Research article

Impact assessment of trade on environmental performance: accounting for the role of government integrity and economic development in 79 countries

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A B S T R A C T

Trade has become a carrier for transporting both clean and dirty (pollution-intensive) goods, services and technologies between countries. While the impact of trade on economic development has been reported in the extant literature, insufficient and inconsistent results exist between pollution-embedded trade and environmental performance. Using the Ordinary Least Squares (OLS), Generalized method of moments and panel quantiles via Moments, this study explored the role of government integrity on trade-environment nexus in the post-Kyoto protocol era for 79 countries between 2008 and 2018. The empirical results suggest that per capita GDP and government integrity improve environmental performance whereas trade impedes it. In the quantile regression model, the effect of government integrity is significant at the median quantiles with a stronger effect in countries with higher environmental performance. The negative effect of trade is not only significant from the lower quantile through the median quantile but decreases in magnitude, tracking from countries with lower to higher environmental performance. While the positive effect of government integrity is significant from the median quantile onwards, the negative effect of trade is only significant in the lower quantile. Robustness analysis from the GMM dynamic panel estimation technique shows that interacting government integrity with trade yields a positive and significant coefficient. Meaning that improved government integrity averts the negative effect of trade on environmental performance. The study suggests that outsourcing the regulations of trade-oriented multinational companies operating in developing economies with weak institutions to global humanitarian organisations such as the United Nations would be the first step to reduce trade-attributable environmental degradation.

1. Introduction

The Environmental Kuznets Curve (EKC) hypothesis has taken center stage among researchers across the globe following its inception. The existence of an inverted U-shaped relationship between environmental quality and economic development implies that, at early stages of economic development, environmental quality deteriorates rapidly due to poor and lack of prioritization of environmental quality as a policy objective (Grossman and Krueger, 1991; Dinda, 2004; Gozgor, 2017). However, at later stages of development, the awareness of promoting a cleaner environment and the willingness to pay for environmental quality leads to a decline in environmental degradation (Grossman and Krueger, 1991). Several empirical studies have subsequently tested the

validity of the EKC in both developed and developing economies, however, the findings are inconsistent. While some studies confirm the existence of the EKC, others submit that it does not apply to some nations (see Hafeez et al., 2018; Gozgor, 2017; Maryam et al., 2017; Dogan and Turkekul, 2016; Shahbaz et al., 2014). However, extant literature shows that the shape of the EKC is affected by international trade and foreign direct investment (Dinda, 2004; Sarkodie and Strezov, 2019a, 2019b). The mainstream of the debate is the channel of the growth-environment relationship. Researchers and policymakers seek more insight into the policy dilemma of choosing between economic development and environmental sustainability.

The policy dilemma of trade-environment has recently attracted numerous concerns. Two major strands of literature emanating from

these concerns. The first group of studies submit that trade openness reduces environmental pollution (Shirazi and Manap, 2005; Hye et al., 2013). These studies elaborate that trade enhances national income and thus, intensifies the public demand for a cleaner environment. Trade also promotes the adoption of environmentally friendly production technologies and warrants the shift to less pollution-driven sectors of the economy (pollution-hallo hypothesis). Contrarily, other researchers argue that trade exacerbates environmental pollution. It promotes large-scale industrial production and hence, increases carbon emissions, which aggravates environmental degradation, *alias*, the pollution-haven hypothesis (Harrison and Eskeland, 1997; Cole, 2004; Taylor, 2004; Shen et al., 2019).

Despite a plethora of studies on this issue, little or less attention has investigated the role of institutional quality in reshaping the trade-environment relationship. This is tantamount to neglecting the integral function of governance in shaping the dynamics of economic fundamentals. Meanwhile, the EKC hypothesis is government-induced rather than the income (market)-induced approach that dominates the extant literature (Copeland and Taylor, 1996). Equally, institutions fundamentally affect the effectiveness of trade flows (see Kilishi, 2017; Alhassan and Payaslioglu, 2019).

Even though a few studies have considered the role of institutions on environmental quality, most of these studies employ narrow measures of environmental quality (carbon emissions and ecological footprint). Employing such narrow indicators as a proxy for environmental quality might lead to misleading conclusions. Another limitation of these studies has a methodological element, which is the utilization of traditional mean estimators. Consequently, traditional mean estimators fail to account for the change in trade-environment dynamics along with the conditional distribution of environmental quality. This underscores the need to investigate the inconsistencies of the nexus between trade and environmental quality. The objectives of the study are based on the following questions: first, does trade matter for environmental performance? Second, does institutional quality matter for the trade-environmental performance nexus? Third, how do the dynamics change with the level of environmental performance? To answer these questions, this study provides an empirical insight concerning the role of government integrity on the trade-environmental performance nexus. To the best of our knowledge, no other study has empirically analyzed the environmental performance effects of trade and government integrity employing the Environmental Performance Index as environmental sustainability indicator for seventy-nine countries. The EPI is an agglomeration of 24 performance indicators within 10 issue categories under two core policies of environmental health and ecosystem vitality. It differs from other traditional environmental indicators such as pollutant emissions and ecological footprint in that it is more oriented towards sustainable environmental policies. Two core policy objectives employed in constructing the index, which are environmental health and ecosystem vitality differ in certain regards. Environmental health which is assigned a lower weight of 40% is assigned three issue categories which are air quality, sanitation and drinking water and heavy metals while ecosystem vitality has under it —biodiversity and habitat, forests, fisheries, climate and energy, air pollution, water resources and agriculture and is assigned the greater weight of 60%. While improvement in environmental health is reliant on conditions that arise from economic development, ecosystem vitality, on the other hand, can deteriorate due to industrial activities which are necessary for economic growth. Thus, environmental performance entails maintaining a balance between economic growth and environmental sustainability. Compared to the previously used proxies of CO_2 emissions and ecological footprint, this novel indicator provides a more comprehensive calibration of environmental sustainability which better captures the proximity of countries to policy targets which align to the attainment of much of the sustainable development goals of the United Nations.

We further employ the index of government integrity to control for institutional effects wherein higher index values indicate higher government integrity and sustainable institutions. In terms of methodology, a novel empiric—Quantiles via Moments *a.k.a* the Method of Moments Quantile Regression (MMQR) proposed by Machado and Silva (2019) is used. Contrary to the traditional mean estimators reported in existing literature, the MMQR technique has numerous desirable properties and advantages. The MMQR specification differs from other quantile regression techniques due to its ability to determine the effect of the independent variables across the conditional distribution of environmental performance while employing fixed effects which affect the entire distribution without shifting locations.

The study is subsequently organized as follows: Section 2 presents a literature review in relation to the scope; Section 3 presents the data description and methodological procedure. The results are discussed in Section 4 whereas Section 5 entails the conclusion and policy implications of the empirical results.

2. Review of related literature

The literature on trade and environment is quite extensive, nevertheless, until date — no consensus has been reached on a definite relationship between trade and the environment. However, two schools of thought have emerged from this important research debate. The first group, the "pro-trade" proponents postulate a positive relationship between trade and economic growth which would have a positive spillover effect on environmental quality. The second group, the "pro-environment" advocates posit the environmental degrading component of trade. The perspectives of the pro-environment and pro-trade groups are founded on two key hypotheses namely the pollution-haven hypothesis (Harrison and Eskeland, 1997; Cole, 2004; Taylor, 2004; Shen et al., 2019) and the trade-led growth hypothesis (Shirazi and Manap, 2005; Hye et al., 2013). The pollution haven hypothesis is valid when environmentally harmful goods and 'dirty' (pollution-intensive) industrial processes from more advanced economies with stringent environmental laws find its way into developing economies with flexible environmental policies (Sarkodie and Strezov, 2019b). Studies that validate this hypothesis include Mukhopadhyay (2006) who used input-output analysis to validate the pollution-haven hypothesis for Thailand in the year 2000. The findings show that foreign direct investment further promotes exports with negative environmental effects.

In a panel of 132 countries within the period 1950 to 1992, Heil and Selden (2001) developed a trade-emissions model with an income-trade interaction term. The study showed that the intensity of trade has abatement effects on CO_2 emissions in higher-income countries compared to lower-income countries. This validates the pollution-haven hypothesis for lower-income countries and the pollution-halo hypothesis for upper-income countries. In contrast, trade is observed to intensify CO_2 emissions in a panel of new EU member countries between the period 1992–2010 (Kasman and Duman, 2015). Relative to country-income levels around the world, EU countries are probably not in the lower-income bracket. Inferences from the two studies can be attributed to differences in empirical methods and the periodicity of data employed. In another study of 189 countries in six regions across the world from 1990 to 2011, trade, import and export were found to have a positive long-run effect on energy consumption (Al-Mulali and Sheau-Ting, 2014). The study validates a pollution-embedded trade scenario, by way of imports and exports — mostly in developed economies with high trade to GDP ratios. However, the effects of trade, import and export-driven carbon emissions and energy consumption were negative and non-significant in developing countries with low trade to GDP ratios. This contradicts the results of Heil and Selden (2001), probably attributable to omitted variable bias, different periods and the bi-variate analysis

employed in Al-Mulali and Sheau-Ting (2014). Furthermore, in a different study, the environmental degrading effect of trade via a positive relationship between trade and CO_2 emissions was validated in a panel of eight trade-dependent Southeast and East Asian economies— within the period 1971–2019 (Ibrahim and Rizvi, 2015).

Studies that support the pollution abatement effects of trade include Hossain (2011) who showed that trade openness has a negative relationship with CO_2 emissions in a panel of newly industrialized economies within the 1971 to 2007 period. This result is corroborated by Dogan et al. (2017) where trade is observed to abate the effect of increasing CO_2 emissions for a panel of OECD-member countries spanning 1995 to 2010. In a panel data of 58 countries within the period 1990 to 2012, a negative relationship between trade and CO_2 emissions is found for both the European and North Asian region, as well as, the Middle Eastern and African countries (Kais and Sami, 2016). In the same way, CO_2 emissions-abatement effect of trade was confirmed in the European Union within the period 1980 to 2012 (Dogan and Seker, 2016). In another study of the oil-producing countries, accounting for trade, electricity production, and democracy were confirmed to exacerbate the driving force of atmospheric-related environmental degradation (Ike et al., 2020a,b). Several other studies (Halicioglu, 2009; Kohler, 2013; Shahbaz et al., 2013; Farhani et al., 2014; Sarkodie, 2020) find support for either one of the emissions abatement or intensification effect of trade.

Another strand of studies employs the ecological footprint as a proxy indicator of environmental degradation (Sarkodie, 2021; Destek and Sarkodie, 2019). In a study of 137 countries, export to core industrialized economies was observed to decline ecological consumption (ecological footprint) (Rice, 2007). The study implies that the ecological space is unequally tilted towards rich industrialized economies to the detriment of developing countries. This effect is weakly corroborated by Uddin et al. (2017) wherein an insignificant negative relationship between trade and EF was confirmed for a panel of 27 highest emitting countries within the period 1991 to 2012. In a panel of 14 Middle East and North African countries within the period 1996–2012, a positive relationship between trade and EF was found (Al-Mulali and Ozturk, 2015). Further empirical evidence for the ecological degrading effect of trade was confirmed in 93 countries (Al-Mulali et al., 2015). The majority of studies reviewed do not account for institutional dynamics, an effect that underpins the trade-environment nexus. Not accounting for institutional quality especially in panel studies may lead to coefficient bias. It is reported that the EKC hypothesis of reducing emissions at a specific turning point of income threshold is not market-driven but government-induced (Copeland and Taylor, 1996). As a result, the income-induced effect requires the willingness of the government to deploy stricter environmental regulations aimed at curbing pollutant emissions. In a study that accounts for the effect of trade liberalization on the environment in regimes with different corruption levels, increasing trade liberalization in highly corrupt countries was found to trigger environmental degradation and vice versa in countries with low levels and perception of corruption (Chang, 2015).

The limitations of previous studies reviewed employ: first, either CO_2 emissions or the Ecological Footprint as a proxy for environmental degradation; second, traditional mean estimators to estimate the coefficients of the independent variables. All the studies reviewed only employ a single component of atmospheric or ecological degradation as a proxy indicator of environmental degradation. Furthermore, these proxies do not account for the sustainable environmental policy orientation of their respective countries. Again, the model specifications using traditional mean estimators fail to account for the conditional and heterogeneous distribution across quantiles, a situation that is challenging to a panel of diverse countries with differences in income and technology. These challenges of previous studies are accounted for in this study by utilizing a novel environmental quality indicator (EPI) compared to the previously used proxies namely CO_2 and EF. The study further incorporates the index of government integrity to control for institutional effects via a panel quantile estimation technique.

3. Data and materials

3.1. Data

We applied data collected from various databases for the estimations in this study. The data comprises a panel of 79 countries — both developing and developed countries over the period 2008 to 2018. The starting date is justified by data availability which constitutes one of the main limitations of the present research. The period under study coincides with the 2008 global financial crisis and falls within the post-Kyoto protocol enactment period of 2005. The empirical analysis is performed using four variables, namely environmental performance index as a dependent variable, and government integrity, economic growth, and the trade — as independent variables. Index values for government integrity range from 1 to 100. These Values are converted to percentage from 0-49.9 indicating a 'repressed' status, from 50-59.9 indicating a 'mostly unfree' status, from 60-69.9 indicating a 'moderately free' status, from 70-79.9 indicating a 'mostly free' status and from 80-100 indicating a 'free' status. Economic growth is proxied by the per capita Gross Domestic Production (Constant 2010 USD). Trade per capita corresponds to the imports and exports as a percentage of real GDP divided by total population while environmental performance index is measured by 24 indicators, 10 issue categories and 2 broad policy objectives with weights at each level as a percentage of the total score. We also present the variable sources and measurements in Table 1.

3.2. Econometric methodology

The econometric methods applied in this study are based on the conventional Ordinary Least Squares (OLS) and the Method of Moments Quantile Regression (MMQR)[1]. The functional form of the environmental performance equation is expressed as:

$$\text{EPI}_{it} = \beta_0 + \varphi_1 \ln GDPK_{it} + \varphi_2 GINT_{it} + \varphi_3 \text{TRADK}_{it} + \mu_{it} \tag{1}$$

where EPI is the dependent variable, which measures the environmental performance of country *i* at year *t*. LnGDPK is the measure of economic growth, GINT represents the integrity of the government while TRADK captures the effect of international trade. We estimated Eq. (1) using the Method of Moments Quantile Regression (MMQR).

Essentially, making use of the OLS estimator only helps to approximate the conditional mean, which usually approximates to the average of the distribution, hence, this kind of estimation procedure can only provide a partial and incomplete description of a conditional distribution. To capture the distributional heterogeneity of the nexus between government integrity, economic growth, trade and environmental performance at the conditional distribution of environmental performance, we applied both the OLS and panel quantile regressions. Specifically, we applied the Quantiles via Moments otherwise called the Method of Moments Quantile Regression (MMQR) with fixed effects proposed by Machado and Silva (2019). This panel quantile estimator has some desirable qualities over the conventional panel quantile regression developed by Koenker (2004), Lamarche (2010) and Canay (2011). First, the MMQR assumes that the covariate only affects the distribution of the variables of interest through the location and scale functions rather than just being location shifters as described in the literature. Besides, this estimator allows individual effects to influence the entire distribution captured by the incorporation of fixed

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[1] The method of moment quantile regression is more suitable for short data period since it does not require the integrating properties of the series and their cointegration.

Table 1. Definition and measurement of variables.

Variable	Measurement	Source
Government Integrity (GINT)	Index values of 1–100. These values are converted to percentage from 0-49.9 indicating a 'repressed' status, from 50-59.9 indicating a 'mostly unfree' status, from 60-69.9 indicating a 'moderately free' status, from 70-79.9 indicating a 'mostly free' status and from 80-100 indicating a 'free' status.	Heritage Foundation (heritage.org)
Economic Growth (GDPK)	Per Capita Gross Domestic Production (Constant 2010 USD).	World Development Indicator (WDI)
International Trade (TRADK)	Trade (imports and exports) as a percentage of real GDP. We divided this value by the total population to obtain per capita value of trade.	World Development Indicator (WDI).
Environmental Performance Index (EPI)	Measured by 24 indicators, 10 issue categories and 2 broad policy objectives with weights at each level as a percentage of the total score.	Socioeconomic Data and Application Centre (SEDAC): http://www.ciesin.columbia.edu/indicators/ESI/.http://www.ciesin.columbia.edu/indicators/ESI/.

effects. Therefore, estimation of the conditional quantiles for a model of the location-scale variant is expressed as follows:

$$QEPI_{it}(\tau|X_{it}) = \beta_0 + \varphi_1 \ln GDPK_{it} + \varphi_2 GINT_{it} + \varphi_3 TRADK_{it} + \mu_{it} \quad (2)$$

where ln is the natural logarithm, $QEPI_{it}(\tau|X_{it})$ denotes τ^{th} conditional quantile function, and EPI as the dependent variable measures the environmental performance over the sample period of the study. X_{it} represents the explanatory variables which include lnGDPK – a measure of economic growth; GINT represents government integrity, and TRADK denotes international trade. μ_{it} denotes the error term that is independently and identically distributed across individual countries i at time t. The residuals are orthogonal to X_{it} and normalized to satisfy the moment conditions described in Machado and Silva (2019). From Eq. (2), it implies that:

$$QEPI_{it}(\tau|X_{it}) = (\alpha_i + \delta_i q(\tau)) + X'_{it}\beta + Z'_{it}\gamma q(\tau) \quad (3)$$

where $\alpha_i(\tau) \equiv \alpha_i + \delta_i q(\tau)$ is the scalar parameter which is indicative of the quantile-τ fixed effect for individual i. Z is a k-vector of identified components of X which are differentiable transformations with element l given by $Z_l = Z_l(X)$, $l = 1,...,k$. Contrasting the least-squares fixed effects; the individual effects in this method do not represent intercept shifts. They are time-invariant parameters whose heterogeneous impacts differ across the quantiles of the conditional distribution of the environmental performance variable. From Eq. (2), the conditional quantile environmental performance's function is estimated based on the MMQR approach, which gives a solution to the following optimization problem:

$$min_q \sum_i \sum_t \rho_\tau \left(\widehat{R}_{it} - \left(\widehat{\delta}_i + Z'_{it}\widehat{\gamma} \right) q \right) \quad (4)$$

here, $\rho_\tau(A) = (\tau-1)AI\{A \leq 0\} + \tau AI\{A > O\}$ is the standard quantile loss function. Due to marginal change in i, the parameter for a dependent variable (EPI) i may represent the marginal change in the rth conditional quantile of $QEPI_{it}(\tau|X_{it})$.

4. Empirical results

From the summary statistics in Table 2, the values for the standard deviations show that EPI and GINT have the most spread out distributions of the datasets with the implication of higher volatility and less

precision when traditional mean-based estimation techniques are employed to estimate parameter values. This is corroborated by the disparity between the minimum and maximum points of both variables. EPI and per capita GDP are both negatively skewed while government integrity and per capita trade volume are both positively skewed with slightly positive and negative skewness emanating from both the per capita trade volume and per capita GDP series, respectively.

The scatterplots presented in Figure 1 shows the different cross-sectional relationships between per capita GDP, per capita trade volume, government integrity and environmental performance. Scatterplots for per capita GDP and per capita trade volume are both augmented with frequency weights for government integrity. As such, thicker circles in the respective scatterplots indicate countries with higher government integrity and thinner plots indicate countries with lower government integrity. We observe that countries with higher government integrity tend to have higher per capita trade volume, as well as, higher environmental performance, whereas countries with lower government integrity have lower per capita trade volume and lower environmental performance. A few outliers can be observed in the graphs, which can bias the values for the estimated coefficients of traditional mean-based estimators, thus, necessitating the use of quantile regression techniques. These graphs represent bi-variate cross-sectional relationships, as such does not control for the effects of other variables in the model. This is evidenced by the positive relationship between per capita trade volume and EPI, which later turns negative when the effects of per capita GDP and government integrity are both controlled for in both OLS and MMQR models.

Figure 2 provides a clearer picture of the variable coefficients in the estimation of MMQR as divulged in Table 3. The dotted gray lines represent the upper and lower bounds of the 95% confidence interval while the continuous curve shows the change in the coefficient estimates of MMQR following a movement from one quantile to another. The results of the OLS and MMQR estimations presented in Table 3 show that the MMQR technique uncovers some latent relationships in the underlying distribution that are hitherto not observed by the traditional mean based OLS regression. The OLS-based regression, analogous to the location parameters, indicates that a one percent increase in per capita GDP (lnGDPk) increases environmental performance by about 20 unit points. This shows that environmental performance is greatly influenced by the standards of living. Per capita trade volume (TRADk) has a negative and statistically insignificant relationship with environmental performance as a one percent increase in trade volume is associated with ~6.8 unit

Table 2. Summary statistics.

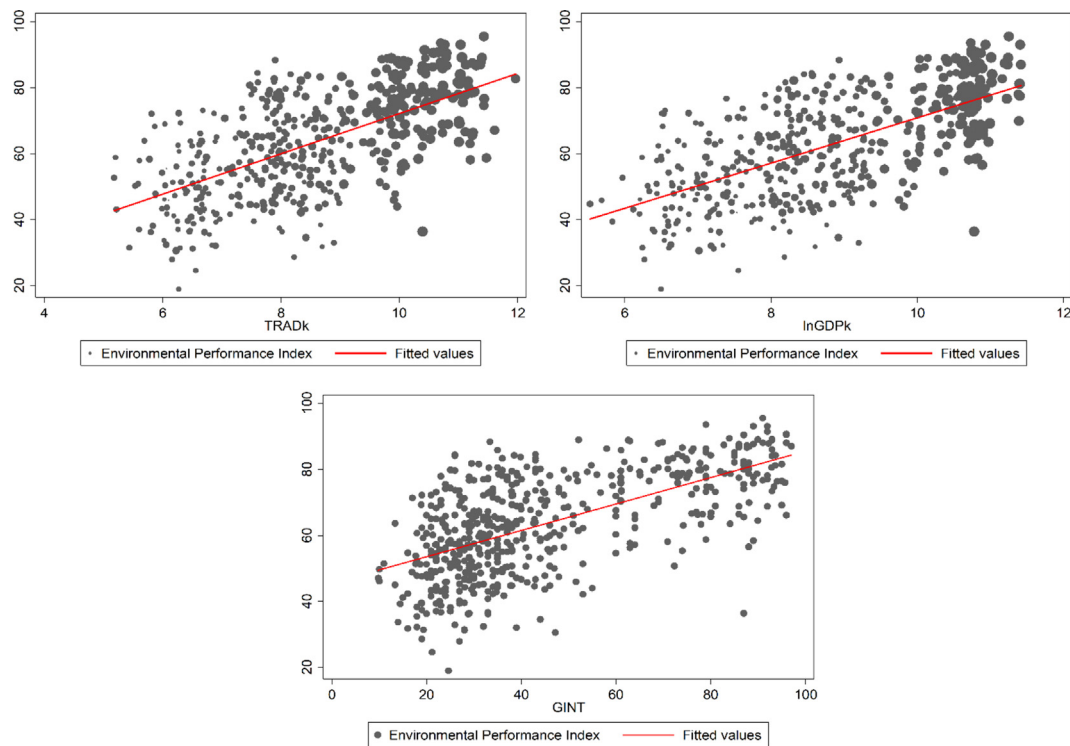| Variables	Mean	S.D	Skewness	Kurtosis	Minimum	Maximum
EPI	63.18	15.28	-0.17	2.29	19.01	95.5
TRADk	8.53	1.56	0.05	2.05	5.18	11.97
lnGDPk	8.87	1.44	-0.02	1.85	5.53	11.43
GINT	45.43	23.46	0.77	2.28	9.8	96

Note: S.D denotes standard deviation.

Figure 1. Scatterplots of trade volume, per capita GDP and government integrity against environmental performance. Frequency weights for government integrity are used for the trade and GDP scatterplots. The thicker circles indicate countries with higher government integrity, which happen to cluster around higher EPI axis while the thinner circles indicate regions of lower EPI which tend to cluster around the lower EPI axis.

point reduction in environmental performance. Government integrity, however, has a positive relationship with environmental performance. One percent increase in government performance is associated with a 0.2 unit increase in environmental performance. This implies that the quality of political institutions plays a vital role in improving the performance of the environment. The dynamics get a bit more interesting when distributional heterogeneity is controlled for. The scale parameters further validate the use of the MMQR approach based on the highly significant and same positive direction scale coefficients for trade volume and government integrity from the lowest to the highest quantile. This indicates that the scale of the positive effect of government integrity as denoted by the location parameter becomes stronger in terms of the magnitude across the conditional distribution of environmental performance from the lowest to the highest quantile. The scale of the negative effect of trade volume becomes weaker (less negative) in terms of the magnitude across the conditional distribution of environmental performance from the lowest to the highest quantile. The scale parameters for per capita GDP are negative but insignificant, showing that the positive effect of living standards diminishes across the conditional distribution of environmental performance with less statistical evidence. It can be observed in Table 3 that the significance of per capita GDP is sustained in all except the 9th quantile of the conditional distribution of environmental performance. This implies a sort of convergence phenomenon as the magnitude of the coefficient also diminishes across the conditional distribution of environmental performance. This probably implies that living standards may have a greater influence on environmental performance in countries with low environmental performance. This is in stark contrast with various studies which confirm a negative association between economic growth and environmental quality (Nasir and Rehman, 2011; Shahbaz et al., 2014; Dogan and Turkekul, 2016; Maryam et al., 2017).

However, there is a need to be aware of other studies that confirm an inverted U-shaped relationship between growth and environmental degradation, an inverse depiction of environmental quality (Narayan and

Narayan, 2010; Gani, 2012; Gozgor, 2017; Usman et al., 2019, Usman et al., 2020; Ike et al., 2020b). What also needs to be taken into consideration is the differences in the data between the present study and other studies which employ a less comprehensive measure of environmental sustainability (CO_2 emissions and ecological footprint) and the periodicity of data for this study spanning the era of the post-Kyoto protocol. This is a time when awareness of the debilitating effects of climate change has been well established and procedures to stem the tide of global warming have already been put into effect.

The empirical results infer that trade is harmful to the environment below the 80th percentile. The statistical evidence begins at the 5th quantile with stronger statistical evidence from the 4th to 1st quantiles. The positive effect of government integrity begins to attain statistical significance at the median quantile. Interestingly, the positive effect of government integrity and the negative effect of trade have weak statistical evidence at the median quantile ($0.1 > p > 0.05$). However, as the positive effect of government integrity attains stronger statistical evidence ($p < 0.05$) from the 6th to 9th quantiles, the negative effect of trade loses trace of significance. At 1st to 4th quantiles, the positive effect of government integrity is insignificant whereas the significance of the negative effect of trade prevails. This implies that at quantiles above the median, the positive effect of government integrity would have a greater effect on the conditional distribution of environmental performance. This underscores the importance of government integrity, supporting the government-driven environmental quality findings reported in Copeland and Taylor (1996). Meaning that the negative effect of GDP per capita on CO_2 emissions after a certain income threshold is not market-driven but depends on the will of the government to enact environmental policies and deploy resources towards the improvement of environmental quality. Environmental quality may not improve if the integrity of the government, which is saddled with the responsibility of deploying fiscal policies targeted towards that effect, is questionable.

As reported in the literature (see Halkos and Paizanos, 2016; Katircioglu and Katircioglu, 2018; Ike et al., 2020a), fiscal policies initiated by

Table 3. OLS and MMQR estimation resultns.

Variables	OLS	Method of Moments Quantile regression (MMQR) with fixed effects										
		Location Parameters	Scale Parameters	Quantiles								
				0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
lnGDPk	20.197*** (5.7158)	20.178*** (5.2259)	-1.8335 (2.3377)	23.114** (0.7139)	22.298** (8.8539)	21.507*** (7.1738)	20.886*** (6.2969)	20.318*** (6.0159)	19.561*** (6.5166)	18.569** (8.3317)	17.994* (9.7349)	17.438 (11.233)
GINT	0.2021* (0.11610)	0.2021* (0.1151)	0.1591*** (0.3206)	-0.0509 (0.2075)	0.0203 (0.1674)	0.0884 (0.1360)	0.1423 (0.1194)	0.1917* (0.1147)	0.2574** (0.1248)	0.3435** (0.1579)	0.3933** (0.1834)	0.4416** (0.2116)
TRADk	-6.965 (4.2682)	-6.7873 (4.3179)	6.7873*** (1.9425)	-17.759** (7.6490)	-14.721** (6.1777)	-11.812** (5.0243)	-9.5136** (4.4104)	-7.4103* (4.2456)	-4.6068 (4.6257)	-0.9366 (5.8304)	1.1907 (6.7540)	3.2498 (7.7937)
Constant	-65.775 (45.892)	-65.775 (51.129)	-40.442** (19.974)									

Note: *, ** and *** indicate significance at 10%, 5% and 1% levels. The values in the parentheses are robust standard error of parameters.
Source: Authors' computations.

the government can have several implications for long-run environmental quality. Hence, the effective deployment and execution of fiscal policies could have positive ramifications for environmental quality only if the integrity of the government is at optimal levels. Notably, as the effect of government integrity becomes significant, the harmful effect of trade becomes less significant, implying that a government with high integrity can curb the negative effect of trade in the environment or in some cases reverse it. This implication is in strong consonance with Chang (2015), revealing that trade liberalization tends to degrade the environment in countries with higher levels of corruption. In contrast, liberalizing trade has the reverse effect (i.e. improving environmental quality) in countries with lower levels of corruption. This implies a moderating effect of governance on trade which our MMQR model alludes to but does not confirm empirically.

Since quantile estimation is limited in terms of diagnostics, we checked the model average marginal effects and its plots at a 95% confidence interval as shown in Figures 3, 4, and 5. The results of the average marginal plots confirm the validity of the estimated parameters.

4.1. Robustness analysis

Even though we employ the method of moment quantile regression technique to obtain conditional quantile coefficients which are traditionally robust to incidences of outliers in the dataset — it is still important to ascertain the sensitivity of our model to alternate specifications and estimators to reach more comprehensive empirical conclusions. For this purpose, we employ the Arellano-Bover/Blundell-Bond GMM estimator which is designed for large N and small T panel data models with large autoregressive parameters. This estimator is better suited to handle problems with endogeneity which may be latently embedded in the regression model of $N > T$ panels. Not controlling for endogeneity can spuriously distort the parameter estimates of regression models. To confirm our earlier suspicions about the possible moderating effect of government integrity on trade due to the obtained quantile estimates, we introduce an interaction term, more specifically — the interaction of government integrity and trade. We also explore other avenues of moderation through a series of other interaction terms notably — the interaction of government integrity and per capita GDP as well the interaction between trade and per capita GDP.

The results from Table 4 Model 1 show that the original location model of the quantile regression is robust to the inclusion of the lagged dependent variable which implies that endogeneity does not significantly distort the parameter estimates. On the contrary, the GMM estimator seems to enhance the magnitude and significance of the parameter estimates of the location model. Specifically, the coefficient on trade seems to have a higher magnitude and has attained statistical significance at the 1% level. A one percent increase in trade which hitherto was associated with a 6.7 unit point reduction in EPI in the location model now has an 18 unit point reduction effect on EPI in the GMM model. Other parameter estimates in model 1 of the GMM specification notably the coefficients on per capita GDP and government integrity are quite close to the original location parameters of the MMQR regression.

Moving forward to model 2 of Table 4, it can be observed that the interaction of trade and government integrity is positive and statistically significant implying a positive moderation effect of government integrity on trade. At lower levels of government integrity, trade has a positive significant effect on EPI but at higher levels of government integrity, the effect of trade becomes positive and statistically significant. The same scenario is observed for government integrity. At lower levels of trade, government integrity has a negative and significant relationship with EPI but at higher levels of trade, the effect of government integrity becomes positive and significant. This implies that the economic priorities of government institutions tend to change at different levels of trade intensity. A similar scenario seems to hold in model 3 when per capita GDP interacts with government integrity. At low levels of per capita GDP, government integrity has a significant negative relationship with EPI
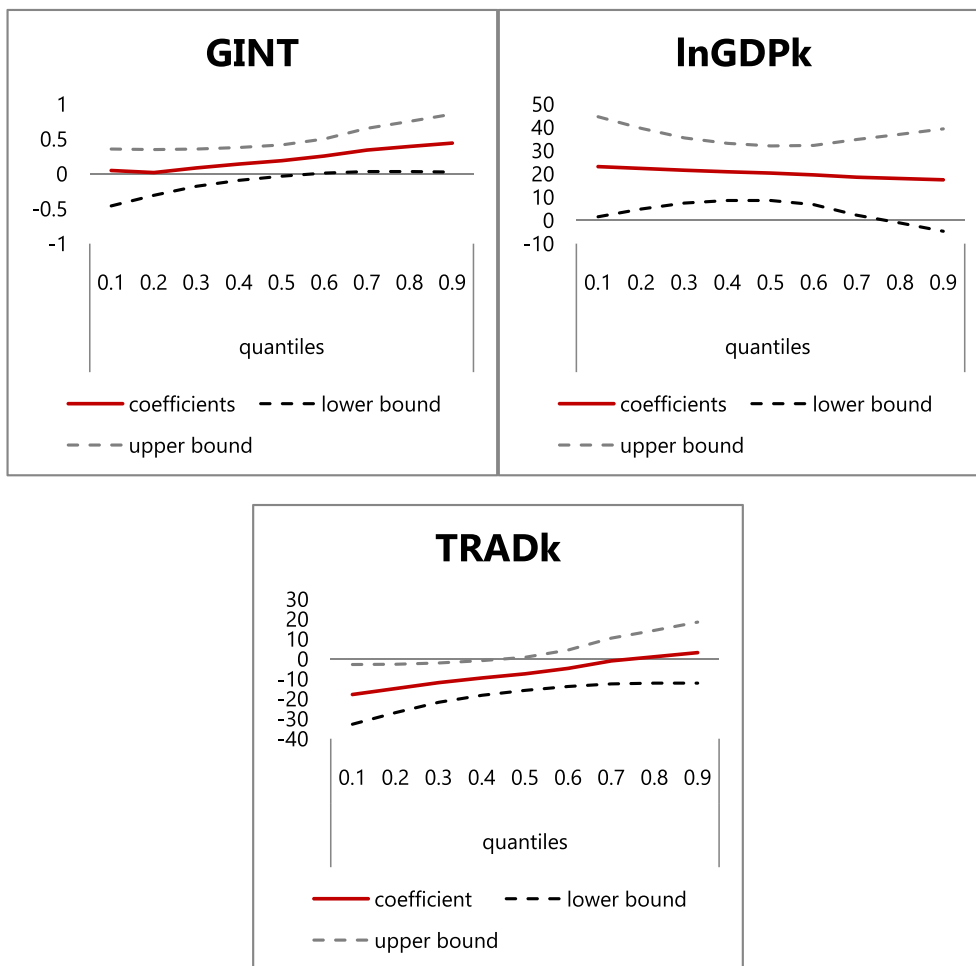
Figure 2. Graphical representation of MMQR coefficients across quantiles. Dashed lines represent lower and upper bounds of the 95% confidence intervals.

which becomes positive at higher levels of per capita GDP. The effect of per capita GDP, however, seems to exhibit a positive monotonic trend. It becomes a bit more interesting in model 4 when trade interacts with per capita GDP. At lower levels of per capita GDP trade has quite a debilitating effect on environmental performance but at higher levels of per capita GDP, trade effects become positive. Analogous to the observed pattern in model 3, per capita GDP has a positive monotonic trend in model 4. This is

consistent with the findings of Heil and Selden (2001) wherein pollution abatement effects of trade was discovered in higher-income countries as against pollution intensification effects in lower-income countries. A core difference of the two studies is that while Heil and Seldon (2001) employ a CO_2 emissions indicator which captures pollution proliferation, our study employs the EPI environmental performance indicator which captures sustainable environmental policy targets.
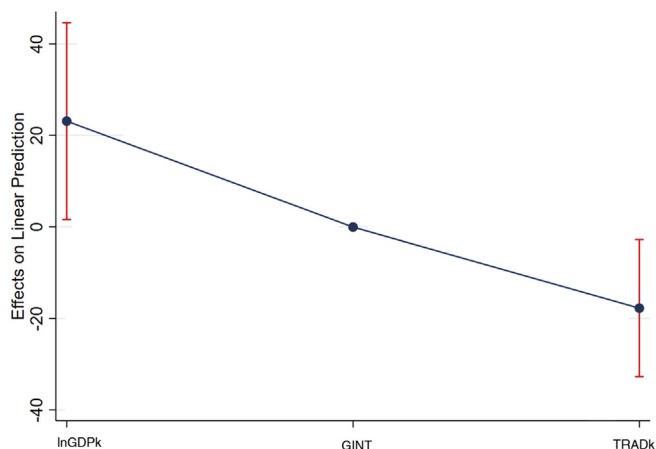

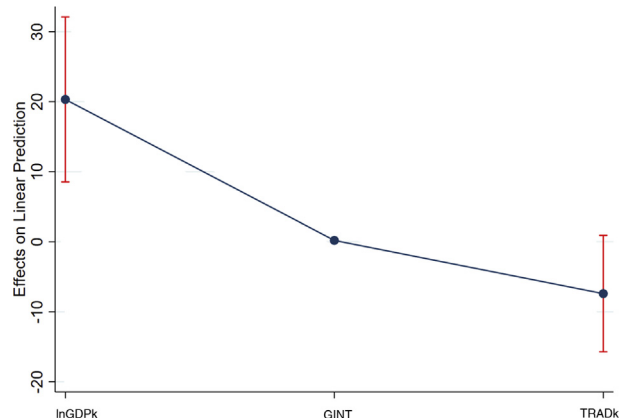**Figure 3.** Average marginal effect at 5th percentile.

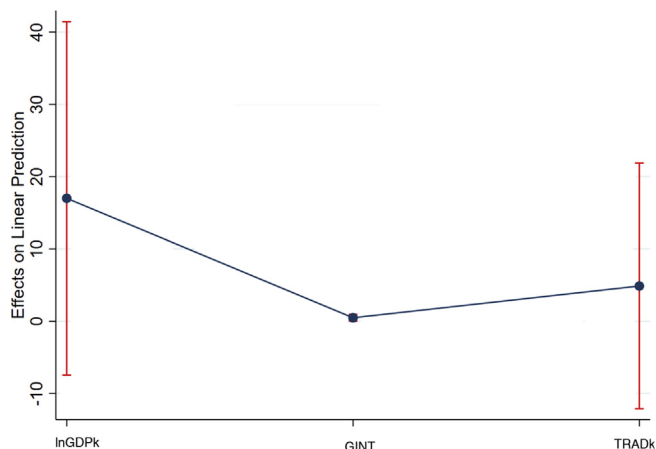**Figure 4.** Average marginal effect at 50th percentile.

Figure 5. Average marginal effect at 95th percentile.

4.2. Discussion of results

The MMQR empirical results show that while environmental performance effect of government integrity and trade seems to be non-monotonic across quantiles, the effect of per capita GDP which can effectively proxy living standards is observed to be positively monotonic across quantiles. This comes with the implication that living standards or the state of the economy seem to be an important factor in the quest to environmental sustainability. The positive environmental performance effect of living standards is invariant to the state of the environment. Also, the fact that trade intensity has a deleterious effect on environmental performance in countries with lower environmental performance implies either the existence of environmentally unsustainable trade policies or the prioritization of environmentally degrading trade activities to fill the economic vacuum left by low trade volumes. This result is complementary to that which is obtained for government integrity. Government integrity has a negative but statistically insignificant effect on environmental performance in countries at the lowest quantile of the conditional distribution of environmental performance but begins to have a statistically significant positive relationship from the 6th quantile onwards with the implication that institutional focus begins to shift from pollution-intensive activities to sustainable development practices at the higher quantiles of the conditional distribution of EPI.

From what can be observed in the GMM empirical results, government integrity tends to ensure that the environmental degrading effect of trade is kept at bay in countries with higher trade intensities. However, at lower levels of trade, government integrity tends to be deleterious to environmental performance. This, as noted above, may be due to the existence of a different set of priorities for the governing institutions at countries with lower trade intensities. Governing institutions of countries with lower trade intensities may prioritize environmentally degrading economic activities to fill in the economic vacuum that may exist due to

lower trade volumes. However, in countries with higher trade intensities, priorities may shift towards environmentally sustainable practices which may reverse the environmentally degrading effects of trade. In addition, countries with lower living standards are more likely to become pollution havens as increasing trade intensity in these countries are seen to have debilitating effects on environmental performance. However as the economy grows and living standards improve, countries move to a better position to offset the cost implications of improving environmental health and can afford to make the needed sacrifices to curtail the degradation of ecosystem vitality, a process which would improve overall environmental performance. A comparative assessment of both MMQR and GMM results show that trade intensive countries with higher environmental performance are more likely to have quality institutions. Countries with lower living standards are more likely to become pollution havens as increasing trade intensity in these countries is seen to have debilitating effects on environmental performance.

5. Conclusion and policy remarks

In this study, we examined the critical role of institutional variables vis-a-vis government integrity on the trade-environment nexus in the Post Kyoto-protocol era for a panel of 79 countries—comprising developing and developed countries over the period 2008 to 2018. To achieve this objective, we applied a large sample size with a broad-based measure of environmental performance, constructed based on 24 performance indicators, 10 issue categories and 2 core policies of environmental health and ecosystem vitality. The empirical results of the traditional mean estimator via OLS revealed that per capita GDP and government integrity positively affect environmental performance whereas trade hampers environmental performance. After controlling for the effects of per capita GDP and government integrity across the conditional distribution of environmental performance through the MMQR estimation with fixed effects, the results indicate that per capita GDP positively and significantly affects environmental performance across all quantiles except the 90th percentile. This finding is attributed to the implementation of the Kyoto protocol, which has curtailed the effect of environmental degradation and climate change. The positive effect of government integrity was statistically significant at the median quantiles with stronger effects in countries with higher environmental performance. The effect of trade on environmental performance was negative but only significant up to the 5th quantile, after which the trace of significance was expunged. The positive effect of government integrity had stronger statistical evidence from the 6th quantile onwards whereas the negative effect of trade turned insignificant after the 5th quantile. It can be observed from the GMM estimator that the locational model estimates are robust to incidences of endogeneity and heteroskedasticity which would also entail the consistency of the quantile estimates. Furthermore, a series of interaction terms have shown that institutions and living standards tend to moderate the negative environmental performance effects of trade intensity. Based on the empirical results, the following conclusions are adroitly crafted:

Table 4. Arellano-Bover/Blundell-Bond system GMM estimator.

Variables	Model 1	Model 2	Model 3	Model 4
EPI$_{t-1}$	0.1005*** (0.0376)	0.1014*** (0.0382)	0.1065*** (0.0381)	0.0881*** (0.0441)
lnGDPk	25.503*** (6.0563)	23.651*** (6.1121)	15.952** (6.8124)	23.171*** (7.1556)
GINT	0.3122** (0.1394)	-1.2516* (0.7462)	-1.6544* (0.7977)	0.2488* (0.1438)
TRADk	-18.147*** (4.9896)	-24.956*** (5.8311)	-19.045*** (4.957)	-114.21*** (24.364)
GINT*TRADk	_	0.1799*** (0.0790)	_	_
GINT*GDPk	_	_	0.2193*** (0.0830)	_
GDPk*TRADk	_	_	_	5.899*** (1.489)
Constant	-28.925* (17.7294)	41.373 (30.844)	57.792* (32.704)	37.124*** (10.525)

Note: "***","**"and "*" denote statistical significance at the 1%, 5% and 10% levels respectively. Heteroskedasticity robust standard errors in parentheses.

(i) The effect of trade on environmental quality is largely dependent on the level of government integrity and living standards.
(ii) High level of government integrity possibly averts the environmental deteriorating effect of trade.
(iii) Strengthening government integrity entails the provision of a sound regulatory framework for achieving higher environmental performance and efficiently dampening the environmental degradation effect of trade.

Based on all these, implications for policy would entail the need to hold trade-related industries accountable to strict regulatory compliance in line with sustainable occupational practices which would construe minimal environmental hazards. Developed economies with stronger institutions should also make it mandatory for trade-oriented multinational companies which originate from their countries to adhere to environmentally sustainable practices while operating in lower-income economies with weak institutions and negligible regulatory frameworks. We recommend the inauguration of an international oversight committee by the United Nations to track the activities of trade-oriented multinational companies especially in developing economies with weak institutions. This would mitigate the proliferation of pollution havens and would reduce the burden on the environment especially burdens inflicted by multinational companies incentivized by corporate profit. Future research should dwell on disaggregated regional and country group studies of the trade environmental performance nexus. This would include classifying these regions according to trade intensity and institutional strength and including them in the empirical analysis to gain a broader perspective.

Declarations

Author contribution statement

Samuel Asumadu Sarkodie, George N. Ike: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Abdulkareem Alhassan: Conceived and designed the experiments; Wrote the paper.

Ojonugwa Usman: Analyzed and interpreted the data; Wrote the paper.

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Additional information

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