

Globalization and the Nordics Environment: New Insight from Quantile Autoregressive Distributed Lag (Q-ARDL)

O. B. Aworinde¹ and J. O. Badmus²

¹Department of Economics, Pan-Atlantic University,
Lekki, Lagos, Nigeria
Email : oaworinde@pau.edu.ng

²Department of Economics, Tai Solarin University of Education,
Ijebu-Ode, Ogun State, Nigeria
Email : muhammedjamiubadmus@gmail.com

ABSTRACT

This study investigates the possibility of the Environmental Kuznets Curve (EKC) in four NORDIC nations (Denmark, Finland, Norway, and Sweden) while accounting for the role of globalization on their environments. This study utilized the recently developed Quantile Autoregressive Distributed Lag (Q-ARDL) model for the period of 1970Q1-2018Q4. The findings of this approach unveil the existence of the inverted EKC phenomenon for Denmark, Finland, and Norway in the long run while U-shaped EKC holds for Sweden. In addition, there is evidence that overall globalization improves the environment of the four Nordic countries in the short-run and long-run periods. Therefore, this study recommends that the government of these countries should continue to adopt energy-efficient environmental policies to promote a green growth environment. Also, the government should maintain and propagate the continuous improvement of green growth methods through the provision of cleaner energy projects.

Keywords: Globalization; Environment; Ecological Footprint; Environmental Kuznets Curve (EKC); the Nordics; Quantile Autoregressive Distributed Lag (Q-ARDL)

JEL Classification: C22, O1, Q4

1. INTRODUCTION

The growing rate of carbon emission due to the increase in world outputs has consequently played a significant role in environmental degradation across the globe. Thus, this has aroused the interest of policymakers, researchers as well as environmental economists on how to mitigate the externalities through the imposition of environmental taxation and granting subsidies as well as the campaign on the promulgation on renewable energy resources utilisation. Accordingly, the establishment of the Environmental Protection Agency (EPA) in 1970 by the United States government was to proffer solutions to environmental externalities and the Kyoto Protocol reached in 1997 by developed nations to reduce the carbon (CO₂) emission served as a pragmatic approach to curb the menace of environmental degradation. However, before the Kyoto protocol, the NORDIC nations have adopted environmental-related policies to cushion pollution, where Finland takes the lead as the pioneer of the

world carbon tax on energy consumption in 1990. This is closely followed by Norway and Sweden in 1991 and Denmark in 1994. Thus, the continuous effort on how to abate the effect of pollution on the environment actuates the examination of the role of globalisation in environmental degradation-growth nexus in NORDIC nations.

Conventionally, the nexus between the environment and economic growth is explicitly illustrated by the Environmental Kuznets Curve (EKC) phenomenon. The hypothesis states that as the economy progresses, the environment deteriorates at the initial stage of development, however, the continuous increase in economic activities, in the long run, stimulates the quality of the environment (Grossman & Krueger, 1991). Nevertheless, there are some studies (see, *inter alia*, Dogan et al., 2020; Magazzino, 2018; Udemba et al., 2020; Ali et al., 2021; Akadiri et al., 2021; Purcel, 2020; Sarkodie & Ozturk, 2020) that have modeled the EKC phenomenon inappropriately, most especially failing to account for the role of globalisation on the environment. Thus, evaluating the position of environmental deterioration and economic growth in the absence of globalisation could result in a biased conclusion. This is because, in recent time, the interconnectedness among countries through foreign direct investment flows, trade liberalisation, and geographical mobility of the workforce, goods, and services may either influence the environment positively or negatively, therefore, indicating the relevance of globalisation in the EKC model in the NORDIC environments for a proper and adaptable policy proposal.

The evaluation of the effect of globalisation on the environment has generated mixed reactions based on evidence from advanced and developing countries. While the positive influence of globalisation is perceived as a blessing, some of its adverse effects are considered a curse; therefore, suggesting that globalisation is a “double-edged sword”. The favourable contribution of globalisation relates to the fact that it promotes the utilisation of natural resources for the sustainability of the economy through the development of human and material resources, production and exportation of goods and services, exploitation of natural endowments like, *inter alia*, crude oil, natural gas, minerals and coal, free flow of trade among nations and increased flow of foreign direct investment (Suki et al., 2020). In addition, the process of globalisation often demands countries to develop sustainable environmental standards which could in turn have a leverage effect on their socio-cultural and political integration.

Conversely, it has been observed that the process of attaining sustainable environmental and economic progress through globalisation often affects the environment adversely. According to Bilgili et al. (2020), globalisation and its constituents, as well as population growth, contributes to the increasing rate of an ecological footprint because the growing populations demand corresponding increase in production of good and services for domestic consumption, exportation, and importation of machinery (economic globalisation). Meanwhile, urbanisation, as well as socio-cultural changes, promotes urban settlements (social globalisation) thereby leading to the depletion of biodiversity (Suki et al., 2020). Furthermore, globalisation also leads to biocapacity deficit, continuous natural resources consumption, the growing rate of hazardous carbon emission, deforestation, and ecological imbalance (Ahmed et al., 2019).

Focusing on the unfavourable influence of globalisation on the environment, it is obvious that environmental pollution occurs due to the inflow of multinational companies in form of foreign direct investment since the majority of these organisations often overrule the environmental standards of the

nations (Habib-Ur-Rahman et al., 2020). It also affects the growing manufacturing companies in the local environment due to competition and most time the earnings of the foreign companies are expatriated to foreign nations for their development leaving the developing countries as the receiving end.

In the light of these backdrops, our focus to revisits the EKC phenomenon in NORDIC nations by considering the role of globalisation is however motivated by some peculiar reasons. First, our particular interest in these countries is largely due to the economic transformation that the countries have experienced through globalisation in terms of economic competitiveness, civil, and political autonomies as well as the development of human capital (Klaus, 2013). Also, the Nordics have been consistently ranked as global leaders in terms of low carbon energy modulation. According to United Nations' Human Development Index (HDI) ranking, the Nordics have been considered as part of the top 20 most developed countries in the world, especially Norway (Urban & Nordensvärd, 2018). In addition, these countries have propagated a sustainable environment, technological advancement, and globalisation which made it possible in conciliating an efficient economy with social equality (Andersen et al., 2007). Therefore, the need to deliver required policy implications on sustainable ecological consumption and production patterns becomes imperative which is the major thrust of this study.

To further strengthen our discussion on the major innovations of this study, we conceptualise ecological footprint as a measure of environmental degradation compared to the conventional carbon emission index used in previous studies. The essence of utilising the ecological footprint is that it serves as a robust overall index that measures how human being utilises various natural endowments and generate waste in the environment. This measure is considered paramount over carbon emission following its relevance of being able to analyse all aspects of natural resources exploitation which include freshwater, mineral resources, energy resources, fertile land, etc as well as carbon dioxide emission through fossil fuel. Also, Altıntaş & Kassouri (2020) argued in an empirical study that while studying the relationship between economic growth and environmental degradation using the ecological footprint and carbon emission proxy, there is evidence that the former is more relevant to measure environmental degradation compare to the latter.

Furthermore, this study adopts the quantile cointegrating autoregressive distributed lag (Q-ARDL) model to estimates the quantile conditional long-run and the short-run relationship between economic growth, environmental degradation, and overall globalisation. The peculiarity of the methodology includes; first, it can accommodate series that are either purely level stationary, purely first difference stationary, or the mixture, just like symmetric and asymmetric ARDL. Also, the technique helps to locate the asymmetric influence of the explanatory variables over the dependent variable across conditional quantile distribution (Shahbaz et al., 2018). In addition, the Q-ARDL also allows the co-integrating coefficient to vary across the innovative quantile. This shows the superiority of the model against the linear ARDL and nonlinear ARDL bound testing approach that justifies the absence of co-integration among variables of EKC which might be due to the presence of varying quantile dependence (see Xiao, 2009). Lastly, this method also surpasses the asymmetric ARDL in the sense

that asymmetry distribution is determined by the data-driven process rather than the exogenously determined asymmetries.

Also, addressing the importance of globalisation on environmental deterioration is imperative following the understanding that the effect of globalisation is perplexed and as such it requires further investigation. Therefore, this study considered the overall globalisation which measures the combined effect of the economic, political, and social dimensions of globalisation. Thus, this shines more light on the overall influence of globalisation on the environment of the Nordics.

Aside from this section, the remaining parts of this article are organized as follows; the next immediate section presents the empirical literature. This is followed by the data and methodology section, the empirical findings section presents the preliminary and main analyses of this study while the last section wraps up the paper and suggests appropriate policy implications.

2. EMPIRICAL LITERATURE

From a theoretical standpoint, the EKC demonstrates the synergy between ecological debasement and economic growth. Specifically, the hypothesis posits that ecological indicators deteriorate in the process of attaining progressive economic growth, however, in the long run, economic growth tends to improve the quality of the environment (Grossman & Krueger, 1991; Shafik, 1994). The continuous debate on the growth-environment degradation nexus has invented a different approach to capturing the relationship resulting in mixed conclusions. The first strand of the literature includes studies that examined the relationship between the environment and economic growth using the carbon (CO₂) emission as a proxy for environmental deterioration either from a country-specific or panel analysis perspective.

The country-specific examination of the EKC phenomenon using the carbon emission includes studies like Ongan et al. (2021) which evaluates the relationship between environmental degradation and economic growth using decomposed and undecomposed time-series dataset of per-capita income of the United States. The study applies the ARDL technique for the period ranging from January 1990 to July 2019 and reveals that the inverted U-shaped EKC model is valid for the decomposed time series but otherwise for the undecomposed series. Sarkodie and Ozturk (2020) explore the growth-environment nexus in the case of Kenya from 1971 to 2013 using the ARDL, the U-test, and the partial least squares regression techniques. Overall evidence from the study shows that there is the presence of inverted U-shaped EKC in Kenya when the first two outlined techniques are employed. Also, there is evidence that the consumption of energy resources is detrimental to the Kenyan environment in the long run.

Furthermore, Miranda et al. (2020) consider the EKC phenomenon for North America's Free Trade Agreement (NAFTA) countries from 1990 to 2016. The study adopts a variant of econometric techniques like OLS, vector autoregressive (VAR), and Granger causality tests which indicates the validity of the EKC phenomenon in the case of Mexico and the US but otherwise for Canada. Ullah and Khan (2020) examine the validity of EKC in the presence of the green revolution for the Pakistani environment between 1972 and 2014 through the application of the ARDL techniques. The result of the study is sensitive to different factors that influence carbon emission in the country, however, the

study finds that there is the existence of an inverted U-shaped EKC relationship between crops production and carbon emission. Meanwhile, empirical evidence from the Nordics has reported inconsistent conclusions on the validity of the EKC hypothesis. While some categories of studies like, inter alia, Pauli (2003); Shahbaz et al. (2019); Hoffrén and Hellman (2007) and Krström and Lundgren (2005) confirm the presence of inverted U-shaped EKC, per alia, Beşe and Kalayci (2019) and Urban and Nordensvård (2018) confirm the absence of the inverted U-shaped EKC in the Nordics countries. The panel analysis of the first strand includes the study of Akadiri et al. (2021) which examines the EKC phenomenon for a group of sixteen tourism countries from 1995 to 2016. The study adopts the panel ARDL estimator of the pooled mean group (PMG) to estimate the relationship between carbon emission, economic growth, globalisation, and tourism arrivals. The findings of the study revealed evidence of globalisation-tourism induced EKC phenomenon and long term significant positive impact of real gross domestic product and globalisation on carbon emission. The study also documents that there is the presence of feedback relationship between globalisation and carbon emission through the application of the Granger causality test. On the contrary, Demissew Beyene and Kotosz (2020) reveals that when the PMG estimator is applied for a group of twelve East African countries between 1990 and 2013, there is evidence of a U-shaped EKC between environmental degradation proxy by carbon emission and economic growth in the long run, however, there is the presence of inverted U-shaped EKC in the short run.

The role of economic structure is considered in the study of Dogan and Inglesi-Lotz (2020) for a group of Eurozone countries from 1980 to 2014. The study suggests that there is the presence of inverted U-shaped EKC in the region when considering the relationship between overall economic growth and carbon emission using the fully modified ordinary least square (FMOLS) technique. Conversely, Erdogan et al. (2020) adopts the FMOLS with the dynamic OLS and the augmented mean group (AMG) estimators and report that the inverted U-shaped EKC does not exist in the case of twenty-five Organisation for Co-operation and Development (OECD) from 1990 to 2014. Meanwhile, empirical evidence from Ng et al. (2020) reveals that the relationship between environmental degradation and economic growth is sensitive to econometric techniques while considering seventy-six countries between 1971 and 2014. The study support evidence of inverted U-shaped EKC for sixteen out of seventy-six countries when the common correlated effect mean group (CCEMG) estimator is applied, however, the evidence from the AMG technique suggests the existence of inverted U-shaped EKC for twenty-four out of seventy-six countries.

The other strand of the EKC literature is a group of studies that evaluates the relationship between economic growth and environmental degradation proxy with the ecological footprint. The major argument advocated in this category is that the ecological footprint is more robust to measure environmental degradation than the conventional carbon emission index since it evaluates the cumulative human impact on the environment. This category also includes studies that examine the EKC hypothesis from the time series and panel approaches. Focusing on the country-specific analysis, Bulut (2020) reviews the nexus between ecological footprint and economic growth in Turkey from 1970 to 2016 using the ARDL and the dynamic OLS techniques. The study finds evidence supporting the validity of the EKC hypothesis for the period under review. Also, the result further reports evidence

of the negative impact of energy resource consumption on ecological footprint, however, industrialisation is not a significant factor that influences the level of ecological footprint in Turkey.

In addition, Wang (2013) explores the EKC hypothesis for Albania and Sweden using the OLS and the ARDL techniques for the period between 1984 to 2012. The empirical findings of the study show that EKC does not exist in Sweden but there is a presence of EKC hypothesis between ecological footprint and per capita income in Albania. Similarly, Hassan et al. (2019) investigate the contribution of economic growth and natural resources endowments on the ecological footprint in Pakistan through the application of the ARDL estimator. The findings of the study support the EKC hypothesis following the apparent positive impact of natural resources on ecological footprint. Further evidence also supports the feedback causality between the variables. Khan et al. (2020) evaluate the possibility of the EKC phenomenon in China, India, and Pakistan between 1970 and 2016. The study adopts the FMOLS and DOLS techniques which validate the inverted U-shaped EKC for Pakistan but otherwise for China and India.

Furthermore, a group of studies examines the EKC phenomenon by considering the ecological footprint as a proxy of environmental degradation using the Q-ARDL technique. For instance, Suki et al. (2020) review the extant literature of the EKC hypothesis for the Malaysian economy by accounting for the role of globalisation and its components on the environment. The study validates the existence of an inverted U-shaped EKC in Malaysia for the quarterly time series dataset from 1970Q1 to 2018Q4. Also, the evidence shows that overall and economic globalisation promotes ecological footprint while political and social globalisation are found to mitigate the level of ecological footprint in the long run. Aziz et al. (2020) also empirically investigates the validity of EKC in Pakistan from the first quarter of 1990 to the fourth quarter of 2018 while considering the relevance of forestry, agriculture, and renewable energy resources. The findings of the study support the presence of an inverted U-shaped EKC in Pakistan and that renewable energy resource consumption and the forest area contribute to the reduction in environmental degradation in Pakistan. Sharif et al. (2020) also test for the role of renewable and non-renewable energy consumption in Turkey from the first quarter of 1965 to the fourth quarter of 2017. The prevailing estimation technique validates the EKC phenomenon in the country and suggests further that renewable energy consumption contributes to the reduction in environmental degradation in Turkey.

The panel analysis category of the second strand of the EKC literature reviews the hypothesis for different countries with varying conclusions. Gormus and Aydin (2020) investigate the EKC hypothesis for a group of ten innovative countries from 1990 to 2015 using the mean group (MG) and augmented mean group (AMG) estimators within the framework of panel ARDL. The study reports evidence that innovation improves the quality of the environment of the countries; however, the study invalidates the existence of the EKC hypothesis based on the panel analysis. Saqib and Benhmad (2021) review the relationship between ecological footprint and economic growth for some European countries between 1995 to 2015. The study adopts a variant of econometric techniques ranging from PMG, AMG, FMOLS, DOLS to the panel non-causality test and the study reveals that EKC is valid for these countries.

Also, Ansari et al. (2020) consider the review of EKC for thirty-seven Asian nations using the PMG, DOLS, and differenced panel generalised methods of moments (GMM). The study validates the existence of the EKC hypothesis in the Central and Eastern Asia countries while EKC is invalid for other regions. In a similar vein, Al-Mulali et al. (2015) consider the review of the EKC literature for a group of ninety-three countries using the fixed effect regression and GMM techniques. The study considers the relationship between environmental degradation and economic growth based on the countries' income levels and there is evidence that the environment of upper-middle and high-income countries supports the validation of the EKC phenomenon while inverted U-shaped is not valid for the low and lower-middle-income countries. In addition, Ulucak et al. (2020) present the panel analysis for the EKC of emerging countries for the period starting from 1974 to 2016. The study shows that an inverted U-shaped EKC is not valid for the countries, however, there is evidence of favourable impact of financial globalisation on the sustainability of the environment.

From the extant review, it is apparent that studies that have reviewed the nexus between environmental degradation and economic growth have not considered the relationship using ecological footprint index in the case of Nordic countries. Also, the role of globalisation has not been considered to the best of our knowledge by any previous studies on the EKC hypothesis in Nordic countries. Finally, in the aspect of methodology, there is a paucity of studies that have considered the Q-ARDL technique to examine the EKC phenomenon, particularly for the Nordics. Thus, this study further conceptualised the appealing gap.

3. DATA AND METHODOLOGY

3.1 Data Description

To observe the pattern of relationship between economic growth, environmental degradation, and globalization, three variables were used. The variables are real gross domestic product per capita (GDP) proxy for economic growth, overall globalization index (GLOB), and ecological footprints (EFT) proxy for environmental degradation. The three variables were sourced from three different sources; first, the dataset of real GDP per capita was sourced from the World Bank World Development Indicator (WDI). Second, times series data on GLOB were collected from the KOF Swiss Economic Institute website¹, and third, the EFT per capita was retrieved from the website of Global Footprint Network². This study collected yearly data for four Nordic nations, namely Denmark, Finland, Norway, and Sweden for the period covering 1970-2018. In addition, the yearly time series were interpolated into quarterly time series using the quadratic match-sum approach, thus, amounting to one hundred and ninety-six (196) observations. The rationale for this approach includes; first, it helps to account for occasional discrepancies in the data generating process as the data collected are litigated from a smaller observation to a larger number of observations by dangling the serial changes in the dataset (Shahbaz et al., 2018; Sharif, Afshan, et al., 2020). Second, the procedure is more sufficient when compared to other interpolation processes as it provides an average match of the dataset (Arain et al., 2020).

¹ <https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html>

² <http://data.footprintnetwork.org/#/>

3.2 Method

Theoretically, the EKC phenomenon draws its formulation from the seminar paper of Kuznets (1955) which postulates that an inverted U-shaped relationship exists between income inequality and economic growth. Further investigation on the validity of this hypothesis led to its development in environmental economics. Accordingly, Grossman & Krueger (1991) evaluates the effect of economic activity expansion on the environment and suggest that periods of low economic activity are characterised by a high level of environmental degradation, however, periods of high growth level improve the quality of the environment. Hence, this scenario is termed the EKC phenomenon. This evidence further led to the continuous investigation of whether the expansion in economic growth level is responsible for environmental degradation. Meanwhile, some studies have modeled this relationship inappropriately due to the inability to account for the role of globalisation in the model. Thus, this study examines the quantile dependent association between ecological footprint, economic growth, and globalisation using the recently developed Q-ARDL technique by Cho et al. (2015). The technique is the advanced version of the linear ARDL which can capture the possibility of an asymmetric association between EFT, GDP, and GLOB. Thus, we begin the specification with the linear ARDL as follow;

$$EFT_t = \beta_0 + \alpha_1 GDP_t + \alpha_2 GDP_t^2 + \alpha_3 GLOB_t + \varepsilon_t \quad (1)$$

The specification in equation (1) represents the long-term EKC model where EFT is ecological footprints, GDP is the real gross domestic product per capita, GDP^2 is the squared term of real gross domestic product per capita, GLOB represents overall globalization, and ε_t is the white noise residual. In addition, EFT, GDP, GDP^2 , and GLOB represent the natural logarithm of the series. Separating the long-run effects from the short-run effects of economic growth and globalization on ecological footprint, a new equation is written in an error-correction modeling form as

$$\begin{aligned} \Delta EFT_t = & \beta + \sum_{i=1}^{p_1} \Phi_i \Delta EFT_{t-k} + \sum_{i=0}^{q_1} \Psi_i \Delta GDP_{t-k} + \sum_{i=0}^{q_2} \omega_i \Delta GDP_{t-k}^2 + \sum_{i=0}^{q_3} \delta_i \Delta GLOB_{t-k} + \rho EFT_{t-1} \\ & + \alpha_1 GDP_{t-1} + \alpha_2 GDP_{t-1}^2 + \alpha_3 GLOB_{t-1} + \varepsilon_t \end{aligned} \quad (2)$$

Equation (2) corrects for the possibility of autocorrelation where the p_1 , q_1 , q_2 and q_3 are the optimal lag orders based on Schwarz Information Criterion (SIC). The first differenced variables reflect the short-term effect of economic growth and globalization on ecological footprint. To achieve symmetry cointegration as proposed by Pesaran et al. (2001), the F-test for bounds test to cointegration was used. With the achievement of cointegration in equation (2), the coefficients of $\alpha_1 - \alpha_3$ are normalized on ρ to yield the long-term effects of all the regressors.

Complementing the objective stated in the introductory section to account for the quantile dependent relationship among the variables using the Q-ARDL, equation (2) is re-written as;

$$Q_{\Delta EFT_t} = \beta(\tau) + \rho(\tau)EFT_{t-1} + \alpha_1(\tau)GDP_{t-1} + \alpha_2(\tau)GDP_{t-1}^2 + \alpha_3(\tau)GLOB_{t-1} + \sum_{i=1}^{p_1} \Phi_i(\tau) \Delta EFT_{t-k} \\ + \sum_{i=0}^{q_1} \Psi_i(\tau) \Delta GDP_{t-k} + \sum_{i=0}^{q_2} \omega_i(\tau) \Delta GDP_{t-k}^2 + \sum_{i=0}^{q_3} \delta_i(\tau) \Delta GLOB_{t-k} + \varepsilon_t(\tau) \quad (3)$$

where, $\varepsilon_t(\tau) = EFT_t - Q_{EFT_t}(\tau/\varepsilon_{t-1})$ and $0 < \tau < 1$ shows the quantile. The study employs the eleven (11) successive quantiles (τ) of (0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.8, 0.9 and 0.95) in the estimation process. Following Cho et al. (2015)'s specification, the quantile dependent error correction model is specified as:

$$Q_{\Delta EFT_t} = \beta(\tau) + \rho(\tau)[EFT_{t-1} - \alpha_1(\tau)GDP_{t-1} - \alpha_2(\tau)GDP_{t-1}^2 - \alpha_3(\tau)GLOB_{t-1}] + \sum_{i=1}^{p_1} \Phi_i(\tau) \Delta EFT_{t-k} \\ + \sum_{i=0}^{q_1} \Psi_i(\tau) \Delta GDP_{t-k} + \sum_{i=0}^{q_2} \omega_i(\tau) \Delta GDP_{t-k}^2 + \sum_{i=0}^{q_3} \delta_i(\tau) \Delta GLOB_{t-k} + \varepsilon_t(\tau) \quad (4)$$

The sum of lagged short run effects of ecological footprints on the current ecological footprint is computed as $\Phi_* = \sum_{k=1}^r \Phi_k$. In addition, $\Psi_* = \sum_{k=1}^r \Psi_k$, $\omega_* = \sum_{k=1}^r \omega_k$ and $\delta_* = \sum_{k=1}^r \delta_k$, represents the cumulative effects short run effects of GDP, GDP² and GLOB, respectively. Also, the long run cointegrating parameters for GDP, GDP² and GLOB are calculated as $\alpha_{1*} = -\Phi_{GDP}/\rho$, $\alpha_{2*} = -\Phi_{GDP^2}/\rho$ and $\alpha_{3*} = -\Phi_{GLOB}/\rho$, respectively. It is worthy to note that the quantile dependent error correction term “ ρ ” in equation (4) should be negative and statistically significant to achieve long run equilibrium.

Finally, to ascertain the possibility of quantile dependent short run, long run and asymmetric adjustment effects of GDP, GDP² and GLOB on EFT, the Wald test which follows a Chi-squared distribution was used. For instance, the null hypothesis of the quantile dependent error correction term ρ , holds that $H_0: \rho_*(0.05) = \rho_*(0.10) = \rho_*(0.20) = \rho_*(0.30) = \dots = \rho_*(0.90) = \rho_*(0.95)$. Also, the long-run estimates were tested for $\alpha_1 GDP$, $\alpha_2 GDP^2$ and $\alpha_3 GLOB$ and the short run parameters were tested for specific lags for Φ_* , Ψ_* , ω_* and δ_* .

4. EMPIRICAL FINDINGS

4.1 Preliminary Analysis

The descriptive statistics of economic growth, overall globalization, and ecological footprint are reported in Table 1. The analyses show that EFT is positively skewed for all countries except Denmark which is negatively skewed. In addition, the GDP is positively skewed in Finland and Sweden, whereas it was negatively skewed in Denmark and Norway. Furthermore, globalization is negatively skewed for all the four countries under review. The results imply that variables that are negatively (positively) skewed have longer right (left) tails than the normal distribution. The null of normality was rejected because Jacque Bera statistics are statistically significant for all the variables of interest in the four NORDIC countries. The non-normality of these variables allows the study to use the Q-ARDL model which accounts for non-linearity and asymmetry in the time series dataset (Aziz et al., 2020; Godil et al., 2020).

4.2 Unit root tests

Asides from the descriptive statistics analysis, this study also examines the time series statistical properties of the variables through the Augmented Dickey-Fuller (ADF, 1979) and Phillip-Perron (PP, 1988) unit root tests. Due to the weak power of these tests, this study employs the Zivot and Andrews (ZA, 2002) unit root test to determine the order of integration of the variables while accounting for a structural break.

From Table 2, the conventional unit root tests (ADF & PP) show that majority of the series have unit root at level form. Thus, to make the variables stationary, we perform the unit root tests on the first differenced series of the variables. The result later showed that they were stationary in their first differences. In sharp contrast to the traditional unit root tests, the analysis of the ZA test revealed that some series are stationary at level form with one structural break, while some were first difference stationary. The majority of the breaks identified range from 1989Q4 to 2008Q4 which concise with the Gulf War in 1990, the Oil price surge of 1999, and the Global Financial Crisis of 2008. In sum, the results suggest that the variables employed in this study are fractionally integrated [$I(0)$ and $I(1)$], therefore, in line with our objective, the Q-ARDL is the appropriate approach to determine the quantile dependent relationship among the variables.

Table 1: Descriptive Statistics

Denmark									
Variables	Mean	Max	Min	Skewness	Kurtosis	Std. Dev.	Jarque-Bera	Prob	Obs
EFT	2.08	2.42	1.69	-0.64	2.42	0.19	16.25	0.00	196
GDP	11982.31	16090.89	7588.59	-0.15	1.58	2626.24	17.12	0.00	196
GLOB	20.38	22.32	17.29	-0.35	1.80	1.60	15.93	0.00	196
Finland									
Variables	Mean	Max	Min	Skewness	Kurtosis	Std. Dev.	Jarque-Bera	Prob	Obs
EFT	1.68	2.03	1.30	0.06	2.25	0.17	4.69	0.09	196
GDP	8669.09	12516.14	4578.6	0.03	1.60	2464.11	16.06	0.00	196
GLOB	19.16	21.92	14.46	-0.43	1.81	2.34	17.63	0.00	196
Norway									
Variables	Mean	Max	Min	Skewness	Kurtosis	Std. Dev.	Jarque-Bera	Prob	Obs
EFT	1.93	2.85	1.37	0.63	1.97	0.44	21.53	0.00	196
GDP	16871.48	23029.47	7908.8	-0.26	1.62	4916.27	17.64	0.00	196
GLOB	19.93	21.71	17.36	-0.29	1.71	1.33	16.32	0.00	196
Sweden									
Variables	Mean	Max	Min	Skewness	Kurtosis	Std. Dev.	Jarque-Bera	Prob	Obs
EFT	1.67	2.21	1.30	1.12	3.88	0.20	47.4	0.00	196
GDP	10156.64	14530.24	6597.31	0.29	1.68	2486	17.13	0.00	196
GLOB	20.5	22.66	17.49	-0.22	1.59	1.67	17.88	0.00	196

Source: Authors' computation

Notes: Table 1 shows the mean, maximum, minimum, standard deviation and Jarque-Bera statistics of the variables. The dependent variable is ecological footprints (EFT), GDP per capita (GDP) and overall globalization (GLOB).

Table 2: Unit Root tests

Denmark				
Variables	ADF	PP	ZA	Break Dates
EFT	-0.994	-1.523	-6.390**	2008Q4
ΔEFT	-8.768***	-8.614***	-13.807***	2008Q2
GDP	-2.293	-1.601	-5.150*	2008Q2
ΔGDP	-6.718***	-6.791***	-8.824***	2008Q2
GLOB	-2.865	-2.204	-4.751	1999Q2
ΔGLOB	-7.807***	-7.825***	-11.029***	1990Q4
Finland				
EFT	-1.874	-2.806	-5.804*	2000Q4
ΔEFT	-7.842***	-7.846***	-10.362***	1993Q2
GDP	-2.963	-1.883	-4.510	2010Q2
ΔGDP	-5.277***	-5.358***	-5.570***	2008Q2
GLOB	-4.329***	-3.040**	-3.475	1999Q2
ΔGLOB	-7.155***	-7.165***	-10.552***	1990Q3
Norway				
EFT	-1.094	-1.415	-6.219**	1989Q4
ΔEFT	-8.110***	-8.069***	-10.950***	1992Q1
GDP	-9.825***	-5.313***	-3.881	1999Q2
ΔGDP	-4.014***	-3.877**	-5.954**	2007Q2
GLOB	-2.441	-1.811	-4.509	1999Q2
ΔGLOB	-7.018***	-7.093***	-8.708***	1990Q3
Sweden				
EFT	-3.045*	-3.635**	-7.986***	1994Q3
ΔEFT	-9.063***	-8.848***	-15.436***	2005Q3
GDP	-0.347	-0.411	-4.238	2001Q2
ΔGDP	-6.222***	-6.308***	-7.350***	1993Q2
GLOB	-2.558	-1.840	-4.177	1996Q2
ΔGLOB	-7.015***	-7.065***	-9.758***	1990Q2

Source: Authors' computation

Notes: Table 2 shows the unit root tests for Augmented Dickey Fuller (ADF), Phillip-Perron (PP) and Zivot and Andrews (ZA) unit root test with one structural break, the variables are ecological footprints (EFT), GDP per capita (GDP) and overall globalization (GLOB). ***, ** and * represent level of significance at 1, 5 and 10 percent, respectively.

4.3 Analysis of the symmetric ARDL and the Q-ARDL models

The regression results of the linear ARDL and Q-ARDL are presented in Tables 3-6 for Denmark, Finland, Norway, and Sweden, respectively. From the Tables, the linear ARDL shows that there is the presence of a linear cointegrating relationship among EFT, GDP, GDP², and GLOB for Denmark, Finland, and Sweden, since the linear error correction coefficient ρ^* of these countries are statistically significant and negative. Meanwhile, the speed of adjustment term for Norway is statistically insignificant but negative. Among these nations, the slowest speed of adjustment is recorded in Norway with 1.8%, followed by Denmark with 4.5%, Sweden with 12.3%, and the fastest is accorded to Finland with 28.7%. In addition, the symmetric long-run cointegrating coefficients between EFT and

GDP, EFT and GDP², and EFT and GLOB are found to be significant in Denmark and Sweden. GLOB is only negatively significantly related to ecological footprints in the long run for Finland. However, there is an absence of a long-run relationship among the variables in Norway.

In Tables 3-6, the Q-ARDL regression result across eleven innovative quantiles for the variables is reported. Specifically, the quantile cointegrating error correction term (ρ^*), the long-term parameters (α_i), short-term parameters (Φ , Ψ , ω , and δ) and their respective standard errors were reported in these tables. The Q-ARDL model shows that the coefficient (ρ^*), is highly significant at the lower, middle, and upper quantiles at 5% and 1% in Denmark, Finland, and Sweden. However, the parameter only shows weak significance at the lower quantiles only for Norway. In addition, the parameters of the speed of adjustment were all negative; this further suggests long-run equilibrium adjustment among the variables.

Furthermore, the results show that α GDP is positive and highly significant across all quantiles of EFT in Denmark. Also, α GDP is only significant and positively related to EFT at the 0.95 quantiles in Finland and the 0.60 quantiles for Norway. In sharp contrast, α GDP is significant and negatively related to EFT in Sweden from the 0.2 to 0.8 quantiles. This negates the proposition that economic growth degrades the environment at the initial stage of development due to the findings that economic growth improves the Swedish environment in the short-run period.

Also, the α GDP² are negative and statistically significant for all quantiles of ecological footprint in Denmark. Similar results were only found in the 0.95 and 0.60 quantiles for Finland and Norway respectively. This suggests evidence of the EKC in Denmark, Finland, and Norway. This was supported by Shahbaz et al. (2019) for Sweden and Urban and Nordensvärd (2018) for Denmark, Finland, and Sweden. Conversely, the squared of economic growth is positively related to ecological footprints for 0.2 to 0.8 quantiles in Sweden. This shows the absence of the EKC in Sweden which was also reported by Lindmark and Acar (2014) for Sweden and Skonhoft and Solem (2001) for Norway.

The results for α GLOB are negative and statistically significant for most of the quantiles of EFT for all the four sampled NORDIC countries. This suggests that globalization helps in reducing environmental degradation in these countries in the long run. These findings corroborate with that of Shahbaz et al. (2018) for the Netherlands, Ahmed et al. (2019), and Suki et al. (2020) for Malaysia that political and social globalization reduces environmental degradation.

Next is the analysis of the short-run models, the results reveal that the lagged term of EFT has a significant and negative influence on current EFT for all the four NORDIC nations. Also, the cumulative lagged and present values of GDP and GDP² are statistically significant across all quantiles of EFT in Denmark and Norway. The cumulative present and previous values of GDP and GDP² are insignificant for all the quantiles of EFT in Finland and Sweden.

Meanwhile, in the short run, the lagged and current changes in GLOB are negatively related but do not significantly affect current changes in EFT for Denmark. In sharp contrast, the lagged and current changes of GLOB are significantly related to EFT in Finland, Norway, and Sweden. It should be noted that for Sweden, the lagged and current changes in GLOB has a positive and significant influence on EFT only across the lower and latter part of the upper quantiles.

Table 3: ARDL Estimation and Quantile Autoregressive Distributed Lag (Q-ARDL) Results for Denmark

ARDL Estimation Results

β^*	ρ^*	αGDP	αGDP^2	$\alpha GLOB$	Φ_1	Ψ_1	ω_1	δ_1
-29.255*** (3.967)	-0.045** (0.020)	15.456*** (1.984)	-1.863*** (0.242)	-1.881*** (0.369)	-0.343*** (0.076)	23.313*** (6.189)	-2.697*** (0.766)	-0.010 (0.366)

Quantile ARDL Estimation Results

Quantiles	$\beta^*(\tau)$	$\rho^*(\tau)$	$\alpha GDP(\tau)$	$\alpha GDP^2(\tau)$	$\alpha GLOB(\tau)$	$\Phi_1(\tau)$	$\Psi_1(\tau)$	$\omega_1(\tau)$	$\delta_1(\tau)$
0.05	-30.882*** (5.174)	-0.131** (0.061)	16.757*** (2.588)	-1.962*** (0.315)	-3.455*** (0.481)	-0.022 (0.017)	22.274*** (6.233)	-2.569*** (0.771)	-0.084 (0.365)
0.10	-35.952*** (5.739)	-0.143** (0.064)	19.124*** (2.871)	-2.274*** (0.349)	-2.989*** (0.534)	-0.028** (0.010)	22.489*** (6.230)	-2.596*** (0.771)	-0.076 (0.365)
0.20	-35.365*** (4.582)	-0.232* (0.119)	18.649*** (2.292)	-2.250*** (0.279)	-2.259*** (0.426)	-0.036*** (0.011)	22.226*** (6.295)	-2.563*** (0.779)	-0.081 (0.367)
0.30	-30.847*** (4.601)	-0.333* (0.159)	16.298*** (2.301)	-1.974*** (0.280)	-1.883*** (0.428)	-0.073*** (0.019)	22.281*** (6.291)	-2.569*** (0.778)	-0.066 (0.367)
0.40	-30.479*** (6.910)	-0.429 (0.319)	15.965*** (3.456)	-1.956*** (0.421)	-1.354** (0.642)	-0.132*** (0.033)	22.406*** (6.304)	-2.584*** (0.780)	-0.062 (0.368)
0.50	-34.844*** (7.485)	-0.430 (0.343)	18.180*** (3.744)	-2.221*** (0.456)	-1.555** (0.696)	-0.208*** (0.067)	22.482*** (6.287)	-2.594*** (0.778)	-0.065 (0.368)
0.60	-18.618*** (7.032)	-0.450*** (0.119)	10.045*** (3.517)	-1.203*** (0.428)	-1.530** (0.654)	-0.245*** (0.103)	24.540*** (6.171)	-2.847*** (0.764)	0.061 (0.368)
0.70	-10.784*** (3.843)	-0.468*** (0.148)	6.032*** (1.922)	-0.716*** (0.234)	-1.194*** (0.357)	-0.258*** (0.108)	25.601*** (6.190)	-2.977*** (0.766)	0.108 (0.370)
0.80	-12.552*** (2.693)	-0.449*** (0.118)	6.920*** (1.347)	-0.824*** (0.164)	-1.235*** (0.250)	-0.344*** (0.118)	25.657*** (6.189)	-2.984*** (0.766)	0.108 (0.370)
0.90	-15.686*** (4.497)	-0.447** (0.219)	8.406*** (2.249)	-1.024*** (0.274)	-0.920** (0.418)	-0.356*** (0.121)	24.897*** (6.187)	-2.891*** (0.766)	0.083 (0.370)
0.95	-8.362 (5.604)	-0.468** (0.219)	4.623 (2.803)	-0.585* (0.341)	-0.319 (0.521)	-0.405*** (0.125)	24.222*** (6.202)	-2.807*** (0.768)	0.062 (0.372)

Source: Authors' Computation Notes: Table 3 reports the ARDL and quantile ARDL results. The standard errors are in parenthesis and they are calculated using the delta method emphasized in Cho *et al.* (2015). ***, ** and * indicate significance at 1, 5 and 10 per cent levels respectively. The lag lengths are selected using the Schwarz Information Criteria.

Table 4: ARDL Estimation and Quantile Autoregressive Distributed Lag (Q-ARDL) Results for Finland
ARDL Estimation Results

	β^*	ρ^*	αGDP	αGDP^2	$\alpha GLOB$	Φ_1	Ψ_1	ω_1	δ_1
	0.065 (2.748)	-0.287*** (0.089)	0.701 (1.433)	0.003 (0.179)	-2.064*** (0.195)	-0.062** (0.013)	-1.086 (4.808)	0.366 (0.610)	-2.346*** (0.395)
Quantile ARDL Estimation Results									
Quantiles	$\beta^*(\tau)$	$\rho^*(\tau)$	$\alpha GDP(\tau)$	$\alpha GDP^2(\tau)$	$\alpha GLOB(\tau)$	$\Phi_1(\tau)$	$\Psi_1(\tau)$	$\omega_1(\tau)$	$\delta_1(\tau)$
0.05	5.412 (7.884)	-0.183*** (0.032)	-1.974 (4.113)	0.360 (0.513)	-2.367*** (0.558)	0.062 (0.041)	-2.697 (4.807)	0.571 (0.610)	-2.362*** (0.396)
0.10	0.373 (5.697)	-0.185*** (0.037)	0.673 (2.972)	0.024 (0.370)	-2.501*** (0.404)	0.066 (0.043)	-3.108 (4.820)	0.621 (0.612)	-2.413*** (0.398)
0.20	-0.078 (3.436)	-0.186*** (0.042)	0.831 (1.793)	-0.016 (0.223)	-2.138*** (0.243)	0.069 (0.035)	-3.371 (4.800)	0.651 (0.609)	-2.469*** (0.397)
0.30	-3.535 (2.977)	-0.198*** (0.053)	2.548 (1.553)	-0.246 (0.194)	-1.926*** (0.211)	-0.071 (0.046)	-2.320 (4.796)	0.516 (0.608)	-2.452*** (0.397)
0.40	-1.606 (3.070)	-0.207*** (0.055)	1.525 (1.602)	-0.116 (0.200)	-1.850*** (0.217)	-0.075 (0.051)	-1.745 (4.791)	0.445 (0.608)	-2.414*** (0.395)
0.50	-2.127 (4.242)	-0.217*** (0.058)	1.797 (2.213)	-0.148 (0.276)	-1.896*** (0.301)	-0.077 (0.046)	-1.350 (4.800)	0.396 (0.609)	-2.391*** (0.395)
0.60	-2.914 (4.518)	-0.225*** (0.062)	2.245 (2.357)	-0.194 (0.294)	-2.094*** (0.320)	-0.083*** (0.011)	-0.933 (4.820)	0.345 (0.611)	-2.354*** (0.396)
0.70	1.731 (4.628)	-0.234*** (0.073)	-0.226 (2.414)	0.123 (0.301)	-1.947*** (0.328)	-0.094*** (0.026)	0.963 (4.888)	0.108 (0.619)	-2.217*** (0.395)
0.80	-1.785 (3.071)	-0.238*** (0.077)	1.559 (1.602)	-0.111 (0.200)	-1.846*** (0.218)	-0.105*** (0.031)	1.324 (4.914)	0.061 (0.622)	-2.229*** (0.395)
0.90	-7.154 (5.296)	-0.242*** (0.082)	4.406 (2.763)	-0.462 (0.344)	-2.147*** (0.375)	-0.116*** (0.037)	1.018 (4.931)	0.098 (0.624)	-2.254*** (0.397)
0.95	-13.454*** (4.521)	-0.255*** (0.088)	7.717*** (2.358)	-0.871*** (0.294)	-2.439*** (0.320)	-0.123*** (0.042)	1.033 (4.993)	0.095 (0.632)	-2.247*** (0.400)

See Table 3 notes

Table 5: ARDL Estimation and Quantile Autoregressive Distributed Lag (Q-ARDL) Results for Norway
ARDL Estimation Results

	β^*	ρ^*	αGDP	αGDP^2	$\alpha GLOB$	Φ_1	Ψ_1	ω_1	δ_1
	2.532 (3.442)	-0.018 (0.026)	-0.756 (1.500)	-0.003 (0.189)	0.746 (0.710)	-0.214*** (0.057)	-15.174* (7.959)	1.924** (0.967)	1.352* (0.773)
Quantile ARDL Estimation Results									
Quantiles	$\beta^*(\tau)$	$\rho^*(\tau)$	$\alpha GDP(\tau)$	$\alpha GDP^2(\tau)$	$\alpha GLOB(\tau)$	$\Phi_1(\tau)$	$\Psi_1(\tau)$	$\omega_1(\tau)$	$\delta_1(\tau)$
0.05	2.359 (2.525)	-0.039 (0.024)	-1.679 (1.100)	0.045 (0.138)	3.173*** (0.521)	-0.131 (0.112)	-16.116** (7.846)	2.025** (0.951)	1.243 (0.760)
0.10	4.311 (4.567)	-0.042* (0.023)	-2.733 (1.990)	0.168 (0.250)	3.421*** (0.942)	-0.146 (0.124)	-15.955** (7.831)	2.007** (0.950)	1.226 (0.758)
0.20	3.163 (5.392)	-0.041* (0.022)	-2.095 (2.349)	0.093 (0.296)	3.268*** (1.113)	-0.150 (0.122)	-16.242** (7.843)	2.040** (0.951)	1.236 (0.759)
0.30	3.096 (4.638)	-0.032 (0.025)	-1.555 (2.021)	0.060 (0.254)	2.028** (0.957)	-0.153** (0.071)	-15.398* (7.876)	1.944** (0.956)	1.273* (0.766)
0.40	3.167 (4.876)	-0.025 (0.027)	-1.304 (2.124)	0.049 (0.267)	1.318 (1.006)	-0.177** (0.087)	-15.044* (7.924)	1.905** (0.962)	1.306* (0.770)
0.50	-3.185 (4.669)	-0.010 (0.026)	1.964 (2.034)	-0.332 (0.256)	0.836 (0.964)	-0.184*** (0.059)	-15.331* (8.023)	1.946** (0.975)	1.412* (0.773)
0.60	-4.593 (4.529)	-0.011 (0.033)	3.319* (1.973)	-0.457* (0.248)	-0.766 (0.935)	-0.197*** (0.068)	-16.626** (8.088)	2.114** (0.984)	1.564** (0.775)
0.70	-1.770 (4.164)	-0.017 (0.028)	2.384 (1.814)	-0.319 (0.228)	-1.780** (0.859)	-0.204*** (0.071)	-17.079** (8.083)	2.172** (0.983)	1.619** (0.777)
0.80	-1.564 (6.152)	-0.021 (0.035)	2.512 (2.680)	-0.319 (0.337)	-2.345* (1.270)	-0.212*** (0.079)	-17.696** (8.153)	2.249** (0.992)	1.660** (0.777)
0.90	3.222 (5.103)	-0.027 (0.037)	0.658 (2.223)	-0.056 (0.280)	-3.605*** (1.053)	-0.223* (0.112)	-19.184** (8.653)	2.421** (1.050)	1.682** (0.780)
0.95	2.954** (1.213)	-0.041 (0.029)	0.806 (0.528)	-0.069 (0.066)	-3.686*** (0.250)	-0.236* (0.114)	-19.551** (8.807)	2.464** (1.068)	1.684** (0.780)

See Table 3 notes

Table 6: ARDL Estimation and Quantile Autoregressive Distributed Lag (Q-ARDL) Results for Sweden
ARDL Estimation Results

	β^*	ρ^*	αGDP	αGDP^2	$\alpha GLOB$	Φ_1	Ψ_1	ω_1	δ_1
	31.536*** (5.633)	-0.123*** (0.037)	-15.181*** (2.890)	1.903*** (0.353)	-0.812** (0.348)	-0.004*** (0.002)	-16.669 (17.077)	2.280 (2.119)	1.783 (1.103)
Quantile ARDL Estimation Results									
Quantiles	$\beta'(\tau)$	$\rho'(\tau)$	$\alpha GDP(\tau)$	$\alpha GDP^2(\tau)$	$\alpha GLOB(\tau)$	$\Phi_1(\tau)$	$\Psi_1(\tau)$	$\omega_1(\tau)$	$\delta_1(\tau)$
0.05	12.164 (11.150)	-0.116*** (0.036)	-5.199 (5.719)	0.680 (0.699)	-1.597** (0.689)	0.103 (0.113)	-18.773 (17.229)	2.546 (2.138)	1.756 (1.109)
0.10	34.000*** (11.464)	-0.119*** (0.035)	-16.305*** (5.881)	2.073*** (0.718)	-1.361* (0.709)	0.117 (0.112)	-12.126 (16.904)	1.726 (2.097)	1.973* (1.090)
0.20	28.540*** (6.801)	-0.120*** (0.037)	-13.763*** (3.489)	1.728*** (0.426)	-0.738* (0.421)	-0.126 (0.102)	-12.867 (16.936)	1.807 (2.101)	1.862* (1.098)
0.30	26.613*** (6.349)	-0.122*** (0.038)	-12.799*** (3.257)	1.603*** (0.398)	-0.678* (0.393)	-0.132 (0.102)	-13.978 (16.976)	1.943 (2.106)	1.822* (1.101)
0.40	27.342*** (6.156)	-0.125*** (0.041)	-13.068*** (3.158)	1.636*** (0.386)	-0.803** (0.381)	-0.203* (0.102)	-18.231 (17.169)	2.473 (2.130)	1.735 (1.108)
0.50	30.344*** (6.011)	-0.128*** (0.043)	-14.633*** (3.084)	1.824*** (0.377)	-0.604 (0.372)	-0.224** (0.082)	-18.534 (17.197)	2.508 (2.134)	1.728 (1.110)
0.60	32.566*** (6.146)	-0.132*** (0.046)	-15.757*** (3.153)	1.969*** (0.385)	-0.637* (0.380)	-0.235*** (0.072)	-16.598 (17.080)	2.269 (2.119)	1.783 (1.104)
0.70	32.613*** (7.259)	-0.137*** (0.048)	-15.665*** (3.724)	1.960*** (0.455)	-0.838* (0.449)	-0.256*** (0.082)	-20.085 (17.289)	2.705 (2.145)	1.726 (1.110)
0.80	33.578*** (9.085)	-0.141*** (0.051)	-16.218*** (4.660)	2.021*** (0.569)	-0.624 (0.562)	-0.277*** (0.092)	-19.867 (17.286)	2.675 (2.145)	1.718 (1.111)
0.90	10.188 (19.809)	-0.144*** (0.053)	-3.949 (10.161)	0.552 (1.241)	-2.258* (1.225)	-0.310*** (0.102)	-17.284 (17.127)	2.371 (2.126)	1.849* (1.101)
0.95	5.339 (21.837)	-0.147*** (0.062)	-1.296 (11.202)	0.267 (1.368)	-3.162** (1.350)	-0.311*** (0.103)	-9.942 (16.890)	1.470 (2.095)	2.102* (1.086)

See Table 3 notes

The Wald test results are reported in Table 7. From the Table, the assumption of parameter constancy for the error correction term is rejected for all the four NORDIC countries except Norway. The results also support evidence of a long-term relationship between αGDP and αGDP^2 in Denmark and Sweden validating the significance of nonlinear long-term association between EFT and GDP and EFT and GDP^2 in the Danish and Swedish economies. However, the null hypothesis of symmetric long-term association was not rejected for Finland and Norway. For GLOB on EFT, the assumption of parameter constancy was rejected according to the Wald statistics for all the four NORDIC countries. Also, in Table 7, we report the Wald test used to check for parameter constancy across all the quantiles for the short-term effect of the lagged values of ecological footprint for all the countries examined. Furthermore, the outcomes of the test show that GDP and GDP^2 maintain a quantile dependent past and current effect on EFT due to the output of the Wald tests that negate the H_0 of parameter constancy across quantiles only in Denmark and Norway. Also, the study did not suggest the nonlinear impact of GDP and GDP^2 on EFT in the short run for Finland as well as Sweden.

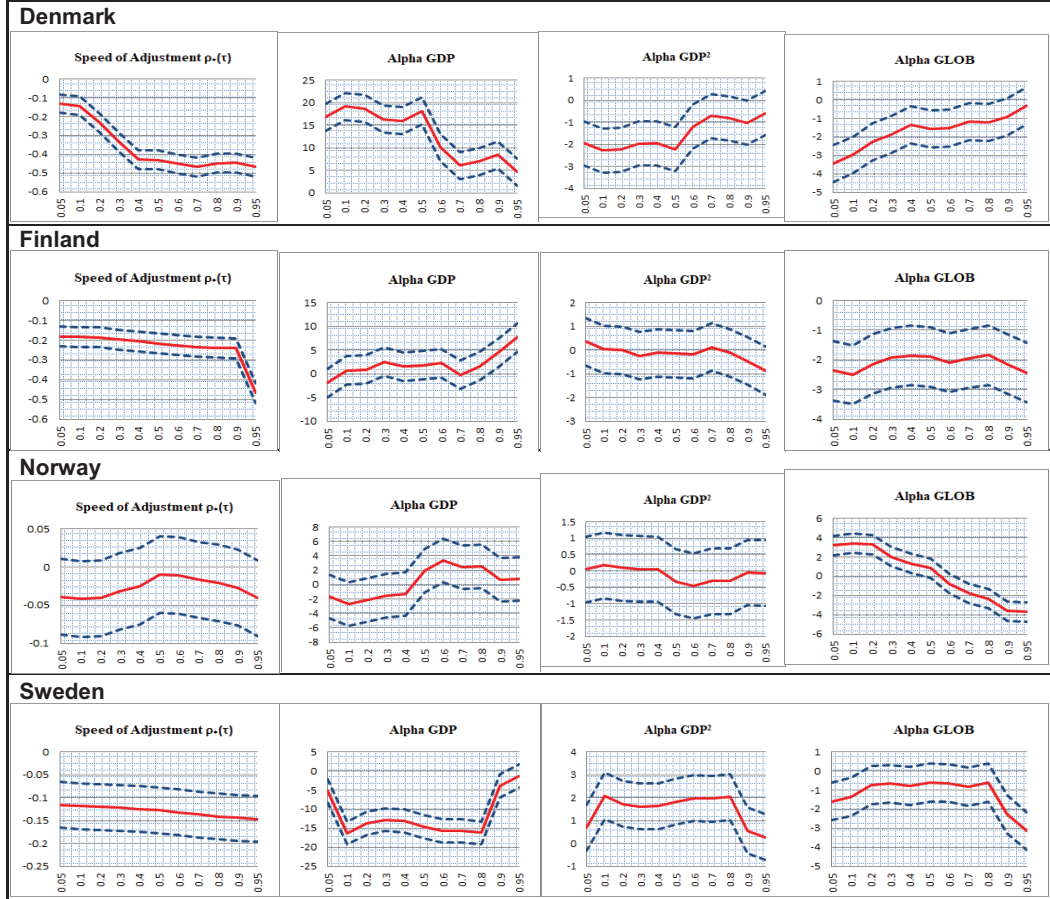
Regarding the short-term impact of GLOB on EFT, it is apparent that there is an asymmetric relationship between the variables in Finland, Norway, and Sweden ditto to the outcomes of the Wald statistics that reject the H_0 of parameter constancy for the three NORDIC nations. Conversely, there is an absence of a nonlinear quantile relationship between GLOB and EFT in Denmark due to the insignificant value of the Wald statistics.

Table 7: Parameter Stability Wald test Results

Variables	Denmark	Finland	Norway	Sweden
ρ^*	6.851*** [0.000]	7.323*** [0.000]	0.651 [0.416]	6.728*** [0.000]
α_{GDP}	5.716*** [0.000]	0.308 [0.646]	0.343 [0.689]	4.964*** [0.000]
α_{GDP^2}	6.008*** [0.000]	0.254 [0.732]	0.266 [0.707]	4.688*** [0.000]
α_{GLOB}	5.605*** [0.000]	4.308*** [0.000]	3.853*** [0.000]	3.501*** [0.000]
Φ_1	5.583*** [0.000]	2.894*** [0.000]	3.471*** [0.000]	3.487*** [0.000]
Ψ_1	7.484*** [0.000]	0.321 [0.546]	6.549*** [0.000]	0.307 [0.573]
ω_1	7.146*** [0.000]	0.208 [0.812]	5.406*** [0.000]	0.243 [0.704]
$\bar{\delta}_1$	0.228 [0.702]	6.843*** [0.000]	4.056*** [0.000]	2.865*** [0.000]

Source: Authors' Computation. The probability values are in parenthesis.

Figure 1 shows the parameter estimates dynamics for all the eleven (11) quantiles considered for the four NORDIC countries. As shown in the figure, the quantile estimates for the parameters differ across all the quantiles considered in this study, thus, suggesting that the behaviour of the parameters are not the same across the quantiles.

Figure-1: Parameter estimations with 95% CI over the quantile (outer blue dotted lines)


Note: the dark red line shows the flow of the predictable parameters for all quantiles of conditional distribution.

The blue-dashed lines signify the lesser and higher frequency of the 95% CI level

5. CONCLUSION AND POLICY IMPLICATIONS

In this paper, we investigate the validity of the Environmental Kuznets Curve (EKC) in four NORDIC countries, namely Denmark, Finland, Norway, and Sweden, by examining the effects of economic growth and its squared term and overall globalization on ecological footprint from 1970Q1 to 2018Q4. This study applied the symmetric ARDL and quantile ARDL approaches to provide answers to the question of non-linearity and asymmetries of the EKC relationship. The findings of the linear ARDL suggest the presence of long-term relationship and validity of EKC in three out of the four countries considered. Turning to the Q-ARDL, there is evidence that the speed of adjustments is negative and statistically significant across the majority of the quantiles, except only in Norway where only the lower quantiles were significant. The result thus proves there is the possibility of a long-run equilibrium relationship among the variables.

The result of the long-run analysis reveals that economic growth enhances environmental degradation in Denmark, Finland, and Norway, while economic growth improves the Swedish environment, this implies at the initial stage of development, the ecological footprint consumption of these countries improves their environments. In addition, there is evidence that the squared term of economic growth enhances the Danish, Finnish and Norwegian environments. The results suggest that in the long run, the inverted U-Shaped EKC holds for Denmark, Finland, and Norway, while the U-shaped curve only holds for Sweden. While accounting for the relevance of globalization on the NORDICS environment which complements the major thrust of this study, there is a shred of overwhelming evidence that overall globalization is a significant factor that promotes the sustainable environment of the four countries.

The implication of these findings is that increase in economic growth and globalization dampen the rate of environmental degradation in these countries suggesting that with the increased level of growth and globalization, the environments will improve. Thus, the government of these countries should continue to adopt energy-efficient environmental policies to promote a green growth environment. Similarly, the government of these countries should maintain and propagate the continuous improvement of green growth methods through the provision of cleaner energy projects.

From the foregoing results, it is strongly recommended that there should be a synergy of ideas and transfer of technology from the technologically advanced countries to less developed countries to reduce the future occurrence of environmental degradation. The rationale for this call is that with the growth of globalization, there is a tendency that an increase in energy usage could lead to the deterioration of the environment globally.

Lastly, with the increase in global trade, the level of capital stock will increase which later boasts the level of output and an increase in energy usage, thus affecting the environment. Therefore, there is a need for the government of these countries to gauge the appropriate level of capital formation that will not affect the environment negatively.

6. REFERENCES

- Ahmed, Z., Wang, Z., Mahmood, F., Hafeez, M., & Ali, N. (2019). Does globalization increase the ecological footprint? Empirical evidence from Malaysia. *Environmental Science and Pollution Research*, 26(18), 18565–18582. <https://doi.org/10.1007/s11356-019-05224-9>
- Akadiri, S. Saint, Uzuner, G., Akadiri, A. C., & Lasisi, T. T. (2021). Environmental Kuznets curve hypothesis in the case of tourism island states: The moderating role of globalization. *International Journal of Finance and Economics*, 26(2), 2846–2858. <https://doi.org/10.1002/ijfe.1938>
- Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. H. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators*, 48, 315–323. <https://doi.org/10.1016/j.ecolind.2014.08.029>

- Ali, S., Yusop, Z., Kaliappan, S. R., & Chin, L. (2021). Trade-environment nexus in OIC countries: fresh insights from environmental Kuznets curve using GHG emissions and ecological footprint. *Environmental Science and Pollution Research*, 28(4), 4531–4548. <https://doi.org/10.1007/s11356-020-10845-6>
- Altıntaş, H., & Kassouri, Y. (2020). Is the environmental Kuznets Curve in Europe related to the per-capita ecological footprint or CO2 emissions? *Ecological Indicators*, 113(106187), 1-14. <https://doi.org/10.1016/j.ecolind.2020.106187>
- Andersen, T. M., Holmstrom, B., Honkapohja, S., Korkman, S., Soderstrom, H. T. & Vartiainen, J. (2007). The Nordic model: embracing globalization and sharing risks. *The Research Institute of the Finnish Economy Paper* 232.
- Araın, H., Han, L., Sharif, A., & Meo, M. S. (2020). Investigating the effect of inbound tourism on FDI: The importance of quantile estimations. *Tourism Economics*, 26(4), 682–703. <https://doi.org/10.1177/1354816619859695>
- Ansari, M. A., Haider, S., & Khan, N. A. (2020). Environmental Kuznets curve revisited: An analysis using ecological and material footprint. *Ecological Indicators*, 115(46), 106416. <https://doi.org/10.1016/j.ecolind.2020.106416>
- Aziz, N., Sharif, A., Raza, A., & Rong, K. (2020). Revisiting the role of forestry, agriculture, and renewable energy in testing environment Kuznets curve in Pakistan: evidence from Quantile ARDL approach. *Environmental Science and Pollution Research*, 27(9), 10115–10128. <https://doi.org/10.1007/s11356-020-07798-1>
- Beşe, E., & Kalaycı, S. (2019). Environmental Kuznets curve (EKC): Empirical relationship between economic growth, energy consumption, and CO2 emissions: Evidence from 3 developed countries. *Panaeconomicus*, 1-26. <https://doi.org/10.2298/pan180503004b>
- Bilgili, F., Ulucak, R., Koçak, E., & İlkay, S. Ç. (2020). Does globalization matter for environmental sustainability? Empirical investigation for Turkey by Markov regime switching models. *Environmental Science and Pollution Research*, 27(1), 1087–1100. <https://doi.org/10.1007/s11356-019-06996-w>
- Bulut, U. (2020). Environmental sustainability in Turkey: an environmental Kuznets curve estimation for ecological footprint. *International Journal of Sustainable Development and World Ecology*, 1–11. <https://doi.org/10.1080/13504509.2020.1793425>
- Cho, J. S., Kim, T. H., & Shin, Y. (2015). Quantile cointegration in the autoregressive distributed-lag modeling framework. *Journal of Econometrics*, 188(1), 281–300. <https://doi.org/10.1016/j.jeconom.2015.05.003>
- Demissew Beyene, S., & Kotosz, B. (2020). Testing the environmental Kuznets curve hypothesis: an empirical study for East African countries. *International Journal of Environmental Studies*, 77(4), 636–654. <https://doi.org/10.1080/00207233.2019.1695445>
- Dickey, D.A. & Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366a), 427–431.
- Dogan, E., & Inglesi-Lotz, R. (2020). The impact of economic structure to the environmental Kuznets curve (EKC) hypothesis: evidence from European countries. *Environmental Science and Pollution Research*, 27(11), 12717–12724. <https://doi.org/10.1007/s11356-020-07878-2>
- Dogan, E., Ulucak, R., Kocak, E., & Isik, C. (2020). The use of ecological footprint in estimating the Environmental Kuznets Curve hypothesis for BRICST by considering cross-section dependence and heterogeneity. *Science of the Total Environment*, 723, 138063. <https://doi.org/10.1016/j.scitotenv.2020.138063>
- Erdogan, S., Okumus, I., & Guzel, A. E. (2020). Revisiting the Environmental Kuznets Curve

- hypothesis in OECD countries: the role of renewable, non-renewable energy, and oil prices. *Environmental Science and Pollution Research*, 27(19), 23655–23663. <https://doi.org/10.1007/s11356-020-08520-x>
- Godil, D. I., Sharif, A., Agha, H., & Jermisittiparsert, K. (2020). The dynamic nonlinear influence of ICT, financial development, and institutional quality on CO2 emission in Pakistan: new insights from QARDL approach. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-020-08619-1>
- Gormus, S., & Aydin, M. (2020). Revisiting the environmental Kuznets curve hypothesis using innovation: new evidence from the top 10 innovative economies. *Environmental Science and Pollution Research*, 27(22), 27904–27913. <https://doi.org/10.1007/s11356-020-09110-7>
- Grossman, G., & Krueger, A. (1991). Environmental Impacts of a North American Free Trade Agreement. *National Bureau of Economic Research*, 3914. <https://doi.org/10.3386/w3914>
- Habib-Ur-Rahman, Ghazali, A., Bhatti, G. A., & Khan, S. U. (2020). Role of economic growth, financial development, trade, energy and fdi in environmental kuznets curve for Lithuania: Evidence from ARDL bounds testing approach. *Engineering Economics*, 31(1), 39–49. <https://doi.org/10.5755/j01.ee.31.1.22087>
- Hassan, S. T., Xia, E., Khan, N. H., & Shah, S. M. A. (2019). Economic growth, natural resources, and ecological footprints: evidence from Pakistan. *Environmental Science and Pollution Research*, 26(3), 2929–2938. <https://doi.org/10.1007/s11356-018-3803-3>
- Hoffrén, J., & Hellman, J. (2007). Impacts of increasing consumption on material flows over time: Empirical results from Finland 1970–2005. *Progress in Industrial Ecology*, 4(6), 463–483. <https://doi.org/10.1504/PIE.2007.016354>
- Khan, A., Chenggang, Y., Xue Yi, W., Hussain, J., Sicen, L., & Bano, S. (2020). Examining the pollution haven, and environmental kuznets hypothesis for ecological footprints: an econometric analysis of China, India, and Pakistan. *Journal of the Asia Pacific Economy*, 1–21. <https://doi.org/10.1080/13547860.2020.1761739>
- Klaus, M. H. (2013). Nordic Statistical Yearbook. *Nordic Council*. ISBN 978-92-893-2481-6.
- Krström, B., & Lundgren, T. (2005). Swedish CO2-emissions 1900–2010: An exploratory note. *Energy Policy*, 33(9), 1223–1230. <https://doi.org/10.1016/j.enpol.2003.11.020>
- Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, 45(1), 1–28.
- Lindmark, M., & Acar, S. (2014). The environmental Kuznets curve and the Pasteur effect: Environmental costs in Sweden 1850–2000. *European Review of Economic History*, 18(3), 306–323. <https://doi.org/10.1093/ereh/heu011>
- Magazzino, C. (2018). GDP, energy consumption and financial development in Italy. *International Journal of Energy Sector Management*, 12(1), 28–43. <https://doi.org/10.1108/IJESM-01-2017-0004>
- Miranda, R. A., Hausler, R., Lopez, R. R., Glaus, M., & Pasillas-Diaz, J. R. (2020). Testing the Environmental Kuznets Curve Hypothesis in North America's Free Trade Agreement .pdf. *Energies*, 13(12), 1–13.
- Ng, C. F., Choong, C. K., & Lau, L. S. (2020). Environmental Kuznets curve hypothesis: asymmetry analysis and robust estimation under cross-section dependence. *Environmental Science and Pollution Research*, 27(15), 18685–18698. <https://doi.org/10.1007/s11356-020-08351-w>
- Ongan, S., Isik, C., & Ozdemir, D. (2021). Economic growth and environmental degradation: evidence from the US case environmental Kuznets curve hypothesis with application of decomposition. *Journal of Environmental Economics and Policy*, 10(1), 14–21.

<https://doi.org/10.1080/21606544.2020.1756419>

- Pauli, F. (2003). *Environmental Kuznet curve investigation using a varying coefficient AR model. Ecological and Environmental Economics Working Papers Series No. 12.*
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds Testing Approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289–326. <https://doi.org/10.1002/jae.616>
- Phillips, P.C.B. & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335-346.
- Purcel, A. A. (2020). New insights into the environmental Kuznets curve hypothesis in developing and transition economies: a literature survey. *Environmental Economics and Policy Studies*, 22(4), 585-631. <https://doi.org/10.1007/s10018-020-00272-9>
- Saqib, M., & Benhmad, F. (2021). Does ecological footprint matter for the shape of the environmental Kuznets curve? Evidence from European countries. *Environmental Science and Pollution Research*, 28(11), 13634–13648. <https://doi.org/10.1007/s11356-020-11517-1>
- Sarkodie, S. A., & Ozturk, I. (2020). Investigating the Environmental Kuznets Curve hypothesis in Kenya: A multivariate analysis. *Renewable and Sustainable Energy Reviews*, 117, 109481. <https://doi.org/10.1016/j.rser.2019.109481>
- Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers* 46, 757–773.
- Shahbaz, M., Khraief, N., & Mahalik, M. K. (2019). Investigating the environmental Kuznets's curve for Sweden: evidence from multivariate adaptive regression splines (MARS). *Empirical Economics*, 59(4), 1883-1902. <https://doi.org/10.1007/s00181-019-01698-1>
- Shahbaz, M., Lahiani, A., Abosedra, S., & Hammoudeh, S. (2018). The role of globalization in energy consumption: A quantile cointegrating regression approach. *Energy Economics*, 71, 161–170. <https://doi.org/10.1016/j.eneco.2018.02.009>
- Sharif, A., Afshan, S., Chrea, S., Amel, A., & Khan, S. A. R. (2020). The role of tourism, transportation and globalization in testing environmental Kuznets curve in Malaysia: new insights from quantile ARDL approach. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-020-08782-5>
- Sharif, A., Baris-Tuzemen, O., Uzuner, G., Ozturk, I., & Sinha, A. (2020). Revisiting the role of renewable and non-renewable energy consumption on Turkey's ecological footprint: Evidence from Quantile ARDL approach. *Sustainable Cities and Society*, 57, 102138. <https://doi.org/10.1016/j.scs.2020.102138>
- Skonhoft, A., & Solem, H. (2001). Economic growth and land-use changes: The declining amount of wilderness land in Norway. *Ecological Economics*, 37(2), 289–301. [https://doi.org/10.1016/S0921-8009\(00\)00282-2](https://doi.org/10.1016/S0921-8009(00)00282-2)
- Suki, N. M., Sharif, A., Afshan, S., & Suki, N. M. (2020). Revisiting the Environmental Kuznets Curve in Malaysia: The role of globalization in sustainable environment. *Journal of Cleaner Production*, 264, 121669. <https://doi.org/10.1016/j.jclepro.2020.121669>
- Udemba, E. N., Magazzino, C., & Bekun, F. V. (2020). Modeling the nexus between pollutant emission, energy consumption, foreign direct investment, and economic growth: new insights from China. *Environmental Science and Pollution Research*, 27(15), 17831–17842. <https://doi.org/10.1007/s11356-020-08180-x>
- Ullah, A., & Khan, D. (2020). Testing environmental Kuznets curve hypothesis in the presence of green revolution: a cointegration analysis for Pakistan. *Environmental Science and Pollution Research*, 27(10), 11320–11336. <https://doi.org/10.1007/s11356-020-07648-0>

- Ulucak, Z. Ş., İlkay, S. Ç., Özcan, B., & Gedikli, A. (2020). Financial globalization and environmental degradation nexus: Evidence from emerging economies. *Resources Policy*, 67(101698). <https://doi.org/10.1016/j.resourpol.2020.101698>
- Urban, F., & Nordensvärd, J. (2018). Low carbon energy transitions in the nordic countries: Evidence from the environmental kuznets curve. *Energies*, 11(9), 1-17. <https://doi.org/10.3390/en11092209>
- Wang, M. N. (2013). Investigating the environmental Kuznets curve of consumption for developing and developed countries: a study of Albania and Sweden. In *Aalto University: Vol. №3*. Aalto University.
- Xiao, Z. (2009). Quantile cointegrating regression, *Journal of econometrics*, 150(2), 248–260.
- Zivot, E., & Andrews, D. W. K. (2002). Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of business & economic statistics*, 20(1), 25-44.