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Environmental Trends and the Competitiveness of the Transportation Industry

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Abstract: By mid-century, some nations aim to have produced electric vehicles with zero emissions. Transportation currently accounts for 25% of carbon emissions, and this percentage is only going up. Using data from June 2012 through June 2023, the study looks at 75 nations to see how transportation competitiveness affects carbon emissions reduction. The research uses Panel Quantile Regression to classify transportation-related carbon emissions into four evolving quantiles. Groups 2 and 3 of the quantile scale suggest that carbon emissions are driven by transportation rivalry, whereas group 1 shows the opposite. Quantiles 2 and 4 show a U-shaped Environmental Kuznets Curve, according to the research. The point at which the EKC shifts from quantiles 2 to 4 is moderated by transportation competition. Particularly in the group with highCO_2 quantiles, this moderating effect flattens the EKC and reduces sensitivity. The results suggest that lowering carbon emissions across quantiles is a goal of population growth and institutional quality plans.

Keywords: Transportation industry, Carbon dioxide emissions, Environmental Kuznets Curve (EKC), Panel Quantile Regression Model, 75 countries

1. Introduction

The transportation industry plays a vital role in driving economic growth as it facilitates commerce and enables mobility (Chen & Li, 2021). Transportation links that connect different economic sectors play a crucial role in job creation and driving economic growth (Magazzino & Mele, 2020). Although the transportation industry plays a crucial role in driving economic growth, it heavily relies on fossil fuels and is responsible for emitting a significant amount of greenhouse gases, as highlighted by Aslan et al. (2021). Over time, the rise of globalization and urbanization has significantly contributed to the increased use of fossil fuels and the subsequent rise in carbon emissions within the transport sector (Pradhan et al., 2021). Transportation-related greenhouse gas emissions are a growing concern due to their negative impacts on the environment, public health, and food security (Baz et al., 2021). Academics and policymakers have been looking into the environmental sustainability of the transport sector due to its rapidly increasing carbon emissions (Amin et al., 2020). Promote the adoption of renewable fuel in transportation and support the development of zero-emission green technology (Wanke et al., 2020). Several countries have made a firm commitment to achieving net zero emissions and ramping up electric car production by 2050, as stated in the Global EV Outlook by the IEA in 2021. The transportation industry has seen improvements in environmental sustainability through measures such as energy price control, tax incentives for green technology, recycling, and carbon taxation in various countries

(Shan et al., 2021). In addition to transportation, the transportation industry is also environmentally friendly. In order to effectively reduce carbon emissions, it is crucial to focus on strengthening institutions, ensuring a corruption-free government, and fostering close collaboration between the transportation industry and other sectors (Zhao et al., 2020). The services industry has experienced significant growth over the past 20 years, evident in the sector's increased contribution to the global GDP, which has risen from 50% to 64% (World Development Indicators, World Bank). According to Hou et al. (2021), the services sector, which includes travel and transportation, is not completely free from carbon emissions due to its reliance on fossil fuels. The study objectives to address thecurrent research gap in several ways. (a) Assessing the impact of transportation competitiveness on carbon emissions in the transportation sector. (b) Conducting a practical analysis of carbon emissions in the transportation sector using the services-based EKC. To analyze the potential impact of transportation competitiveness on turning points and service levels, an EKC approach can be used. This research paper explores the role of the services sector in establishing the services Environmental Kuznets Curve (EKC) by analyzing the carbon emissions from the transportation sector. The research assesses the carbon emissions of the transportation industry by evaluating transportation competitiveness. Through an analysis of transportation competitiveness and its impact on the turning points of the Environmental Kuznets Curve (EKC), the study provides insights into the evolving dynamics of services EKC. The Stochastic Impact by Regression on Population, Affluence, and Technology (STIRPAT) framework and the Environmental Kuznets Curve (EKC) are two widely recognized environmental models that form the basis for this research study (Kuznets, 1955; Grossman & Kruger, 1991).

2. Literature Review

The literature evaluation includes recent EKC and STIRPAT model validation articles and carbon emission moderation investigations. Simon Kuznets proposed EKC in 1955 to explain income growth and inequality. Many environmental economists investigated this idea on different data sets. The hypothesis of EKC was validated for inverted U, U, and N forms. Below is an overview of recent research on EKC validation for different data types:

Table 1: Summary of Recent Studies Regarding Validation of EKC Hypothesis

Authors	Sample Size	Time	Outcome of EKC
Ulucak and Bilgili (2018)	Low, Middle and High Income Countries	1961 to 2013	Inverted U Shape
Balado-Naves et al. (2018)	173 Countries	1975 to 2014	Inverted U Shape
Churchill et al. (2018)	20 OECD Countries	1870 to 2014	Inverted U Shape for 05 countries and N Shape for 04 countries
Du et al. (2018)	27 Capital Cities of China	2011 to 2015	Shape for Central Region and inverted N Shape for other Regions
Fujii et al. (2018)	276 Metropolitan Cities of World	2000, 2005 and 2008	Inverted U Shape
Rauf et al. (2018)	65 BRI Countries	1981 to 2016	Inverted U Shape and EKC not Supported in 14 Countries
Sarkodie (2018)	17 African Coun	1971 to 2013	U Shape
Zhang and Zhao (2019)	30 Provinces of China	1996 to 2015	Inverted U Sh
Azizalrahman (2019)	Different Income Group Countries	1973 to 2013	Inverted U Shape
Xie et al. (2019)	249 Cities of China	2015	Inverted U Shape
Isik et al. (2019)	50 States of USA	1980 to 2015	Inverted U Shape in 13 States
Zhang (2019)	04 Countries of Central Asia	1992 to 2013	U Shape
Chen et al. (2019)	China	1980 to 2014	Inverted U Shape
He and Lin (2019)	Provincial Data of China	2003 to 2017	Inverted U Shape
Jin and Kim (2020)	34 Countries	1975 to 2016	U Shape

Dogan and Inglesi-Lotz (2020)	European Countries	1980 to 2014	U Shape
Huangfu et al. (2020)	275 Municipal Cities of China	2003 to 2016	Inverted U Shape EKC in more developed Cities and no EKC in less Developed Cities
Halliru et al. (2020)	06 West African	1970 to 2017	U Shape
Aydoğan and Vardar (2020)	E7 Countries	1975 to 2014	Inverted U Shape
Nguyen et al. (2020)	33 Emerging Economies	1996 to 2014	Inverted U Shape
Dogan et al. (2020)	BRICS Countries	1980 to 2014	U Shape
Pandey et al. (2020)	Asian Countries	1971 to 2014	Not supported for consumption based approach
Cheikh et al. (2021)	Middle East and North African (MENA) Countries	1980 to 2015	Inverted U Shape
Tenaw and Beyene (2021)	20 Sub-Saharan African Countries	1975 to 2015	Inverted U Shape
Liu and Lai (2021)	134 Countries	2001 to 2018	Inverted U Shape
Isik et al. (2021)	08 OECD Countries	1962 to 2015	EKC Not Supported in 04 Countries
Arshed et al. (2021a)	80 Countries	1975 to 2017	U Shape
Jiang et al. (2021)	China	1985 to 2014	Inverted U Sh
Bibi and Jamil (2021)	122 Countries	2000 to 2018	Inverted U Shape but not supported in Sub-Saharan Africa
Usman and Jahanger (2021)	93 Countries	1975 to 2016	Inverted U Sh
Wang et al. (2021)	198 Countries	1975 to 2018	U Shape

Literature Review Regarding STIRPAT Framework

Researchers have incorporated additional factors such as globalization, financial development, institutional quality, and others into the baseline STIRPAT model to evaluate their environmental impact, demonstrating their expertise in the field. The IPAT identity was initially utilized to evaluate environmental impact by combining population, prosperity, and technology (Ehrlich & Holdren, 1971). In subsequent studies, researchers utilized STIRPA to investigate the impact of IPAT identity basis characteristics on environmental contamination (Dietz & Rosa, 1994; York et al., 2004). Population, prosperity, and technology were incorporated into the STIRPAT model to uphold the IPAT model. The STIRPAT model provides a more accurate framework for estimating the environmental impact of IPAT variables on pollution compared to the IPAT identity (Xu et al., 2020; Wang et al., 2021). Arshed (2021a) and Wang (2021) have provided references for further reading. Considering the importance of institutional quality in the implementation of environmental regulations, it has a direct impact on carbon emissions (Shah et al., 2020; Khan, 2021). Transportation carbon emissions can be more effectively tackled in regions or countries with robust institutions. Countries with weak institutions and high corruption tend to experience higher levels of pollution. Research indicates that organizations with limited resources often face challenges in implementing environmental conservation practices (Acheampong et al., 2019; Sheraz, 2021; Habiba, 2021). Moderator, the third variable helps to clarify the relationship between interdependent variables. Environmental economics examines the impact of various factors on income and carbon emissions. Katircioğlu and Taşpinar (2017) conducted an analysis of data spanning from 1960 to 2020, aiming to establish a correlation between energy consumption and economic progress in Turkey. The study calculates long- and short-run coefficients using ARDL methodology. The study discovered that financial development moderation led to an increase in the inverted U-shaped EKC. In a study conducted by Wang et al. (2018), the focus was on analyzing the relationship between income-induced carbon emissions in BRICS states from 1996 to 2015 and the potential influence of corruption as a moderating factor. A recent study suggests that addressing corruption could potentially reduce income-based carbon emissions in BRICS countries. In a study conducted by Qi et al. (2019), it was discovered that carbon emissions were significantly reduced in various locations across China. According to Naz et al. (2019), carbon emissions tend to increase when foreign direct investment and GDP growth are balanced with renewable consumption. In a study conducted by Gill et al. (2019), it was discovered that Malaysia did not exhibit an Environmental Kuznets Curve (EKC). Nevertheless, the progress of the economy significantly mitigates the carbon emissions caused by income. In a study conducted by Ehigiamusoe et al. (2020), it was discovered that there is no evidence to suggest that moderating energy consumption for economic growth leads to a reduction in carbon emissions in the sampled nations. In a study conducted by Uddin (2020), it was discovered that there is a stronger relationship between income and environmental quality when financial development is taken into account. Kirikkaleli and Kalmaz (2020) found that urbanization plays a moderating role in the relationship between carbon emissions and other explanatory factors, such as the inverted U shape EKC. In a study conducted by Badeeb et al. (2020), it was discovered that the moderation of natural resources has an impact on the income-based Environmental Kuznets Curve (EKC). It was confirmed that Malaysia's carbon emissions are influenced by its dependency on natural resourcesin relation to both linear and non-linear GDP. In a study conducted by Ehigiamusoe (2020), various econometric methods were utilized to determine the negative impact of tourism on carbon-based economic development in a selection of countries. In their study, Sheraz et al. (2021) found that the moderation of globalization had a positive impact on human capital and financial development in relation to carbon emissions. Liobikienė and Butkus (2021) argue that the connection between environmental degradation and economic growth is intricate. Rjoub et al. (2021) discovered that the progress of financial systems played a role in influencing the relationship between economic growth, urbanization, and environmental degradation. In a recent study by Sharma et al. (2021), they confirmed the presence of a U-shaped Environmental Kuznets Curve (EKC) when examining greenhouse gas (GHG) emissions and agricultural value. Reducing greenhouse gas emissions by moderating pesticide use and utilizing renewable energy sources. Yuan et al. (2021) found that carbon emissions in China are influenced by the quality of institutions. Moderation can hinder economic development.

3. Research Methodology

3.1 Theoretical Framework

The theoretical framework of the research study is developed using the EKC and STIRPAT frameworks in order to accomplish the research objectives. Two options for the theoretical framework are taken into consideration in this regard. The link between the value addition of the services sector and the carbon emissions of the transportation sector is shown by an inverted U shape in Figure 1. The services of the inverted form The first stage, which is represented by EKC, is the expansion of the services sector and is positively correlated with the carbon emissions of the transportation sector. For testing purposes, the study has taken into account U-shaped and inverted U-shaped EKC possibilities. Transportation competitiveness is used to assess how service EKC behavior has changed.

Figure 1: Theoretical Model

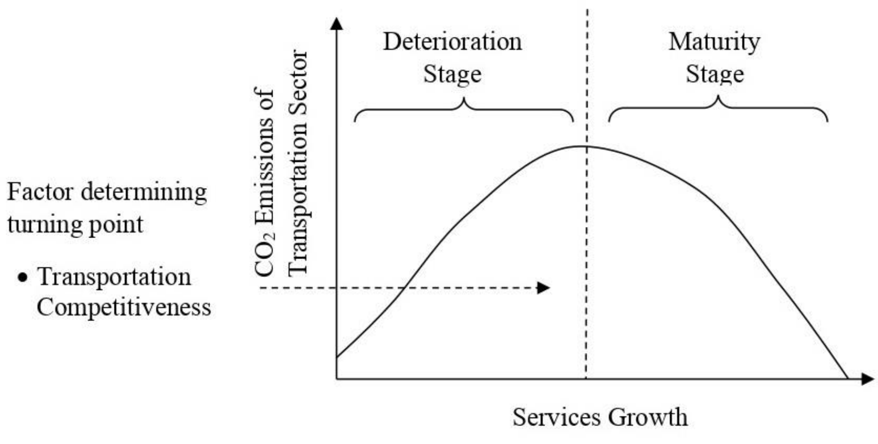
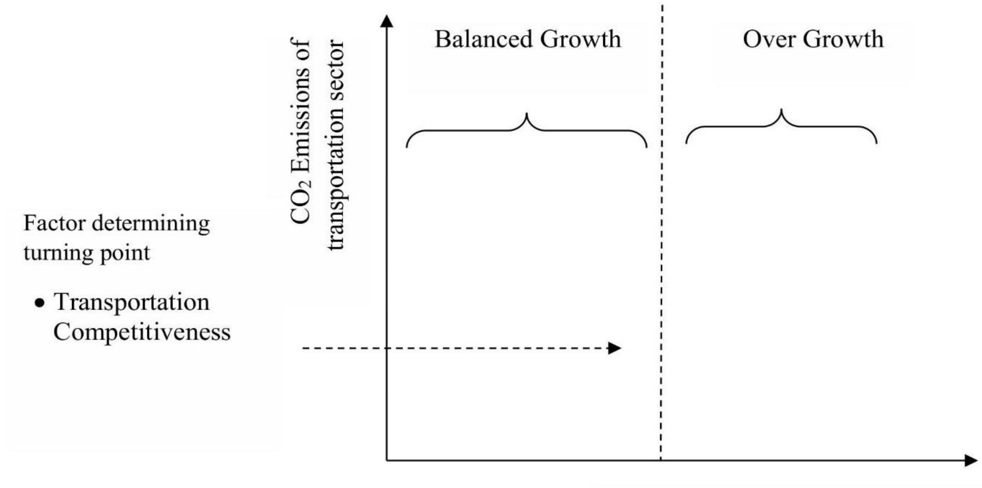


Figure 2: Theoretical Model



3.2 Research Design

A panel of 75 nations is utilized to accomplish the research objectives (Appendix-A). According to the data on transportation competitiveness from WEF, the following countries are included in the list. In 2008, the WEF monitored the competitiveness of transportation. Due to the globalimpact of the COVID-19 pandemic, transportation was suspended worldwide, which restricted the scope of research to the year 2018. The data is organized based on transportation carbon emissions. Four dynamic quantiles are created based on transportation carbon emissions. Groups with varying levels of CO2 emissions: low, low-medium, high-medium, and high. These groupings are determined by the annual CO2 values. Therefore, it is important for developing countries to make significant advancements. The study variables with the source of data are presented in Table 1.

Table 1: Study Variables

Abbreviation of Variables	Full Name of Variables	Data Sources
CO_2	Log of Transportation Sector CO2 Emissions (Mt/Capita)	EDGAR*
SVC	Log of Services Value Added	WDI**
SVC^2	Square of Log of Services Value Added	WDI**
PDEN	Log of Population Density	WDI**
TC	Transportation Competitiveness Index	WEF***
INST	Institutional Quality Index	ICRG****

* Emissions Database for Global Atmospheric Research (EDGAR); **World Development Indicators (WDI); ***World Economic Forum (WEF); ****International Country Risk Guide (ICRG)

Table 1 shows transportation carbon emissions as the dependent variable. Emissions Database for Global Atmospheric Research provides metric tons per capita data for this variable. World Development Indicators data is used for services value addition and square of value addition, independent variables. Several studies have employed this variable to explain environmental contamination fluctuations (Arshed et al., 2021a; Wang, 2021). Environmental analysts often employ demographic variables. Population density is one of the factors used to explain transportation pollution (Dogan et al., 2020; Nguyen et al., 2020; Wang et al., 2021). The high Institutional quality rating guarantees carbon emission standards are properly implemented. Institutional quality is included in the study to evaluate transportation sector carbon emissions due to its relevance. The transportation competitiveness index assesses transportation quantity and quality. Therefore, the model includes transportation competitiveness' moderating function to decide transportation sector carbon emissions. Research study functionality is as follows:

$CO_{2(T)}$= f (SVC, SVC^2, TQ, POP, TEC)…………………………………………………………...…….Eq-1

Based on the functional form of the research study, the standard form of the equation is as under:

$CO_{2it} = \beta_0 + \beta_1 SVC_{it} + \beta_2 SVC_{it}^2 + \beta_3 SVC_{it}{*}TC_{it} + \beta_4\ SVC^2_{it}{*}TC_{it} + \beta_5 TC_{it} + \beta_6 PDEN_{it} + \beta_7 INST_{it} + \mu_{it}$……………………………………………………………………………………………………Eq-2

The non-linear term of the services sector is included in the model to empirically validate the services EKC based on carbon emissions of the transportation sector. For inverted U shape EKC, $\beta_1 > 0$ & $\beta_2 < 0$ and both have to be significant. However, in case of U shape EKC $\beta_1 < 0$ & $\beta_2 > 0$ and significant. The moderation of transportation competitiveness is included in the model to determine the changes in the direction of the slope of services EKC and its relative flattening / steepening (Haans et al., 2016). To determine the changes in the direction of the slope of EKC, we differentiate the Equation 2 concerning SVC and then, by equating it to zero, we obtain:

$SVC^* = (-\beta_1 - \beta_3\ TC) / (2\beta_2 + 2\beta_4\ TC)$……………………………………………………….…………………....Eq-3

The above equation 3 indicates that the turning point of services EKC depends on the value of transportation competitiveness, which is the moderator. To determine the changes in the turning point, we differentiate the equation 3 concerning transportation competitiveness and obtain the following equation:

$\delta SVC^* / \delta TC = (\beta_1\ \beta_4 - \beta_2\ \beta_3) / 2(\beta_2 + \beta_4 TC)^2$ ………………………………………………………………...Eq-4

The denominator of equation 4 is positive due to the square term. Therefore, the changes in the turning point depend on the numerator term $\beta_1\ \beta_4 - \beta_2\ \beta_3$. If the numerator term, i.e., $\beta_1\ \beta_4 - \beta_2\ \beta_3$, is positive, then the turning point will tend to the right side and vice versa. This derivation indicates that the changes in the direction of the slope of services EKC do not only depend on $\beta 3$ but also on β_1, β_2 and β_4 (Lind & Mehlum, 2010; Haans et al., 2016; Arshed et al., 2021b). On the contrary, the flattening or steepening of services EKC is straightforward as it only depends on $\beta 4$. The cross product of square term of services growth with the moderator, i.e., transportation competitiveness, indicates the flattening or steepening of services EKC and depends on β_4. If β_4 is positive and significant, then services EKC will tend towards flattening for inverted U shape services EKC. The steepening will occur for inverted U shape services EKC when β_4 is negative and significant. Similarly, in U shape services EKC, the positive and negative significance of β_4 indicates the steepening and flattening of services EKC for transportation competitiveness, respectively (Lind & Mehlum, 2010; Haans et al., 2016).

The Dawson method was used to prepare further the graphs to validate transportation competitiveness moderation. The regression coefficients of services growth, square of services growth and cross products are used (Dawson, 2014). The graph shows the moment of services curve at low and high levels of transportation competitiveness and indicates the changes in curvilinear behaviour of services growth for different levels of the moderator (Arshed et al., 2021b).

The basic foundations of IPAT identity and STIRPAT framework are used to derive the research study model in its logarithm form. The STIRPAT model is derived based on standard IPAT identity, which is as under:

$I_i = a\ P_i^b A_i^c T_i^d ei$ ………………………………………………………………………….........................Eq. 5

Where "I_i" denotes the environmental impact, "P_i" denotes population size, "A_i" shows affluence, and "T_i" is the technology. By using a natural log, the following standard form of the STIRPAT model is derived:

$\ln I_{it} = a + b\ (\ln P_{it}) + c\ (\ln A_{it}) + d\ (\ln T_{it}) + \ln e_i$ ……………………………………………………………Eq. 6

It is also appropriate that once the standard STIRPAT model is derived, additional variables can also be added according to the scope and dimensions of the research study (Lv et al., 2019; Xu et al., 2020; Arshed et al., 2021a; Wu et al., 2021). Accordingly, the extended STIRPAT model of the study based on the variables highlighted in Table 1 is as under:

$\ln (CO_{2it}) = \beta_0 + \beta_1\ (\ln SVC_{it}) + \beta_2\ (\ln SVC_{it})^2 + \beta_3\ (\ln SVC_{it}{*}TC_{it}) + \beta 4\ (\ln SVC^2_{it}{*}TC_{it})$
$+ \beta_5\ (TC_{it}) + \beta_6\ (\ln PDEN_{it}) + \beta_7\ (INST_{it}) + \mu_{it}$ ………………………………………………….......................Eq. 7

The Panel Quantile Regression (PQR) is used to estimate the research study results. The PQR estimation technique has many benefits over conventional regression estimation techniques. The PQR estimation technique uses the median as the average rather than the mean because the mean is affected by extreme values in the data set. In panel data sets having large cross-sections are observed that most of the variables are non-normal, but the PQR is a very suitable technique for estimation of results having non-normal variables as it uses median as a measure of central tendency. The PQR estimation procedure dates back to 1978 when Koenker and Bassett advocated this estimation model in their seminal paper (Koenker& Bassett, 1978). Furthermore, the PQR estimation technique is not distribution sensitive and produces robust results (Powell, 2015; Baker et al., 2016). The general form based on the quantile regression equation is as under:

$Q_{yi} (\tau | x_i) = x_i^T \beta_\tau$

However, the fixed effect based PQR can be written as:

$Q_{yi} (\tau | \alpha_i x_{it}) = \alpha_i + x'^{it} (\tau k)$

Koenker (2004) advocated a more suitable estimation technique to deal with unobserved effects by incorporating different quantiles for estimation purposes. Thus, the appropriate parameter estimation procedure for PQR is as under:

$$\min_{(\alpha,\beta)} \Sigma^K_{k=1}\Sigma^T_{t=1}\Sigma^N_{i=1} wkP_{\tau k}(yit - \alpha i - x^T it\ \beta_{(\tau k)}) + \lambda\ \Sigma^N I\ |\alpha I|$$

In this above equation, the countries N index is shown by I, the number of observations is indicated by T for countries, K represents quantile index, explanatory variables matrix is represented by x, while Ptk shows loss function for quantiles, Wk indicates the weight given to kth quantile and λ shows tuning parameter. The recently available literature shows that PQR is extensively engaged in analysing panel data for large cross-sections by considering various quantiles for envisaging environmental pollution (Zheng et al., 2019; Khan et al., 2020; Chowdhury et al., 2021).

4. Results and Discussions

The descriptive statistics of the variables included in the research study are calculated to ascertain the information regarding the concentration and dispersion of the data. The measures of central tendency include mean, median mode and percentiles, while the indicators for dispersion are standard deviation, interquartile range, skewness and kurtosis. The summary of these different measures of central tendency and measures of dispersion regarding different variables is presented in Table 2. The variance inflation factor (VIF) was also calculated to detect multicollinearity based on the correlation coefficient among the study variables. The results of VIF indicated that none of the values of VIF > 10 indicates no issue of multicollinearity (Gujarati, 2011).

Table 2: Descriptive Statistics of the Study Variables

	lnCO_2	**lnSVC**	**TC**	**INST**	**lnPDEN**
N	1331	1288	1282	1282	1331
Mean	2.0040	3.9828	4.2214	4.1299	4.3050
Median (P_{50})	1.8780	4.0188	4.2217	3.9227	4.4557
SD	1.8978	0.2194	1.2030	0.8754	1.4328
IQR	2.4183	0.2621	1.8283	1.3881	1.7611
Range	10.2119	1.4858	5.2558	3.7275	8.4541
P_{25}	0.7798	3.8691	3.2911	3.4180	3.4813
P_{75}	3.1982	4.1312	5.1194	4.8062	5.2425
Skewness	0.1539	-0.9675	0.0868	0.5314	-0.1784
Kurtosis	2.8588	4.3175	2.1617	2.2769	3.5289

The skewness/kurtosis normality test tests the normality of the data series included in the analysis. The significant results of this normality test for all the variables indicated that all the series included in the analysis are not normally distributed, and the normality test results are summarized in Table 4.

Table 3: Variance Inflation Matrix for Study Variables

	lnCO_2	**lnSVC**	**TC**	**INST**	**lnPDEN**
lnCO_2	-	-	-	-	-
lnSVC	1.0870	-			
TC	1.1366	1.2745	-	-	-
INST	1.0625	1.1636	3.2059	-	-
lnPDEN	1.0008	1.0695	1.0303	1.0099	-

Based on the non-normal data series of the variables, the Panel Quantile Regression (PQR) estimation procedure is engaged for data analysis as this technique is not distribution sensitive and can generate robust results (Powell, 2015; Baker et al., 2016). The analyzed results of PQR estimation technique are presented in Table 5.

Table 4: Skewness / Kurtosis Tests for Normality

Variables	Observations	Pr(Skewness)	Pr(Kurtosis)	Adj. $Chi^2(2)$	$Prob>Chi^2$
$lnCO_2$	1331	0.0219	0.2983	6.31	0.0426
lnSVC	1228	0.0000	0.0000	-	0.0000
TC	1282	0.2025	0.0000	-	0.0000
INST	1282	0.0000	0.0000	-	0.0000
lnPDEN	1331	0.0080	0.0011	16.12	0.0003

The study results are analyzed in four quantile groups, and these quantile groups are created based on carbon emissions of the transportation sector. These quantile groups are named based on the level of carbon emissions of the transportation sector, such as low CO2, low medium CO2, high medium CO2 and high CO2 group. The services sector value addition significantly increases carbon emissions of the transportation sector across quantile group-1&3. The growth of the services sector in low CO2 group countries requires more transportation to commute people and goods from one place to another, which tends to increase the transportation sector's carbon emissions. However, in quantile, group-2&4 services sector significantly tends to mitigate carbon emissions of transportation sector indicating that services sector is using such type of transportation which has the potential to mitigate carbon emissions across high CO2 emitting group of countries (Arshed et al., 2021a; Wang et al., 2021).

The higher levels of the services sector in the form of the squared term are included in the model to ascertain its behaviour with carbon emissions. This non-linear aspect of services sector growth also empirically validates the EKC hypothesis for services-emissions nexus (Arshed et al., 2021a; Wang et al., 2021). The sign of the coefficients for services growth and its square term in group-1 has not changed, which indicates that the EKC hypothesis is not supported. However, in group-2, the sign of the coefficient of services growth and its square term has changed from negative to positive, indicating the validation of U shape EKC (Arshed et al., 2021a; Wang et al., 2021). Furthermore, the EKC hypothesis was not supported in group-3 as the square term of services growth coefficient is insignificant. Finally, the EKC hypothesis in U shape is supported in group-4 as both coefficients of services growth and its square term are significant and have negative and positive signs, respectively (Arshed et al., 2021a; Wang et al., 2021). The validation of U shape services EKC across group-2&3 indicates that the services sector has crossed the sustainability phase, and expansion of the services sector exacerbates environmental pollution.

Table 5: Estimation of PQR Results for four Quantile Groups (Dependent Variable: $lnCO_2$)

	Quantile Group-1 (Low CO2)		Quantile Group-2 (Low Medium CO2)		Quantile Group-3 (High Medium CO2)		Quantile Group-4 (High CO2)	
Variables	**Coefficient**	**P-Values**	**Coefficient**	**P-Values**	**Coefficient**	**P-Values**	**Coefficient**	**P-Values**
lnSVC	2.5636	0.0000*	-22.2697	0.0000*	4.3341	0.0680***	-45.3359	0.0000*
$lnSVC^2$	0.2797	0.0005*	2.7748	0.0000*	-0.3026	0.2230	5.6323	0.0000*
lnSVC*TC	-0.7915	0.0000*	0.1266	0.0020*	-0.2753	0.0080*	0.5913	0.0000*
$lnSVC^2$*TC	-0.0304	0.0000*	0.0053	0.0000*	0.0086	0.0000*	-0.0504	0.0000*
TC	4.2621	0.0000*	-0.6238	0.0000*	0.8563	0.0510***	-0.5256	0.4160
INST	-0.3846	0.0000*	-0.1695	0.0000*	-0.0295	0.0140**	0.1125	0.0220**
lnPDEN	-0.2107	0.0000*	0.0178	0.2375	-0.0997	0.0000*	-0.0929	0.0000*

*, **and *** shows level of significance at 1%, 5% and 10%

The role of institutional quality index and population density is also included in the STIRPAT model to assess its detrimental role in explaining carbon emissions in the transportation sector. The institutional quality is observed to significantly mitigate the transportation sector's carbon emissions across quantile group-1,2&3 (Ali et al., 2019; Salman et al., 2019; Zakaria & Bibi, 2019; Khan et al., 2021). This indicates that environmental protection policies are more efficiently pursued and implemented in these groups of countries. However, the institutional quality index is reported to be insignificant in group-4. The analysis further revealed that population density is playing its role in significantly mitigating the transportation sector's carbon emissions across quantile group-1,3&4 (Katircioglu et al., 2018; Dogan et al., 2020; Nguyen et al., 2020; Wang et al., 2021). The inverse relationship of population density with carbon emission footprint indicates that planned expansion of population requires lesser means of transportation for commuting from one place to another as most of the necessary amenities of life like commercial hubs, education, and health facilities are available within the community which tends to reduce carbon footprint.

Transportation competitiveness has two aspects: the extensiveness and the quality of different modes of transportation. The survey results indicated that transportation competitiveness significantly determines the transportation sector's carbon emissions in group-1 2 & 3. However, in group-4, the role of transportation competitiveness is reported to be insignificant. Furthermore, it is observed that transportation competitiveness tends to increase carbon emissions in quantile group-1&3 indicating that the extensive use of the transportation sector for services sector growth is increasing carbon emissions. The role of transportation competitiveness in creating carbon emissions is strongest in quantile group-1, indicating that the services sector is growing, but environmental protection has not been prioritized. In quantile group-2, the transportation competitiveness tends to mitigate carbon emissions in the transportation sector which indicates that the quality of different modes of transportation is seriously taken into account to protect the environment from carbon emissions pollution.

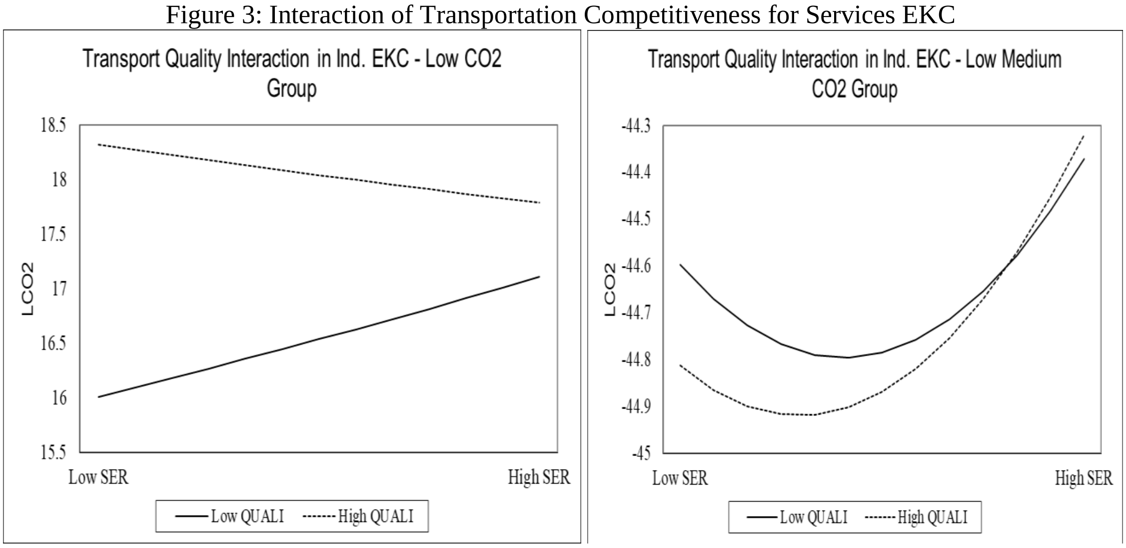
The moderation of transportation competitiveness was also considered by including the cross-product terms. The results of moderation are summarized in Table 6 and figure 3. The results revealed that EKC was not validated in group-1&3. However, U shape EKC was validated in quantile group-2&4. In quantile group-2, the moderation of transportation competitiveness has shifted the turning point towards the left side and has further steepened the services EKC. In quantile group-4, the moderator has shifted the turning point towards the left side and further flattened the EKC. The moderation analysis also indicates that the left side shifting of the turning point of U shape services EKC in group-2&4 shows the early maturity of the turning point. This indicates the early completion of the sustainability phase of U shape services EKC. However, in group-4, the flattening of U shape services EKC indicates that the moderator has reduced the sensitivity of emitting carbon emissions by the services sector. The group-4 having high CO_2 emission countries are mostly advanced countries and are adopting environmental protection policies in the transportation sector. The adoption of green technologies in the transportation sector by group-4 countries has improved the transportation competitiveness, implicitly moderating services sector carbon emissions.

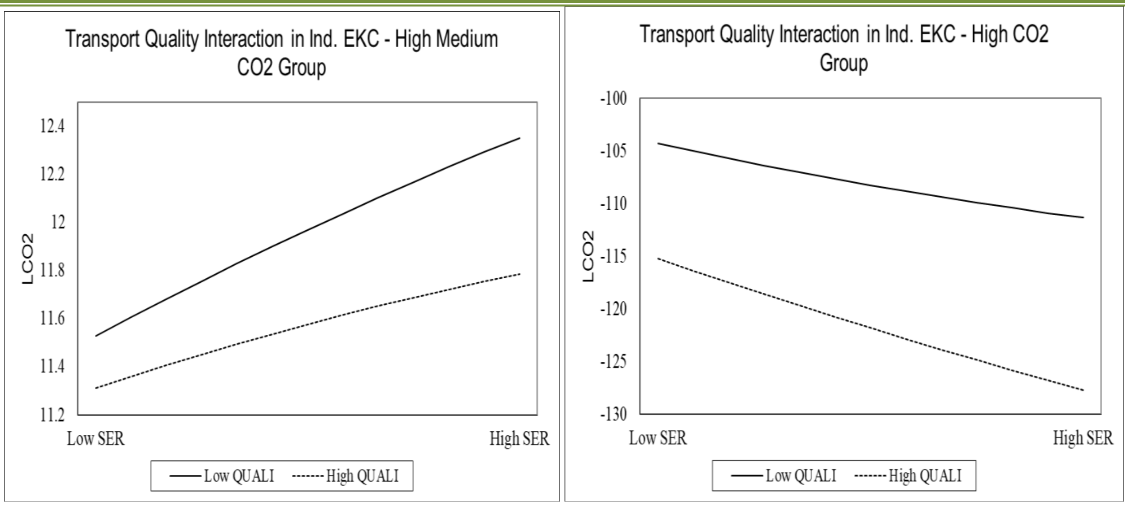
The Dawson methodology used in figure 3 also indicates the significant contribution of moderators in determining the carbon emissions across quantile group-2 (low, medium CO_2 group) and group-4 (High CO_2 group). In group-4, it is evident that a higher level of transportation competitiveness at increasing services growth tends to mitigate the transportation sector's carbon emissions. The possible explanation is the adoption of green technology and sustainable fuels used in the transportation sector.

Table 6: Moderation of Transportation Competitiveness for Changes in EKC

Quantile Groups	**Category**	**Shape of EKC**	**Changes in Turning Point**	**Flattening/Steepening**
Group-1	Low CO_2	Not Validated	-	-
Group-2	Low Medium CO_2	U Shape	Left	Steepening
Group-3	High Medium CO_2	Not Validated	-	-
Group-4	High CO_2	U Shape	Left	Flattening

Figure 3: Interaction of Transportation Competitiveness for Services EKC





5. Conclusions and Policy Implications

This study is conducted on a sample of 121 countries for assessing the moderation of transportation competitiveness in determining the transportation sector's carbon emissions. The novelty of this research study is to engage transportation competitiveness to study services sector growth and transportation based carbon emissions nexus. This aspect has not been found in the literature to the best of my knowledge. To address the research gap, three precise objectives of the research study are considered. Firstly, the role of transportation competitiveness is assessed in determining the environmental pollution of the transport sector. Secondly, the empirical validation of services EKC was tested and finally, the moderation of transportation competitiveness was envisaged to ascertain changes in services EKC. The robust approach of Panel Quantile Regression (PQR) is used to estimate data analysis as it is not distribution sensitive. The Dawson methodology was used to confirm the moderation of transportation competitiveness. The population density and institutional quality index are considered to control variables of the study model.

The services growth across quantile group-1&3 significantly emits carbon emissions of transportation, while it tends to mitigate carbon emissions of the transportation sector in quantile group-2&4. It was further analyzed that the transportation competitiveness tends to mitigate carbon emissions in quantile group-2, indicating that the quality of transportation in this group of countries is mitigating carbon emissions. However, in quantile group-1&3, the extensiveness of the transportation sector to support services sector growth tends to stimulate the transportation sector's carbon emissions. The U shape services EKC was validated across quantile group-2&4, while, in group-1&3, the services EKC was not supported. The moderation of transportation competitiveness was analyzed for changes in services EKC. The changes in the turning point of services EKC across quantile group-2&4 were observed to shift towards the left side. However, the moderator has steepened the services EKC in quantile group-2 and flattened the services EKC in quantile group-4. The quantile group-4 is the high CO2 group and includes mostly those countries opting for green technologies such as electric vehicles and zero-emission commitments. Therefore, in these countries, the quality of transportation has improved, and transportation competitiveness reduces the sensitivity of services EKC by flattening its shape.

The quality of different modes of transportation needs to be improved in terms of green technologies and transportation sustainability. This will improve transportation competitiveness, which will help mitigate services growth led to the transportation sector's carbon emissions, especially across quantile group-1&3. In quantile group-1&3, where services EKC was not validated, the sample countries need to improve transportation competitiveness to enter the sustainability phase. The moderation of transportation competitiveness is observed, which elucidates increasing transportation quality to mitigate carbon emissions. Furthermore, the planned population expansion and improvement in institutions across all quantile groups of countries help mitigate pollution in the transportation sector. The study results are very helpful for international donors, policymakers, urban developers and transport planners. The research study has data limitations and limited scope of transportation competitiveness. In the future, more variables like renewable energy, institutional quality, and innovations can be used to moderate the transportation sector's carbon emissions.

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Appendix -1: Sample of Four Quantile Groups Based on Carbon Emissions of Transportation Sector (Total Sample of 121 countries and 33 Countries are Overlapping Due to Dynamic Panel Quantile Grouping Based on Carbon Emissions of Transportation Sector).

Group -1 (Low CO2)	**Group-2 (Low Medium CO2)**	**Group-3 (High Medium CO2)**	**Group-4 (High CO2)**
Armenia	Albania	Austria	Algeria
Barbados	Azerbaijan	Azerbaijan	Argentina
Bhutan	Bahrain	Bangladesh	Australia
Botswana	Bangladesh	Belgium	Belgium
Brunei Darussalam	Benin	Bolivia	Brazil
Burundi	Bolivia	Bulgaria	Canada
Cambodia	Bosnia and Herzegovina	Colombia	Chile
Chad	Botswana	Chile	China
Cyprus	Cambodia	Czech Republic	Colombia
Estonia	Cameroon	Denmark	France
Gabon	Costa Rica	Ecuador	Germany
Georgia	Croatia	Ethiopia	Greece
Guinea	Cyprus	Finland	India
Haiti	Dominican Republic	Ghana	Indonesia
Iceland	El Salvador	Greece	Italy
Jamaica	Estonia	Guatemala	Japan
Lesotho	Ethiopia	Hungary	Malaysia
Liberia	Georgia	Ireland	Mexico
Madagascar	Ghana	Israel	Netherlands
Malawi	Guatemala	Jordan	Nigeria

Mali	Honduras	Kazakhstan	Pakistan
Malta	Jordan	Kenya	Philippines
Mauritania	Kenya	Kuwait	Poland
Mauritius	Latvia	Luxembourg	Russia
Mongolia	Lebanon	Morocco	Saudi Arabia
Mozambique	Lithuania	New Zealand	South Africa
Namibia	Luxembourg	Nigeria	Spain
Nepal	Mongolia	Norway	Thailand
Nicaragua	Mozambique	Oman	Turkey
Rwanda	Namibia	Paraguay	Ukraine
Senegal	Nepal	Peru	UAE
Seychelles	Nicaragua	Philippines	UK
Sierra Leone	Panama	Portugal	US
Tajikistan	Paraguay	Qatar	
Uganda	Senegal	Romania	
Zambia	Singapore	Singapore	
Zimbabwe	Slovenia	Sri Lanka	
	Sri Lanka	Sweden	
	Tajikistan	Switzerland	
	Trinidad and Tobago	Tunisia	
	Tunisia	Ukraine	
	Uruguay		
	Zimbabwe		
37 countries (24 % of total Sample)	43 countries (29 % of Total Sample)	41 countries (26 % of Total Sample)	33 countries (21 % of Total Sample)

