Pakistan Journal of Commerce and Social Sciences
2020, Vol. 14 (1), 202-254
Pak J Commer Soc Sci

Reexamination of Environmental Kuznets Curve for Ecological Footprint: The Role of Biocapacity, Human Capital, and Trade

Muhammad Tariq Majeed
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: tariq@qau.edu.pk

Maria Mazhar
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: mariamazhar28@yahoo.com

Abstract

Climate change has emerged as a global challenge because of its threat to sustainable development goals. Economic development is responsible for climate change as well as it is complementary to sustainability. Hence, environmental Kuznets curve (EKC) hypothesis is central to the development plans and formulation of climate change policy. However, the evidence on EKC is largely conflicting because it is provided using narrow measures of environment, small samples, short time durations and ignoring updated estimation methods. This study reinvestigates the EKC by exploiting the lager panel data set, covering a longer time horizon more than half century (1961-2018) and using ecological footprint as a comprehensive environmental indicator and employing first-generation and second-generation panel time's series methods. The study sample comprises 20 upper-income countries (UICs), 36 middle-income countries (MICs) and 20 low-income countries (LICs). The results conclude the presence of cross-sectional dependence, unit root at level and long run relationship among the variables allowing for long run estimates. The findings of different estimators validate an inverted U-shaped EKC for UICs while U-shaped EKC for MICs and LICs, respectively. The results of fixed effects quantile (FEQ) estimates suggest that the scale and technique effects depend upon the existing levels of EFP within and across different groups of countries according to development level and regional location. Moreover, the role of biocapacity, human capital, and trade is conducive in managing global EFP. The findings imply that global environmental policies need to be aligned with the heterogeneity of different groups of countries.

Keywords: ecological footprint, biocapacity, fixed effects quantile regression, cross section dependence, human capital, EKC, OECD, SAARC, BRICS, and South Asian Economies.

1. Introduction

Globally, many economies have achieved high growth rates and welfare gains at the cost of environmental quality. Whereas, an accelerating pace of industrialization ensured more growth and development, it has also led to climate change and global warming. Rising levels of greenhouse gas emissions (GHG) are becoming a matter of great concern as they impose huge cost on economies in terms of low long-term growth, species extinction, extreme weather, and food supply shocks. Among all, the effect of carbon emissions is more dangerous as it contributes almost 60 percent of the total greenhouse gases (Kaygusuz, 2009; Majeed & Mumtaz, 2017; Khan & Majeed, 2019).

The world's ecological footprint (EFP) also soared over time and the gap between ecological consumption and earth's carrying capacity has been growing constantly (Panayotou, 1993). EFP is a comprehensive indicator of ecological sustainability owing to its multidimensional nature. First, it shows the overall carrying capacity of earth (Majeed & Mazhar, 2019b). Second, it tracks the demand for regenerative capacity of earth (Wackernagel, 2002; Kitzes & Wackernagel, 2009). Third, it provides the assessment about the demand for overall natural resources. Fourth, it monitors the pressure of human activities on environmental services. Thus, increase in EFP signifies the greater environmental stress and ecological deficit when compared with earth's biocapacity.

United Nations (2017) reported that the priority to increase economic development has increased the energy and other natural resources demand which surpasses the ecological footprint (EFP) from the biological capacity of earth. The speed of natural resource use is now 1.75 times faster than its regenerative capacity placing many countries into the ecological deficit. According to Global Footprint Network (GFN, 2019) 86 percent of our world's population is living in ecological deficit countries and about 71 percent of the total population is living in ecological deficit and below-average income countries, reflecting the severe environmental challenge in both developed and developing economies. Therefore, the urgency of reexamining the EKC theory by using the EFP as an environmental indicator has become vital.

In the environmental and natural resource economics the association between economic growth and environmental pollutants often appears as interconnected and highly debatable concept. It is widely acknowledged that ecological services are crucial for the economy's development as they provide the resource base. These services are regarded as inputs to the production of several goods and services. In conjunction with this, the environment also has some absorption capacity to absorb water and air pollutants, toxic and solid waste implying that within certain limits environment provides the opportunity to develop allowing absorption capacity.

However, if utilization of environmental services goes beyond the certain desirable limits, the growth slows down or even becomes negative. This happens when priority is given to development and growth by neglecting the environmental quality. Though, environmental quality tends to improve along with higher development levels (Brock & Taylor, 2005). Grossman & Kruger (1995) term these associations between economic growth and environmental pollutants as EKC. Because in the initial stages, economic development increases irrespective of maintaining environmental quality. However, after reaching a certain level of environmental degradation societies focus more on environmental conservation. Numerous researchers have empirically tested the EKC hypothesis and have provided mixed evidence based on different estimation techniques, study samples and environmental indicators (Ekins, 1997; Lau et al., 2014; Al-Mulali et al., 2015; Ozturk, 2016; Majeed, 2018; Majeed & Luni, 2019).

One major limitation of these studies is that they largely use CO_2 emission as a measure of environmental degradation to test the EKC hypothesis. However, CO_2 emission is just a part of environmental degradation. In contrast, ecological footprint is a comprehensive indicator of environmental degradation since it covers the six major components of ecosystem “cropland, grazing land, fishing grounds, forestland, carbon footprint, and built-up land.” As an indicator of environmental quality, the ecological footprint has received focus in the recent years. Nevertheless, due to complex feedback in the associations among economic development, biocapacity, ecosystem services, human capital and quality of life, the footprint continues to be little known and largely ignored in policy decision.

Thus, this study reinvestigates the EKC hypothesis for upper-income countries (UICs), middle income countries (MICs) and low-income countries (LICs) by considering the above-mentioned limitations. In addition, this study exploits the larger data set for reinvestigating the EKC hypothesis covering the period 1961-2018, however, previous research did not provide the estimates of EKC for such a long time period. It also utilizes the recently known econometric methods; second generation econometrics and fixed effects quantile (FEQ) regression approach. Moreover, unlike exiting studies that focus on country specific evidence or some regional evidence, this study focuses on global evidence. Finally, this study provides a comparative regional analysis of Organization for Economic Co-operation and Development (OECD), South Asian Association for Regional Cooperation (SAARC), Brazil, Russia, India, China and South Africa (BRICS), and South Asian economies, which is ignored in the existing literature.

This study aims to answer following research questions: (1) Is EKC hypothesis valid for all groups of economies irrespective of their development level and regional location? (2)

Does the shape of EKC sustain over a longer time horizon? (3) What is the shape of EKC while controlling for biocapacity, human capital and trade?

The main implication of this study is that the shape of EKC is not identical across all income groups and regions. An inverted U-shaped EKC is confirmed only for UICs and OECD economies while U-shaped EKC is validated for MICs, LICs, South Asian economies, SAARC and BRICS. These findings remain consistent even after controlling for biocapacity, human capital and trade. However, the technical effect of EKC is stronger for the economies experiencing high level of EFP.

This type of analytical attempt is useful for designing an efficient environmental policy framework along with formulating macroeconomic framework particularly for MICs, LICs, BRICS, SAARC and South Asian economies. Because the U-shaped relationship can hold due to the locational displacement of pollution intensive industries toward these economies. Moreover, the results are helpful for less developed or emerging economies having no or minimum environmental regulations.

The remaining part of the study is arranged as follows: Section 2 presents the theoretical underpinnings of the study along with empirical literature. Section 3 defines the methodology to be used in the study. Section 4 discusses the results obtained by using the econometrics techniques and last section concludes the study.

2. Literature Review

Environment remains the hot issue for various researchers and environmental health practitioners around the world. The research on this topic, therefore, developed over time and we find both theoretical and empirical literature in the current academia. In this section, first, we will focus on the theoretical foundations of this study in which we briefly discuss theories and theoretical arguments related to the nature of this study and in the second section we will present brief review of the available empirical literature.

2.1 Theoretical Underpinnings of the Study

The theoretical underpinnings of the present study are based on EKC hypothesis, environmental transition theory, the ecological modernization theory, and ecologically unequal exchange theory. Moreover, theoretical arguments are compiled for trade, human capital and biocapacity in relation to environmental quality.

2.1.1 The Environmental Kuznets Curve

The concept of EKC hypothesis emerged in the early 1990s, which claims that environmental pollutants and economic growth (or per capita income) carry an inverted U-shaped relationship. The idea is primarily based on three effects: scale, composite/structural and technique effect. The scale effect refers to the effect on pollution as a result of increased economic activity or more production. However, over the path of development economy moves from agriculture (or pre-industrial) to manufacturing or manufacturing to services sector (composite effect), then the economy started to improve its relationship with environment as old technology is replaced by cleaner technology (technique effect).

2.1.2 The Environmental Transition Theory

The advocates of environmental transition theory argue environmental pollution increases during the process of transition from agriculture to manufacturing sector because of more demand for energy resources. However, after achieving the development benefits economies struggle for reducing GHGs concentration from the atmosphere through better technology and structural changes.

2.1.3 The Ecological Modernization Theory

According to ecological modernization theory a smooth relationship between economic growth and environmental degradation can exist, however, these favorable effects can be realized after achieving certain level of growth, institutional and cultural changes. Thus, moving toward environmentalism can assist the economies to preserve the natural resources.

2.1.4 The Ecologically Unequal Exchange Theory

The ecologically unequal exchange theory provides an important insight about environmental protection through world-system analysis. According to the postulation, an unequal material exchange between Global North (developed nations) and Global South (less-developed nations) creates environmental hazards. The Global North economies extract energy and other natural resources from Global South economies, destroying the resource base of these economies. Moreover, Global North economies have high absorption capacity and strict environmental regulation, therefore, they displace their waste and dirty industries to Global South nations. Thus, an unequal global system for poor nations (less powerful) and advance nations (more powerful) increases the environmental stress in less developed economies.

2.1.5 The Theoretical Arguments: Trade and Environment

Trade flows play an important role in worsening or improving the environment. According to Stoessel (2001) expansion in trade flows increases the process of transferring waste and toxic material which results in higher environmental damages. Trade also enhances production, investment and energy consumption (Majeed, 2016). All that result in overexploitation of natural resources deterioration of environmental quality. International trade hurts the environment by increasing the competition in the presence of weaker environmental regulations. This channel works according to the "race to bottom" hypothesis. In contrast, according to the "gain from trade" hypothesis environmental conditions improve with trade liberalization as it encourages the flow of technological innovations, green and clean technologies and the information about environmental preservation (Majeed and Mazhar, 2019a; Porter & Van der Linde, 1995).

2.1.6 The Theoretical Arguments: Human Capital and Environment

Human capital has a dominant impact on environment and its sustainability. For example, human capital can help the economies to save energy, preserve natural resources (like timber, minerals and water) and reduce the extent of waste in landfills (Zen et al., 2014) by encouraging the use of renewable energy products and recycling activities. In addition, it encourages humans to follow environmental rules and regulations, therefore, improving environmental quality (Desha et al., 2015).

2.1.7 The Theoretical Arguments: Biocapacity and Environment

Biocapacity is the capacity of regenerating certain biological materials (natural resources) and absorbing and filtering the waste from the atmosphere. It is negatively associated with ecological footprint because a rise in ecosystem's biological capacity increases the earth capacity to absorb waste and other harmful gases, therefore, alleviating the environmental stress. More often in this situation biocapacity is greater than EFP creating ecological surplus (Rees, 2006). On the other hand, biocapacity is also dependent on population growth and its ecological budget. In this case increase in biocapacity may further deteriorate EFP due to higher population growth and its demand toward ecosystem services. Thus, ecological deficit may appear inducing the economies to fulfill demand by importing biological capacity (Kwon, 2009; Lau, 2019).

2.2 Empirics of Environmental Kuznets Curve Hypothesis

The empirical literature on validation of EKC hypothesis is classified into different categories. Firstly, the validation of EKC hypothesis is tested by some cross-country studies and then by single country studies. The EKC is not only proved by taking per capita income and its square term in the model, but some studies also control for the important indicators such as energy consumption, trade, education and recently the biocapacity which is considered more vital in explaining EKC hypothesis.

2.2.1 EKC: Evidence from Cross-Country Approach

Using different indicators such as sulfur dioxide, nitrous oxide, and carbon monoxide many studies have tested EKC hypothesis. Based on traditional panel data techniques and panel cointegration approaches Panayotou (1993), Shafik (1994), Selden & Song (1994), Torras & Boyce (1998), List & Gallet (1999), Halkos (2003), Millimet (2003), Leitão (2010), Wang et al. (2016), Atasoy (2017), Majeed (2018), and Majeed & Luni (2019) found the evidence of EKC hypothesis in the group of different panel data sets for different time coverage. The estimates of these studies are based on only per capita income and its square term in the model along with some studies have included other determinants such as population density, urbanization, trade, renewable energy, information and communication technology, time trend, locational dummies, political and civil rights. These studies conclude that technological advancement, good governance and better institutional cause an inverted U-shaped EKC.

Similarly, by considering the global pollutant CO_2 emissions researchers across the globe confirmed the existence of EKC hypothesis. As Xu & Song (2010) for Eastern and Central areas of China, Narayan & Narayan (2010) and Apergis & Ozturk (2015) for Middle Eastern and South Asian panel, and Jaunky (2011), Pao & Tsai (2011), Alvarado et al. (2018), Majeed (2018), Majeed & Luni (2019) for high-income and global panel find an inverted U-shaped relationship between economic growth and carbon emissions. According to these studies an inverted U-shaped relationship may hold due to the locational displacement of dirty industries in less developed economies; whereas, information and knowledge spillovers about the importance of environment may improve environment in developed economies.

Recently, the studies are using EFP as comprehensive environmental indicator. An inverted U-shaped relationship between economic growth and ecological footprint is proved for different income groups by Ozturk et al. (2016), Middle East and North Africa (MENA) region by Charfeddine & Mrabet (2017), and newly industrialized countries by Destek & Sarkodie (2019). These studies suggest that an inverted EKC is validated in these economies because of sustainable management policies that helped to reduce environmental pressure. In addition, using various component of EFP, Aydin et al. (2019) found out mixed patterns of EKC. They validated EKC by incorporating the component of carbon footprint, cropland and fishing and employing panel smooth transition regression.

There are some studies who challenged the existence of EKC and some who ended up with obtaining sulfur emissions as monotonic function of per capita income (Stern & Common, 2001). Some other studies found U-shaped EKC. For example, Ozcan (2013) and Alvarado et al. (2018) found U-shaped EKC for low-income and middle-high-income countries. Similarly, Destek & Sinha (2020) validated the U-shaped EKC for OECD economies.

Altıntaş & Kassouri (2020) concluded that shape of EKC is very sensitive to the environmental indicator. They found U-shaped relationship between growth and carbon emissions for European countries. However, they found an inverted U-shaped relationship when environment is measure with EFP. Some studies found N-shaped relationship between income per capita and carbon emissions (Martínez-Zarzoso & Bengochea-Morancho, 2004; Majeed and Luni, 2019). The study by Rahman et al. (2019) confirmed N-shaped EKC for Central and Eastern European Countries (CEECs).

Overall, the literature presents mixed evidence. However, more importantly, due to the lack of simultaneity issue in the data set studies largely present the similar findings by validating the presence of an inverted U-shaped EKC. This might be due to the use of similar methodologies or the bias in estimation as most of the studies used traditional panel data models. On the other, the difference in the result can be due to the presence of econometrics problems in the estimation such as endogeneity, multicollinearity, cross-sectional dependence and omitted variable bias. Moreover, the use of environmental indicator also matters for unbiased estimates.

2.2.2 EKC: Evidence from Single-Country Approach

The second strand of the literature includes the studies who attempted to examine EKC hypothesis using time-series data and performing single-country analysis. Fodha & Zaghdoud (2010) supported the existence of EKC hypothesis (in the case of SO_2 emissions) and monotonically increasing relationship (in the case of CO_2 emissions) for Tunisian economy. Likewise, taking the data of CO_2 emissions Shahbaz et al. (2012) supported EKC hypothesis for Pakistan while Al-Mulali (2015) did not confirm it for Vietnam. Under the time series analysis there are some studies who incorporated ecological footprint as an environmental indicator along with using CO_2 emissions and found diverse results due to omitted variable bias. Charfeddine (2017) used the data of Qatar economy and concluded that an inverted U-shaped relationship holds between income per capita and CO_2 emissions and ecological carbon footprint while U-shaped relationship holds between incomes per capita and total ecological footprint. With the same objective, Mrabet & Alsamara (2017) proved EKC hypothesis using ecological footprint, whereas, they could not validate EKC hypothesis using CO_2 emissions.

In sum, a sizeable work has been done to test the ECK hypothesis. However, the evidence shows that not only inverted U-shaped relationship between income per capita and environmental degradation exists but also U-shaped, N shaped, and inverted N-shaped EKC also observed in the literature. This is mainly because of the divergence of indicator used to measure environmental degradation and the empirical methodology taken to perform an empirical exercise. As most of the studies relied on CO_2 emissions and other air pollutants such as SO_2.

The new measure of ecological footprint is used by some of the studies, but much work has been done in the time series field. There are very few studies, which tested EKC using EFP as an indicator of the environment. However, their analysis is limited to Central and Eastern European Countries, European countries, and newly industrialized countries. Thus, the testimony of EKC hypothesis is not yet clear completely as there is a dearth of literature using EFP. Therefore, this study contributes in the existing literature through multiple ways. First, it uses the recently developed environmental indicators of ecological footprint and performs an analysis for UICs, MICs, and LICs. Second, this study uses large and globally representative dataset covering the time period from 1961 to 2018. Third, this study improves the methodological part by employing second generation econometrics techniques and FEQ regression. Lastly, the present study provides a comparative for OECD, SAARC, BRICS, and South Asian economies.

3. Methodology

To reinvestigate the EKC hypothesis the data is retrieved from secondary sources. Data for trade and GDP per capita is retrieved from World Bank (2019), data for EFP and biocapacity is taken from Global Footprint Network (2019), and data for human capital (HC) index, is collected from Penn World Table 9.0 suggested by Feenstra et al., (2015). The study time is covered over the period 1961-2018 for different development levels: 20 UICs, 36 MICs and 20 LICs. The countries are categorized following World Bank (2019). The empirical model for EKC is specified following the studies of Grossman & Kruger (1995), Majeed (2018), and Majeed & Luni, (2019). The specification of control variables is based on the theoretical foundations discussed above and five equations are specified following the study of Ulucak & Bilgili (2018):

$$LEFP_{it} = \propto_1 LGDP_{it} + \propto_2 LGDP_{it}^2 + \propto_3 1973_i + \propto_4 1980_i + \varepsilon_{it} \ldots (1)$$
$$LEFP_{it} = \gamma_1 LGDP_{it} + \gamma_2 LGDP_{it}^2 + \gamma_3 TO_{it} + \gamma_4 1973_i + \gamma_5 1980_i + e_{it} \quad (2)$$
$$LEFP_{it} = \beta_1 LGDP_{it} + \beta_2 LGDP_{it}^2 + \beta_3 HC_{it} + \beta_4 1973_i + \beta_5 1980_i + \tau_{it} (3)$$
$$LEFP_{it} = \delta_1 LGDP_{it} + \delta_2 LGDP_{it}^2 + \delta_3 TO_{it} + \delta_4 HC_i + \delta_5 1973_i + \delta_6 1980_i + \vartheta_{it} (4)$$
$$LEFP_{it} = \varsigma_1 LGDP_{it} + \varsigma_2 LGDP_{it}^2 + \varsigma_3 TO_{it} + \varsigma_4 HC_i + \varsigma_5 BC_{it} + \varsigma_6 1973_i + \varsigma_7 1980_i + v_{it} \ (5)$$

Where, LEFP is the log of EFP measured in global hectares (GHA) per person. LGDP is the log of GDP per capita in 2010 constant US Dollars and $LGDP^2$ is the square term of LGDP. Trade openness is gauged in terms of percentage of GDP and considered important in explaining EKC (Cole, 2003; Ozturk & Bilgili, 2015; Dogan & Turkekul, 2016). HC is the human capital index, based on years of schooling and returns to education. Lastly, the variable BC shows the biocapacity (GHA per capita) which is currently used in EKC model to capture the important dynamics of resource (Aşıcı & Acar, 2016; Ozturk & Bilgili, 2018). D1973 and D1980 are the two dummies added to capture the effects of structural breaks. ε, e , τ , ϑ , and v are the error terms. The subscript i indicates cross sections and t represents the time period.

The empirical methodology of this study involves five important steps; testing the cross-sectional dependence (CSD), presence of unit roots, cointegration, estimates of fully modified ordinary least squares (FMOLS) and estimates at different quantiles. Cross-sectional dependence is checked through four tests namely, Friedman's test, Bruesh-Pagan LM test, Pesaran Scaled LM test, Pesaran CD test. Friedman (1937)'s test is the oldest the non-parametric test based on the average of Spearman's rank correlation coefficient. It involves the addition of pairwise correlation coefficients of the residual matrix and might overlook the CSD in case of large negative and positive correlations in the residuals as they cancelled out with each other during averaging process.

Breusch & Pagan (1980) developed Bruesh-Pagan LM test based on the estimates of pair-wise correlation of the residuals computed by OLS. It does not necessitate the specific ordering of cross-sectional units (CSUs) and produces efficient results when time is greater than cross-sectional units. However, if time is limited or finite and cross-sections are large the test can result in substantial size distortion. Considering theses flaws, Pesaran (2004) proposed two tests. Using the standardized version of LM statistics the Pesaran Scaled test provides the efficient estimates for sufficiently large time (T) and for finite cross-sections. Similarly, based on the average of pair-wise correlation coefficient, Pesaran CD test gives efficient estimates in case of infinite number of years and CSUs.

The test has zero mean in case of large panels. The null hypotheses of the tests are "no cross-sectional dependence".

The stationary property of the variables is checked through widely used four common panel unit root tests (URTs) of first generation namely, Levin, Lin & Chu, Im, Pesaran and Shin W-Stat, ADF-Fisher Chi-Square and PP-Fisher Chi-Square along with second generation panel URTs namely CADF and CIPS recommended by Pesaran (2007). Levin & Lin (1992) is the extension of DF test that assumes individual process as cross-sectionally independent by including unit-specific fixed effects and unit-specific time trends. Later, Im et al. (2003) extended the LL test based on the overall average of unit-root test statistics for obtaining different parametric values, lag length and residual by performing separate estimation for each CSU. This test assumes panel to be balanced.

Further, the fisher type tests present another approach to panel URTs using Fisher's (1932) results to derive tests that combine the p-values from an individual URT. This idea has been suggested by Maddala and Wu (1999), who proposed the test for unbalanced panels. Although these tests provide valuable results to check the variable stationarity but ignore the potential interdependence among cross-sections. To counter that, second-generation panel URT test proposed by Pesaran (2007) is used in this study. This test is the extension of Im, Pesaran and Shin W-Stat (IPS) test known as cross-sectional augmented IPS (CIPS) works through CADF test statistics. CADF test augments the DF regression with cross-sectional averages of lagged levels and first differences of the i-th cross-section in the panel and then provides CIPS statistics through simple average. The test is adjusted for the issue of CSD as it assumes least one unobserved common element in the error term which accounts the CSD (Gengenbach et al., 2009).

In the third step, we have applied both first and second-generation panel cointegration tests (CT). Firstly, the Kao and Pedroni CT (first generation) tests are used to check the long run relationship among the variables. Kao (1999) test is based on ADF-Dickey Fuller type tests which restricts numerous exogenous variables in cointegrating vector. The Pedroni test is proposed by Pedroni (1999) which allows the heterogeneity in panel and multiple regressors in cointegrating vector. The test shows the seven cointegration statistics in which four deal with the within dimension (Panel V-Statistics, Panel rho-Statistics, Panel PP-Statistics, Panel ADF-Statistics) and three deal with between dimension (Group rho-Statistics, Group PP-Statistics, Group ADF-Statistics). The within dimension does not allow heterogeneity (averaging AR coefficients across different cross-sections for URT on residual) while between dimension allows the heterogeneity dimension (averaging AR coefficients for each cross-section for URT on residuals).

Furthermore, to counter the CSD the second-generation panel CT is used proposed by Westerlund (2007).

The long run estimates are obtained through FMOLS which was introduced by Hansen & Phillips (1990) to provide efficient results in the presence of cointegration. FMOLS modifies OLS to explain serial correlation effects and uses a semi-parametric correction to remove endogeneity issue. In fact, FMOLS technique covers the deficiencies of simple OLS technique (Phillips, 1995; Halicioglu, 2009). Lastly, for allowing the various features of the distribution of the data (dependent variable) and controlling the unobserved heterogeneity, we employ the fixed effects quantile regression suggested by Canay (2011). This technique also provides efficient estimates in the presence of outliers in the response variable (Canay, 2011; Mallick et al., 2019).

The specification of the τth quantile of the conditional distribution of the LEFP (outcome variable) is expressed in the following form:

$$Q_t\left(\frac{LEFP_{it}}{X_{it}}\right) = \varphi_\tau + \pi_\tau X_{it} + \varphi_\tau \varepsilon_{it} \ldots\ldots (eq. 1.1)$$

$$Q_t\left(\frac{LEFP_{it}}{X_{it}}\right) = \theta_\tau + \aleph_\tau X_{it} + \theta_\tau \varepsilon_{it} \ldots\ldots (eq. 5.1)$$

Equations 1.1 and 5.1 refer to equation 1 and 5, respectively. The term X_{it} is the vector of control variables namely GDP, GDP^2, TO, HC, and BC, respectively. The term ε_{it} shows the unobserved factors. Then, the parameter estimates are obtained by minimizing absolute value of residuals (Koenker, 2004).

$$(Q_t(\pi_\tau) = \min_{\pi} \sum_{i=1}^{n} [|lnEFP_{i,t} - \pi_\tau X_{it}|]) \ldots . (eq. 1.1.1)$$

$$(Q_t(\aleph_\tau) = \min_{\aleph} \sum_{i=1}^{n} [|lnEFP_{i,t} - \aleph_\tau X_{it}|]) \ldots . (eq. 5.1.1)$$

4. Results and Discussion

This section presents and discusses estimated results through Eviews 9 and Stata15.

4.1 Results of CSD Tests

Table 1 portrays the finding of CSD test for the UICs, MICs and LICs. According to the results Ho “no cross-sectional dependence or correlation in residuals” is rejected on the bases of p-values less than 0.1 (critical value). This shows that CSD exists in almost all cases. The last column of this table presents the results of Pesaran (2015) test for checking the degree of CSD. The findings suggest that in most of the cases probability values are significant indicating the rejection of null hypothesis “errors are weakly cross-sectional dependent”. Therefore, we conclude that the strong CSD is present among the CSUs.

Table 1: Results of CSD Tests

Models	Cross-Sectional Dependence Tests				
	Friedman's Test	**Bruesh-Pagan LM Test**	**Pesaran Scaled LM Test**	**Pesaran CD Test**	**Pesaran Test (for Weak CSD)**
Results for Upper Income Countries					
Model 1	235.87***	8705.89***	162.97***	28.743***	1.037
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.300)
Model 2	221.31***	8610.34***	165.49***	26.955***	-0.748
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.454)
Model 3	178.75***	7298.81***	140.76***	24.842***	-4.027***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)
Model 4	176.01***	7391.80***	147.17***	38.959***	-4.016***
	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.000)
Model 5	152.23***	5920.46***	129.13***	32.027***	-4.161***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.000)
Results for Middle Income Countries					
Model 1	74.793***	4183.52***	192.86***	9.298***	-3.079***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.002)
Model 2	71.860***	2847.86***	127.69***	-0.18328***	-4.079***
	(0.0000)	(0.0000)	(0.0000)	(0.8546)	(0.000)
Model 3	66.225***	3154.03***	142.62***	3.9169***	-4.032***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.000)
Model 4	49.720***	2742.93***	122.56***	5.580***	-3.294***
	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.001)
Model 5	53.013***	2314.03***	101.64***	2.9718***	-2.889***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.004)
Results for Low Income Countries					
Model 1	69.365***	3445.71***	105.65***	11.896***	-3.508***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.000)
Model 2	93.284***	2366.31***	83.336***	6.797***	-2.050***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.040)
Model 3	49.333***	2366.31***	83.336***	6.797***	-3.378***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.001)
Model 4	70.083***	1919.05***	68.911***	5.229***	-3.311***
	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.001)
Model 5	46.945***	1729.24***	73.107***	3.670***	-4.015***
	(0.0001)	(0.0000)	(0.0000)	(0.0002)	(0.000)

4.2 Results of Panel URTs

The results of first-generation panel URTs are presented in table 2. It is observed that probability values (bold values) of each variable are greater than 0.1 indicating the acceptance of null hypothesis that all variables EFP, GDP, TO, HC, and BC are non-stationary at level. These results are applicable across all income groups and provide the evidence of non-stationarity of series. These tests, however, ignore the dependence among the cross-sections and may offer misleading conclusion.

Table 2: Results of First-Generation Panel URTs at Level

Results for Upper Income Countries							
Panel Unit Root Tests		**Variables**					
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	2.6698	3.37713	9.4071	8.5171	-3.362	0.4433
	Probability	**(0.9962)**	**(0.9996)**	**(1.0000)**	**(1.0000)**	**(0.0004)**	**(0.6676)**
Im, Pesaran and Shin W-Stat	**Statistics**	-0.2010	3.08490	11.1030	-1.3657	2.5714	2.2923
	Probability	**(0.4203)**	**(0.9990)**	**(1.0000)**	(0.0860)	**(0.9949)**	**(0.9891)**
ADF-Fisher Chi-Square	**Statistics**	86.652	98.4683	89.6364	130.9hc4	93.050	73.130
	Probability	**(0.6920)**	**(0.9955)**	**(0.9995)**	**(0.4112)**	**(0.6757)**	**(0.7955)**
PP-Fisher Chi-Square	**Statistics**	132.67	66.8555	38.6172	184.51	62.940	225.67
	Probability	(0.0053)	**(1.0000)**	**(1.0000)**	(0.0008)	**(0.9986)**	(0.0000)
Results for Middle Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	7.4552	9.9132	28.5327	14.8336	-5.3635	-6.5324
	Probability	**(1.0000)**	**(1.0000)**	**(1.0000)**	**(1.0000)**	(0.0000)	(0.0000)
Im, Pesaran and Shin W-Stat	**Statistics**	2.2503	11.6327	28.6812	-0.5810	1.7607	0.0312
	Probability	**(0.9878)**	**(1.0000)**	**(1.0000)**	**(0.2806)**	**(0.9609)**	**(0.5125)**
ADF-Fisher Chi-Square	**Statistics**	116.33	103.171	67.4851	165.49	127.18	126.656
	Probability	**(0.8620)**	**(1.0000)**	**(1.0000)**	**(0.8577)**	**(0.5534)**	**(0.1061)**
PP-Fisher Chi-Square	**Statistics**	225.95	116.435	94.6088	310.31	110.60	311.22
	Probability	(0.0000)	**(1.0000)**	**(1.0000)**	(0.0000)	**(0.8900)**	(0.0000)
Results for Low Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	2.9224	10.1362	22.5733	9.8893	-2.3540	-2.6039
	Probability	**(0.9983)**	**(1.0000)**	**(1.0000)**	**(1.0000)**	(0.0093)	(0.0046)
Im, Pesaran and Shin W-Stat	**Statistics**	0.7271	13.3573	19.1936	-1.3268	4.1570	3.6648
	Probability	**(0.7664)**	**(1.0000)**	**(1.0000)**	(0.0923)	**(1.0000)**	**(0.9999)**
ADF-Fisher Chi-Square	**Statistics**	69.438	21.9897	18.0752	64.959	52.849	34.807
	Probability	**(0.3624)**	**(1.0000)**	**(1.0000)**	**(0.3740)**	**(0.4411)**	**(0.996)**
PP-Fisher Chi-Square	**Statistics**	154.45	15.1419	14.6834	143.454	32.719	99.388
	Probability	(0.0000)	**(1.0000)**	**(1.0000)**	(0.0000)	**(0.9832)**	(0.0010)

Based on the drawbacks of first-generation panel URTs, we move toward second generation panel URTs. In this regard, we applied both CADF and CIPS tests. The results are displayed in table 3 where probability vales are greater than critical level (0.1), accepting the null hypothesis of presence of unit root in series of UICs, MICs and LICs.

Table 3: Results of Second-Generation Panel URTs at Level (CADF & CIPS)

Results for Upper Income Countries							
Panel Unit Root Tests		**Variables**					
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	-0.868	2.218	0.567	0.117	0.820	0.853
	Probability	**(0.193)**	**(0.987)**	**(0.715)**	**(0.546)**	**(0.794)**	**(0.803)**
CIPS Test	**Statistics**	-0.513	6.832	5.181	-1.015	-0.668	2.522
	Probability	**(0.304)**	**(1.000)**	**(1.000)**	**(0.155)**	**(0.252)**	**(0.994)**
Results for Middle Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	0.118	2.785	2.043	-0.483	3.331	1.672
	Probability	**(0.547)**	**(0.997)**	**(0.979)**	**(0.314)**	**(1.000)**	**(0.953)**
CIPS Test	**Statistics**	2.614	2.401	1.509	1.977	0.739	-0.349
	Probability	**(0.996)**	**(0.992)**	**(0.934)**	**(0.976)**	**(0.770)**	**(0.364)**
Results for Low Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP^2**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	-0.991	-0.919	-1.164	-1.243	-1.934	1.165
	Probability	**(0.161)**	**(0.821)**	**(0.641)**	**(0.107)**	**(0.973)**	**(0.878)**
CIPS Test	**Statistics**	-0.743	3.107	2.255	-0.929	6.825	0.666
	Probability	**(0.229)**	**(0.999)**	**(0.988)**	**(0.176)**	**(1.000)**	**(0.747)**

It is shown in the above tables (table 2 & 3) that variables are non-stationary at level, so the next step is to check their stationarity at first difference. Findings of panel URTs at first difference are discussed in table 4 suggesting the rejection of null hypothesis as probability values are significant ($P<0.1$). Here, it is confirmed that variables are stationary at first difference according to the first-generation panel URTs.

Table 4: Results of First-Generation Panel URTs at First Difference

Results for Upper Income Countries							
Panel Unit Root Tests		**Variables**					
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	3.377	22.2497	-18.9065	34.599	2.565	19.523
	Probability	(1.0000)	(1.0000)	**(0.0000)**	(1.0000)	(0.9948)	(1.0000)
Im, Pesaran and Shin W-Stat	**Statistics**	-10.775	-9.53282	-19.0042	-13.959	-1.7656	-12.665
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0387)**	**(0.0000)**
ADF-Fisher Chi-Square	**Statistics**	316.72	366.736	677.791	497.002	130.16	356.304
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0230)**	**(0.0000)**
PP-Fisher Chi-Square	**Statistics**	1346.85	878.085	909.419	1417.52	115.00	1444.41
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	(0.1449)	**(0.0000)**
Results for Middle Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	47.378	23.8481	2.4276	68.321	4.3454	30.538
	Probability	(1.0000)	(1.0000)	**(0.9924)**	(1.0000)	(1.0000)	(1.0000)
Im, Pesaran and Shin W-Stat	**Statistics**	-10.047	-7.5770	-7.74296	-12.0107	-1.4789	-10.4977
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0696)**	**(0.0000)**
ADF-Fisher Chi-Square	**Statistics**	376.87	401.54	561.702	502.62	151.28	356.38
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0977)**	**(0.0000)**
PP-Fisher Chi-Square	**Statistics**	2032.39	1269.11	984.397	2421.99	97.396	1908.96 7
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	(0.9853)	**(0.0000)**
Results for Low Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
Levin, Lin & Chu	**Statistics**	33.300	20.8653	-0.04421	43.389	3.4246	18.774
	Probability	(1.0000)	(1.0000)	**(0.4824)**	(1.0000)	(0.9997)	(1.0000)
Im, Pesaran and Shin W-Stat	**Statistics**	-13.619	-3.5914	-3.04352	-7.960	2.314	-10.705
	Probability	**(0.0000)**	**(0.0002)**	**(0.0012)**	**(0.0000)**	(0.9897)	**(0.0000)**
ADF-Fisher Chi-Square	**Statistics**	325.56	123.646	181.910	182.00	83.546	242.68
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0036)**	**(0.0000)**
PP-Fisher Chi-Square	**Statistics**	1423.43	542.635	337.781	998.982	32.006	867.500
	Probability	**(0.0000)**	**(0.0000)**	**(0.0000)**	**(0.0000)**	(0.9869)	**(0.0000)**

Table 5 illustrates the outcomes of panel URTs suggested by second generation econometrics. Here, also the probability values associated with each of the variable are less than 0.1 (critical level), confirming the rejection of null hypothesis. Hence, we accept the alternative hypothesis that variables are stationary at first difference.

Table 5: Results of Second-Generation Panel URTs at First Difference

Results for Upper Income Countries							
Panel Unit Root Tests		**Variables**					
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	-6.779	-3.239	-4.792	-6.639	-2.129	-6.779
	Probability	**(0.000)**	**(0.001)**	**(0.000)**	**(0.000)**	**(0.017)**	**(0.000)**
CIPS Test	**Statistics**	-6.464	-2.028	-2.095	-4.552	-1.361	-8.313
	Probability	**(0.000)**	**(0.021)**	**(0.018)**	**(0.000)**	**(0.087)**	**(0.000)**
Results for Middle Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	-5.255	-3.101	-2.529	-2.679	-2.352	-4.024
	Probability	**(0.000)**	**(0.001)**	**(0.006)**	**(0.004)**	**(0.009)**	**(0.000)**
CIPS Test	**Statistics**	-7.233	-5.930	-10.483	-5.378	-1.784	-8.629
	Probability	**(0.000)**	**(0.021)**	**(0.000)**	**(0.000)**	**(0.037)**	**(0.000)**
Results for Low Income Countries							
Tests	**Statistics**	**EFP**	**GDP**	**GDP²**	**TO**	**HC**	**BC**
CADF Test	**Statistics**	-8.120	-6.740	-6.468	-8.575	1.202	-4.901
	Probability	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	(0.885)	**(0.000)**
CIPS Test	**Statistics**	-6.678	-3.523	-2.850	-4.644	-1.293	-2.937
	Probability	**(0.000)**	**(0.021)**	**(0.000)**	**(0.000)**	**(0.098)**	**(0.000)**

4.3 Results of Panel Cointegration Tests

The results for first-generation panel CTs (Kao and Pedroni) are presented in table 6 and 7. The probability values associated with ADF test of Kao test are significant. Similarly, majority of the probability values associated with Panel v-Statistic, Panel rho-Statistic, Panel PP-Statistic, Panel ADF-Statistic, Group rho-Statistic, Group PP-Statistic and Group ADF-Statistic provided by Pedroni test are less than critical value (0.1). So, we reject the null hypothesis of “no cointegration” and conclude the presence of cointegration.

Table 6: Results of Kao Residual Test for CTs (First Generation)

Results for Upper Income Countries			
Models		**Statistics**	**Probability**
Model 1	**ADF**	2.268474	**0.0117**
Model 2	**ADF**	2.268474	**0.0117**
Model 3	**ADF**	2.819252	**0.0024**
Model 4	**ADF**	2.359529	**0.0091**
Model 5	**ADF**	2.076115	**0.0189**
Results for Middle Income Countries			
Model 1	**ADF**	1.568278	**0.0584**
Model 2	**ADF**	1.940707	**0.0261**
Model 3	**ADF**	-12.02646	**0.0000**
Model 4	**ADF**	3.392921	**0.0003**
Model 5	**ADF**	2.829624	**0.0023**
Results for Low Income Countries			
Model 1	**ADF**	4.152814	**0.0000**
Model 2	**ADF**	3.893334	**0.0000**
Model 3	**ADF**	5.450419	**0.0000**
Model 4	**ADF**	4.864047	**0.0000**
Model 5	**ADF**	4.144126	**0.0000**

Table 7: Result of Pedroni CTs (First Generation)

Results for Upper Income Countries				
Model 1				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	5.136317	**0.0000**	3.780483	**0.0001**
Panel rho-Statistic	-5.998055	**0.0000**	-4.765736	**0.0000**
Panel PP-Statistic	-6.928778	**0.0000**	-5.242138	**0.0000**
Panel ADF-Statistic	-4.301474	**0.0000**	-1.751872	**0.0399**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-2.597675		**0.0047**	
Group PP-Statistic	-6.000841		**0.0000**	
Group ADF-Statistic	-2.875901		**0.0020**	
Model 2				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	3.385729	**0.0004**	2.448514	**0.0072**
Panel rho-Statistic	-4.312156	**0.0000**	-3.439470	**0.0003**
Panel PP-Statistic	-6.604069	**0.0000**	-5.042996	**0.0000**
Panel ADF-Statistic	-3.090229	**0.0010**	-1.221066	0.1110
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-1.008595		0.1566	
Group PP-Statistic	-5.880393		**0.0000**	
Group ADF-Statistic	-2.397404		**0.0083**	
Model 3				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	0.692436	0.2443	-0.325025	0.6274
Panel rho-Statistic	-3.113385	**0.0009**	-5.097778	**0.0000**
Panel PP-Statistic	-6.534166	**0.0000**	-9.268040	**0.0000**
Panel ADF-Statistic	-3.635111	**0.0001**	-3.989571	**0.0000**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-2.158219		**0.0155**	
Group PP-Statistic	-10.39084		**0.0000**	
Group ADF-Statistic	-4.657318		**0.0000**	

Model 4				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	0.992135	0.1606	-1.952047	0.9745
Panel rho-Statistic	-1.602346	**0.0545**	-3.241807	**0.0006**
Panel PP-Statistic	-6.077322	**0.0000**	-8.370365	**0.0000**
Panel ADF-Statistic	-2.509121	**0.0061**	-2.956692	**0.0016**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-0.425222		0.3353	
Group PP-Statistic	-11.59534		**0.0000**	
Group ADF-Statistic	-4.545837		**0.0000**	
Model 5				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	-0.158347	0.5629	-2.684271	0.9964
Panel rho-Statistic	-1.123990	0.1305	-1.586389	**0.0563**
Panel PP-Statistic	-6.038577	**0.0000**	-7.683665	**0.0000**
Panel ADF-Statistic	-2.345621	**0.0095**	-3.339023	**0.0004**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	1.539271		0.9381	
Group PP-Statistic	-8.954590		**0.0000**	
Group ADF-Statistic	-2.712057		**0.0033**	
Results for Middle Income Countries				
Model 1				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	2.039207	**0.0207**	1.752519	**0.0398**
Panel rho-Statistic	-4.921846	**0.0000**	-5.340078	**0.0000**
Panel PP-Statistic	-6.104354	**0.0000**	-5.911755	**0.0000**
Panel ADF-Statistic	-0.400545	0.3444	-0.811314	0.2086
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-3.778825		**0.0001**	
Group PP-Statistic	-9.392475		**0.0000**	
Group ADF-Statistic	-2.535029		**0.0056**	

Model 2				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	0.091702	0.4635	-0.333979	0.6308
Panel rho-Statistic	-2.027664	**0.0213**	-2.157923	**0.0155**
Panel PP-Statistic	-4.338709	**0.0000**	-4.246278	**0.0000**
Panel ADF-Statistic	-0.186403	0.4261	0.543831	0.7067
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-0.342475		0.3660	
Group PP-Statistic	-7.381866		**0.0000**	
Group ADF-Statistic	-1.442824		**0.0745**	
Model 3				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	3.394570	**0.0003**	0.647607	0.2586
Panel rho-Statistic	-6.401761	**0.0000**	-6.311404	**0.0000**
Panel PP-Statistic	-8.854787	**0.0000**	-8.926758	**0.0000**
Panel ADF-Statistic	-2.867794	**0.0021**	-3.253854	**0.0006**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-4.171355		**0.0000**	
Group PP-Statistic	-10.95572		**0.0000**	
Group ADF-Statistic	-4.248019		**0.0000**	
Model 4				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	1.191171	0.1168	-2.022262	0.9784
Panel rho-Statistic	-4.256148	**0.0000**	-3.800964	**0.0001**
Panel PP-Statistic	-8.281953	**0.0000**	-9.237042	**0.0000**
Panel ADF-Statistic	-1.590883	**0.0558**	-2.322330	**0.0101**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-1.231211		0.1091	
Group PP-Statistic	-11.30963		**0.0000**	
Group ADF-Statistic	-4.182587		**0.0000**	

Model 5				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	0.309058	0.3786	-1.355381	0.9124
Panel rho-Statistic	-1.706336	**0.0440**	-3.147413	**0.0008**
Panel PP-Statistic	-5.386937	**0.0000**	-7.221256	**0.0000**
Panel ADF-Statistic	-0.342227	0.3661	-1.894695	**0.0291**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	0.118224		0.5471	
Group PP-Statistic	-6.832101		**0.0000**	
Group ADF-Statistic	-2.442179		**0.0073**	
Results for Low Income Countries				
Model 1				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	1.527764	**0.0633**	0.628605	0.2648
Panel rho-Statistic	-6.620172	**0.0000**	-4.437585	**0.0000**
Panel PP-Statistic	-6.365527	**0.0000**	-4.911929	**0.0000**
Panel ADF-Statistic	-1.969042	**0.0245**	-1.690078	**0.0455**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-4.339182		**0.0000**	
Group PP-Statistic	-7.189359		**0.0000**	
Group ADF-Statistic	-3.617322		**0.0001**	
Model 2				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	2.230395	**0.0129**	-0.276147	0.6088
Panel rho-Statistic	-4.800034	**0.0000**	-2.786569	**0.0027**
Panel PP-Statistic	-6.590312	**0.0000**	-4.787306	**0.0000**
Panel ADF-Statistic	-1.949430	**0.0256**	-1.320741	**0.0933**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-2.653333		**0.0040**	
Group PP-Statistic	-7.541771		**0.0000**	
Group ADF-Statistic	-2.790903		**0.0026**	

Model 3				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	3.604949	**0.0002**	-0.505629	0.6934
Panel rho-Statistic	-7.504181	**0.0000**	-4.275370	**0.0000**
Panel PP-Statistic	-10.48110	**0.0000**	-6.396723	**0.0000**
Panel ADF-Statistic	-5.254809	**0.0000**	-2.806291	**0.0025**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-4.158915		**0.0000**	
Group PP-Statistic	-9.441534		**0.0000**	
Group ADF-Statistic	-5.109042		**0.0000**	
Model 4				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	4.173834	**0.0000**	-0.650282	0.7422
Panel rho-Statistic	-6.079005	**0.0000**	-3.194156	**0.0007**
Panel PP-Statistic	-10.69205	**0.0000**	-7.736770	**0.0000**
Panel ADF-Statistic	-4.694301	**0.0000**	-3.195361	**0.0007**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-2.389617		**0.0084**	
Group PP-Statistic	-12.68325		**0.0000**	
Group ADF-Statistic	-5.113040		**0.0000**	
Model 5				
Alternative Hypothesis: Common AR coefs. (within-dimension)				
Tests	**Statistic**	**Probability**	**Weighted Statistic**	**Probability**
Panel v-Statistic	2.223866	**0.0131**	-0.245326	0.5969
Panel rho-Statistic	-2.609561	**0.0045**	-1.855052	**0.0318**
Panel PP-Statistic	-5.910486	**0.0000**	-5.495894	**0.0000**
Panel ADF-Statistic	-3.941265	**0.0000**	-3.600579	**0.0002**
Alternative Hypothesis: Individual AR coefs. (between-dimension)				
Tests	**Statistic**		**Probability**	
Group rho-Statistic	-0.388196		0.3489	
Group PP-Statistic	-7.148971		**0.0000**	
Group ADF-Statistic	-3.298605		**0.0005**	

The result of second-generation panel CT (Westerlund) is reported in the table 8. In majority of the models, the probability values associated with variance ratio statics are significant at 1, 5, and 10 percent level of significance indicating the rejection of null hypothesis. This implies the presence of cointegration among variables even after accounting cross-sectional dependence.

Table 8: Results of Westerlund CTs (Second Generation)

Results for Upper Income Countries			
Model 1	Variance Ratio	-1.8041	**0.0356**
Model 2	Variance Ratio	-0.9877	0.1617
Model 3	Variance Ratio	-1.7786	**0.0376**
Model 4	Variance Ratio	-1.3368	**0.0906**
Model 5	Variance Ratio	-1.3674	**0.0858**
Results for Middle Income Countries			
Model 1	Variance Ratio	-0.4845	**0.3140**
Model 2	Variance Ratio	-0.9877	0.2746
Model 3	Variance Ratio	0.5989	**0.0474**
Model 4	Variance Ratio	-1.2672	0.1025
Model 5	Variance Ratio	-1.8737	**0.0305**
Results for Lower Income Countries			
Model 1	Variance Ratio	0.0890	0.4646
Model 2	Variance Ratio	0.9756	0.1646
Model 3	Variance Ratio	-1.8504	**0.0321**
Model 4	Variance Ratio	-1.7491	**0.0401**
Model 5	Variance Ratio	-1.5723	**0.0579**

5. Results of FMOLS

Table 9 reports the long run estimates obtained through FMOLS. While reinvestigating the EKC hypothesis for different income group level we observe that it does not hold for all countries. The EKC holds only for UICs while U-shaped relationship exists for MICs and LICs. These findings are consistent with the study of Alvarado et al. (2018). This means that environmental transition theory holds for UICs as highly developed economies have more restrictive environmental rules and regulations due to which they transfer pollution intensive production activities to less-developed nations augmenting their pollution stock. Similarly, our findings are consistent with Charfeddine (2017) and Apergis & Ozturk (2015) who proved the existence of an inverted U-shaped EKC while Perman & Stern (2003) validated the U-shaped EKC.

Among the other explanatory variables trade, human capital and biocapacity are considered important for explaining EKC hypothesis. For the UICs and LICs 1% increase in trade will lead to 0.0001 to 0.0015 and 0.0002 to 0.0010 percent decrease in EFP, respectively. This is because rich countries do not allow the trade of polluted products and FDI in their countries. Whereas, poor countries are surviving in the kind of pre-industrial era and do not have much access to global trade. In addition, with the trade openness countries have more access to green and clean technology which helps to control the rising level of EFP. These findings are similar with Destek et al. (2018). In contrast, the MICs consist of larger population and their trade liberalization policies damage the environment. By prioritizing the growth factor, they allow material flows and investment without any pollution restrictions. Therefore, energy consumption and other GHGs increase, disrupting environmental quality. These findings are consistent with Ozturk & Bilgili (2015) and Dogan & Turkekul (2016).

Table 9: Estimates of FMOLS

Dependent Variable: Ecological Footprint (1961-2018)					
Results for Upper Income Countries					
	(1)	(2)	(3)	(4)	(5)
Gross Domestic Product	0.8170***	1.4609***	1.4279***	1.3718***	1.5383***
	(0.1078)	(0.1017)	(0.0869)	(0.0884)	(0.0814)
Gross Domestic Product ^{2}	-0.0112**	-0.0228***	-0.0191***	-0.0178***	-0.0017***
	(0.0020)	(0.0019)	(0.0017)	(0.0017)	(0.0015)
Trade		-0.0015***		-0.0001***	-0.0011***
		(0.0001)		(0.0001)	(0.0001)
Human Capital			-0.3100***	-0.2835***	-0.5121***
			(0.0290)	(0.0280)	(0.0255)
Biocapacity					0.0648***
					(0.0021)
D1973	0.1522***	0.1376***	0.0962***	0.0976***	0.1150***
	(0.0277)	(0.0224)	(0.0215)	(0.0203)	(0.0180)
D1980	0.0771***	0.0225	0.0111	-0.0120	0.0166
	(0.0275)	(0.0242)	(0.0214)	(0.0202)	(0.0175)
Results for Middle Income Countries					
Gross Domestic Product	-0.5984**	-0.7197***	-0.5474***	-0.6776***	-0.5322***
	(0.0620)	(0.0522)	(0.0464)	(0.0441)	(0.0386)
Gross Domestic Product ^{2}	0.0158***	0.0173***	0.0157***	0.0168***	0.0139**
	(0.0012)	(0.0010)	(0.0009)	(0.0008)	(0.0007)
Trade		0.0025***		0.0033***	0.0033***
		(0.0001)		(0.0001)	(9.64E-05)
Human Capital			-0.0868***	-0.0615***	-0.0379***
			(0.0155)	(0.0149)	(0.0131)
Biocapacity					0.0119***
					(0.0003)
D1973	0.0542**	0.0445**	0.0181	0.0139	0.0242**
	(0.0244)	(0.0185)	(0.0141)	(0.0117)	(0.0100)
D1980	0.0707***	0.0589***	0.0384***	0.0378***	0.0413***

	(0.0243)	(0.0184)	(0.0141)	(0.0118)	(0.0101)
Results for Low Income Countries					
Gross Domestic Product	-0.6913***	-1.0301***	-1.0282***	-1.2635***	-1.8305***
	(0.2304)	(0.2373)	(0.1845)	(0.2001)	(0.1575)
Gross Domestic Product ^{2}	0.0140***	0.0219***	0.0240***	0.0295***	0.0433***
	(0.0052)	(0.0054)	(0.0042)	(0.0046)	(0.0036)
Trade		-0.0002		-0.0005**	-0.0010***
		(0.0003)		(0.0002)	(0.0001)
Human Capital			-0.3045***	-0.2994***	-0.4625***
			(0.0236)	(0.0331)	(0.0292)
Biocapacity					-0.0101***
					(0.0010)
D1973	0.0622**	0.0512*	0.0378*	0.0429*	-0.0045
	(0.0295)	(0.0295)	(0.0222)	(0.0211)	(0.0178)
D1980	0.0344	0.0284	0.0127	-0.0009	-0.0059
	(0.0293)	(0.0294)	(0.0221)	(0.0234)	(0.0178)

$p < 0.1$, $^{**}\, p < 0.05$, $^{***}\, p < 0.01$

Human capital is considered crucial for sustainability. Our results show that HC has a strong negative and significant impact on EFP in all countries irrespective of their development levels. Thus, increase in education level in any nation will lower the environmental stress by improving the importance of environmental protection. Our results are consistent with the findings of Yang et al. (2017) and Bano et al. (2018). Therefore, improvement in human capital helps to mitigate environmental stress by shrinking fossil fuel consumption and other GHG emissions. This study, however, disagrees with the conclusion drawn by Wang (2019) that there is no relationship between human capital and environment.

In the recent studies biocapacity is frequently used as an important indicator of EFP because it dominantly influences the biological resources and overall ecological services. In our case, the effect of biocapacity is positive and significant for UICs and MIC countries showing that increase in biocapacity will increase ecological footprint. This is because of the fact that industrial/manufacturing activities in these economies compose high pollution that increase footprint level. Moreover, with the increase in biocapacity the environmental care is often overlooked. These findings are consistent with Hassan *et al.* (2019b) who argued that positive relationship between biocapacity and EFP signals the inefficient utilization of natural resources. On the other side, the relationship is inverse in LICs because people in these countries do not have enough income for purchasing high energy demanding products like automobiles and air-conditions. Thus, biocapacity lowers ecological footprint in these economies. This finding is consistent with Ulucak & Bilgili (2018).

Overall, findings of FMOLS validated the existence of an inverted U-shaped KEC for UICs and U-shaped EKC for MICs and for the LICs. The results of trade and biocapacity also differ based on development level of economies while the relationship between human capital and EFP remains same across all income groups. These results are, however, based on linear regression analysis, which does not allow parameter estimates to vary across multiple points of the EFP distribution. To address this issue, FEQ regression analysis is proceeded.

5.1 Results of Quantile Regression for UICs

Tables 10 and 11 report the results for FEQ regression. The results reported in table 10 confirm the validity of EKC across all quantiles for UICs (except square term in last quantile). Furthermore, the results show that the influence of GDP on emissions becomes smaller at consecutive higher levels of quantiles, implying that scale effect diminishes in developed economies having higher EFP.

Table 10: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	1.281***	1.132***	1.036***	0.969***	0.891***	0.799***	0.698***	0.608***	0.509*
	-4.27	-5.03	-5.58	-5.85	-5.8	-5.04	-3.79	-2.76	-1.9
GDP^2	-0.0194***	-0.0168***	-0.0151***	-0.0139***	-0.0126***	-0.0109***	-0.00918***	-0.00760*	-0.00587
	(-3.39)	(-3.90)	(-4.26)	(-4.40)	(-4.28)	(-3.62)	(-2.61)	(-1.80)	(-1.15)
d73	0.0848	0.0981	0.107*	0.113**	0.120**	0.128***	0.137**	0.145**	0.154*
	-0.91	-1.4	-1.85	-2.19	-2.51	-2.61	-2.39	-2.12	-1.85
d80	0.0907	0.0856	0.0823*	0.0801**	0.0774**	0.0742*	0.0708	0.0677	0.0643
	-1.23	-1.55	-1.81	-1.97	-2.06	-1.92	-1.57	-1.25	-0.98
Obs.	2066	2066	2066	2066	2066	2066	2066	2066	2066
$p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$									

Similarly, the impact of GDP and its square term remains same even after controlling for trade openness, human capital and biocapacity (table 11). However, the coefficients become larger signifying the issue of omitted variable bias in our previous estimation. The results support the ecological modernization theory that in initial stages of development the level of EFP increases however, after some structural changes in the economies EFP begins to decline. However, the technique effect, in terms of GDP square, is stronger for the economies belonging to upper quantiles. This finding implies that all UICs have reached at the sustainable development level after enduring a structural shift. Particularly, UICs at higher ladder of economic development contributing more to environmental quality.

The impact of trade on EFP is favorable across all quantiles. Comparatively, it is higher for those economies having low level of existing EFP because these economies can control environmental pressure at a larger scale through trade integration. But, the economies with high level of exiting EFP find it difficult to control their EFP because the role of trade becomes less effective at higher quantiles. Similarly, the effect of HC is also negative and significant across all quantiles. However, the magnitude of its effect increases at higher quantiles implying that the HC contributes to environmental quality in the presence of more pressure on ecosystem. Thus, both trade and HC contribute to environmental quality. However, relatively, it is HC that contributes more to retain ecosystem balance.

Contrary to these findings, the impact of biocapacity is positive and highly significant across all quantiles. It can be argued that UICs are prioritizing more development projects having high returns at the cost of environment. Nevertheless, the worsening effect of BC is smaller in the UICs as technique effect (in terms of GDP square) is stronger in these economies. This finding is consistent with Hassan et al. (2019a).

Table 11: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	1.607***	1.514***	1.446***	1.390***	1.325***	1.246***	1.172***	1.098***	1.023***
	-6.58	-7.8	-8.88	-9.67	-10.04	-9.14	-7.43	-5.78	-4.46
GDP^2	-0.0207***	-0.0187***	-0.0173***	-0.0162***	-0.0148***	-0.0132***	-0.0117***	-0.0101***	-0.00860*
	(-4.41)	(-5.03)	(-5.54)	(-5.86)	(-5.86)	(-5.05)	(-3.86)	(-2.78)	(-1.95)
TO	-0.0012**	-0.0010**	-0.0009***	-0.0008***	-0.00070**	-0.00056*	-0.00042	-0.00029	-0.00015
	(-2.29)	(-2.48)	(-2.60)	(-2.62)	(-2.44)	(-1.88)	(-1.23)	(-0.69)	(-0.30)
HC	-0.261***	-0.294***	-0.319***	-0.338***	-0.362***	-0.390***	-0.417***	-0.443***	-0.470***
	(-3.09)	(-4.39)	(-5.67)	(-6.82)	(-7.96)	(-8.29)	(-7.66)	(-6.76)	(-5.94)
BC	0.0616***	0.0614***	0.0613***	0.0612***	0.0611***	0.0610***	0.0609***	0.0608***	0.0606***
	-10.27	-12.89	-15.34	-17.36	-18.94	-18.28	-15.75	-13.01	-10.74
d73	0.0434	0.0544	0.0625	0.0691	0.0769**	0.0861**	0.0949**	0.104*	0.113*
	-0.6	-0.95	-1.3	-1.63	-1.98	-2.15	-2.04	-1.85	-1.66
d80	0.0877*	0.0725*	0.0613*	0.0522*	0.0414	0.0286	0.0164	0.00427	-0.00806
	-1.74	-1.81	-1.82	-1.76	-1.52	-1.02	-0.5	-0.11	(-0.17)
Obs.	1672	1672	1672	1672	1672	1672	1672	1672	1672

$p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$

5.2 Results of Quantile Regression for MICs

Table 12 shows that MICs are experiencing U-shaped relationship. The coefficients of both GDP per capita and its square term are significant in most of the cases. This implies that countries' development level affects EFP. As UICs have high income per capita and stable growth so MICs and LICs often follow these economies for achieving such macroeconomic goals. Consequently, their environmental quality also gets affected. Since, the EFP is already high and these economies experience harmful effects of environment, so they give prioritize environmental quality. They adopt measures taken by UICs and make efforts to import energy-efficient technology and save energy locally. In turn along with increase in development a negligible fall in EFP can be observed (as initially EFP is high). However, after observing a fall in EFP these economies neglect environmental concern and prioritize development. As a result, destructive development effects can be observed in the later stages. These results are consistent with Doğan et al. (2019).

Table 12: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.0868	-0.13	-0.160*	-0.192***	-0.227***	-0.268***	-0.309***	-0.348***	-0.389***
	(-0.74)	(-1.38)	(-1.95)	(-2.66)	(-3.35)	(-3.66)	(-3.54)	(-3.29)	(-3.03)
GDP^2	0.0061***	0.0070***	0.0075***	0.0082***	0.0089***	0.0097***	0.0105***	0.0113***	0.0121***
	-2.64	-3.73	-4.66	-5.75	-6.63	-6.72	-6.1	-5.4	-4.77
d73	0.033	0.0377	0.0409	0.0443	0.0481	0.0525	0.0569	0.0611	0.0655
	-0.61	-0.86	-1.07	-1.32	-1.53	-1.55	-1.41	-1.24	-1.1
d80	0.0629	0.0575	0.0538*	0.0499*	0.0455*	0.0405	0.0354	0.0306	0.0255
	-1.4	-1.58	-1.71	-1.8	-1.75	-1.45	-1.06	-0.75	-0.52
Obs.	2827	2827	2827	2827	2827	2827	2827	2827	2827

$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Likewise, the U-shaped relationship holds for MICs while including other explanatory variables in EKC model (table 13). These findings support our FMOLS results and the conclusion drawn by Ulucak & Bilgili (2018). Here, we can argue that these results are in favor of ecologically unequal exchange theory as an inverted U-shaped EKC hold for UICs and U-shaped EKC holds for MICs. So, this relationship might hold due to the locational displacement of pollution-intensive activities from UICs to MICs. Further, the impact of trade and biocapacity on emissions is positive and significant across all quantiles signaling the unfavorable impact of these variables on all economies irrespective of existing levels of EFP. The economies with low development and low EFP level (at low quantile) integrate with other economies to gain from trade and might import highly polluted products or investment in projects that increase EFP (vice versa). These results are supported by Al-Mulali et al., (2015); Hassan et al., (2019a). The effect of HC is negative and statistically significant from 2^{nd} to 8^{th} quantile. The effect is more dominant in case of lower quantiles comparative to higher quantiles. Similar findings are obtained by Hassan et al., (2019b).

Table 13: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.331***	-0.387***	-0.424***	-0.463***	-0.509***	-0.556***	-0.599***	-0.646***	-0.701***
	(-2.38)	(-3.50)	(-4.46)	(-5.56)	(-6.52)	(-6.63)	(-6.13)	(-5.44)	(-4.75)
GDP^2	0.0109***	0.0120***	0.0126***	0.0134***	0.0142***	0.0151***	0.0159***	0.0167***	0.0177***
	-4.27	-5.87	-7.22	-8.72	-9.89	-9.75	-8.82	-7.64	-6.53
TO	0.00227***	0.00243***	0.00253***	0.00264***	0.00276***	0.00289***	0.00301***	0.00314**	0.00329***
	-5.13	-6.89	-8.35	-9.95	-11.13	-10.83	-9.68	-8.29	-7.000
HC	-0.0711	-0.0706*	-0.0702**	-0.0698**	-0.0694***	-0.0689**	-0.0685**	-0.0680*	-0.0674
	(-1.55)	(-1.93)	(-2.23)	(-2.54)	(-2.70)	(-2.49)	(-2.12)	(-1.73)	(-1.38)
BC	0.00928***	0.0102***	0.0108***	0.0114***	0.0122***	0.0129***	0.0136***	0.0144***	0.0153***
	-3.42	-4.72	-5.81	-7.04	-8.01	-7.91	-7.16	-6.21	-5.32
d73	0.0346	0.0331	0.0321	0.0311	0.0299	0.0286	0.0275	0.0262	0.0248
	-0.7	-0.84	-0.95	-1.05	-1.08	-0.96	-0.79	-0.62	-0.47
d80	0.0618	0.0523	0.0459	0.0393	0.0314	0.0235	0.0162	0.008	-0.00128
	-1.48	-1.58	-1.61	-1.58	-1.35	-0.94	-0.55	-0.22	(-0.03)
Obs.	1810	1810	1810	1810	1810	1810	1810	1810	1810
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

5.3 Results of Quantile Regression for LICs

The results of FEQ regression for LICs are illustrated in tables 14 and 15. The results suggest that U-shaped relationship holds for LICs. However, EKC holds at 1st quantile, no clear pattern at 2nd quantile and from 3rd to last quantile U-shaped relationship holds. The effect up to 3rd quantile can be ignored as coefficients are statistically insignificant.

Table 14: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	0.293	-0.0504	-0.228	-0.481**	-0.677***	-0.885***	-1.091***	-1.290***	-1.571***
	(0.78)	(-0.18)	(-0.92)	(-2.34)	(-3.58)	(-4.56)	(-4.99)	(-5.03)	(-4.86)
GDP^2	-0.0082	-0.0004	0.0035	0.0093**	0.0138***	0.0185***	0.0232***	0.0277***	0.0341***
	(-0.97)	(-0.07)	(0.64)	(2.01)	(3.23)	(4.22)	(4.69)	(4.78)	(4.67)
d73	0.0644	0.0555	0.0509	0.0443	0.0392	0.0339	0.0285	0.0234	0.0161
	(1.21)	(1.37)	(1.46)	(1.54)	(1.48)	(1.24)	(0.92)	(0.64)	(0.35)
d80	0.0533	0.0410	0.0347	0.0257	0.0187	0.0113	0.0039	-0.0031	-0.0132
	(1.17)	(1.18)	(1.16)	(1.04)	(0.82)	(0.48)	(0.15)	(-0.10)	(-0.33)
Obs.	1342	1342	1342	1342	1342	1342	1342	1342	1342
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

We re-estimated the EKC by including TO, HC and BC in the model. The results provide a clear picture of growth-EFP relationship. Now, the impact of GDP and its square term remains negative and positive, respectively, across all quantiles indicating U-shaped relationship. These findings are consistent with Ulucak & Bilgili (2018). The impact of TO, HC and BC is negative and statistically significant in most of the cases. These findings are consistent with existing studies (Porter & Van der Linde, 1995; Rees, 2006; Ahmed et al., 2020).

Table 15: Results of QR (Fixed Effects)

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.629	-0.794**	-0.918***	-1.037***	-1.155***	-1.263***	-1.361***	-1.483***	-1.605***
	(-1.49)	(-2.41)	(-3.39)	(-4.54)	(-5.53)	(-5.84)	(-5.63)	(-5.09)	(-4.54)
GDP^2	0.0149	0.0187**	0.0216***	0.0244***	0.0272***	0.0297***	0.0319***	0.0348***	0.0376***
	(1.55)	(2.49)	(3.50)	(4.67)	(5.69)	(6.01)	(5.79)	(5.22)	(4.66)
TO	-0.00117**	-0.0010**	-0.0009***	-0.0008***	-0.00072***	-0.0006**	-0.0005*	-0.0004	-0.0003
	(-2.14)	(-2.41)	(-2.63)	(-2.78)	(-2.67)	(-2.25)	(-1.75)	(-1.17)	(-0.74)
HC	-0.421***	-0.418***	-0.416***	-0.413***	-0.411***	-0.409***	-0.407***	-0.404***	-0.402***
	(-7.19)	(-9.12)	(-11.06)	(-13.05)	(-14.19)	(-13.64)	(-12.11)	(-9.97)	(-8.16)
BC	-0.0110***	-0.0107***	-0.0105***	-0.0103***	-0.0101***	-0.0099***	-0.0098***	-0.0096***	-0.0094***
	(-3.77)	(-4.70)	(-5.62)	(-6.55)	(-7.04)	(-6.69)	(-5.87)	(-4.77)	(-3.85)
d73	0.0487	0.0410	0.0353	0.0298	0.0243	0.0193	0.0148	0.00915	0.00348
	(0.90)	(0.97)	(1.02)	(1.02)	(0.91)	(0.70)	(0.48)	(0.24)	(0.08)
d80	0.0124	0.0084	0.0054	0.0026	-0.00017	-0.0027	-0.0050	-0.0080	-0.0109
	(0.23)	(0.20)	(0.16)	(0.09)	(-0.01)	(-0.10)	(-0.17)	(-0.22)	(-0.24)
Obs.	920	920	920	920	920	920	920	920	920
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

5.4 Robustness Check by incorporating Alternative Environmental Measures

Tables 16-21 show the estimation performed for confirming the robustness of the findings. Tables 16 and 17 show that EKC hypothesis is still validated for UICs even incorporating the carbon footprint as environmental indicator. This mean our finding are robust.

Table 16: Robustness Check for UICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	2.588***	2.189***	1.975***	1.809***	1.638***	1.437***	1.234***	1.023***	0.787*
	(3.73)	(4.36)	(4.83)	(5.21)	(5.49)	(5.29)	(4.31)	(3.01)	(1.84)
GDP^2	-0.0392***	-0.0324***	-0.0287***	-0.0259***	-0.0229***	-0.0195***	-0.0160***	-0.0124*	-0.00836
	(-2.99)	(-3.41)	(-3.71)	(-3.94)	(-4.07)	(-3.80)	(-2.96)	(-1.93)	(-1.03)
d73	0.0460	0.0949	0.121	0.141	0.162	0.187**	0.212**	0.238**	0.267*
	(0.20)	(0.56)	(0.88)	(1.21)	(1.62)	(2.06)	(2.21)	(2.08)	(1.85)
d80	0.235	0.200*	0.181**	0.166**	0.151**	0.133**	0.115*	0.0968	0.0760
	(1.60)	(1.88)	(2.09)	(2.27)	(2.40)	(2.34)	(1.92)	(1.35)	(0.84)
Obs.	2065	2065	2065	2065	2065	2065	2065	2065	2065

Table 17: Robustness Check for UICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	4.211***	3.814***	3.426***	3.097***	2.772***	2.451***	2.085***	1.764***	1.378***
	(6.18)	(6.79)	(7.53)	(8.19)	(8.51)	(7.95)	(6.22)	(4.50)	(2.83)
GDP^2	-0.0640***	-0.0566***	-0.0493***	-0.0431***	-0.0371***	-0.0310***	-0.0242***	-0.0181**	-0.0109
	(-4.95)	(-5.31)	(-5.72)	(-6.02)	(-6.00)	(-5.31)	(-3.80)	(-2.44)	(-1.18)
TO	-0.0031**	-0.0027**	-0.0024**	-0.0021***	-0.0018***	-0.0015**	-0.0011*	-0.0008	-0.0005
	(-2.15)	(-2.31)	(-2.50)	(-2.65)	(-2.66)	(-2.36)	(-1.69)	(-1.08)	(-0.52)
HC	-0.284	-0.332**	-0.378***	-0.417***	-0.455***	-0.493***	-0.537***	-0.575***	-0.621***
	(-1.39)	(-1.98)	(-2.79)	(-3.73)	(-4.75)	(-5.46)	(-5.44)	(-4.94)	(-4.27)
BC	0.0425***	0.0417***	0.0408***	0.0401***	0.0394***	0.0387***	0.0379***	0.0372***	0.0363***
	(3.21)	(3.83)	(4.66)	(5.53)	(6.35)	(6.62)	(5.93)	(4.92)	(3.85)
d73	-0.0913	-0.0447	0.000715	0.0394	0.0774	0.115	0.158	0.196	0.241
	(-0.43)	(-0.26)	(0.01)	(0.34)	(0.78)	(1.23)	(1.55)	(1.62)	(1.60)
d80	0.225*	0.192**	0.160**	0.133**	0.106*	0.0793	0.0490	0.0223	-0.00965
	(1.93)	(2.00)	(2.07)	(2.08)	(1.93)	(1.54)	(0.87)	(0.34)	(-0.12)
Obs.	1671	1671	1671	1671	1671	1671	1671	1671	1671
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

The tables 18 and 19 show the robustness check for MICs using carbon footprint as environmental indicator. The results suggest that all coefficients become insignificant and U-shaped relation does not remain valid as for as table 12 is concerned. It can be due to the omitted variable bias that makes our findings highly sensitive. Because after incorporating TO, HC, and BC the results remain robust as EKC turns out to be U-shaped.

Table 18: Robustness Check for MICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	0.553	0.536	0.523	0.508	0.496	0.483	0.471**	0.457**	0.443
	(0.44)	(0.53)	(0.63)	(0.79)	(1.04)	(1.49)	(2.22)	(2.10)	(1.24)
GDP^2	0.00319	0.00323	0.00326	0.00330	0.00333	0.00336	0.00339	0.00342	0.00345
	(0.13)	(0.16)	(0.20)	(0.26)	(0.35)	(0.52)	(0.80)	(0.79)	(0.48)
d73	0.0179	0.0469	0.0691	0.0932	0.114	0.135	0.156	0.178	0.202
	(0.03)	(0.09)	(0.16)	(0.29)	(0.47)	(0.82)	(1.45)	(1.62)	(1.12)
d80	0.0718	0.0659	0.0614	0.0565	0.0523	0.0480	0.0438	0.0392	0.0343
	(0.14)	(0.16)	(0.19)	(0.22)	(0.28)	(0.37)	(0.52)	(0.45)	(0.24)
Obs.	2825	2825	2825	2825	2825	2825	2825	2825	2825
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

Table 19: Robustness Check for MICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.0429	-0.149	-0.224	-0.303	-0.365**	-0.425**	-0.489**	-0.549**	-0.610**
	(-0.11)	(-0.51)	(-0.96)	(-1.56)	(-2.02)	(-2.25)	(-2.26)	(-2.16)	(-2.02)
GDP^2	0.0122*	0.0142**	0.0156***	0.0170***	0.0182***	0.0193***	0.0205***	0.0216***	0.0228***
	(1.67)	(2.53)	(3.44)	(4.55)	(5.21)	(5.30)	(4.90)	(4.40)	(3.91)
TO	0.0048***	0.0049***	0.0049***	0.0049***	0.0050***	0.0050***	0.0050***	0.0051***	0.0051***
	(3.83)	(5.07)	(6.30)	(7.68)	(8.27)	(7.97)	(6.98)	(5.97)	(5.06)
HC	0.149	0.112	0.0854	0.0578	0.0358	0.0147	-0.00808	-0.0290	-0.0506
	(1.26)	(1.24)	(1.17)	(0.95)	(0.63)	(0.25)	(-0.12)	(-0.36)	(-0.54)
BC	-0.0278***	-0.0243***	-0.0218***	-0.0192***	-0.0171***	-0.0151***	-0.0129**	-0.0109*	-0.00890
	(-3.04)	(-3.48)	(-3.84)	(-4.08)	(-3.90)	(-3.30)	(-2.47)	(-1.78)	(-1.22)
d73	0.0790	0.0804	0.0815	0.0825	0.0834	0.0842	0.0851	0.0859	0.0868
	(0.50)	(0.67)	(0.83)	(1.02)	(1.11)	(1.07)	(0.94)	(0.81)	(0.69)
d80	0.279***	0.232***	0.199***	0.164***	0.137***	0.110**	0.0820	0.0558	0.0287
	(2.71)	(2.96)	(3.13)	(3.12)	(2.78)	(2.15)	(1.39)	(0.81)	(0.35)
Obs.	1809	1809	1809	1809	1809	1809	1809	1809	1809
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

Tables 20 and 21 also confirm the robustness of results for LIC countries after using carbon footprint as dependent variable. Thus, U-shaped EKC is not sensitive to the use of carbon footprint as a measure of environmental quality.

Table 20: Robustness Check for LICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	0.980	0.301	-0.372	-0.823	-1.416***	-1.992***	-2.511***	-3.021***	-3.573***
	(1.01)	(0.38)	(-0.59)	(-1.50)	(-2.84)	(-3.84)	(-4.24)	(-4.32)	(-4.25)
GDP^2	-0.00437	0.0104	0.0249*	0.0347***	0.0476***	0.0600***	0.0713***	0.0823***	0.0943***
	(-0.20)	(0.59)	(1.78)	(2.83)	(4.27)	(5.17)	(5.38)	(5.26)	(5.02)
d73	0.196	0.166	0.137	0.117	0.0906	0.0653	0.0424	0.0199	-0.00435
	(1.40)	(1.47)	(1.52)	(1.49)	(1.28)	(0.88)	(0.50)	(0.20)	(-0.04)
d80	0.151	0.153	0.155	0.157*	0.159**	0.161*	0.163*	0.165	0.166
	(0.96)	(1.21)	(1.54)	(1.79)	(2.01)	(1.94)	(1.71)	(1.46)	(1.22)
Obs.	1341	1341	1341	1341	1341	1341	1341	1341	1341
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

Table 21: Robustness Check for LICs

Dependent Variable: Carbon Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.0429	-0.149	-0.224	-0.303	-0.365**	-0.425**	-0.489**	-0.549**	-0.610**
	(-0.11)	(-0.51)	(-0.96)	(-1.56)	(-2.02)	(-2.25)	(-2.26)	(-2.16)	(-2.02)
GDP^2	0.0122*	0.0142**	0.0156***	0.0170***	0.0182***	0.0193***	0.0205***	0.0216***	0.0228***
	(1.67)	(2.53)	(3.44)	(4.55)	(5.21)	(5.30)	(4.90)	(4.40)	(3.91)
TO	0.0048***	0.0049***	0.0049***	0.0049***	0.0050***	0.0050***	0.0050***	0.0051***	0.0051***
	(3.83)	(5.07)	(6.30)	(7.68)	(8.27)	(7.97)	(6.98)	(5.97)	(5.06)
HC	0.149	0.112	0.0854	0.0578	0.0358	0.0147	-0.00808	-0.0290	-0.0506
	(1.26)	(1.24)	(1.17)	(0.95)	(0.63)	(0.25)	(-0.12)	(-0.36)	(-0.54)
BC	-0.0278***	-0.0243***	-0.0218***	-0.0192***	-0.0171***	-0.0151***	-0.0129**	-0.0109*	-0.00890
	(-3.04)	(-3.48)	(-3.84)	(-4.08)	(-3.90)	(-3.30)	(-2.47)	(-1.78)	(-1.22)
d73	0.0790	0.0804	0.0815	0.0825	0.0834	0.0842	0.0851	0.0859	0.0868
	(0.50)	(0.67)	(0.83)	(1.02)	(1.11)	(1.07)	(0.94)	(0.81)	(0.69)
d80	0.279***	0.232***	0.199***	0.164***	0.137***	0.110**	0.0820	0.0558	0.0287
	(2.71)	(2.96)	(3.13)	(3.12)	(2.78)	(2.15)	(1.39)	(0.81)	(0.35)
Obs.	1809	1809	1809	1809	1809	1809	1809	1809	1809
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

5.5 Analysis of OECD Economies

The results for the OECD economies are presented in table 22. The results confirm the presence of EKC in OECD economies. Estimates at different quantiles give clearer picture of relationship as coefficient size differs across all quantiles. The scale effect is dominant for the economies having low level of EFP and technique effect is dominant for the economies having high level of EFP. The findings are in lines with environmental transition theory, ecological modernization theory and the conclusion drawn by Alvarado et al. (2018) and Destek & Sarkodie (2019). The remaining control variables also carry the correct signs.

Table 22: Results for OECD Economies

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	2.275***	2.166***	2.087***	2.019***	1.926***	1.808***	1.706***	1.600***	1.473***
	(9.01)	(10.52)	(11.73)	(12.59)	(12.82)	(11.15)	(8.92)	(6.84)	(5.03)
GDP^2	-0.0307***	-0.0287***	-0.027***	-0.0261***	-0.0244***	-0.0223***	-0.0205***	-0.0185***	-0.0163***
	(-6.41)	(-7.36)	(-8.09)	(-8.58)	(-8.58)	(-7.26)	(-5.64)	(-4.18)	(-2.93)
TO	-0.00185***	-0.00177***	-0.00171***	-0.00166***	-0.00159***	-0.00150***	-0.00143***	-0.00135***	-0.00126**
	(-3.88)	(-4.56)	(-5.10)	(-5.50)	(-5.65)	(-4.95)	(-3.97)	(-3.06)	(-2.28)
HC	-0.496***	-0.498***	-0.499***	-0.500***	-0.502***	-0.504***	-0.506***	-0.508***	-0.510***
	(-6.49)	(-8.00)	(-9.27)	(-10.34)	(-11.13)	(-10.34)	(-8.76)	(-7.18)	(-5.76)
BC	0.0511***	0.0515***	0.0517***	0.0520***	0.0523***	0.0527***	0.0530***	0.0534***	0.0538***
	(11.47)	(14.18)	(16.48)	(18.42)	(19.88)	(18.53)	(15.75)	(12.94)	(10.41)
d73	0.0602	0.0631	0.0652*	0.0669**	0.0694**	0.0724**	0.0751*	0.0779	0.0812
	(1.15)	(1.48)	(1.76)	(2.01)	(2.24)	(2.16)	(1.89)	(1.60)	(1.33)
d80	0.0438	0.0370	0.0321	0.0279	0.0222	0.0149	0.00856	0.00194	-0.00589
	(1.03)	(1.07)	(1.07)	(1.03)	(0.88)	(0.55)	(0.27)	(0.05)	(-0.12)
Obs.	1427	1427	1427	1427	1427	1427	1427	1427	1427
$p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$									

5.6 Analysis of South Asian Economies

Table 23 presents the results for South Asian economies. Here, the coefficient of GDP is positive while the coefficient of GDP square is negative indicating the U-shaped relationship between GDP per capita and EFP. This finding implies that these economies are suffering from high environmental stress with more economic growth. This signifies that the risk of unsustainability increases for these economies. This might be due to the locational displacement of dirty industry toward these economies. The negative coefficient of trade confirms the “gain from trade” hypothesis. Thus, trade openness increases the access to energy efficient technologies that, in turn, help to improve the environmental quality.

In contrast, human capital and biocapacity are positively related with EFP. The effect of human capital is unexpected. The channel behind this relationship might be due to the nature of human capital. Because human capital is a broader term as it not only includes higher education but also experience, technical expertise and innovations. In our case, it can be argued that with higher innovations and information access, travel and tourism activities increase causing greater environmental stress. In addition, resources such as land, forest, and water are depleting with increasing industrialization induced by higher innovations and technological development. The relationship between biocapacity and EFP is also not favorable. This can be due to the higher population in these economies as larger economies have high demand for resource and energy use that can increase EFP level (Lau, 2019).

Table 23: Results for South Asian Economies

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.160	-0.203	-0.228**	-0.262***	-0.280***	-0.306***	-0.335***	-0.354***	-0.392**
	(-0.91)	(-1.56)	(-2.09)	(-2.93)	(-3.30)	(-3.45)	(-3.20)	(-2.96)	(-2.52)
GDP^2	0.00539	0.00642***	0.00701***	0.00780***	0.00825***	0.00886***	0.00954***	0.00999***	0.0109***
	(1.64)	(2.62)	(3.40)	(4.63)	(5.14)	(5.28)	(4.85)	(4.44)	(3.73)
TO	-0.00119	-0.00130	-0.00136*	-0.00144**	-0.00148***	-0.00154***	-0.00161**	-0.00166**	-0.00175*
	(-1.08)	(-1.57)	(-1.96)	(-2.54)	(-2.75)	(-2.74)	(-2.43)	(-2.19)	(-1.77)
HC	0.370***	0.352***	0.342***	0.328***	0.320***	0.310***	0.298***	0.290***	0.275***
	(3.17)	(4.03)	(4.67)	(5.48)	(5.63)	(5.21)	(4.26)	(3.63)	(2.65)
BC	1.338***	1.309***	1.292***	1.270***	1.257***	1.240***	1.221***	1.208***	1.183***
	(4.59)	(6.01)	(7.08)	(8.52)	(8.87)	(8.37)	(6.99)	(6.04)	(4.55)
d73	0.0172	0.0211	0.0233	0.0263	0.0280	0.0303	0.0329	0.0346	0.0380
	(0.27)	(0.44)	(0.58)	(0.80)	(0.89)	(0.92)	(0.85)	(0.78)	(0.66)
d80	0.0486	0.0390	0.0336	0.0262	0.0221	0.0165	0.0102	0.00601	-0.00224
	(1.19)	(1.28)	(1.31)	(1.25)	(1.11)	(0.79)	(0.41)	(0.21)	(-0.06)
Obs.	250	250	250	250	250	250	250	250	250
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

5.7 Analysis of SAARC Economies

FEQ regression estimates for the SAARC economies are reported in table 24. The convergence hypothesis does not hold for these economies as GDP per capita is negative and its square term is positive. Instead a U-shaped EKC is observed which shows that ecological services are depreciating as economies move from lower to upper quantile. It means the scale effect is more dominant in this group of countries in the presence of higher EFP. These findings are in line with Destek & Sinha (2020). The impact of human capital and trade is positive indicating the unfavorable impact on EFP. In contrast, the effect of biocapacity is helpful for achieving sustainable development goals as increase in biocapacity reduces EFP. The findings are supported by Rees, (2006) who argued that higher biocapacity increases the earth's capacity to absorb and filter waste and other harmful gases from the atmosphere and improves the environmental quality.

Table 24: Results for SAARC Economies

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.427	-0.472*	-0.519***	-0.545***	-0.575***	-0.607***	-0.634***	-0.667***	-0.721***
	(-1.34)	(-1.84)	(-2.67)	(-3.31)	(-4.15)	(-4.83)	(-4.86)	(-4.35)	(-3.35)
GDP^2	0.00953	0.0106**	0.0118***	0.0124***	0.0132***	0.0140***	0.0146***	0.0154***	0.0168***
	(1.57)	(2.18)	(3.19)	(3.97)	(5.00)	(5.84)	(5.90)	(5.29)	(4.10)
TO	0.00139	0.00104	0.000675	0.000470	0.000237	-0.0000144	-0.000226	-0.000484	-0.000909
	(1.13)	(1.06)	(0.90)	(0.74)	(0.44)	(-0.03)	(-0.45)	(-0.81)	(-1.09)
HC	0.305*	0.295**	0.286***	0.280***	0.274***	0.267***	0.262***	0.255***	0.244**
	(1.81)	(2.19)	(2.79)	(3.23)	(3.75)	(4.03)	(3.80)	(3.15)	(2.14)
BC	-0.0817	-0.0937**	-0.107***	-0.114***	-0.122***	-0.131***	-0.138***	-0.147***	-0.162***
	(-1.56)	(-2.23)	(-3.33)	(-4.19)	(-5.32)	(-6.27)	(-6.41)	(-5.79)	(-4.56)
d73	0.0528	0.0547	0.0568	0.0580	0.0593	0.0608	0.0620	0.0634	0.0658
	(0.50)	(0.65)	(0.89)	(1.08)	(1.31)	(1.47)	(1.45)	(1.26)	(0.93)
d80	0.0467	0.0362	0.0249	0.0186	0.0115	0.00380	-0.00268	-0.0106	-0.0236
	(0.79)	(0.76)	(0.69)	(0.61)	(0.45)	(0.16)	(-0.11)	(-0.37)	(-0.59)
Obs.	304	304	304	304	304	304	304	304	304
$p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$									

5.8 Analysis of BRICS Economies

Table 25 shows the results of FEQ regression for BRICS economies. According to the findings U-shaped relationship exists between GDP per capita and EFP. It is observed that environmental quality in these economies worsens as we move from 1st quantile to 9th quantile indicating that development hurts the economies more which are already having high EFP. The results are consistent with Perman & Stern (2003) and Altıntaş & Kassouri (2020). Trade and human capital are positively associated with EFP signaling their detrimental effects on the environment. However, the impact of biocapacity is favorable indicating that increase in biocapacity helps the BRICS economies to achieve sustainable development goals.

Table 25: Results for BRICS Economies

Dependent Variable: Ecological Footprint (1961-2018)									
	0.1	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
GDP	-0.0429	-0.149	-0.224	-0.303	-0.365**	-0.425**	-0.489**	-0.549**	-0.610**
	(-0.11)	(-0.51)	(-0.96)	(-1.56)	(-2.02)	(-2.25)	(-2.26)	(-2.16)	(-2.02)
GDP^2	0.0122*	0.0142**	0.0156***	0.0170***	0.0182***	0.0193***	0.0205***	0.0216***	0.0228***
	(1.67)	(2.53)	(3.44)	(4.55)	(5.21)	(5.30)	(4.90)	(4.40)	(3.91)
TO	0.00487***	0.00492***	0.00495***	0.00499***	0.00502***	0.00504***	0.00507***	0.00510***	0.00513***
	(3.83)	(5.07)	(6.30)	(7.68)	(8.27)	(7.97)	(6.98)	(5.97)	(5.06)
HC	0.149	0.112	0.0854	0.0578	0.0358	0.0147	-0.00808	-0.0290	-0.0506
	(1.26)	(1.24)	(1.17)	(0.95)	(0.63)	(0.25)	(-0.12)	(-0.36)	(-0.54)
BC	-0.0278***	-0.0243***	-0.021***	-0.0192***	-0.0171***	-0.0151***	-0.0129**	-0.0109*	-0.00890
	(-3.04)	(-3.48)	(-3.84)	(-4.08)	(-3.90)	(-3.30)	(-2.47)	(-1.78)	(-1.22)
d73	0.0790	0.0804	0.0815	0.0825	0.0834	0.0842	0.0851	0.0859	0.0868
	(0.50)	(0.67)	(0.83)	(1.02)	(1.11)	(1.07)	(0.94)	(0.81)	(0.69)
d80	0.279***	0.232***	0.199***	0.164***	0.137***	0.110**	0.0820	0.0558	0.0287
	(2.71)	(2.96)	(3.13)	(3.12)	(2.78)	(2.15)	(1.39)	(0.81)	(0.35)
Obs.	1809	1809	1809	1809	1809	1809	1809	1809	1809
$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$									

5.9 Comparison of Regional Analysis

Economic development varies across regions and has diverse impacts on the environmental quality. By employing FEQ regression we performed an analysis for OECD, South Asian economies, SAARC, and BRICS. Among all groups, OECD consists of developed nations. These economies largely have similar economic characteristics. According to our findings an inverted U-shaped EKC holds for these economies as most of the economies completed their transition period. They adopted new technologies (energy efficient) at a much faster rate and responsible for many breakthrough and scientific development around the globe (Yilanci *et al.*, 2020). These findings are similar with the outcomes of UICs which further highlight the strength of developed and high-income countries that they have achieved the development threshold level and completed their transition period. Therefore, these economies are in sustainable position. From the theoretical point of view, the ecological modernization theory and environmental transitional theory hold for these nations.

In contrast, the findings for other regions South Asia, SAARC and BRICS reject the EKC hypothesis and favor the U-shaped relationship between GDP per capita and EFP. South Asian and SAARC economies are middle-income countries and are transiting from agriculture to manufacturing sector (near to the transition towards service-driven economies), going through extreme environmental challenges. Moreover, with larger population the demand and consumption of energy use are high in these countries making EKC U-shaped (Srinivasan, 2014). The group of BRICS, however, consists of emerging economies and has achieved significant development in term of growth, technological innovation and financial mechanism in the last few decades (Radulescu *et al.*, 2014). Thus, with the new technology manufacturing activities increased in these economies at much faster rate increasing harmful gases in the atmosphere (Samargandi & Kutan 2016). This, in turn, created hurdles for the economies in achieving sustainability goals. These findings are similar with the results obtained for MICs and LICs. This ensures the ecologically unequal exchange theory for these economies.

6. Conclusion

This study aims to reinvestigate the EKC by taking EFP as comprehensive environmental indicator and incorporating trade, human capital and biocapacity in the EKC model. For this purpose, the globally representative data set is used covering the period of 1961-2018. The cross-sectional units are consisting of 20 UICs, 36 MICs and 20 LICs. Empirical strategy is proceeded in following steps. Firstly, cross-sectional dependence among the sampled countries is tested using following tests: Friedman's Test, Bruesh-Pagan LM Test, Pesaran Scaled LM Test and Pesaran CD Test. The results of all four tests consistently suggest that all countries within a group are cross-sectionally dependent. Secondly, the stationary property of the variables is tested using first-generation tests of Levin, Lin & Chu, Im, Pesaran and Shin W-Stat, ADF-Fisher Chi-Square, and PP-Fisher Chi-Square), respectively. Moreover, second-generation tests of CADF and CIPS are applied. The tests confirm that all variables are non-stationary at level, but they become stationary at first difference.

Thirdly, both first- (Kao and Pedroni) and second-generation (Westerlund) cointegration tests are applied. The results suggest the long run association between the variables. Therefore, we move further to obtain long run estimates. Fourthly, we employed FMOLS on all income groups data. The results confirm the existence of an inverted EKC hypothesis for UICs while U-shaped EKC for MICs and LICs. These findings are supported by the previous literature. However, FMOLS is based on linear regression and do not provide the results for distributional dimension of EFP.

In the fifth step, we applied FEQ regression to test the EKC hypothesis at different points of EFP. The shape of EKC remains same across all quantile. However, FEQ provides an important insight about the dominancy of EKC effect. In the UICs the scale effect dominates for the economies with low EFP while technique effect dominates for the economies with high EFP. In the MICs and LICs increase in development worsens environmental quality, indicating the dominancy of scale effect as EFP is increasing continuously.

Further, we perform sensitivity analysis to check the robustness of findings. While using the carbon footprint as outcome variable we find that results are robust across all income groups, particularly, in the presence of all control variables. Hence, we then present the regional analysis of OECD, South Asian economies, SAARC and BRICS along with their comparative analysis with the model incorporating these variables. The findings conclude an inverted U-shaped EKC for OECD and U-shaped relationship for South Asian economies, SAARC and BRICS.

6.1 Contribution of the Study

This study contributes in the existing literature through several ways. It incorporates EFP as comprehensive environmental indicator because most of the existing studies rely on carbon emission which is one component of EFP (Majeed & Mazhar (2019a); Wang et al., 2016; Pao & Tsai, 2011; Alvarado et al., 2018). Although, few recent studies used this indicator, but they are regional (MENA, CEECs, EU) specific (Charfeddine & Mrabet, 2017; Rahman et al., 2019; Altıntaş & Kassouri, 2020), country specific (Charfeddine, 2017; Mrabet & Alsamara, 2017), and use traditional methodologies (Leitão, 2010). This study performs an analysis for different income groups along with regional analysis. The study also covers longer period from 1961 to 2018. Furthermore, both first and second-generation econometrics techniques along with FEQ regression are employed in the study.

6.2 Theoretical Implications

The relationship between economic development and environmental quality remains the hot topic in theoretical debates and empirical controversies. The results of this study for UICs and OECD support the threshold theories (EKC, environmental transition theory, and ecological modernization theory) by validating an inverted U-shaped relationship between per capita income and EFP. This finding implies that these economies achieved the sustainability level after experiencing the structural changes. However, it cannot be ignored that they cared about their environmental standards and have completed their successful transitional period. In contrast, the results for MICs, LICs, South Asian economies, SAARC and BRICS reject the conclusion of threshold theories and did not follow the inverted U-shaped curve. Instead, U-shaped relation is observed in these economies. These findings favor the implications of ecologically unequal exchange theory that developed economies contribute to the pollution stock of these economies.

6.3 Practical Implications

The validity of EKC hypothesis for UICs and OECD indicates sustainability and policy effectiveness in respective economies. Thus, these countries need to focus on the consistency and stability of existing environmental policies at the same time innovating more energy efficient methods. Contrary, the absence of EKC in other groups of countries suggests redesigning of environmental policies such as enhancing public awareness of the environment, adopting clean technologies, improving environmental regulating policies. Similarly, in the context of global economy, these countries need to discourage trade flows of unnecessary polluted materials while seeking green foreign capital flows. Finally, investment in human capital is critical to materialize the effectiveness of environmental policies.

REFERENCES

Ahmed, Z., Zafar, M. W., & Ali, S. (2020). Linking urbanization, human capital, and the ecological footprint in G7 countries: An empirical analysis. *Sustainable Cities and Society*, *55*, 102064.

Al-Mulali, U., Saboori, B., & Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, *76*, 123-131.

Altıntaş, H., & Kassouri, Y. (2020). Is the environmental Kuznets Curve in Europe related to the per-capita ecological footprint or CO2 emissions? *Ecological Indicators*, *113*, 106187.

Alvarado, R., Ponce, P., Criollo, A., Córdova, K., & Khan, M. K. (2018). Environmental degradation and real per capita output: New evidence at the global level grouping countries by income levels. *Journal of Cleaner Production*, *189*, 13-20.

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

Aşıcı, A. A., & Acar, S. (2016). Does income growth relocate ecological footprint? *Ecological Indicators*, *61*, 707-714.

Atasoy, B. S. (2017). Testing the environmental Kuznets curve hypothesis across the US: Evidence from panel mean group estimators. *Renewable and Sustainable Energy Reviews*, *77*, 731-747.

Aydin, C., Esen, Ö., & Aydin, R. (2019). Is the ecological footprint related to the Kuznets curve a real process or rationalizing the ecological consequences of the affluence? Evidence from PSTR approach. *Ecological Indicators*, *98*, 543-555.

Bano, S., Zhao, Y., Ahmad, A., Wang, S., & Liu, Y. (2018). Identifying the impacts of human capital on carbon emissions in Pakistan. *Journal of Cleaner Production*, *183*, 1082-1092.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies*, *47*(1), 239-253.

Brock, W. A., & Taylor, M. S. (2005). Economic growth and the environment: A review of theory and empirics. In *Handbook of Economic Growth* (Vol. 1, pp. 1749-1821). Elsevier.

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

Charfeddine, L. (2017). The impact of energy consumption and economic development on Ecological Footprint and CO_2 emissions: Evidence from a Markov Switching Equilibrium Correction Model. *Energy Economics*, *65*, 355-374.

Charfeddine, L., & Mrabet, Z. (2017). The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. *Renewable and Sustainable Energy Reviews*, *76*, 138-154.

Cole, M. A. (2003). Development, trade, and the environment: How robust is the Environmental Kuznets Curve? *Environment and Development Economics*, *8*(4), 557-580.

Desha, C., Robinson, D., & Sproul, A. (2015). Working in partnership to develop engineering capability in energy efficiency. *Journal of Cleaner Production*, *106*, 283-291.

Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development. *Science of the Total Environment*, *650*, 2483-2489.

Destek, M. A., & Sinha, A. (2020). Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. *Journal of Cleaner Production*, *242*, 118537.

Destek, M. A., Ulucak, R., & Dogan, E. (2018). Analyzing the environmental Kuznets curve for the EU countries: The role of ecological footprint. *Environmental Science and Pollution Research*, *25*(29), 29387-29396.

Doğan, B., Saboori, B., & Can, M. (2019). Does economic complexity matter for environmental degradation? An empirical analysis for different stages of development. *Environmental Science and Pollution Research*, *26*(31), 31900-31912.

Dogan, E., & Turkekul, B. (2016). CO 2 emissions, real output, energy consumption, trade, urbanization and financial development: Testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research*, *23*(2), 1203-1213.

Ekins, P. (1997). The Kuznets curve for the environment and economic growth: Examining the evidence. *Environment and Planning A*, *29*(5), 805-830.

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The next generation of the Penn World Table. *American Economic Review*, *105*(10), 3150-3182.

Fisher, R. A. (1932). Inverse probability and the use of likelihood. In *Mathematical Proceedings of the Cambridge Philosophical Society* (Vol. 28, No. 3, pp. 257-261). Cambridge University Press.

Fodha, M., & Zaghdoud, O. (2010). Economic growth and pollutant emissions in Tunisia: An empirical analysis of the environmental Kuznets curve. *Energy Policy*, *38*(2), 1150-1156.

Friedman, M. (1937). The use of ranks to avoid the assumption of normality implicit in the analysis of variance. *Journal of the American Statistical Association*, *32*(200), 675-701.

Gengenbach, C., Palm, F. C., & Urbain, J. P. (2009). Panel unit root tests in the presence of cross-sectional dependencies: Comparison and implications for modelling. *Econometric Reviews, 29*(2), 111-145.

Global Footprint Network (2019). Living planet report. Species and spaces, people and places. [Online] Available at: https://www.footprintnetwork.org/ (September 4th, 2019).

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, *110*(2), 353-377.

Halicioglu, F. (2009). An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy*, *37*(3), 1156-1164.

Halkos, G. E. (2003). Environmental Kuznets Curve for sulfur: evidence using GMM estimation and random coefficient panel data models. *Environment and Development Economics*, *8*(4), 581-601.

Hansen, B. E., & Phillips, P. C. (1990). Estimation and inference in models of cointegration: A simulation study. *Advances in Econometrics*, *8*(1989), 225-248.

Haseeb, A., Xia, E., Baloch, M. A., & Abbas, K. (2018). Financial development, globalization, and CO_2 emission in the presence of EKC: Evidence from BRICS countries. *Environmental Science and Pollution Research*, *25*(31), 31283-31296.

Hassan, S. T., Baloch, M. A., Mahmood, N., & Zhang, J. (2019). Linking economic growth and ecological footprint through human capital and biocapacity. *Sustainable Cities and Society*, *47*, 101516.

Hassan, S. T., Xia, E., Khan, N. H., & Shah, S. M. A. (2019b). Economic growth, natural resources, and ecological footprints: Evidence from Pakistan. *Environmental Science and Pollution Research*, *26*(3), 2929-2938.

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

Jaunky, V. C. (2011). The CO2 emissions-income nexus: Evidence from rich countries. *Energy Policy*, *39*(3), 1228-1240.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics*, *90*(1), 1-44.

Kaygusuz, K. (2009). Energy and environmental issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews*, *13*(1), 253-270.

Khan, S., & Majeed, M. T. (2019). Decomposition and decoupling analysis of carbon emissions from economic growth: A case study of Pakistan. *Pakistan Journal of Commerce and Social Sciences, 13*(4), 868-891.

Kitzes, J., & Wackernagel, M. (2009). Answers to common questions in ecological footprint accounting. *Ecological Indicators*, *4*(9), 812-817.

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

Kwon, D. B. (2009). Human capital and its measurement. In *The 3rd OECD World Forum on "Statistics, Knowledge and Policy" Charting Progress, Building Visions, Improving Life* (pp. 27-30).

Lau, L. S., Choong, C. K., & Eng, Y. K. (2014). Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: do foreign direct investment and trade matter? *Energy Policy*, *68*, 490-497.

Lau, L. S., Choong, C. K., Ng, C. F., Liew, F. M., & Ching, S. L. (2019). Is nuclear energy clean? Revisit of Environmental Kuznets Curve hypothesis in OECD countries. *Economic Modelling*, *77*, 12-20.

Leitão, A. (2010). Corruption and the environmental Kuznets Curve: Empirical evidence for sulfur. *Ecological Economics*, *69*(11), 2191-2201.

Levin, A., & Lin, C. F. (1992). *Unit root tests in panel data: Asymptotic and finite sample properties* (Working Paper No. 92-3). University College of San Diego.

List, J. A., & Gallet, C. A. (1999). The environmental Kuznets curve: Does one size fit all? *Ecological Economics*, *31*(3), 409-423.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics, 61*(S1), 631-652.

Majeed, M. T. (2016). Economic growth, inequality and trade in developing countries. *International Journal of Development Issues, 15*(3), 240-253.

Majeed, M. T. (2018). Information and communication technology (ICT) and environmental sustainability in developed and developing countries. *Pakistan Journal of Commerce and Social Sciences, 12*(3), 758-783.

Majeed, M. T., & Luni, T. (2019). Renewable energy, water, and environmental degradation: A global panel data approach. *Pakistan Journal of Commerce and Social Sciences, 13*(3), 749-778.

Majeed, M. T., & Mazhar, M. (2019a). Environmental degradation and output volatility: A global perspective. *Pakistan Journal of Commerce and Social Sciences, 13*(1), 180-208.

Majeed, M. T., & Mazhar, M. (2019b). Financial development and ecological footprint: A global panel data analysis. *Pakistan Journal of Commerce and Social Sciences, 13*(2), 487-514.

Majeed, M. T., & Mumtaz, S. (2017). Happiness and environmental degradation: A global analysis. *Pakistan Journal of Commerce and Social Sciences, 11*(3), 753-772.

Mallick, H., Alhamzawi, R., & Yu, K. (2019). Quantile regression and beyond in statistical analysis of data. *Journal of Probability and Statistics*, *2019*, 1-1.

Martínez-Zarzoso, I., & Bengochea-Morancho, A. (2004). Pooled mean group estimation of an environmental Kuznets curve for CO2. *Economics Letters*, *82*(1), 121-126.

Millimet, D. L., List, J. A., & Stengos, T. (2003). The environmental Kuznets curve: Real progress or misspecified models? *Review of Economics and Statistics*, *85*(4), 1038-1047.

Mrabet, Z., & Alsamara, M. (2017). Testing the Kuznets Curve hypothesis for Qatar: A comparison between carbon dioxide and ecological footprint. *Renewable and Sustainable Energy Reviews*, *70*, 1366-1375.

Narayan, P. K., & Narayan, S. (2010). Carbon dioxide emissions and economic growth: Panel data evidence from developing countries. *Energy Policy*, *38*(1), 661-666.

Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: A panel data analysis. *Energy Policy*, *62*, 1138-1147.

Ozturk, I., & Bilgili, F. (2015). Economic growth and biomass consumption nexus: Dynamic panel analysis for Sub-Sahara African countries. *Applied Energy*, *137*, 110-116.

Ozturk, I., Al-Mulali, U., & Saboori, B. (2016). Investigating the environmental Kuznets curve hypothesis: The role of tourism and ecological footprint. *Environmental Science and Pollution Research*, *23*(2), 1916-1928.

Panayotou, T. (1993). *Empirical tests and policy analysis of environmental degradation at different stages of economic development* (No. 992927783402676). International Labour Organization. Geneva, Switzerland.

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36*(1), 685-693.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), 653-670.

Perman, R., & Stern, D. I. (2003). Evidence from panel unit root and cointegration tests that the environmental Kuznets curve does not exist. *Australian Journal of Agricultural and Resource Economics*, *47*(3), 325-347.

Pesaran, M. H. (2004). *General diagnostic tests for cross section dependence in panels* (Discussion Paper No. 1240). IZA, Institute of Labor Economics, University of Bonn, Germany.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, *22*(2), 265-312.

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews*, *34*(6-10), 1089-1117.

Phillips, A. L. (1995). 1995 Derivatives practices and instruments survey. *Financial Management*, *24*(2), 115-125.

Porter, M. E., & Van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, *9*(4), 97-118.

Radulescu, I. G., Panait, M., & Voica, C. (2014). BRICS countries challenge to the world economy new trends. *Procedia Economics and Finance*, *8*, 605-613.

Rahman, S. U., Chen, S., Saud, S., Saleem, N., & Bari, M. W. (2019). Nexus between financial development, energy consumption, income level, and ecological footprint in CEE countries: do human capital and biocapacity matter? *Environmental Science and Pollution Research*, *26*(31), 31856-31872.

Rees, W. E. (2006). Ecological footprints and biocapacity: essential elements in sustainability assessment. *Renewables‐Based Technology: Sustainability Assessment*, 143-157.

Samargandi, N., & Kutan, A. M. (2016). Private credit spillovers and economic growth: Evidence from BRICS countries. *Journal of International Financial Markets, Institutions and Money*, *44*, 56-84.

Selden, T. M., & Song, D. (1994). Environmental quality and development: Is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, *27*(2), 147-162.

Shafik, N. (1994). Economic development and environmental quality: an econometric analysis. *Oxford Economic Papers*, *46*(4), 757-774.

Shahbaz, M., Lean, H. H., & Shabbir, M. S. (2012). Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality. *Renewable and Sustainable Energy Reviews*, *16*(5), 2947-2953.

Srinivasan, P. V. (2014). Dynamics of structural transformation in South Asia. *Asia-Pacific Development Journal*, *20*(2), 53-88.

Stern, D. I., & Common, M. S. (2001). Is there an environmental Kuznets curve for sulfur? *Journal of Environmental Economics and Management*, *41*(2), 162-178.

Stoessel, M. (2001). Trade liberalization and climate change. *The Graduate Institute of International Studies, Geneva*, 69-88.

Torras, M., & Boyce, J. K. (1998). Income, inequality, and pollution: a reassessment of the environmental Kuznets curve. *Ecological Economics*, *25*(2), 147-160.

Ulucak, R., & Bilgili, F. (2018). A reinvestigation of EKC model by ecological footprint measurement for high, middle and low-income countries. *Journal of Cleaner Production*, *188*, 144-157.

United Nations (2017). *World Population Prospects: The 2017 Revision*. Department of Economic and Social Affairs. [ONLINE] Available at: https://www.un.org/development/desa/en/news/population/ (September 25th, 2019).

Wackernagel, M., Schulz, N. B., Deumling, D., Linares, A. C., Jenkins, M., Kapos, V., & Randers, J. (2002). Tracking the ecological overshoot of the human economy. *Proceedings of the National Academy of Sciences*, *99*(14), 9266-9271.

Wang, Y., Han, R., & Kubota, J. (2016). Is there an environmental Kuznets curve for SO2 emissions? A semi-parametric panel data analysis for China. *Renewable and Sustainable Energy Reviews*, *54*, 1182-1188.

Wang, Z. (2019). Does biomass energy consumption help to control environmental pollution? Evidence from BRICS countries. *Science of the Total Environment*, *670*, 1075-1083.

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

World Bank (2019). World Development Indicators. Washington, DC: World Bank. [Online] Available at: https://databank.worldbank.org/source/world-development-indicators (September 4th, 2019).

Xu, G. Y., & Song, D. Y. (2010). An Empirical Study of the Environmental Kuznets Curve for China’s Carbon Emissions——Based on Provincial Panel Data [J]. *China Industrial Economics*, *5*, 37-47.

Yang, L., Wang, J., & Shi, J. (2017). Can China meet its 2020 economic growth and carbon emissions reduction targets? *Journal of Cleaner Production*, *142*, 993-1001.

Yilanci, V., Gorus, M. S., & Aydin, M. (2019). Are shocks to ecological footprint in OECD countries permanent or temporary? *Journal of Cleaner Production*, *212*, 270-301.

Zen, I. S., Noor, Z. Z., & Yusuf, R. O. (2014). The profiles of household solid waste recyclers and non-recyclers in Kuala Lumpur, Malaysia. *Habitat International*, *42*, 83-89.