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The role of information and communication technology in encountering environmental degradation: Proposing an SDG framework for the BRICS countries

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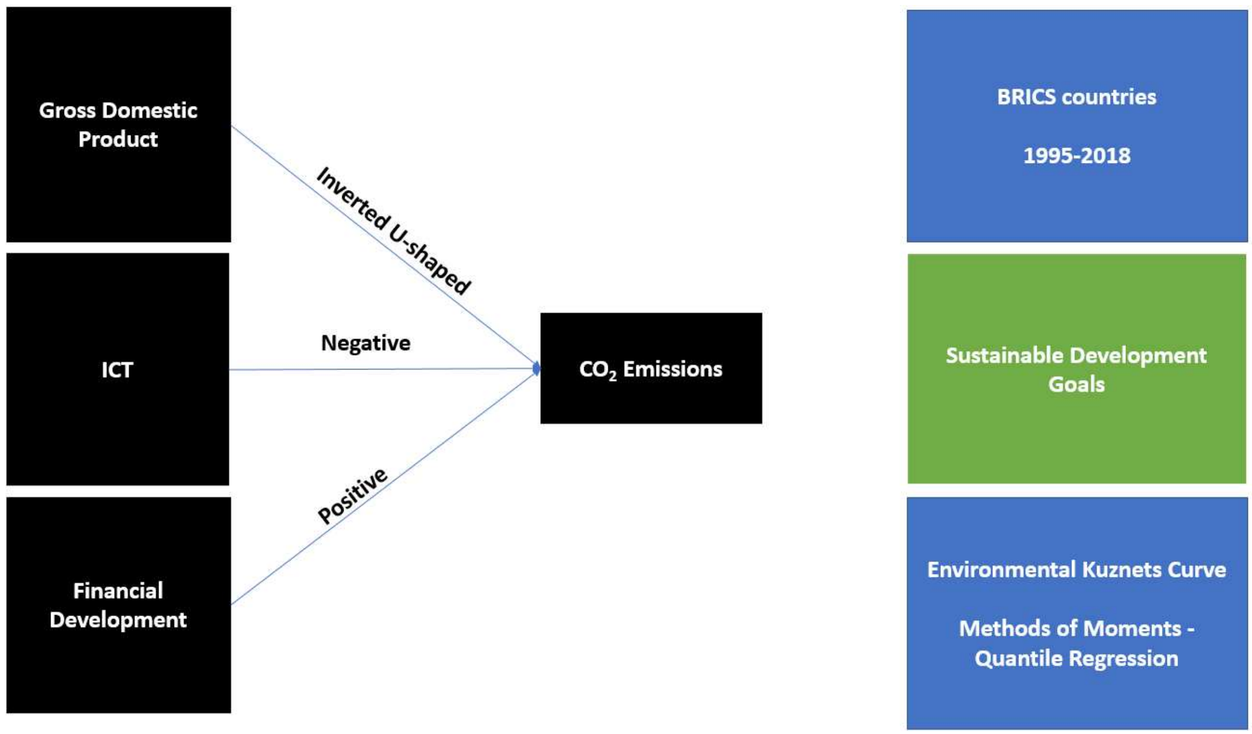
Abstract:

Sustainability through information and communication technologies is a complex matter, raising interesting debate among researchers. Pursuing the same, this research investigates the impact of information and communication technologies, economic growth, and financial development on carbon dioxide emissions by simultaneously testing the Environmental Kuznets curve (EKC) hypothesis in BRICS countries. In doing so, this study employs Methods of Moments - Quantile Regression, which confirms that the effects of the explanatory variables vary across different quantiles of carbon dioxide emissions. The overall results indicate that economic growth and financial development contribute to carbon dioxide emissions across all quantiles, while information and communication technologies significantly mitigate the level of carbon dioxide emissions only at lower emissions quantiles. Moreover, the results confirm the presence of the EKC hypothesis. Interestingly, the effect of economic growth and information and communication technologies on carbon dioxide emissions is lowest in magnitude at lower quantiles and highest at higher quantiles of carbon dioxide emissions. The empirical findings of DH panel heterogenous causality test confirm bidirectional causality between the model parameters, indicating that any policy intervention concerning explanatory variables significantly causes carbon dioxide emissions and vice versa. The results set out the foundation for policymakers to devise a policy framework to attain the objectives of Sustainable Development Goals (SDGs).

Keywords: ICT; Financial development; EKC hypothesis; CO_2 emissions; BRICS; MMQR

Graphical Abstract:



1. Introduction

The 2018 background report submitted by Interagency Task Team on Science, Technology and Innovation for the Sustainable Development Goals (SDGs) has recognized the significance of information and communication technologies (ICT) in achieving the SDGs (IATT, 2018). In view of the economic growth trajectory being attained by the nations around the globe, the role of ICT is being recognized as an enabler of innovation. The recent report by the *International Telecommunication Union* has also identified ICT to be a key enabler in fostering innovation in pursuit of attaining the objectives of SDGs across the nations (ITU, 2020). The effective utilization of ICT sets out the foundations for emerging economies to imitate knowledge and information, improving connectivity worldwide, which increase their competitiveness through technology spillovers (Sinha et al., 2020). This aspect of knowledge and technology diffusion turns out to be more prominent in the era of global warming, which can be considered as the negative environmental externality exerted by the trajectory of economic growth attained by the nations. For initiating revolution in this prevailing growth trajectory, the role of innovation needs to be recognized. A report published by *Climate and Development Knowledge Network* has identified the potential role of innovation in the field of ICT in combating the issue of environmental degradation across the globe (Ansuategi et al., 2015). In order to ascertain environmental sustainability across the nations, reorientation in environmental and innovation policies is necessary, and in this pursuit, the role of ICT might prove to be crucial.

While saying this, it is also necessary to remember that implementation and diffusion of ICT might be a challenging task for the emerging economies. One of the major reasons behind this is the major focus of the emerging economies on the achievement of economic growth, even by destroying ecological value. If the economic growth pattern of these nations is analyzed, then it can be seen that this pattern is principally driven by fossil fuels, and this situation can be traced back to the famous debate on *Limits to Growth* by *Club of Rome* Economists (Meadows et al., 1972). If the reliance of fossil fuel-based solutions is continued, then the economic growth pattern can be harmed by the diminishing pool of natural resources. Under such circumstances, it might be difficult for nations to ascertain energy security, and hence, it might be hard to attain the aims of SDG 7, i.e., affordable and clean energy. At the same time, sustained dependence on fossil fuels might hamper the environmental sustainability of the nations, which will make it problematic to attain the aims of SDG 13, i.e., climate action. In such a situation, a policy reorientation might be necessary for the emerging economies, so that these nations can make a progression in fulfilling Agenda 2030.

In continuation with the discussion on achieving innovation-driven economic growth in the emerging economies, the *11th BRICS Summit* needs a special mention. Driven by persisting issues in the developmental sphere, these nations have started pondering upon various facades of scientific innovation, with the aim of progressing towards accomplishing the SDG objectives, and thereby, ascertain sustainable development in their nations (IISD, 2019a). This approach has been preceded by the *Johannesburg Declaration*, which was signed during the *10th BRICS Summit*

(IISD, 2018). Rationale behind this declaration has been the ascending climatic issues in these nations, along with the financialization issues in the policymaking front. In order to boost the innovation process, financialization towards research and development is necessary. However, the recent report on SDG financing by the United Nations Environment Programme states the potential difficulties of the BRICS nations in channeling the funds for implementing SDGs (UNEP, 2018). While these nations are encountering difficulties in financing innovation in pursuit of implementing SDGs, the United Nations (2017) has recognized the readiness of ICT in these nations. At the same time, BRICS nations are also suffering from the growing environmental concerns, arising out of their prevailing economic growth trajectory. A report by International Institute for Sustainable Development has stressed on this aspect, while deliberating on a possible policy-realignment to encounter this issue (IISD, 2019b), and this issue was already raised by the United Nations Association two years before (UNA-UK, 2017). It is evident from this discussion that the prevailing economic growth trajectory in the BRICS nations is exerting a negative environmental externality, while they have potential to encounter this issue based on their innovation capabilities in the field of ICT. Henceforth, there lies a policy-level dilemma in implementing the ICT solutions in the BRICS nations, given the financialization challenges and growing environmental concerns. Herein lies the focus of the present study.

Taking a cue from this discussion, it can be anticipated that a comprehensive policy realignment is required in the BRICS countries, to facilitate these nations adhering to the objectives of Agenda 2030. In this pursuit, the present study aims at assessing the possible impact of ICT and financial development on CO_2 emissions in the BRICS countries over the period of 1995-2018. By means of this investigation, the present study aims at recommending a comprehensive policy framework for ascertaining sustainable development, and consecutively, reorienting the existing policies. As the BRICS nations can be recognized as laggards in attaining the SDG objectives, therefore developing a policy framework for BRICS is likely to assist remaining emerging economies in developing the policies in their respective nations in pursuit of cognizing sustainable development. Encompassing ICT, financial development, economic growth, and CO_2 emissions under a single policy plan might assist in recommending a broad policy framework for attaining the objectives of SDG 7, SDG 13, SDG 9, and accordingly SDG 8. To the best of our acquaintance with the literature, this multipronged SDG-oriented policy level method to encounter the issues pertaining to the CO_2 emissions has not been carried out in the literature, and there lies the focus and contribution of the present study.

Now, while we talk about developing a sound policy-oriented approach, the impact of policy instruments on the target policy variable is essentially evolutionary, as the nature of impact might evolve over a period of time, based on the external socio-political scenario. Hence, this evolutionary impact needs to be captured through the analytical framework to be employed in this study, as this will encompass the transformation of the impacts of policy instruments over a stint. In this pursuit, this study has utilized Environmental Kuznets Curve (EKC) hypothesis. This hypothesis is capable of capturing the evolutionary impact of policy instruments, given structural similarity and presence of transactional spillover among the study contexts (Aziz et al., 2020a, b; Godil et al. 2020a, b; Razzaq et al., 2020; Sharif et al., 2020a, b; Suki et al., 2020). Adopting this theoretical framework ensures analytical complementarity of the study, with respect to the research problem, and it defines the analytical contribution of this study.

In methodological terms, this study employs the novel approach of Machado and Silva (2019) known as Method of Moments - Quantile Regression (MMQR) to address the research problem. This approach produces empirical understandings of the distributional heterogeneity and produces diverse outcomes at different levels of the target policy variable. Structural dynamics of the BRICS nations might be characterized by distributional heterogeneity, which might be arising out the transactional spillovers among the nations. From the policymaking perspective, this metholodigical approach complements the research problem in several ways. First, unlike the conditional mean estimates those are susceptible to the misrepresenting impact of outliers, conditional quantile estimates are resilient to outliers that emanate from the explained variable (Koenker, 2004). Second, estimations of conditional mean neglect the distributional effects of policy instruments on the target policy variable. On the contrary, quantile regression has additional logical appeal particularly in regressions of panel data since the distributional impact of the explanatory factors on the explained factors is stratified into separate arrays of quantiles. It enables us to characterize the heterogeneous impacts of heterogeneous cross-sectional groups. Thus, the information provided by the estimations of the conditional quantile is not obtainable in case of conditional mean estimations. From this discussion, it can be said that application of MMQR brings about the methodological contribution of the study.

The remaining part of this paper covers the subsequent sections; Section two contains literature review. Section three explains the materials and methods. Section four discusses empirical results, while section five provides conclusion and policy recommendations.

2. Literature review

This section describes the previous studies in three parts, which explain the effect of ICT and growth drivers on CO_2 emissions.

2.1. Effect of ICT on CO_2 emissions

Considering ICT, the EKC can also be used to discover the consequence of ICT on environmental degradation following the direct-indirect rebound effect. The direct effects correspond to the CO_2 emissions instigated by ICT development (Malmodin and Lundén, 2018). The indirect effects demonstrate that the energy intensity of ICT sector is power compared to the secondary sector, and rise in energy efficiency by means of technological change is the reason behind it (Romm, 2002). The rebound effect is frequently utilized to assess the energy efficiency improvements (Gillingham et al., 2016), which might be appraised through an ICT viewpoint. Financialization towards ICT intends to enhance energy efficiency or to directly affect the ecological balance are attributed to rebound effect, that diminish the spillovers of potential benefits from ICT development. The rebound effect is categorized into direct, indirect, and cross-national impacts. Based on direct rebound effects, while improvements in energy efficiency enact comparatively less price level, resultantly push the demand of those goods, i.e., the rebound effects bring about net decline in energy consumption. The indirect rebound effects will cause intensification to the demand for other goods, in the event of energy efficiency for a particular good rise (Gossart, 2015). The cross-national rebound effects ensue when ICT catalyzes a organizational transformation in end-to-end supply chain mechanism and utilization behaviors all over the nation. Various studies have explored the ICT and environment nexus by considering these factors (see Malmodin and Lundén, 2018; Erdmann and Hilty, 2010; Horvath and Toffel, 2004; Coroama et al. 2015; An et al. 2020).

In the last decade, quite a few studies have examined the impact of ICT development on various socio-economic and environmental variables. As an illustration, ICT has been connected with sustainable development (Byrne, 2011); economic prosperity (Asongu, 2017; Levendis and Lee, 2013), CO2 emissions (Tsaurai and Chimbo, 2019; Batool et al., 2019; Sinha, 2018), economic development (Tchamyou, 2017; Murphy and Carmody, 2015; Penard et al., 2012), and banking growth (Watson et al., 2012; Kamel, 2005). The conclusion of the above studies is two-sided. The positive side describes ICT pushing the process of industrialization, which drives economic growth. The negative side shows that growth in industrialization caused higher environmental pollution due to higher energy consumption. In South Africa, Salahuddin and Gow (2016) documented that the utilization of the internet increases the economic development process. Similarly, Latif et al. (2018) established the strong bidirectional causal liaison between economic growth and ICT in BRICS countries. In 2012, Moyer and Hughes investigated the association between ICT, economic development, and emissions in 183 nations. Their result showed that ICT is negatively associated with environmental pollution in the long run, whereas this relationship is not significant in the short term.

Utilizing regional panel data 1990-2015, Danish et al. (2019) examined that ICT increases environmental pollution in low-income countries, whereas ICT reduces environmental deterioration in high and middle-income countries. Ulucak et al. (2020) explored ICT's role in CO2 emanation for BRICS economies during 1990-2015. Their empirical outcomes revealed that ICT reduces the CO_2. Avom et al. (2020) investigated the influence of ICT on environmental pollution in Sub-Saharan African economies. They found that ICT stimulates CO_2. Faisal et al. (2020) explored that ICT increases CO2 emissions at the early phase, and subsequent to an inflection, ICT reduces environmental pollution in China, India, Brazil, and South Africa. From Pakistan, Godil et al. (2020) confirmed that ICT reduces environmental pollution. Similarly, Higón et al. (2017) argued that ICT increases environmental pollution up to a certain level, and after a certain threshold, ICT shows a negative association with pollution. Using time-series data of Japan, Ishida (2015) proved that ICT has a negative impact on energy utilization, whereas ICT has an insignificant association with economic growth. Zhang and Liu (2015) recommended that China's environmental pollution can be reduced by using ICT from 2000 to 2010.

From selected G20 countries, Nguyen et al. (2020) analyzed that FD and income have a positive while ICT possesses a negative influence on CO_2. Raheem et al. (2020) revealed a negative impact of ICT and FD on the CO_2 in G7 economies from 1990 to 2014. Using Belt and Road panel data, Danish (2019) found that ICT recovers ecological balance. Comparable outcomes are endorsed by Nagao et al. (2017) from the firm-level analysis. Contrarily, Lee and Brahmasrene (2014) and Salahuddin and Alam (2015) explored emissions increasing impact of ICT in ASEAN economies and Australia. Based on the above discussion, it is concluded that the environmental impact of ICT is unclear and mainly studied using traditional linear methodologies that only capture average ICT effects. In contrast, ICT emissions increasing/decreasing effect may vary with the level of emissions. Thus, a nonlinear method is imperative to integrate ICT impact at a different level of emissions.

2.2. Impact of financial development of CO_2 emissions

Financial development may provide financial help to industries for improving the quality of the environment through less polluted and green technology. Financial development may attract foreign investment, which increases research and development activities that enhance the quality of the environment through advance and modern technology (Tamazian et al., 2009; Khan and Ozturk, 2020). On the other hand, financial development is helpful for industries to improve production activities that caused industrial pollution and deterioration of environmental quality (Jensen, 1996; Awan et al., 2020). In the previous few years, numerous empirical studies proved the positive influence of financial development on economic development via capital accumulation, technology innovation, expansion of investment resources (Anwar and Nguyen, 2011; Wurgler, 2000; Abu-Bader and Abu-Qarn, 2008; Shahbaz and Rahman, 2012). However, for environmental degradation, the financial development effect is inconclusive in the existing studies; some studies evidenced that financial development and environmental pollution has a positive association. Using the data of eight advance and eight developing economies, Shoaib et al. (2020) examined that financial development increases CO_2 through expansion in industrial units due to easy access to finance. Recently from BRICS sample, Faisal et al. (2020) explored that financial development and per capita income have a positive and negative influence on CO_2, respectively. Similar insights are observed by Shahbaz et al. (2020) from the United Arab Emirates. Javid and Sharif (2016) validated EKC and confirmed that financial development caused higher pollution. Similar outcomes were reported by Ali et al. (2019) for Nigeria and Zhang and Liu (2015) for China. In contrast, few studies documented that financial development increases technology investment that produces eco-friendly technologies. The emissions reduction effect of financial development is found by Dogan and Seker (2016) and Tamazian and Rao (2010) for transition nations, Jalil and Feridun (2011) for China, and Shahbaz et al. (2013) for Indonesia. Concludingly, financial development produced mixed evidence based on the linear procedure adopted in prevailing literature. Unlike previous studies, we propose an asymmetric effect of financial development on the level of emissions. There is rationality to assume that the impact of financial development is varied across different levels of CO_2.

2.3.Impact of economic growth on CO_2 emissions

At the early stages of economic development, the deterioration of the environment such as water and soil contamination, ambient air pollution increases but after a certain level of economic development, the process of deterioration become slow, and a further increase in income leads to improve environmental quality (Sinha and Shahbaz, 2018; Shahbaz and Sinha, 2019). The association between pollution and income is termed as EKC (Grossman and Krueger, 1991), and referred to Simon Kuznets (1955), who initially explained an inverted U-shaped relationship between income inequality and economic growth. The EKC hypothesis are widely studied in empirical literature and produced mixed and inclusive outcomes. For instance, Ozturk and Acaravci (2013) verify the presence of the EKC hypothesis in Turkey, Faiz-Ur-Rehman et al. (2007) for South Asian economies, Apergis and Payne (2009) for 6 Central American economies, Jalil and Mahmud (2009) for China, Jobert et al. (2011) for 55 nations, Esteve and Tamarit (2012) for Spain, Jayanthakumaran et al. (2012) for China and India, Arouri et al. (2014) for Thailand, Farhani et al. (2014) for ten MENA nations, Apergis and Ozturk (2015) for fourteen Asian nations and Zhang et al. (2017) for ten industrialized countries. On the other hand, numerous studies rejected the presence of EKC hypotheses like Musolesi et al. (2010) for forty poorest nations, Hossain (2012) for Japan, Osabuohien et al. (2014) for non-oil producing economies, Rehman and Rashid (2017) for SAARC nations and Pal and Mitra (2017) for China and India. Moreover, few studies claimed that monotonically increasing association among income and pollution such as Shafiei and Salim (2014) for 29 OECD nations, Begum et al. (2015) for Malaysia, Farhani and Ozturk (2015) for Tunisia and Gill et al. (2017) for Malaysia.

Concluding, prevailing literature produces mix and inconclusive results due to the use of different samples, time spam, and methodologies. Interestingly, most previous literature is limited to traditional linear methods that did not consider the distributional heterogeneity during estimations. Moreover, the environmental link between financial development, ICT, and CO_2 is also missing in EKC's multivariate framework in BRICS countries. In compliance, this study analyses the impact of ICT, financial development, and GDP on different levels of CO2 emissions using recently developed MMQR.

3. Materials and method

3.1. Empirical Framework

If BRICS countries are analyzed, then it can be seen that these countries are characterized by high economic growth, which is largely driven by fossil fuel-based solutions (Azam, 2020). Prevalence of this economic growth pattern has resulted in the consistent rise in the CO2 emissions in these countries, and this has led the policymakers to initiate transformations in the energy usage pattern (Sinha and Sen, 2016; Zafar et al., 2019). Now, this transformation necessitates boost in innovation in these nations, and hence, continued dependence on manufacturing-based secondary sector needs to be reduced, while encouraging the growth in the ICT-enabled tertiary sector. Now, for encountering the issue of CO2 emissions, the efforts made towards the development of ICT-based innovations should be complemented by bringing forth additional developmental catalysis in the prevailing economic growth trajectory, and this catalysis needs to be in the form of providing financial assistance to the domestic sector, so that they can be equipped with the newly developed innovative energy solutions for encountering the CO2 emissions (Zafar et al., 2020; Sharma et al., 2021). This boosting in the financialization also needs to be complemented by bringing forth sectoral growth, which might have an evolutionary impact on the CO2 emissions. From a theoretical standpoint, this evolutionary impact is captured by means of the EKC hypothesis framework, as the linear and squared terms of per capita income capture the scale and composition effects exerted by the economic growth, which signify the inclusive evolutionary impact of the growth trajectory (Sinha and Bhattacharya, 2016; Sinha et al., 2019). Now, analysis of this association is necessary from the perspective of an SDG-oriented policymaking for the BRICS nations, and therefore, this association needs to be represented in mathematical terms. In doing so, following empirical model is developed:

$$\mathrm{LnCO}_{2\mathrm{it}} = \gamma_1 \mathrm{LnICT}_{\mathrm{it}} + \gamma_2 \mathrm{LnGDP}_{\mathrm{it}} + \gamma_3 (\mathrm{LnGDP}_{\mathrm{it}})^2 + \gamma_4 \mathrm{LnFD}_{\mathrm{it}} + \varepsilon_{\mathrm{it}} \quad (1)$$

In Eq. (1), Ln indicates natural logarithm, CO_2 represents per capita CO2 emissions, ICT denotes information and communication technology, GDP shows per capita real GDP, FD indicates financial development, ε describes the error term, i and t show the countries and time, respectively. The expected sign of the γ_1 could be positive or negative. For example, the use of ICT in virtual participation in conferences reduces traveling-related environmental pollution (Coroama et al., 2012). On the other hand, the more use of the internet leads to an increase in electricity demand, which caused deterioration of the environment through more emissions (Moyer and Hugh, 2012). The expected sign of γ_2 is positive, whereas the expected sign of γ_3 might be negative (EKC hypothesis) or positive. The sign of γ_4 is unexpected, FD might be favorable or unfavorable for the environment. An established financial sector produces low-cost loans, which enable the industries to use energy-efficient technology and leads to reducing CO2 emissions (Shahbaz et al., 2010; Latif et al., 2017). Contrarily, if the low-cost loan not uses for environmentally friendly technology then it will increase industrial pollution (Raheem et al., 2020).

3.2. Sample selection and data

This study examines the role of ICT and FD in increasing/decreasing CO_2 by simultaneously considering the income-induce EKC hypothesis in BRICS economies. The selection of these countries is the similar features of these countries, for instance, similar growth patterns and youthful population. Another essential common feature of these countries is geographical position as these countries are located near the advanced countries. Brazil is near to the United States, Russia is at the edge of the European Union, India and China are closely situated, South Africa has economic importance for Africa (Asongu et al., 2018). Moreover, all these five countries are the member of G20 countries. According to the World Bank 2019 ranking based on economic position, Brazil, Russia, India, China, and South Africa secured 9th, 11th, 5th, 2^{nd,} and 37th positions, respectively (World Bank, 2019). Since the last two decades, BRICS countries have shown exceptional economic performance, such as GDP (constant US$, 2010) of BRICS countries in 1995 was 2.718 trillion dollars, which rose to 12.041 trillion dollars in 2017 (World Bank, 2019). However, this remarkable economic performance has produced incredible environmental challenges for these BRICS countries in the form of CO_2 emissions. According to the International Energy Agency, the CO_2 emission of the BRICS economies was 682 metric tons in 1995, which rose to 1407 metric tons in 2017 (IEA, 2019).

Based on the above facts, this study uses annual data between 1995-2018, which are derived from the World Development Indicators (WDI) and British Petroleum (BP) websites. The dependent variable CO_2 is measured in metric ton per capita, ICT is measured by individuals using the internet as a percentage of the population, GDP is measured in per capita (constant US$ 2010), and lastly FD is proxied by the disbursement of domestic credit to the private sector (for detail See Table 1).

Table 1: **Description of Variables**

Variable	Symbols	Description	Expected Sign	Source of Data
Carbon Dioxide	CO_2	Carbon Dioxide (Metric Ton per capita oil equivalent)	N/A	BP
Information and Communication Technology	ICT	Individual using the internet (% of the population)	+/-	WDI
Economic Growth	GDP	Gross domestic product, per capita (Constant US$ 2010)	+/-	WDI
Financial Development	FD	Domestic credit to the private sector (% of GDP)	+/-	WDI

WDI: World Development Indicators (World Bank, 2019)
BP: British Petroleum (BP, 2020)

3.3. Summary Statistics

The summary statistics of the model variables are represented in Table 2. It can be observed from Table 2 that the data set is relatively symmetric. The result describes that CO_2 is negatively skewed, whereas GDP, ICT, and FD are positively skewed. FD has the highest tails as it has a high value of kurtosis. On the other hand, CO_2 has the smallest tail as it has the smallest kurtosis value.

Table-2: Summary Statistics

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
CO2	2.549	2.752	4.695	0.325	1.530	-0.099	1.369
GDP	6060.947	5717.916	14874.788	1348.681	3935.850	0.293	1.681
ICT	16.854	11.509	64.684	0.008	18.128	1.052	3.028
FD	25.374	21.340	70.854	6.174	15.526	1.272	4.041

Source: Author Estimation

3.4.Panel Estimation Techniques

For empirical estimations, we utilize Fixed Effects Ordinary Least Squares (FEOLS), Dynamic OLS (DOLS), and Fully Modified OLS (FMOLS). The FEOLS procedure is expanded with standard errors of Driscoll and Kraay, which are vigorous to common types of autocorrelation and cross-sectional dependence (CD) up to a specific lag. The vital issues in evaluating dynamic panel cointegration are issues of heterogeneity as featured by Pedroni (2004) with dissimilarities between the means of cross-sections and dissimilarities in the adjustment of cross-sectional to the cointegrating equilibrium.

The FMOLS method of Pedroni incorporates individual-specific intercepts and takes into consideration the properties of heterogeneous serial correlation of the error procedures throughout the panel, thus manages these problems efficiently. The DOLS technique was reached out to panel setting by Kao and Chiang (2001) in view of the outcomes of Monte Carlo simulations; the technique of DOLS in a limited sample size is seen as rational in contrast to both FMOLS and the OLS techniques. This technique additionally handles the problem of endogeneity via the expansion of lead and lagged differences.

Because of the shortcomings of conventional techniques of estimations, a panel Method of Moment - Quantile Regression (MMQR) is initially applied by Sarkodie and Strezov (2019) to analyze the heterogeneous and distributional impact across quantiles. The simple panel quantile (QR) strategy was presented by Koenker and Bassett (1978) in their seminal paper. Usually, the QR is utilized to assess the conditional median or a diverse range of response variables' quantiles subjected to specific estimations of the exogenous factors, not at all like regular regression of the least-squares variant, which produces endogenous factors' conditional mean values subjected to specific estimations of the exogenous factors. During analysis, the quantile regressions are further strong to the occurrences of outliers. Further, this technique is also very appropriate in situations where the connection between two factors' conditional means is frail or non-existent (Blinder and Coad, 2011).

We utilized the fixed effects MMQR (2019) technique proposed by Machado and Silva in this study. While being vigorous to outliers, the quantile regression does not take into account the feasibility of unnoticed heterogeneity across individuals inside a panel. This technique enables it feasible to recognize the conditional heterogeneous covariance impacts of the factors of CO_2 through permitting the impacts of individuals to influence the whole distribution as opposed to simply shift of means as in the situation of Canay (2011), and Koenker (2004) among others. This technique is mainly pertinent in situations when the model has explanatory factors with endogenous properties and where the panel data is implanted with individual impacts. This technique is likewise very instinctive in light of the fact that it produces non-crossing results of the quantiles of regression. The conditional quantiles $Q_{Y.}(\tau|W)$ estimation for a model of the area scale variation follows the subsequent structure:

$$Y_{it} = \beta_i + W_{it}'\delta + (\gamma_i + X_{it}'\nu)U_{it} \qquad (2)$$

In the above equation (β, δ', γ, ν')' are parameters, and$P(\gamma_i + X_{it}'\tau > 0) = 1$ is the probability. (β_i, γ_i), i = 1,2,3…..,n, identifies the fixed effects for individual i and X is a k-vector of recognized elements of W that are differentiable conversions with component l specified as:

$$X_l = X_l\,(W),\ l = 1,..,k \qquad (3)$$

W_{it} is distributed identically and independently for any fixed i for time t. U_{it} is distributed identically and independently for individuals (i) through time (t), symmetrical to W_{it} and standardized to fulfill the conditions of movement in Machado and Silva (2019). Eq. (2) suggests the accompanying;

$$Q_Y(\tau/W_{it}) = (\beta_i + \gamma_i q(\tau)) + W_{it}'\delta + X_{it}'\nu q(\tau) \qquad (4)$$

The $Q_{Y.}\ (\tau|W_{it})$ in equation 3 is the quantile distribution of Y_{it} contingent on the location of W_{it}. The vector of independent variables denotes through W'_{it} in the above equation, whereas the vector of independent factors are ICT, FD, and GDP in this study. The term $\beta_i\ (\tau) \equiv \alpha_i + \delta_i q(\tau)$ is demonstrative of the fixed effect quantile-τ and exhibits the scalar coefficient for individual i. The impact of the individual does not indicate a shifting of intercept, rather the fixed effects of the least-squares. These parameters are time-invariant. The heterogeneous effects of these time-invariant parameters are permitted to vary over the quantiles of the restrictive distribution of the explained variable. The term q(τ) means τ-th sample quantile that is assessed through resolving the subsequent problem of optimization.

$$min_q \sum_i \sum_t \rho_\tau (R_{it} - (\gamma_i + X_{it}'\nu)q)$$

Such as, $\rho_\tau(B) = (\tau - 1)BI\{B \leq 0\} + TBI\{B > O\}$indicates check function.

4. Empirical results and discussion:

Table 3 shows first-generation stationarity test results by employing Im-Pesaran-Shin (2003) and Breitung (2001) tests and confirms that all variables are stationary at the first difference. Table 4 reports that all model variables possess the issue of cross-sectional dependence. Therefore, all other estimation techniques should include procedures that are vigorous to impact of Cross-sectional dependence (CD), and remove the possible size misrepresentations. To comply with the same, we utilize Cross-sectional Im-Pesaran-Shin (CIPS) and Herwartz & Siedenburg (2008) unit root tests, which efficiently deals with the problem of CD and re-confirms that all model variables are integrated of order (I).

Table-3: Stationary Analysis Results

Variables	Im, Pesaran and Shin (2003)		Breitung (2001)	
	I(0)	I(1)	I(0)	I(1)
ICT	0.591	-7.848***	0.048	-3.059***
FD	-0.756	-10.647***	-1.026	-6.309***
GDP	1.184	-5.545***	1.289	-6.349***

CO_2	1.541	-8.747***	1.002	-7.359***
The significance level at 1%, 5% and 10% are represented by ***, ** and * respectively. Source: Author Estimation				

Table-4: CD and Second-generation unit root test results						
Variables	**CD Test**	**p-value**	**CIPS test**		**Herwartz & Siedenburg (2008)**	
			Level	**1st difference**	**Level**	**1st difference**
ICT	16.542***	0.000	-0.276	-4.301***	-0.813	-1.595*
FD	14.153***	0.000	-0.069	-14.108***	-0.367	-2.316**
GDP	26.100***	0.000	-0.399	-9.918***	0.987	-6.941***
CO2	30.473***	0.000	-0.195	-13.510***	0.574	-5.026***
The significance level at 1% is represented by ***. Source: Author Estimation						

Table 5 shows the results of panel bootstrap cointegration tests (Westerlund, 2007), where the null hypothesis of no cointegration is rejected against the alternative hypothesis of cointegration relationship among model variables. Thus; confirming a long-run relationship between model variables.

Table-5: Bootstrap panel cointegration results (Westerlund, 2007)				
Statistics	**Value**	**Z value**	**p-value**	**Robust p-value**
Gt	-19.463	-16.797	0.000	0.000
Ga	-85.386	-69.808	0.000	0.000
Pt	-94.047	-58.478	0.000	0.000
Pa	-98.860	-85.258	0.000	0.000
The panel cointegration null hypothesis is no cointegration (Westerlund, 2007). The number of replications is 500. Based on the normal distribution, the p-values are for a one-sided test. Based on 500 bootstrap replications, the robust p-value are for a one-sided test. Source: Authors' estimation.				

After confirmation of stationarity and cointegration relationship among variables, we move to explain long-run elasticities from our four estimators. The findings of FMOLS, FEOLS, and DOLS estimators are shown in Table-6. The direction of coefficients is approximately the same across all three estimators. The findings show that GDP has a significant positive impact on CO_2 in all three model specifications, while GDP^2 produces a negative coefficient indicating the presence of EKC hypotheses in all three estimators. The outcome recommends that after a certain threshold the emission-increasing effect of income turns opposite, suggesting a higher income significantly mitigates CO_2. This result is similar to previous literature such as Farhani et al. (2014) for ten MENA nations, Apergis and Ozturk (2015) for fourteen Asian nations, Zhang et al. (2017) for ten industrialized nations, Higon et al. (2017) for developing countries, and Ulucak et al. (2020) for BRICS countries. Whereas these results are contradicted with Osabuohien et al. (2014) for non-oil producing economies, Rehman and Rashid (2017) for SAARC nations, and Pal and Mitra (2017) for China and India, who rejected the validity of the EKC hypothesis.

The coefficient of ICT shows emissions reduction effects across all estimators. This indicates that a 1% increase in ICT mitigates the level of CO_2 by 0.34% in case of FMOLS, 0.29% in case of DOLS, and 0.28% in case of FEOLS. It infers that ICTs in the form of online shopping, online food orders, video conferences, and teleconferences are more favorable, energy-saving, and low carbon-intensive instead of traveling for these purposes, which is a significant source of CO2 emissions. These findings are in line with Ozcan and Apergis (2018) for emerging economies, Danish et al. (2019) for high and middle-income countries, and Ulucak et al. (2020) for BRICS economies. On the other hand, our findings contradict Lee and Brahmasrene (2014) for ASEAN countries and Park et al. (2018) for EU economies. FD shows a positively significant impact on environmental pollution i.e., about a 1% rise in FD accelerates pollution by 0.21%, 0.23%, and 0.19% in all three estimators, respectively. Inherently, the financial sector increases CO2 emanation by expanding the industrial production process through easy access to finance and businesses. This result is similar to the findings of Shahbaz and Lean (2012), Hafeez et al. (2018) and Shoaib et al. (2020); however, contradict with Park et al. (2018) for EU economies and Saidi and Mbarek (2017) for 19 emerging economies.

Table-6: Results of Panel Estimation for BRICS Countries

Variables	FMOLS			DOLS			FE-OLS		
	Coeff.	t-stats	Prob.	Coeff.	t-stats	Prob.	Coeff.	t-stats	Prob.
GDP	0.695***	8.401	0.000	0.409***	14.686	0.000	0.745***	5.737	0.000
GDP^2	-0.253**	-1.978	0.047	-0.173***	-3.274	0.000	-0.200***	-4.152	0.000
ICT	-0.342***	-10.261	0.000	-0.293***	-6.720	0.000	-0.280***	-7.516	0.000
FD	0.209***	5.039	0.000	0.234***	5.128	0.000	0.193***	6.197	0.000

The significance level at 1% and 5% are represented by *** and ** respectively.
Source: Author Estimation

4.1.Panel quantile estimation outcomes

Table 7 reports the findings of MMQR estimator. The results show that GDP and CO_2 emission has a positive and significant association across all quantiles, indicating that GDP growth may stimulates higher emissions through catalyzing energy consumption. The test outcomes confirm the presence of EKC across all quantiles except the 1st and 2nd quantiles. The validity of EKC shows that economic growth increases environmental pollution only at the initial stage of development; however, after crossing a certain income threshold, the emission increasing effect of GDP turns opposite. This outcome is similar to Zhu et al. (2016), Rafindadi and Usman (2019), Ike et al. (2020), and Godil et al. (2020). Moreover, the pattern arising out the quantile estimation of the EKC divulges certain insights regarding the economic growth pattern of these nations. If the turnaround points of the EKCs are analyzed, then it can be seen that the turnaround points are shrinking towards the higher quantiles. This phenomenon gives an idea that with the rise in CO2 emissions, the nations are striving towards bringing transformation in their prevailing economic growth trajectory. Though the existing policy maneuvers might not be sufficient to handle this issue, it gives an idea that any policy intervention in this direction might be able to complement the ongoing efforts towards reduction in CO2 emissions. This justifies the recommendation of an SDG-oriented policy framework for the BRICS nations to encounter the issue of CO2 emissions. On the other hand, in the context of ICT, the findings show a negative association with CO_2 across the quantiles, but the relationship is insignificant between 5th-9th quantiles. It implies that ICT reduces CO_2 emissions by consuming energy efficiently technology only at lower to medium emissions quantiles. These results echo with recent literature (Godil et al. 2020; Ozcan and Apergis 2018).

On the other hand, the emission reduction effect of ICT is insignificant at higher emission quantiles due to higher energy use of ICT related equipment and devices. Although insignificant, the emissions-reduction impact of ICT is negative across higher emission quantiles. These results contradict Sadorsky (2012) and Lee and Brahmasrene (2014), who argued that ICT increase per capita energy consumption that leads to higher CO_2. Finally, MMQR result demonstrates that FD has a significant and positive association with CO_2 across all quantiles, which indicates that FD worsens environmental quality through an increase in CO_2. The intuition behind emission increasing effect of FD is attributed to the economic spillovers emerge from higher FD in emerging economies. FD spurs economic growth through the expanded financial industry in developing countries. The results are consistent with Chen et al. (2019), Ali et al. (2019), and Shahbaz et al. (2020).

Table-7: Results of Panel Quantile Estimations											
Method of Moments - Quantile regression (MMQR)											
Variables	**Location**	**Scale**	**Quantiles**								
			0.10	**0.20**	**0.30**	**0.40**	**0.50**	**0.60**	**0.70**	**0.80**	**0.90**
GDP	0.504***	0.295***	0.449***	0.487***	0.503***	0.526***	0.572***	0.601***	0.625***	0.681***	0.718***
GDP^2	-0.144**	-0.110**	-0.083	-0.107	-0.192***	-0.233***	-0.306***	-0.367***	-0.385***	-0.403***	-0.440***
ICT	-0.296***	-0.138**	-0.308***	-0.261***	-0.215***	-0.181***	-0.127	-0.105	-0.100	-0.087	-0.084
FD	0.371***	0.227***	0.230***	0.204**	0.189**	0.183**	0.181**	0.173**	0.169**	0.167**	0.162**
At 1%, 5% and 10%, ***, ** and * represents the significance level respectively. Source: Author Estimation											

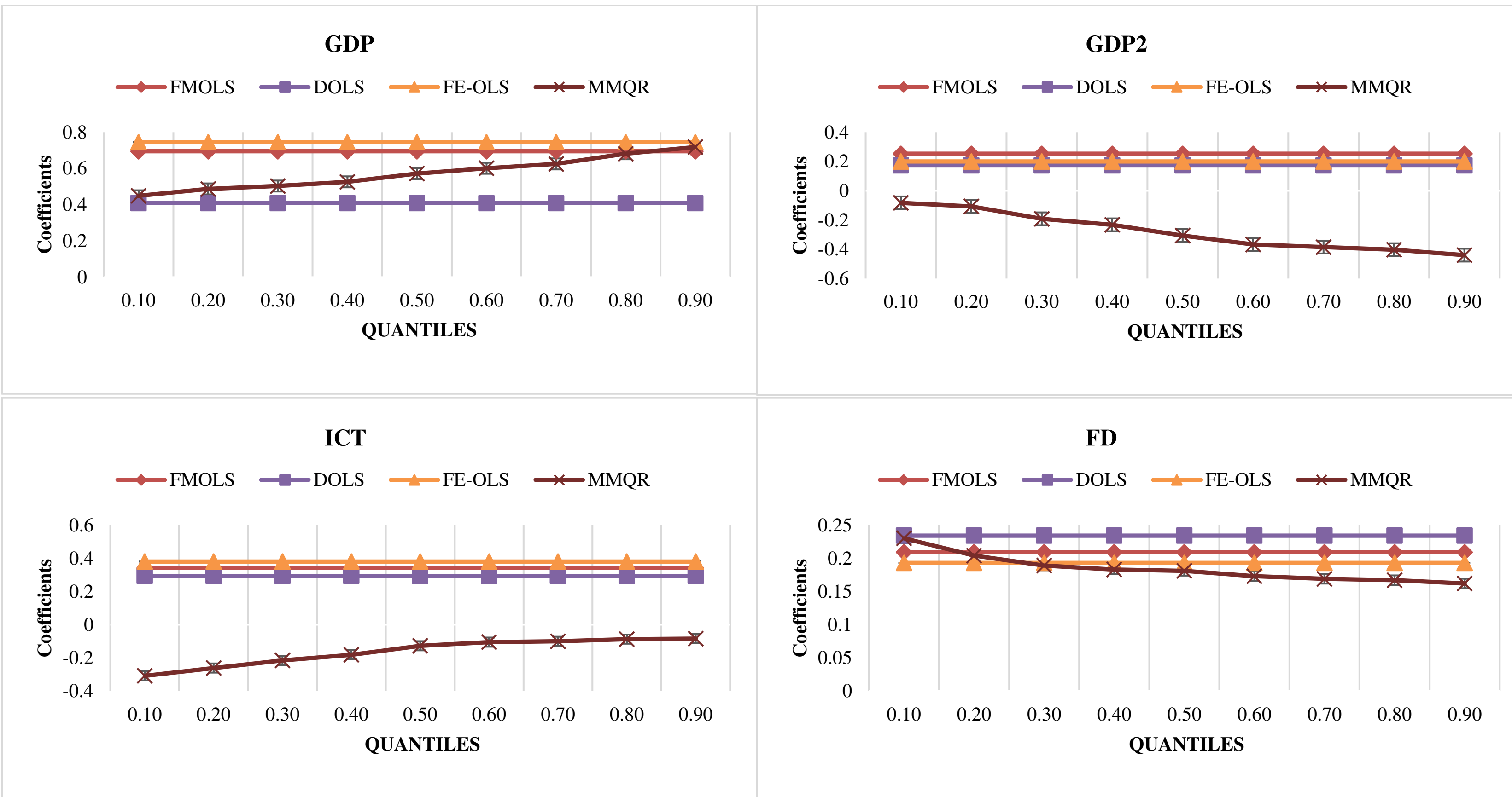


Figure 1: Coefficients across different quantiles in four-panel estimations techniques

The results of all four panel estimation techniques in Figure 1 depict the coefficients of MMQR model diverge across all quantiles as compared to DOLS, FMOLS, and FEOLS, which produce average effects across all quantiles. Unlike DOLS, FMOLS, and FEOLS, Figure 1 represents the effect of GDP, and ICT on CO_2 is lowest at lower quantiles of CO_2 and progressively increases when moving towards higher emissions quantiles. Conversely, the impact of GDP^2 and FD on CO_2 is highest at higher quantiles of CO_2 and decreases when moving from higher to lower emissions quantiles. From the comparison, it is highlighted that the MMQR provide clearer picture between variables at different level (lower, medium, higher) of CO2 emissions, which can help policymakers to devise asymmetric policies to cater different level of emissions.

4.2. Heterogeneous panel causality test

Bidirectionality is an inherent feature of any policy framework, as the policy instruments are also impacted by the target policy parameter over a period of time (Sinha et al., 2018; Shahbaz et al., 2021). Without a possible bidirectional association, i.e., presence of a feedback mechanism between the policy instruments and target policy parameter, further scope of improving the policy decision is shrunk, and in this pursuit, the causality analysis is carried out. The test statistics and probability values of Dumitrescu-Hurlin (DH) procedure are presented in Table 8. The results show two-way causality between GDP, ICT, FD, and CO_2 in BRICS countries. The bidirectional causality implies that any policy intervention with respect to ICT, FD, and GDP significantly causes CO_2 and in return CO_2 significantly causes ICT, FD, and GDP.

Table-8: Heterogeneous panel causality test results

		Independent variables			
		GDP	CO2	ICT	FD
Dependent Variables	GDP	-	13.293***	-	-
	CO2	11.363***	-	11.341***	7.487***
	ICT	-	9.535***	-	-
	FD		14.676***	-	-

*** represents the 1% significance level.
Source: Author Estimation

5. Conclusion and Policy Recommendations

The study is modeled to analyze the impact of ICT and other allied growth drivers on CO_2 emissions under the EKC framework in BRICS countries. For this purpose, Method of Moments - Quantile regression (MMQR) approach has been applied. The results obtained in the study has endowed with several significant insights, which might be crucial for developing and recommending an SDG-focused policy outline for the BRICS countries. Role of the present study is in recommending this policy framework, which can be used as a baseline policy framework for the emerging economies, encountering difficulties in having a control over the issue of rising CO2 emissions.

Economic growth trajectory in the BRICS nations is conducive towards the environmental quality, but the economic growth drivers might have divergent impacts on the same. At one hand, the impact of ICT diminishes at the higher levels of CO2 emissions, whereas the financial development is found to be a driver of CO2 emissions, as well. In such a scenario, it can be assumed that policy-level reorientation is necessary, as these growth drivers are exerting negative environmental externality. Therefore, the recommended policy framework should be able to internalize these negative externalities. Despite this fact, it needs recalling that growth trajectory in these countries is dependent on fossil fuel-based solutions. Hence, any overnight transformation in the energy sources might impair the overall growth pattern. Therefore, the policymakers need to take a phase-wise approach. During the initial phase, the policymakers need to provide easy access to finance to the small and medium manufacturing firms, so that they can implement ICT-based solutions in their existing production processes. Now, the access to finance will be having a differential rate of interest, based on the size and carbon footprint of the firm. Firms with higher carbon footprint will be asked to pay higher rate of interest, whereas the firms with lower carbon footprint will be asked to pay lower rate of interest. On one hand, this policy initiative will encourage the cleaner firms to scale up the innovational capabilities, whereas it will parallelly discourage the dirtier firms to use fossil fuel-based solutions. As a whole, this policy initiative will be directed towards enabling the firms to implement ICT-based solutions. It can be noted that during this phase, the nations might incur certain financial losses. In order to recover the losses, the second phase might be necessary. In the second stage, policymakers need to ease the business environment, so that new ICT-based business ventures can be initiated. In this process, registration process of new businesses should take care of the potential carbon footprint of the firms, and the loan disbursement process should take care of this aspect. Opening of new business ventures will eventually add to the financial gain of the nations. When these two phases of policy framework will be initiated, the energy security of the nation will be gradually ascertained, which will help these nations to make a progression towards attainment of the objectives of SDG 7. While the objectives of SDG 7 are attained, these nations will gradually start reducing their confidence on the fossil fuels, and increasing confidence on renewable energy and ICT-based production processes will gradually reduce the level of CO2 emissions in the ambient atmosphere. It will support these nations to attain the objectives of SDG 13.

Now, in order to withstand this policy framework, it is essential for the policymakers to give more emphasis on mainstreaming the ICT-based innovation process, and in this pursuit, the educational curriculums need to be amended, so that the students can learn about the latest developments about the innovations in the field of ICT, advantages of green energy, and the necessity of environmental protection. This will enable the future labor force to be socio-ecologically responsible innovators. In this pursuit, these nations might be able to make progressions towards the attainment of the objectives of SDG 9. Lastly, when this entire policy framework is operational, livelihood of the citizens will be decent, and thereby, they will certainly progress towards accomplishing the aims of SDG 8.

While this policy framework is being discussed, it is also imperative to discuss about the policy caveats and assumptions, without which the framework might not produce expected results. First, the policymakers need to ensure that the ICT-based solutions should not be labor-replacing, as it might harm the economic growth pattern and social order by creating unemployment issue. Second, the ecological fortification laws should be more rigorous, so that unwarranted diminution of natural resources is reduced. Third, import substitution should be imposed for the fossil fuel-based solutions.

Limitation of any policy framework lies in its inclusivity, and the present study is also not an exception to this. The policy framework could have been improved by considering additional dimensions of innovation, and there lies the limitation of the study. While discussing this aspect, it should be reminisced that this policy framework is a reference point for the emerging economies, which are striving to implement ICT-based solutions for encountering the CO_2 emissions in their respective nations. Generalizability of the policy framework might define the contribution of the present study. Future research in this pursuit can be carried out by considering diverse aspects of innovation and the social dimensions of innovation.

References

Abbasi, F., Riaz, K., 2016. CO2 emissions and financial development in an emerging economy: an augmented VAR approach, Energy Policy, 90, 102-114.

Abu-Bader, S., Abu-Qarn, A.S., 2008. Financial development and economic growth: The Egyptian experience. Journal of Policy Modeling, 30(5), 887-898.

Ali, H.S., Law, S.H., Lin, W.L., Yusop, Z., Chin, L., Bare, U.A.A., 2019. Financial development and carbon dioxide emissions in Nigeria: evidence from the ARDL bounds approach. GeoJournal, 84(3), 641-655.

Al-Mulali. U., Ozturk, I., Lean, H.H., 2015. The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Natural Hazards, 79, 621-644.

An, H., Razzaq, A., Haseeb, M., Mihardjo, L.W., 2020. The role of technology innovation and people's connectivity in testing environmental Kuznets curve and pollution heaven hypotheses across the Belt and Road host countries: new evidence from Method of Moments Quantile Regression. Environmental Science and Pollution Research, 1-17.

Ansuategi, A., Greño, P., Houlden, V., Markandya, A., Onofri, L., Picot, H., Tsarouchi, G.M., Walmsley, N., 2015. The impact of climate change on the achievement of the post-2015 sustainable development goals. Climate and Development Knowledge Network.

Anwar, S., Nguyen, L.P., 2011. Financial development and economic growth in Vietnam. Journal of Economics and Finance, 35(3), 348-360.

Apergis, N., Ozturk, I., 2015. Testing environmental Kuznets curve hypothesis in Asian countries. Ecological Indicators, 52, 16-22.

Apergis, N., Payne, J.E., 2009. CO2 emissions, energy usage, and output in Central America. Energy Policy, 37(8), 3282-3286.

Arouri, M., Shahbaz, M., Onchang, R., Islam, F., Teulon, F., 2013. Environmental Kuznets curve in Thailand: cointegration and causality analysis. The Journal of Energy and Development, 39(1/2), 149-170.

Asongu, S.A., 2013. How has mobile phone penetration stimulated financial development in Africa?. Journal of African Business, 14(1), 7-18.

Asongu, S.A., 2017. Knowledge economy gaps, policy syndromes, and catch-up strategies: Fresh South Korean lessons to Africa. Journal of the Knowledge Economy, 8(1), 211-253.

Asongu, S.A., Le Roux, S., Biekpe, N., 2017. Environmental degradation, ICT and inclusive development in Sub-Saharan Africa. Energy Policy, 111, 353-361.

Asongu, S., Akpan, U.S., Isihak, S.R., 2018. Determinants of foreign direct investment in fast-growing economies: evidence from the BRICS and MINT countries. Financial Innovation, 4(1), 26-35.

Awan, A.M., Azam, M., Saeed, I.U., Bakhtyar, B., 2020. Does globalization and financial sector development affect environmental quality? A panel data investigation for the Middle East and North African countries. Environmental Science and Pollution Research, 27(36), 45405-45418.

Avom, D., Nkengfack, H., Fotio, H.K., Totouom, A., 2020. ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels. Technological Forecasting and Social Change, 155, 120028.

Azam, M., 2020. Energy and economic growth in developing Asian economies. Journal of the Asia Pacific Economy, 25(3), 447-471.

Aziz, N. Mihardjo, L.W.W., Sharif, A., Jermsittiparsert, K., 2020a. The role of tourism and renewable energy in testing the environmental Kuznets curve in the BRICS countries: Fresh evidence from Methods of Moments Quantile Regression. Environmental Science and Pollution Research, 1-21. https://doi.org/10.1007/s11356-020-10011-y

Aziz, N., Sharif, A., Raza, A., Rong, K., 2020b. 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, 10115-10128.

Bakhsh, K., Rose, S., Ali, M. F., Ahmad, N., Shahbaz, M., 2017. Economic growth, CO2 emissions, renewable waste and FDI relation in Pakistan: New evidences from 3SLS. Journal of environmental management, 196, 627-632.

Batool, R., Sharif, A., Islam, T., Zaman, K., Shoukry, A. M., Sharkawy, M. A., Hishan, S. S., 2019. Green is clean: the role of ICT in resource management. Environmental Science and Pollution Research, 26(24), 25341-25358.

Begum, R. A., Sohag, K., Abdullah, S. M. S., Jaafar, M., 2015. CO2 emissions, energy consumption, economic and population growth in Malaysia. Renewable and Sustainable Energy Reviews, 41, 594-601.

Belkhir, L., Elmeligi, A., 2018. Assessing ICT global emissions footprint: trends to 2040 & recommendations.
Journal of Cleaner Production, 177:448–463. https://doi.org/10.1016/j.jclepro.2017.12.2 39.

Binder, M., Coad, A., 2011. From Average Joe's happiness to Miserable Jane and Cheerful John: using quantile regressions to analyze the full subjective well-being distribution. Journal of Economic Behavior & Organization, 79(3), 275-290.

Breitung, J., 2001. The local power of some unit root tests for panel data. In Nonstationary panels, panel cointegration, and dynamic panels. Group Publishing Limited, Emerald, pp. 161–177.

Breitung, J., Das, S., 2005. Panel unit root tests under cross-sectional dependence. Statistical Neerlandica 59 (4), 414–433.

Byrne, E., Nicholson, B., Salem, F., 2011. Information communication technologies and the millennium development goals. Information Technology for Development, 17(1), 1-3.

Canay, I.A., 2011. A simple approach to quantile regression for panel data. The Econometrics Journal 14 (3), 368–386.

Chavanne, X., Schinella, S., Marquet, D., Frangi, J. P., Le Masson, S., 2015. Electricity consumption of telecommunication equipment to achieve a telemeeting. Applied energy, 137, 273-281.

Chavula, H. K., 2013. Telecommunications development and economic growth in Africa. Information Technology for Development, 19(1), 5-23.

Chen, X., Gong, X., Li, D., Zhang, J., 2019. Can information and communication technology reduce CO 2 emission? A quantile regression analysis. Environmental Science and Pollution Research, 26(32), 32977-32992.

Coroama, V. C., Hilty, L. M., Birtel, M., 2012. Effects of Internet-based multiple-site conferences on greenhouse gas emissions. Telematics and Informatics, 29(4), 362-374.

Coroama, V. C., Hilty, L. M., Moberg, Å., 2015. Dematerialization Through Electronic. In: B. Aebischer L. M. Hilty, eds. ICT Innovations for Sustainability. s.l.:Springer, pp. 405-

Danish., 2019. Effects of information and communication technology and real income on CO2 emissions: The experience of countries along Belt and Road. Telematics and Informatics, 45, 101300.

Dogan, E., Seker, F., 2016. The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews, 60, 1074-1085.

Erdmann, L. Hilty, L. M., 2010. Scenario Analysis: Exploring the Macroeconomic Impacts of Information and Communication Technologies on Greenhouse Gas Emissions. Journal of

Esteve, V., Tamarit, C., 2012. Threshold cointegration and nonlinear adjustment between CO2 and income: the environmental Kuznets curve in Spain, 1857–2007. Energy Economics, 34(6), 2148-2156.

European e-Business Report, (2010. ICT and e-Business for an Innovative and Sustainable Economy, s.l: European Commission.

Faisal, F., Tursoy, T., Pervaiz, R., 2020. Does ICT lessen CO 2 emissions for fast-emerging economies? An application of the heterogeneous panel estimations. Environmental Science and Pollution Research, 27(10), 10778-10789.

Faiz-Ur-Rehman, Ali, A., Nasir, M., 2007. Corruption, trade openness, and environmental quality: A panel data analysis of selected South Asian countries. The Pakistan Development Review, 46(4), 673-688.

Farhani, S., Ozturk, I., 2015. Causal relationship between CO 2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. Environmental Science and Pollution Research, 22(20), 15663-15676.

Farhani, S., Mrizak, S., Chaibi, A., Rault, C., 2014. The environmental Kuznets curve and sustainability: A panel data analysis. Energy Policy, 71, 189-198.

Flores, C. A., Flores-Lagunes, A., Kapetanakis, D., 2014. Lessons from quantile panel estimation of the environmental Kuznets curve. Econometric Reviews, 33(8), 815-853.

Ganda, F., 2019. The impact of industrial practice on carbon emissions in the BRICS: A panel quantile regression analysis. Progress in Industrial Ecology, 13(1), 84-107

Gill, A. R., Hassan, S., Haseeb, M., 2019. Moderating role of financial development in environmental Kuznets: a case study of Malaysia. Environmental Science and Pollution Research, 26(33), 34468-34478.

Gillingham, K., Rapson, D., Wagner, G., 2016. The Rebound Effect and Energy Efficiency

Godil, D. I., Sharif, A., Afshan, S., Yousuf, A., Khan, S. A. R., 2020a. The asymmetric role of freight and passenger transportation in testing EKC in the US economy: evidence from QARDL approach. Environmental Science and Pollution Research International. https://doi.org/10.1007/s11356-020-09299-7

Godil, D. I., Sharif, A., Agha, H., Jermsittiparsert, K., 2020b. 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, 1-11.

Gossart, C., 2015. Rebound Effects and ICT: A Review of the Literature. In: ICT Innovations

Grossman, G. M., Krueger, A. B., 1991. Environmental impacts of a North American free trade agreement (No. w3914). National Bureau of Economic Research.

Hafeez, M., Chunhui, Y., Strohmaier, D., Ahmed, M., Jie, L., 2018. Does finance affect environmental degradation: evidence from One Belt and One Road Initiative region?. Environmental Science and Pollution Research, 25(10), 9579-9592.

Har, W. M., Teo, K. L., Yee, K. M., 2008. FDI and economic growth relationship: An empirical study on Malaysia. International Business Research, 1(2), 11-18.

Har, W. M., Teo, K. L., Yee, K. M., 2008. FDI and economic growth relationship: An empirical study on Malaysia. International Business Research, 1(2), 11-18.

Haseeb, A., Xia, E., Saud, S., Ahmad, A., Khurshid, H., 2019. Does information and communication technologies improve environmental quality in the era of globalization? An empirical analysis. Environmental Science and Pollution Research, 26(9), 8594-8608.

Herwartz, H., Siedenburg, F., 2008. Homogenous panel unit root tests under cross sectional dependence: Finite sample modifications and the wild bootstrap. Computational Statistics & Data Analysis, 53(1), 137-150.

Higón, D. A., Gholami, R., Shirazi, F., 2017. ICT and environmental sustainability: A global perspective. Telematics and Informatics, 34(4), 85-95.

Horvath, A. Toffel, M. W., 2004. Environmental Implications of Wireless Technologies: News Delivery and Business Meetings. Environmental science & technology, 38(11), pp.

Hossain, S., 2012. An econometric analysis for CO2 emissions, energy consumption, economic growth, foreign trade and urbanization of Japan. Low Carbon Economy, 3, 92-105.

Ike, G. N., Usman, O., Sarkodie, S. A., 2020. Testing the role of oil production in the environmental Kuznets curve of oil producing countries: New insights from Method of Moments Quantile Regression. Science of the Total Environment, 711, 135208.

Im, K.S., Pesaran, M.H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. Journal of econometrics 115 (1), 53–74.

Interagency Task Team (IATT), 2018. Science, Technology and Innovation for SDGs Roadmaps. United Nations.

International Institute for Sustainable Development (IISD), 2018. BRICS Declaration Calls for Full Implementation of Paris Agreement and 2030 Agenda. Available at: https://sdg.iisd.org/news/brics-declaration-calls-for-full-implementation-of-paris-agreement-and-2030-agenda/

International Institute for Sustainable Development (IISD), 2019a. 11th BRICS Summit. Available at: https://sdg.iisd.org/events/11th-brics-summit/

International Institute for Sustainable Development (IISD), 2019b. BRICS Ministers Commit to Urban Environmental Management, Global Climate and Biodiversity Issues. Available at: https://sdg.iisd.org/news/brics-ministers-commit-to-urban-environmental-management-global-climate-and-biodiversity-issues/

International Telecommunication Union (ITU), 2020. ICTs to achieve the United Nations Sustainable Development Goals. United Nations. Available at: https://www.itu.int/en/mediacentre/backgrounders/Pages/icts-to-achieve-the-united-nations-sustainable-development-goals.aspx

Ishida, H., 2015. The effect of ICT development on economic growth and energy consumption in Japan. Telematics and Informatics, 32(1), 79-88.

Jalil, A., Feridun, M., 2011. The impact of growth, energy and financial development on the environment in China: A cointegration analysis. Energy Economics, 33, 284–291.

Jalil, A., Mahmud, S. F., 2009. Environment Kuznets curve for CO2 emissions: a cointegration analysis for China. Energy policy, 37(12), 5167-5172.

Javid, M., & Sharif, F., 2016. Environmental Kuznets curve and financial development in Pakistan. Renewable and Sustainable Energy Reviews, 54, 406-414.

Jayanthakumaran, K., Verma, R., Liu, Y., 2012. CO2 emissions, energy consumption, trade and income: a comparative analysis of China and India. Energy Policy, 42, 450-460.

Jensen, V., 1996. The pollution haven hypothesis and the industrial flight hypothesis: some perspectives on theory and empirics. Working Paper.

Jobert, T., Karanfil, F., Tykhonenko, A., 2012. Environmental Kuznets Curve for carbon dioxide emissions: lack of robustness to heterogeneity?.

Kamel, S., 2005. The use of information technology to transform the banking sector in developing nations.

Kao, C., Chiang, M.H., 2001. On the estimation and inference of a cointegrated regression in panel data. In Nonstationary panels, panel cointegration, and dynamic panels. Emerald Group Publishing Limited, pp. 179–222.

Khan, M.A., Ozturk, I., 2020. Examining foreign direct investment and environmental pollution linkage in Asia. Environmental Science and Pollution Research, 27(7), 7244-7255.

Koenker, R., 2004. Quantile regression for longitudinal data. Journal of Multivariate Analysis, 91(1), 74-89.

Koenker, R., Bassett Jr, G., 1978. Regression quantiles. Econometrica: journal of the Econometric Society, 33-50.

Kremers, J. J., Ericsson, N. R., Dolado, J. J., 1992. The power of cointegration tests. Oxford bulletin of economics and statistics, 54(3), 325-348.

Kuznets, S., 1955. Economic growth and income inequality. The American economic review, 45(1), 1-28.

Latif, Z., Latif, S., Ximei, L., Pathan, Z. H., Salam, S., Jianqiu, Z., 2018. The dynamics of ICT, foreign direct investment, globalization and economic growth: Panel estimation robust to heterogeneity and cross-sectional dependence. Telematics and Informatics, 35(2), 318-328.

Latif, Z., Xin, W., Khan, D., Iqbal, K., Pathan, Z. H., Salam, S., Jan, N., 2017. ICT and sustainable development in South Asian countries. Human Systems Management, 36(4), 353-362.

Lee, J. W., Brahmasrene, T., 2014. ICT, CO2 emissions and economic growth: evidence from a panel of ASEAN. Global Economic Review, 43(2), 93-109.

Lennerfors, T.T., Fors, P., van Rooijen, J., 2015. ICT and environmental sustainability in a changing society. Inf Technol People, 28,758– 774. https://doi.org/10.1108/ITP-09-2014-0219

Levendis, J., Lee, S. H., 2013. On the endogeneity of telecommunications and economic growth: evidence from Asia. Information Technology for Development, 19(1), 62-85.

Lu, W. C., 2018. The impacts of information and communication technology, energy consumption, financial development, and economic growth on carbon dioxide emissions in 12 Asian countries. Mitigation and Adaptation Strategies for Global Change, 23(8), 1351-1365.

Machado, J. A., Silva, J. S., 2019. Quantiles via moments. Journal of Econometrics, 213(1), 145-173.

Malmodin, J., Lundén, D., 2018. The energy and carbon footprint of the global ICT and E&M sectors 2010-2015, Stockholm: Ericsson AB, Telia Company AB.

Meadows, D.H., Meadows, D.L., Randers, J., Behrens III, W.W., 1972. The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. Universe Books, New York.

Moyer, J. D., Hughes, B. B., 2012. ICTs: Do they contribute to increased carbon emissions?. Technological Forecasting and Social Change, 79(5), 919-931.

Murphy, J. T., Carmody, P., 2015. Africa's information revolution: technical regimes and production networks in South Africa and Tanzania. John Wiley & Sons.

Musolesi, A., Mazzanti, M., Zoboli, R., 2010. A panel data heterogeneous Bayesian estimation of environmental Kuznets curves for CO2 emissions. Applied Economics, 42(18), 2275-2287.

Nagao, T., Hara, M., Hannoe, S., Nakamura, J., 2017. Estimation of reduction in CO 2 emissions by using ICT throughout Japan. In Sustainability Through Innovation in Product Life Cycle Design (pp. 633-649). Springer, Singapore.

Nasreen, S., S. Anwar, I. Ozturk., 2017. Financial stability, energy consumption and environmental quality: evidence from South Asian economies, Renew. Sustain. Energy Rev. 7 1105-1122.

Nguyen, T. T., Pham, T. A. T., Tram, H. T. X., 2020. Role of information and communication technologies and innovation in driving carbon emissions and economic growth in selected G-20 countries. Journal of Environmental Management, 261, 110162.

Osabuohien, E. S., Efobi, U. R., Gitau, C. M. W., 2014. Beyond the environmental Kuznets curve in Africa: evidence from panel cointegration. Journal of Environmental Policy & Planning, 16(4), 517-538.

Ozcan, B., Apergis, N., 2018. The impact of internet use on air pollution: evidence from emerging countries. Environmental Science and Pollution Research, 25(5), 4174-4189.

Özokcu, S., Özdemir, Ö., 2017. Economic growth, energy, and environmental Kuznets curve. Renewable and Sustainable Energy Reviews, 72, 639-647.

Ozturk, I., Acaravci, A., 2013. The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics, 36, 262-267.

Pal, D., Mitra, S. K., 2017. The environmental Kuznets curve for carbon dioxide in India and China: Growth and pollution at crossroad. Journal of Policy Modeling, 39(2), 371-385.

Park, Y., Meng, F., Baloch, M. A., 2018. The effect of ICT, financial development, growth, and trade openness on CO 2 emissions: an empirical analysis. Environmental Science and Pollution Research, 25(30), 30708-30719.

Pedroni, P., 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric theory, 20(3), 597-625.

Pénard, T., Poussing, N., Zomo Yebe, G., Ella, N., 2012. Comparing the determinants of internet and cell phone use in Africa: evidence from Gabon. Communications & Strategies, (86), 65-83.

Pesaran, M. H., 2004. General diagnostic tests for cross section dependence in panels.

Phillips, P. C., Sul, D., 2003. Dynamic panel estimation and homogeneity testing under cross section dependence. The Econometrics Journal, 6(1), 217-259.

Plepys, A., 2002. The grey side of ICT. Environmental Impact Assessment review, 22(5), pp. Policy. Review of Environmental Economics and Policy, 10(1), pp. 68-88.

Razzaq, A., Sharif, A., Ahmad, P., Jermsittiparsert, K., 2020. Asymmetric role of tourism development and technology innovation on carbon dioxide emission reduction in the Chinese economy: Fresh insights from QARDL approach. Sustainable Development.

Rafindadi, A. A., Usman, O., 2019. Globalization, energy use, and environmental degradation in South Africa: Startling empirical evidence from the Maki-cointegration test. Journal of Environmental Management, 244, 265-275

Raheem, I. D., Tiwari, A. K., Balsalobre-Lorente, D., 2020. The role of ICT and financial development in CO 2 emissions and economic growth. Environmental Science and Pollution Research, 27(2), 1912-1922.

Raworth, K., 2017. Doughnut economics: seven ways to think like a 21st-century economist. Chelsea Green Publishing. Recycling, Issue 36, pp. 197-210.

Rehman, M. U., Rashid, M., 2017. Energy consumption to environmental degradation, the growth appetite in SAARC nations. Renewable Energy, 111, 284-294.

Romm, J., 2002. The internet and the new energy economy. Resources, Conservation and

Saatci, M., Dumrul, Y., 2011. The relationship between economic growth and environmental pollution: the estimation of environmental Kuznets curve with a cointegration analysis of structural breaks for Turkish economy. Erciyes University Journal of Economics and Administrative Sciences, 37, 65-86.

Sadorsky., P., 2012) Information communication technology and electricity consumption in emerging economies. Energy Policy, 48, 130-136.

Saidi, K., Mbarek, M. B., 2017. The impact of income, trade, urbanization, and financial development on CO 2 emissions in 19 emerging economies. Environmental Science and Pollution Research, 24(14), 12748-12757.

Salahuddin, M., Alam, K., 2015. Internet usage, electricity consumption and economic growth in Australia: A time series evidence. Telematics and Informatics, 32(4), 862-878.

Salahuddin, M., Gow, J., 2016. The effects of Internet usage, financial development and trade openness on economic growth in South Africa: A time series analysis. Telematics and Informatics, 33(4), 1141-1154.

Salahuddin, M., Alam, K., Ozturk, I., 2016. The effects of Internet usage and economic growth on CO2 emissions in OECD countries: A panel investigation. Renewable and Sustainable Energy Reviews, 62, 1226-1235.

Sarkodie, S. A., Strezov, V., 2019. Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. Science of the Total Environment, 646, 862-871.

Shafiei, S., Salim, R. A., 2014. Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: A comparative analysis. Energy Policy, 66, 547-556.

Shafiei, S., Salim, R. A., 2014. Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: A comparative analysis. Energy Policy, 66, 547-556.

Shafik, N., 1994. Economic development and environmental quality: an econometric analysis. Oxford economic papers, 757-773.

Shahbaz, M., Lean, H. H., 2012. Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy policy, 40, 473-479.

Shahbaz, M., Rahman, M. M., 2012. The dynamic of financial development, imports, foreign direct investment and economic growth: cointegration and causality analysis in Pakistan. Global Business Review, 13(2), 201-219.

Shahbaz, M., Sinha, A., 2019. Environmental Kuznets curve for CO2 emissions: a literature survey. Journal of Economic Studies, 46(1), 106-168.

Shahbaz, M., Haouas, I., Sohag, K., Ozturk, I., 2020. The financial development-environmental degradation nexus in the United Arab Emirates: the importance of growth, globalization and structural breaks. Environmental Science and Pollution Research, 1-15.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., Leita˜o, N. C., 2013a. Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Renewable and Sustainable Energy Reviews, 25, 109–121.

Shahbaz, M., Shamim, S. A., Aamir, N., 2010. Macroeconomic environment and financial sector's performance: econometric evidence from three traditional approaches. The IUP Journal of Financial Economics, 1, 103-123.

Shahbaz, M., Sharma, R., Sinha, A., Jiao, Z., 2021. Analyzing nonlinear impact of economic growth drivers on CO2 emissions: Designing an SDG framework for India. Energy Policy, 148, 111965.

Sharif, A., Afshan, S., Chrea, S., Amel, A., Khan, S. A. R., 2020a. 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 international.27, 2549-25509

Sharif, A., Godil, D. I., Xu, B., Sinha, A., Khan, S. A. R., Jermsittiparsert, K., 2020b. Revisiting the role of tourism and globalization in environmental degradation in China: Fresh insights from the quantile ARDL approach. Journal of Cleaner Production, 122906.

Sharma, R., Sinha, A., Kautish, P., 2021. Does financial development reinforce environmental footprints? Evidence from emerging Asian countries. Environmental Science and Pollution Research, 28, 9067-9083.

Shoaib, H. M., Rafique, M. Z., Nadeem, A. M., Huang, S., 2020. Impact of financial development on CO 2 emissions: A comparative analysis of developing countries (D 8) and developed countries (G 8). Environmental Science and Pollution Research, 27(11), 12461–12475.

Sinha, A., 2018. Impact of ICT exports and internet usage on carbon emissions: a case of OECD countries. International Journal of Green Economics, 12(3-4), 228-257.

Sinha, A., Bhattacharya, J., 2016. Confronting environmental quality and societal aspects: an environmental Kuznets curve analysis for Indian cities. International Journal of Green Economics, 10(1), 69-88.

Sinha, A., Sen, S., 2016. Atmospheric consequences of trade and human development: A case of BRIC countries. Atmospheric Pollution Research, 7(6), 980-989.

Sinha, A., Sengupta, T., Saha, T., 2020. Technology policy and environmental quality at crossroads: Designing SDG policies for select Asia Pacific countries. Technological Forecasting and Social Change, 161, 120317.

Sinha, A., Shahbaz, M., 2018. Estimation of environmental Kuznets curve for CO2 emission: role of renewable energy generation in India. Renewable energy, 119, 703-711.

Sinha, A., Shahbaz, M., Balsalobre, D., 2019. Data selection and environmental Kuznets curve models-environmental Kuznets curve models, data choice, data sources, missing data, balanced and unbalanced panels. In Environmental Kuznets Curve (EKC) (pp. 65-83). Academic Press.

Sinha, A., Shahbaz, M., Sengupta, T., 2018. Renewable energy policies and contradictions in causality: a case of Next 11 countries. Journal of Cleaner Production, 197, 73-84.

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, 121669-76.

Sulemana, I., James, H. S., Rikoon, J. S., 2017. Environmental Kuznets Curves for air pollution in African and developed countries: exploring turning point incomes and the role of democracy. Journal of Environmental Economics and Policy, 6(2), 134-152.

Suri, V., Chapman, D., 1998. Economic growth, trade and energy: implications for the environmental Kuznets curve. Ecological economics, 25(2), 195-208.

Tamazian, A., Rao, B. B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Economics, 32(1), 137–145.

Tamazian, A., Chousa, J. P., Vadlamannati, K. C., 2009. Does higher economic and financial development lead to environmental degradation: evidence from BRIC countries. Energy policy, 37(1), 246-253.

Tchamyou, V. S., 2017. The role of knowledge economy in African business. Journal of the Knowledge Economy, 8(4), 1189-1228.

Tsaurai, K., Chimbo, B., 2019. The impact of information and communication technology on carbon emissions in emerging markets. International Journal of Energy Economics and Policy, 9(4), 320.

United Nations, 2017. 'BRICS' countries well placed to help lead global efforts to tackle hunger. Available at: https://news.un.org/en/story/2017/06/559662-brics-countries-well-placed-help-lead-global-efforts-tackle-hunger-un-agency

United Nations Association – UK (UNA-UK), 2017. Can BRICS lead the way to sustainable development?. Available at: https://www.sustainablegoals.org.uk/can-brics-lead-way-sustainable-development/

United Nations Environment Programme (UNEP), 2018. Rethınkıng Impact to Fınance the SDGs: A Position Paper and Call to Action prepared by the Positive Impact Initiative.

Ulucak, R., Danish, Khan, S. U. D., 2020. Does information and communication technology affect CO2 mitigation under the pathway of sustainable development during the mode of globalization?. Sustainable Development, 1-11.

Usman, O., Iorember, P. T., Olanipekun, I. O., 2019. Revisiting the environmental Kuznets curve (EKC) hypothesis in India: the effects of energy consumption and democracy. Environmental Science and Pollution Research, 26(13), 13390-13400.

Wang, K. M., 2013. The relationship between carbon dioxide emissions and economic growth: quantile panel-type analysis. Quality & Quantity, 47(3), 1337-1366.

Watson, R. T., Corbett, J., Boudreau, M. C., Webster, J., 2012. An information strategy for environmental sustainability. Communications of the ACM, 55(7), 28-30.

Westerlund, J., 2007. Testing for error correction in panel data. Oxford Bulletin of Economics and statistics, 69(6), 709-748.

World Bank., 2018. Global economic prospects. www.world bank.org/en/publication/global-economic-prospects

World Bank., 2019. World development indicators. http:// data.worldbank.org/data-catalog/world-development-indi cators

Wurgler, J., 2000. Financial markets and the allocation of capital. Journal of Financial Economics, 58(1), 187-214.

Zafar, M.W., Shahbaz, M., Hou, F., Sinha, A., 2019. From nonrenewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries. Journal of Cleaner Production, 212, 1166-1178.

Zafar, M. W., Shahbaz, M., Sinha, A., Sengupta, T., Qin, Q., 2020. How renewable energy consumption contribute to environmental quality? The role of education in OECD countries. Journal of Cleaner Production, 268, 122149.

Zhang, C., Liu, C., 2015. The impact of ICT industry on CO2 emissions: a regional analysis in China. Renewable and Sustainable Energy Reviews, 44, 12-19.

Zhang, J., Wang, B., Latif, Z., 2019. Towards cross-regional sustainable development: The nexus between information and communication technology, energy consumption, and CO 2 emissions. Sustainable Development, 27(5), 990-1000.

Zhang, S., Liu, X., Bae, J., 2017. Does trade openness affect CO 2 emissions: evidence from ten newly industrialized countries?. Environmental Science and Pollution Research, 24(21), 17616-17625.

Zhang, Y. J., 2011. The impact of financial development on carbon emissions: An empirical analysis in China. Energy policy, 39(4), 2197-2203.

Zhu, H., Duan, L., Guo, Y., Yu, K., 2016. The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. Economic Modelling, 58, 237-248.

Zhu, H., Xia, H., Guo, Y., Peng, C., 2018. The heterogeneous effects of urbanization and income inequality on CO2 emissions in BRICS economies: evidence from panel quantile regression. Environ. Sci. Pollut. Res. 25, 17176–17193.