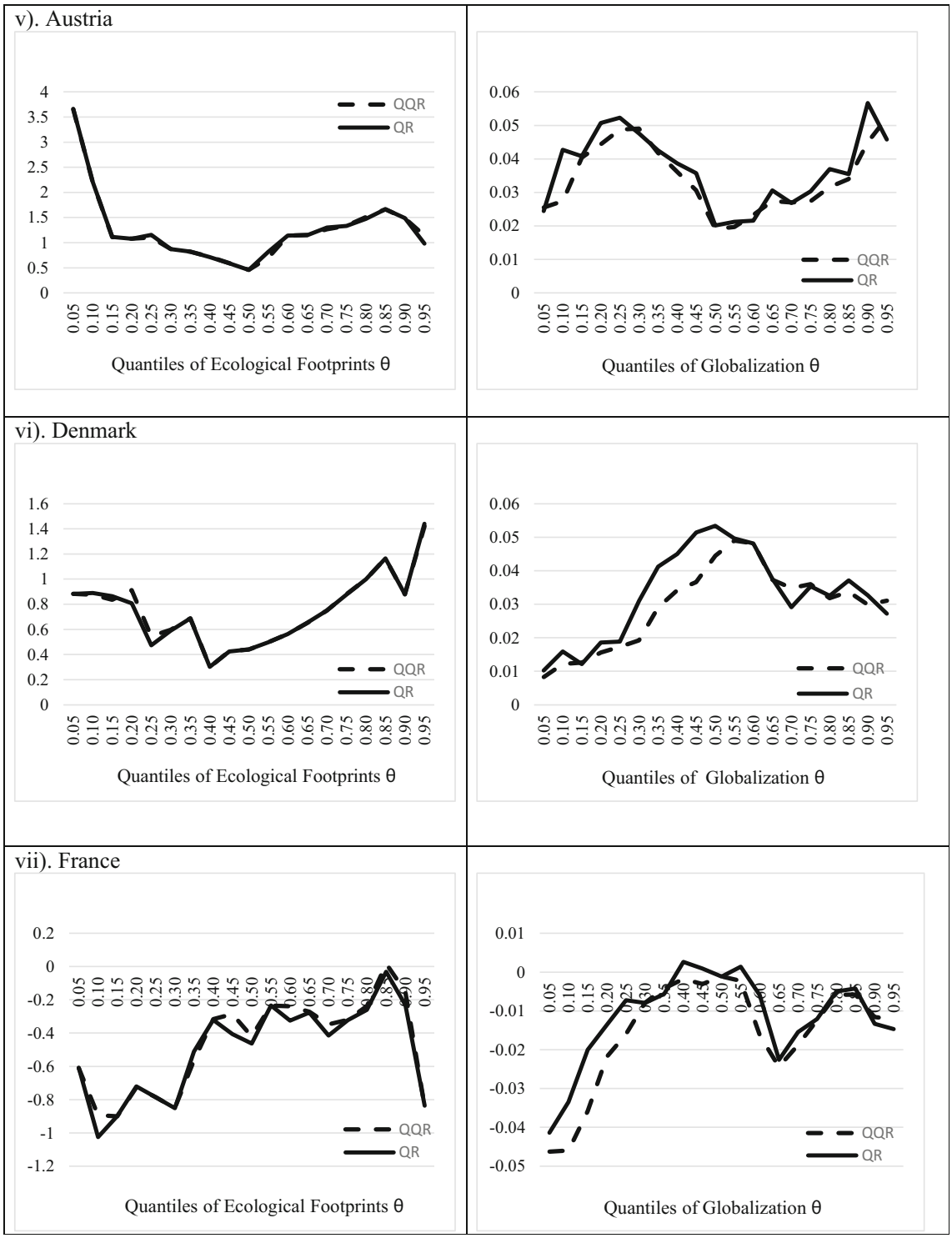


Fig. 2 continued.

footprints with the coefficient of − 0.25 for Germany and − 0.14 for Hungary, whereas the effect of globalization is strongly negative only at low quantiles of globalization with the coefficient value of − 1.00 for Germany and Hungary. Overall, the results reveal a feedback effect of globalization and ecological footprints in Germany and Hungary.

In the case of Ireland, the overall positive and strong effect is seen from globalization to ecological footprints. The globalization and ecological footprint links provide positive value for the various number of groupings of quantiles, indicating that there is a positive effect of globalization on ecological footprints. In fact, a quite significant effect with the positive

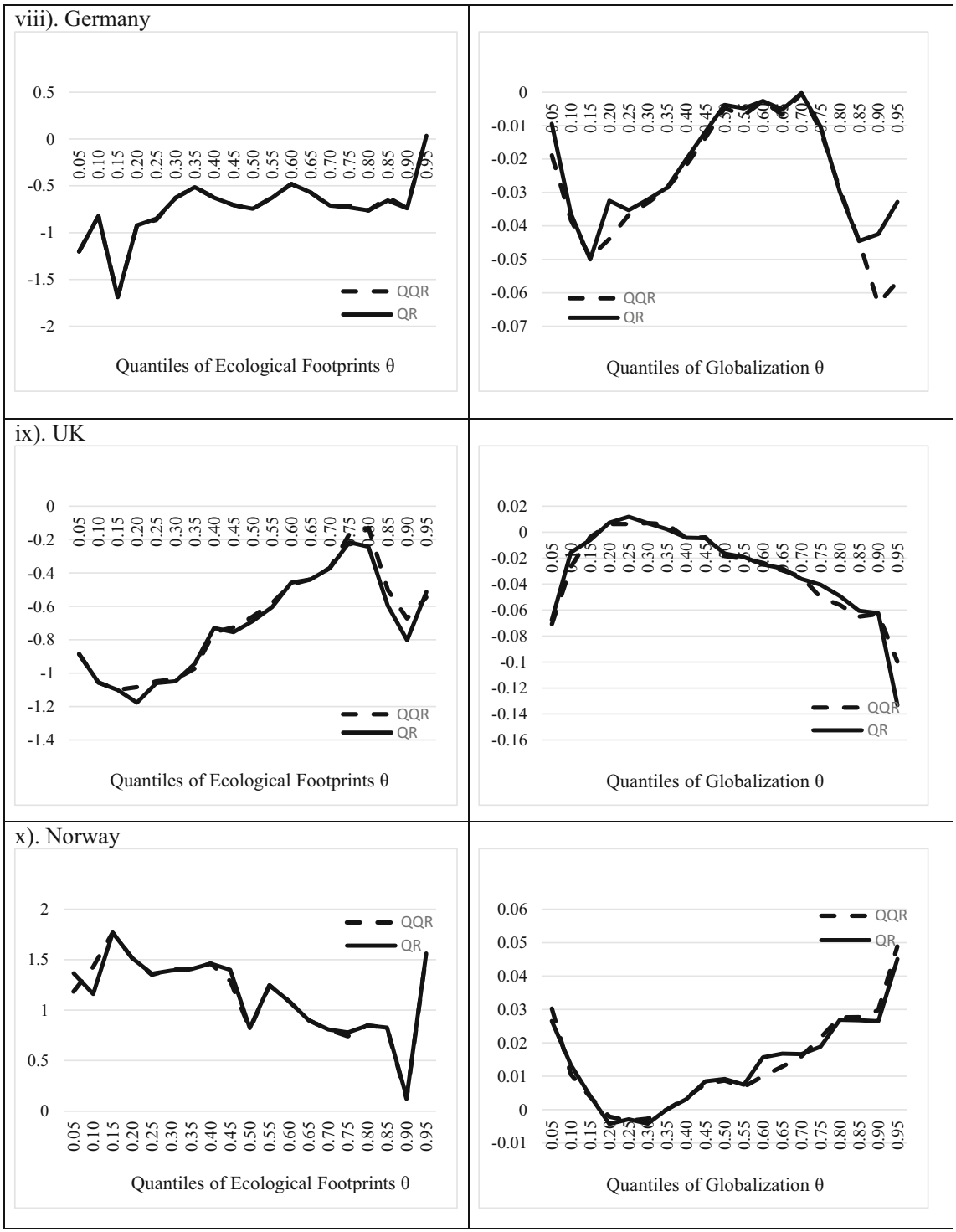


Fig. 2 continued.

sign was observed in the area that collectives the lower quantiles of globalization (i.e., 0.10–0.25) with the link across all quantiles of ecological footprints (i.e., 0.10–0.95). In general, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. However, the current study found some quantiles globalization which negatively affects ecological footprints. This results in acclaims that sharp fluctuations in ecological footprints by globalization which is signified by the lower quantiles of globalization. On the other hand, the effect of ecological footprints is very weak but also positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on

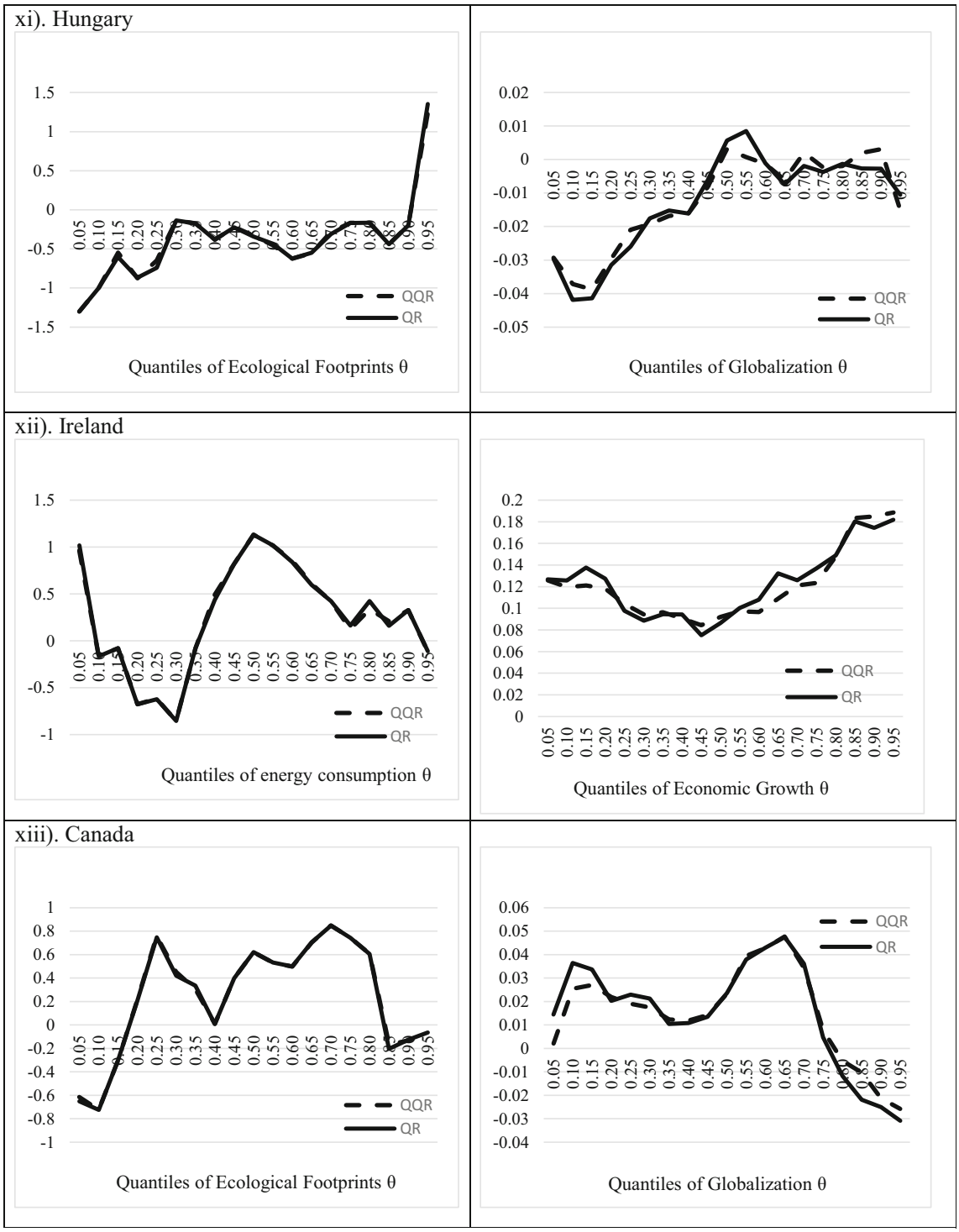
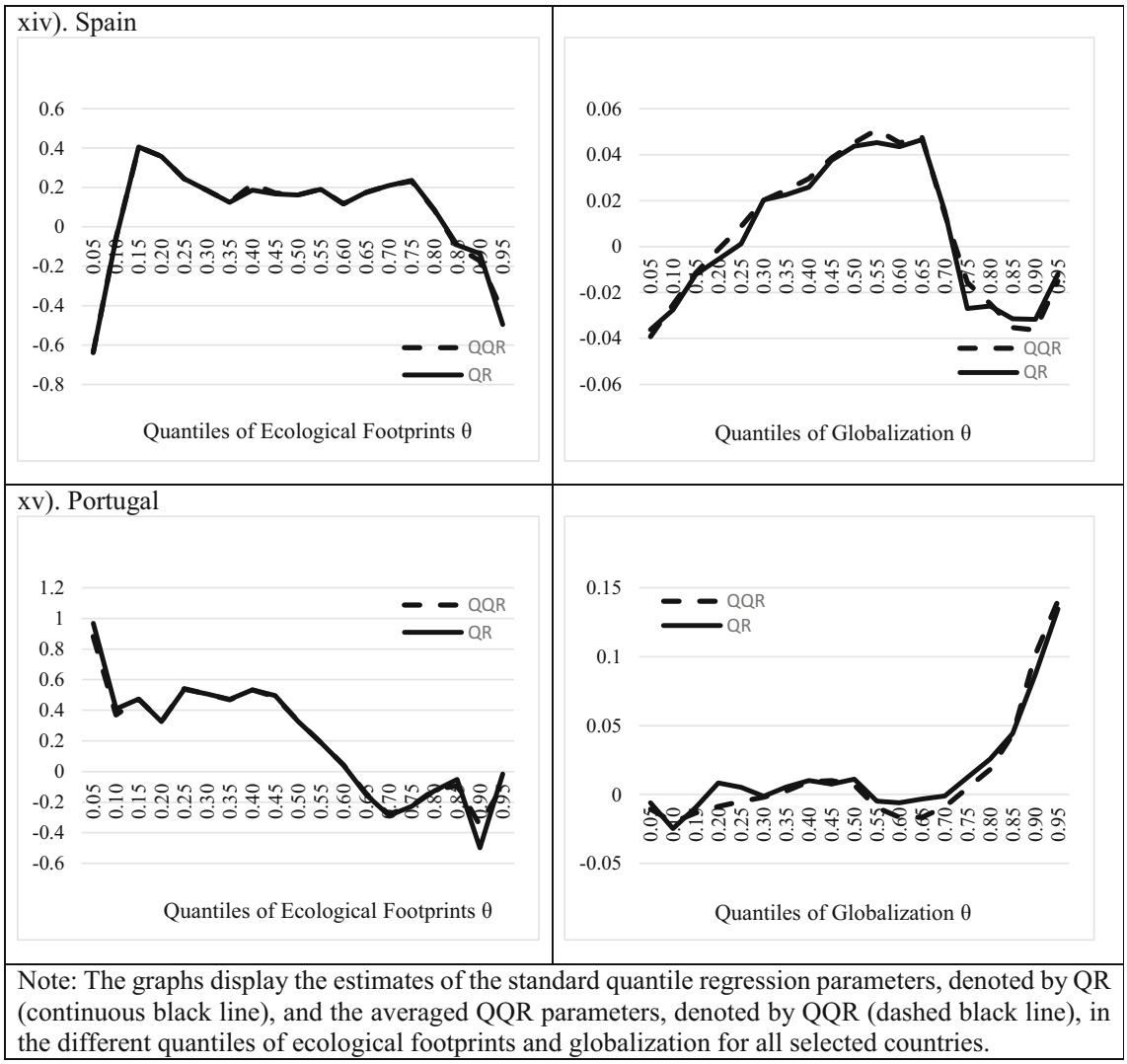


Fig. 2 continued.

globalization is very relatively strong at middle quantiles of ecological footprints (0.55–0.70) and middle of globalization (0.45–0.65). Mostly, these results conclude that both variables have a positive effect on each other in the majority of quantiles. However, the power of this effect is different. In summary, the results reveal a feedback effect of globalization and ecological footprints in Ireland.

In Portugal, the overall positive and strong effect is experienced from globalization to ecological footprints. The globalization and ecological footprints relationships give a strong and positive value for the significant number of quantiles, suggesting that there is a positive effect of globalization on ecological footprints. In fact, a fairly visible effect with the positive sign was detected in the region that combines the



Note: The graphs display the estimates of the standard quantile regression parameters, denoted by QR (continuous black line), and the averaged QQR parameters, denoted by QQR (dashed black line), in the different quantiles of ecological footprints and globalization for all selected countries.

Fig. 2 continued.

middle quantiles of globalization (i.e., 0.20–0.45) with the link across all quantiles of ecological footprints (i.e., 0.50–0.95). Overall, the effect of globalization on ecological is strong across all the quantiles of ecological footprints. However, the current study found a negative effect of globalization on ecological footprints on high quantiles of globalization. This result acclaims that rapid fluctuations in ecological footprints by globalization which is represented by the lowest and highest quantiles of globalization. On the other hand, the effect of ecological footprints is not only weak but also positive for all quantiles of ecological footprints and globalization. The effect of ecological footprints on globalization is very high at upper quantiles of ecological footprints (0.85–0.95) and upper quantiles of globalization (0.55–0.95). Overall, these results conclude that both variables have a positive effect on each other. The effect of globalization on ecological footprint is similar to the effect of ecological footprints on globalization. Though, the power of this effect is different. In simple words, the results reveal a feedback effect of globalization and ecological footprints in the case of Portugal.

Checking the validity of the QQ method

The QQ method is applied as an investigation that allocates the coefficient of traditional quantile regression model. It allows obtaining the explicit coefficients of the independent variable at different quantiles. The quantile regression model is simply created on σ quantile of globalization (ecological footprints) on ecological footprints (globalization) and the quantile regression coefficients can independently index by σ. As discussed previously, the QQ methods takes πth quantile effect of globalization (ecological footprints) on σ quantile of ecological footprints (globalization) at various values of σ and π. Therefore, this method clarifies more inclusive specifics related with globalization and ecological footprints connection linked to the quantile regression model.

Figure 2 confirms the results explained earlier applying the QQ approach. The effect of globalization on ecological footprint is positive particularly at the extreme tails (low and high) in all countries except France, Germany, the UK, and Hungary. The graphs show that the average QQ estimate of the slope coefficients is approximately similar to the QR estimates for all selected countries. These outcomes further check the quantile-on-quantile approach. Figure 2 approves the previous results of the current study that the effect of globalization is positive throughout the quantiles of all selected countries. A negative effect is found in the case of France, the UK, Germany, and Hungary. Furthermore, the results display the existence of heterogeneity between the globalization and ecological footprints in all selected countries. Describing the size of the coefficients, the larger effect of globalization on ecological footprint is found in Sweden, Austria, Belgium, and the Netherlands. A comparatively larger effect is proven in Switzerland, Ireland, Norway, and Portugal; however, a low efficiency is found in the case of Canada, whereas negative larger effect globalization on ecological footprints if found in France, Germany, the UK, and Hungary.

The same description holds when the current study discusses the effect of ecological footprints on globalization. Figure 2 ratifies the results explained formerly using the QQ approach. The effect of an ecological footprint on globalization is positive particularly at the extreme tails (low and high) in all countries except France, Germany, the UK, and Hungary. The graphs display that the average QQ estimate of the slope coefficients is closely related to QR coefficients for all selected countries. The difference is only for the case of France and Denmark where the trend of QQR lines is similar to the QR line; however, the coefficients are slightly different. These results more check the QQ methodology. Figure 2 empowers the previous results of this study that the effect of the ecological footprint is positive throughout the quantiles of all selected countries. A negative effect is found in the case of Germany, France, the UK, and Hungary. Discussing the size of the coefficients, the greater effect of an ecological footprint on globalization is found in Ireland and Portugal. A comparatively greater effect is established in the Belgium, the Netherlands, Switzerland, Sweden, and Norway.

Estimation of Granger causality in quantiles approach

The current study also applies Granger causality in quantiles by using Eq. 5. The results of Granger causality in quantiles are presented in Table 3. It contains the significance value of D_T test for log series. We use the test D_T over an equivalent grid of five quantiles, i.e., (0.05, 0.25, 0.50, 0.75, and 0.95). In Belgium, the results of Table 3 show that fluctuation in globalization does Granger-cause ecological footprints at the 5% level of significance focusing all quantiles of the distribution. However, based on the significant value, it is confirmed that ecological footprints does not Granger cause on globalization at 5% level of significance. In general, the results confirm that there is a uni-directional causal relationship is found from globalization to ecological footprints in all quantile distribution. In the case of Switzerland, Norway, Spain, and Portugal, the causal relationship between globalization and the ecological footprint are significant only in middle quantiles (i.e., 0.25, 0.50, and 0.75), whereas the causal relationship from ecological footprints is insignificant among all quantiles of conditional distribution. Overall, the results of Granger causality in quantiles confirm that a unidirectional causal relationship at 5% level of significance in Switzerland, Norway, Spain, and Portugal where causality is running from globalization to ecological footprints.

Moreover, in the case of Austria, France, Germany, the UK, and Hungary, the causal relationship between globalization and ecological footprints is insignificant in high, medium and low quantiles (i.e., 0.95, 0.50, and 0.05). Similarly, the causal relationship between ecological footprint and globalization is also insignificant in all quantiles of conditional distribution. Generally, the results of Granger causality in quantiles confirm that both variables have no causal relationship at 5% level of significance. On the other hand, the results of the Netherlands, Sweden, Denmark, and Canada are quite similar. The results suggested that a causal relationship from globalization to ecological footprints is significant only in high quantiles, whereas the causal relationship between ecological footprints to globalization is insignificant in all quantiles of conditional distribution. Overall, the results of Granger causality in quantiles confirm that a unidirectional causal relationship between globalization and ecological footprints at 5% level of significance. The causality is running from globalization to ecological footprint, whereas no evidence is found in the case of reverse causality.

In Ireland, the outcomes of Table 3 explain that variation in globalization does Granger-cause ecological footprints at the 5% level of significance aiming low quantiles of the distribution. Though, based on the significant value, it is confirmed that ecological footprints does not Granger cause on globalization at 5% level of significance. Overall, the results confirm that a uni-directional causal relationship is found from globalization to ecological footprints in all quantile distribution.

Conclusion and policy recommendation

The current study investigates the globalization–environment nexus for top globalized countries by utilizing quarterly data from 1970_{QI} to 2016_{QIV}. This study relates quantile-on-quantile (QQ) approach presented by Sim and Zhou (2016). This methodology is applied because it confirms that how various quantiles of globalization affect various quantiles of ecological footprints, hence providing a new complete description of the overall dependence of globalization and

ecological footprints matched to the typical methodology, for instance, OLS or quantile regression. The current study further uses Granger causality in quantiles proposed by Troster (2018) in order to check the causal relationship between the globalization and ecological footprints vice versa.

The empirical results clarify that the linkages between globalization and ecological footprints are mostly positive for all countries even though there is extensive variance throughout countries and also across all quantiles of ecological footprints and globalization in every country. However, the linkages between globalization and ecological footprints are negative in Germany, France, the UK, and Hungary. The heterogeneity between the countries in the globalization–environment nexus could be endorsed to the several factors. It is subject to the degree of differences in considering globalization as a vital element of economic prosperity as well as the level of technical and operational efficiency. Additionally, the Nexus also depends on the potential negative externalities that can arise as a demand from nature in the form of environmental degradation. Moreover, the heterogeneous effect of globalization (ecological footprints) on ecological footprints (globalization) in various countries states that globalization–environment linkages focus on both the stage of technical efficiency, economic period and comparative significance of globalization as an input in economic development. Following this, some countries, for instance, Germany, France, the UK, and Hungary, the most noticeable connection between ecological footprints and globalization is observed throughout the time of high globalization. The results concluded that globalization in these countries does not harm or demand the nature instead of focusing on utilizing technology-oriented resources, whereas the top globalized countries like Belgium, the Netherlands, Switzerland, Sweden, and Austria have a positive effect on ecological footprints.

Moreover, the aim of this study is also to check the newly proposed *Granger* causality in quantiles analysis by Troster (2018). The current study uses Granger-causality in quantiles to investigate whether the change in globalization (ecological footprints) has a causal influence on ecological footprints (globalization) in top globalized countries. Results specify that focusing on the robust *Granger*-causality in quantiles analysis, current research explores that there is an evidence of unidirectional causal relationship between globalization and ecological footprints in all selected countries and the results conclude that the causal relationship of globalization and ecological footprint is significant in Belgium, the Netherlands, Sweden, Denmark, Portugal, Switzerland, Norway, and Spain. The results also found no causal relationship between globalization and ecological footprints in the UK, France, Germany, Austria, and Hungary.

The major query from the investigation pertains to the concern that whether humanity persists to live in the way it is affecting the environment or whether they can amend the trends of globalization in a manner that can have the potential to ameliorate the process of economic development towards the sustainable development, overshadowing the negative effects of globalization. In addition, the emphasis on the eco-friendly corporate practices that can ensure sustainable

Table 3 Granger causality in quantile test results

	0.05	0.25	0.50	0.75	0.95
Belgium					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.344	0.000	0.510	0.000	0.000
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.331	0.000	0.193	0.000	0.268
Netherlands					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.325	0.000	0.179	0.000	0.000
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.579	0.000	0.641	0.000	0.531
Switzerland					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.531	0.000	0.000	0.000	0.482
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.193	0.000	0.225	0.000	0.468
Sweden					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.062	0.000	0.413	0.000	0.000
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.014	0.000	0.124	0.000	0.537
Austria					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.250	0.000	0.200	0.000	0.503
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.662	0.000	0.082	0.000	0.786
Denmark					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.413	0.000	0.462	0.000	0.000
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.268	0.000	0.193	0.000	0.433
France					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.455	0.000	0.359	0.000	0.428
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.455	0.000	0.359	0.000	0.428
UK					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.531	0.000	0.172	0.000	0.476
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.269	0.000	0.069	0.000	0.621
Germany					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.441	0.000	0.372	0.000	0.386
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.742	0.000	0.690	0.000	0.676
Norway					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.297	0.000	0.007	0.000	0.490
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.386	0.000	0.731	0.000	0.766
Hungary					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.186	0.000	0.303	0.000	0.538
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.324	0.000	0.724	0.000	0.469
Ireland					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.000	0.000	0.999	0.000	0.483
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.303	0.000	0.372	0.000	0.497
Canada					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.393	0.000	0.393	0.000	0.000
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.641	0.000	0.448	0.000	0.372
Spain					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.538	0.000	0.000	0.000	0.566
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.742	0.000	0.069	0.000	0.145
Portugal					
$\Delta ECO_t \leftarrow \Delta GLO_t$	0.434	0.000	0.014	0.000	0.566
$\Delta ECO_t \rightarrow \Delta GLO_t$	0.552	0.000	0.172	0.000	0.531

This table presents the subsampling p values of the D_T test. ΔECO_t is the log-difference of ecological footprints in a quarter, and ΔGLO_t is the log difference of overall globalization. $M_i^{\Delta ECO_i}$ is the number of lags of the dependent variable, ΔGLO_t, under the null hypothesis of non-Granger-causality. The subsample size is $\beta = 41$ for a sample of $T = 188$ observations

development should emerge as a counteractive phenomenon. The emphasis on sustainable development is required to be aimed to evaluate how countries are using their natural capacity. By having clarity on the aspects of what causes the natural reserves to decline and what factors can bring positivity in the natural accounts will lead to better understanding of the potentials of business and development opportunities. Furthermore, the management of natural assets will lead to maintaining the goal of environmental finance and green economy.

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