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Asymmetric Approach to Investigating the EKC hypothesis: Evidence from the BRICS Countries

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ABSTRACT

Environmental challenges have emerged as one of the most critical matters affecting the globe today. Human-caused carbon emissions are the primary causes of these environmental challenges, and in order to decrease and mitigate their impacts, officials throughout the world are constantly researching their drivers and determinants. BRICS is considered as significant part of world economy and energy markets. This study examines the EKC hypothesis for the BRICS while applying nonlinear ARDL approach that distinguishes it from previous studies. For this purpose, this study decomposes the per-capita income (GPC) series into two components: the positive and the negative series. Empirical findings indicate that in the decomposed model, the coefficients of positive series of GPC and GPC² have significant negative and positive signs respectively in all countries of the region which supports the EKC hypothesis. Results imply that BRICS governments need to focus to lower to reduce their very considerable dependence on fossil fuel. The clean energy evolution can lead to the abandoning of fossil fuel assets, including those retained or supported by governments.

1 Introduction

After the WTO was established, several reforms were made to international law. By lowering tariff and non-tariff obstacles, the disparity between rich and poor nations was meant to be reduced (Murthy & Gambhir 2018). Since 1970, there has been extensive discussion on how commerce affects the environment. After several organizations began to encourage commercial liberalization around 1990, this issue grew more heated (NAFTA, UNCED, & WTO). 1 As a result, the distribution of global pollution has become a crucial policy issue in the literature on environmental economics. (Gill 2018; Shah et al., 2022; Akram et al., 2022; Wang et al., 2022).

The humans have survived in new era called an Anthropocene, where the human activities are the dominant factors which bring change and affect both human and nature at the same time (IPCC, 2014; Steffen et al., 2008). The rapid economic growth aiming to facilitate the human needs is the obvious reason for climatic change, which in turn damages the biophysical system and the overall environment (Lee et al., 2009; Rockström et al., 2009). It has been pointed out by "Inter-governmental Panel on Climate Change (IPCC) and World Metrological Organization (WMO)" that anthropogenic activities from different sectors like industry, transport, agriculture as well as other human activities are the main culprits of climate change (Deschênes & Greenstone, 2007; IPCC, 2007; Granados & Carpintero, 2013). The consequences of economic activities for climate change have been the focus of many studies since 1980's (Granados & Carpintero, 2013). In 1990's, one of the hypotheses that got popularity was the Environmental Kuznets curve hypothesis (EKC) that associates the quality of environment with the level of economic development. Formally, in 1955 the Kuznets Curve was introduced by Simon Kuznets, who indicated the evidence of inverted-U-shaped relationship between income inequality and growth of income (Kuznets, 1955). Later on the idea of Kuznets curve was applied to the field of environmental economics, where the level of income or economic development was linked with the quality of environment. The term environmental Kuznets curve hypothesis was developed initially in the decade of 1990's and can be traced in the writings of Grossman & Krueger, (1991), who postulated that in case of selected economies, environmental pollution will a have tendency to grow till a time when a certain level of income is attained. However, after a threshold level of income, environmental pollution will begin to decline. This type of phenomena was termed as inverted U shaped curve or EKC hypothesis. The notion behind the EKC hypothesis is that overtime, when the economics grow; they tend to possess better technologies. The goods produced with better and environmental friendly technologies tend to have less pollution effect.

Since then, a number of studies have empirically examined the association between per-capita income and the various factors of environment such as ; carbon emission and the Sulphur-dioxide (Grossman & Krueger, 1995; Selden & Song, 1994) . A number of studies that investigated the EKC hypothesis used different estimation methodologies across different countries at the global level, however, the empirical findings are mixed at large (Andreoni & Levinson, 2001; Brock & Taylor, 2010; Plassmann & Khanna, 2006). Many of the studies have used carbon emission as a proxy for environmental quality while investigating the EKC hypothesis. For example, De Bruyn et al. (1998); Friedl & Getzner, (2003); Lindmark, (2002); Zarzoso & Morancho, (2004) have confirmed the EKC hypothesis, but some studies like Anjum et al. (2014); Cole, (1997); Lee et al. (2009); Shafik and Bandyopadhyay, (1992) show that there is no evidence of EKC hypothesis. Many studies that investigated the EKC hypothesis were based on panel data. For example, (Stern & Common, 2001) conducted the study for low income countries while, (Omri, 2013; Taguchi, 2012; Pao & Tsai, 2010; Tamazian et al., 2009) conducted the study on EKC for BRICS nations. Halkos (2003) examined panel model while taking lag of endogenous variable for the short-term equilibrium of the CO2 emission. Some studies show that there is unidirectional causal relationship between CO_2 emission and income, which find no evidence between environmental degradation and income of the country, McGrath et al., 1995). Likewise, a number of studies have found a significant results for the causality amongst the indicators of environment and per-capita income identified by (Chen & Huang, 2013; Coondoo & Dinda, 2002; Lee et al., 2009). Few studies used simultaneous equation and estimated the hypothesis of EKC by applying a number of statistical tools and proxies while taking income as endogenous variable (Liu, 2005; Omri, 2013; Omri et al., 2014).

The research work done so far while testing the hypothesis of EKC has relied on various estimation techniques and methods and obtained different results. "Congregado et al. (2016) utilized the cointegration test with structural breaks and their results were significant in favor of EKC hypothesis for US. Shahbaz et al. (2017) applied cointegration and the causality tests and found the significant results of EKC in six economies of the G7 countries. Churchill et al. (2018) applied cointegration test on 20 OECD countries and found significant results of EKC hypothesis. Yilanci and Ozgur, (2019) applied panel causality on G7 and supported EKC hypothesis in case of US and Japan. Bulut, (2019) utilized cointegration test" and supported validity of EKC hypothesis for US economy. Baek, (2016) applied ARDL approach and found weak evidence for the hypothesis of EKC in US economy. Soytas et al. (2007) observed no association of EKC hypothesis while applying granger causality on data of US economy. Burnett et al. (2013) applied VECM model on US economy and reported weak results for the hypothesis of EKC significance. Ajmi et al. (2013) applied granger causality test with time varying approach but found no evidence for EKC hypothesis in G7 countries including US. Dogan & Turkekul, (2016) utilized ARDL for cointegration and causality tests while find no evidences for EKC hypothesizes for US economy.(Shahbaz, et al., 2017) formulated bound testing approach to cointegration with structural breaks but find no significant results for EKC hypothesis in US economy. Pablo-Romero & Sánchez-Braza, (2017) used panel data and fixed effect model and find insignificant results for selected 28 countries where the US was the only case where significant results were found for EKC hypothesis. Sarkodie and Strezov, (2018) used both bivariate model and panel causality test and find significant results for Australia and China, while it shows no evidence of EKC hypothesis in case of Ghana and US. Other studies have investigated the EKC hypothesis at state level in US (Aldy, 2005; Apergis et al., 2017; Isik et al., 2019; Işık et al., 2019; List & Gallet, 1999; Ongan et al., 2020; Sencer Atasoy, 2017). However, the empirical results varied and indicated mixed findings for different states. Additionally, Kahn, (1998) utilized a micro level data of California for vehicles and results indicated that there is the evidence of `Kuznets U' shaped hydrocarbon emissions relation. The empirical studies show that the empirical findings impinge upon estimation technique, sampling period and the type of proxies used for environmental variables.

This paper investigates the EKC for Bricks countries by decomposing the income variable. The study contributes to the literature in a number of ways. Earlier studies that investigated the EKC hypothesis relied on symmetric approach to cointegration. In particular, to investigate the EKC hypothesis, the income growth variable was used as a one series which includes both positive and negative values. Using the income variable without decomposition masks the true relationship between the income level and the quality of environment. Since per capital GDP series includes both positive (increase) and negative growth (decrease) values, while the recent literature indicates that the relationship between economic growth and quality of environment is not symmetric rather it is asymmetric. For example, the findings of Armstrong et al. (2015). Ang and Zhang, (2000); Işık et al. (2019); Pacala and Socolow, (2004); Prema and Rao, (2015); Tang et al. (2015); Tessier and Armstrong, (2015) indicated a significant evidence in favor of asymmetric approach while investigating the EKC hypothesis. Hence, the present study is innovative in the sense that it decomposes the per-capita GDP series into its sub-components. While the EKC hypothesis is in fact a relationship between the increasing income level and the quality of environment, hence we ignore the negative values and investigate the impact of positive values on the quality of environment. In other words, this study examines the EKC hypothesis with positive values of income only.

Rest of the study is organized as below: 2nd part included methodology and empirical model while fourth part discusses results and fifth section shows conclusion and policy implication.

2 Model and Methodology

We examine EKC proposition for BRICS economies in natural logarithmic form. The model is given as:

$$lnC_t = a_0 + a_1 lnFFEC_t + a_2 lnREC_t + a_3 lnGPC_t + a_4 lnGPC_t^2 + \epsilon_t \quad (1)$$

Table 1
Variables of the Study

Notation	Variables	Source
C_t	"CO2 emission (metric tons per capita)	World Bank Indicator
$FFEC_t$	Fossil fuel energy consumption (% of total)	World Bank Indicator
REC_t	Renewable energy consumption (% of total final energy consumption)	World Bank Indicator
		World Bank Indicator"
GPC_t	GDP per capita (current US$)	
GPC_t^2	Square of GDP per capita	
GPC_t+	Decomposition of Positive GDP per capita	
GPC_t^2+	Square of Decomposition of Positive GDP per capita"	

Equation 1 C denotes carbon dioxide emissions, FFEC and REC are fossil and per-capita renewable energy consumptions; GPC is "real per-capita income", GPC2 is "real squared per-capita income" and $\epsilon_t$represents the error term. Here, we examine the potential U-shaped relationship; we prefer to use GPC, instead of using traditional and frequently used variable GDP, per capita as independent variable and explain demand side effects on co2. Next, we have decomposition of GPC series positive and negative values as GPC+ t and GPC− t, respectively, and here, only positive values have been used to estimate the EKC relationship. Decomposition is based on the following procedure:

$$lnGPC_t^+ = \sum_{j=1}^{t} \Delta lnGPC_j^+ = \sum_{j=i}^{t} \max(\Delta lnGPC_j, 0) \quad (2)$$

$$lnGPC_t^- = \sum_{j=1}^{t} \Delta lnGPC_j^- = \sum_{j=i}^{t} \min(\Delta lnGPC_j, 0) \quad (3)$$

Where GPC_t^+ and $GPC_t^-$are the of positive and negative values (partial sum process) of GPC. $GPC_t = GPC_0 + lnGPC_t^+ + lnGPC_t^-$ After this decomposition process, we obtain following model based on equation 1 the following model is:

$$lnC_t = a_0 + a_1 lnFFEC_t + a_2 lnREC_t + +a_3 lnGPC_t^2 + a_4 ln(GPC_t^+)^2 + \epsilon_t \quad (4)$$

In above mentioned equation, ln $lnGPC_t^2$ and $ln\ (GPC_t^+)^2$ stand for positive values in "real per-capita income and real squared per-capita income, respectively". The expected sign of a3 is positive, as the effect of real per-capita income on CO2 emissions is direct. Similarly, the expected sign of a4 is negative as after a specific point of rise in real per-capita income, carbon emissions will reduce, over time. Moreover, the expected signs of a_1 and a_2 are positive and negative, respectively. It means rise in REC will reduce carbon emissions, while increases in FFEC increase emissions. Significant positive and negative signs of a3 and a4 verify EKC. For both models (un decomposed and decomposed), we use "autoregressive distributed lag (ARDL) approach to cointegration" in the following equations 5 and 6, correspondingly:

$$\Delta lnC_t = b_0 + \sum_{i=1}^{p} b_1 \Delta lnC_{t-i} + \sum_{i=1}^{p} b_2 \Delta lnFFEC_{t-i} + \sum_{i=1}^{p} b_3 \Delta lnREC_{t-i} + \sum_{i=1}^{p} b_4 \Delta lnGPC_{t-i} + \sum_{i=1}^{p} b_5 \Delta lnGPC_{t-i}^2 + b_6 lnC_{t-i} + b_7 lnFFEC_{t-i} + b_8 lnREC_{t-i} + b_9 lnGPC_{t-i} + b_{10} lnGPC_{t-i}^2 + e_t \quad (5)$$

$$\Delta lnC_t = c_0 + \sum_{i=1}^{p} c_1 \Delta lnC_{t-i} + \sum_{i=1}^{p} c_2 \Delta lnFFEC_{t-i} + \sum_{i=1}^{p} c_3 \Delta lnREC_{t-i} + \sum_{i=1}^{p} c_4 \Delta lnGPC_{t-i} + \sum_{i=1}^{p} c_5 \Delta lnGPC_{t-i}^2 + c_6 lnC_{t-i} + c_7 lnFFEC_{t-i} + c_8 lnREC_{t-i} + c_9 lnGPC_{t-i} + c_{10} lnGPC_{t-i}^2 + e_t \quad (6)$$

Equation 5 denotes un decomposed model, the long-run EKC hypotheses is tested by magnitude and statistical significance of coefficients b9 and b10 while in the short run the theory is tested by size and significance of b4 and b5. While equation 6 implies that in the decomposed model, the long-run and short-run EKC theories are analyzed by magnitudes and significances of coefficientsc_9, c_{10} and c_4, c_5, respectively.

In order to address aggregation bias improves model precision and separate the distinct contributions of economic activity to environmental degradation the decomposition methodology are crucial in EKC analysis. It offers insights into temporal variations and validates the EKC hypothesis at various developmental stages by distinguishing between long-run and short-run effects. This method improves the relevance of policy by pinpointing the main causes of environmental impact and allowing for focused interventions. The analysis's robustness and relevance to sustainable development are further enhanced by decomposition which also captures the interaction effects between economic and environmental factors providing a nuanced understanding of their combined influence.

3 Results

This section presents data analysis and result interpretations. First, we check stationarity of time series data before applying ARDL model. For this we use "Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests." The findings are given in table 2. The results indicate that in case of individual countries "the series are stationary at different levels.

Table 2
Unit Root Test

Countries	Variables	ADF		PP	
Brazil		I(0)	I(1)	I(0)	I(1)
	Ct	-0.97	-5.38*	-0.96	-5.38*
	$FFEC_t$	-2.38	-3.74*	-2.22	-3.74*
	REC_t	-2.29	-3.73*	-1.99	-3.73*
	GPC_t	-1.10	-4.39*	-1.20	-4.43*
	GPC_t^2	-1.08	-4.33*	-1.18	-4.36*
	GPC_t +	-3.03**	-5.63*	-3.07**	-6.13*
	GPC_t^2+	-3.44**	-6.24*	-3.46**	-8.24*
China	Ct	-0.74	-3.06**	-0.31	-6.55*
	$FFEC_t$	-0.13	-4.73*	-0.96	-4.77*
	REC_t	2.05	-3.33**	-1.43	-4.60*
	GPC_t	-0.82	-2.94**	-0.34	-2.93**
	GPC_t^2	-0.24	-2.83***	0.32	-2.81***
	GPC_t +	-2.94**	-4.74*	-2.93**	-7.96*
	GPC_t^2+	-2.93**	-5.48*	-2.93**	-8.94*
India	Ct	-0.51	-5.68*	-0.50	-5.67*
	$FFEC_t$	-2.21	-4.86*	-2.25	-4.86*
	REC_t	1.32	-3.32**	0.90	-3.32**
	GPC_t	0.77	-5.71*	0.69	-5.78*
	GPC_t^2	0.98	-5.42*	0.91	-5.49*
	GPC_t +	-4.42*	-6.27*	-4.42*	-14.36*
	GPC_t^2+	-4.74*	-7.85*	-4.74*	-14.61*
Russia	Ct	-2.23	-4.97*	-2.34	-5.11*
	$FFEC_t$	-1.51	-6.84*	-2.14	-19.13*
	REC_t	-2.27	-8.26*	-2.04	-15.53*
	GPC_t	-0.86	-3.40**	-0.64	-3.35**
	GPC_t^2	-0.85	-3.45**	-0.64	-3.40**
	GPC_t +	-2.78***	-6.11*	-2.70***	-10.32*
	GPC_t^2+	-3.006**	-6.51*	-2.94***	-9.26*
South Africa	Ct	-1.99	-5.44*	-2.03	-5.60*
	$FFEC_t$	-1.36	-7.02*	-1.16	-6.84*
	REC_t	-1.46	-4.40*	-1.76	-4.40*
	GPC_t	-1.28	-3.53**	-0.94	-3.46**
	GPC_t^2	-1.28	-3.50**	-0.93	-3.43**
	GPC_t +	-3.61**	-6.04*	-3.59**	-10.38*
	GPC_t^2+	-3.88*	-6.56*	-3.86*	-12.32*

Note: *, ** and *** show 1%, 5% and 10 % level of significance.

Hence, we apply the ARDL bounds testing approach developed by Pesaran, Shin, and Smith (2001) for cointegration relations. The findings are stated in table 3.

Table 3
ARDL Bound Test

	Un-decomposition				Decomposition				Results
	F-stat	Sig	I0 Bound	I1 Bound	F-stat	Sig	I0 Bound	I1 Bound	
Brazil	7.76	10%	3.03	4.06	6.60	10%	3.03	4.06	Cointegration
		5%	3.47	4.57		5%	3.47	4.57	
		2.5%	3.89	5.07		2.5%	3.89	5.07	
		1%	4.4	5.72		1%	4.4	5.72	
China	5.13	10%	2.45	3.52	5.55	10%	1.9	3.01	Cointegration
		5%	2.86	4.01		5%	2.26	3.48	
		2.5%	3.25	4.49		2.5%	2.62	3.9	
		1%	3.74	5.06		1%	3.07	4.44	
India	6.88	10%	3.03	4.06	5.29	10%	2.45	3.52	Cointegration
		5%	3.47	4.57		5%	2.86	4.01	
		2.5%	3.89	5.07		2.5%	3.25	4.49	
		1%	4.4	5.72		1%	3.74	5.06	
Russia	5.73	10%	3.03	4.06	4.83	10%	1.9	3.01	Cointegration
		5%	3.47	4.57		5%	2.26	3.48	
		2.5%	3.89	5.07		2.5%	2.62	3.9	
		1%	4.4	5.72		1%	3.07	4.44	
South Africa	5.59	10%	2.45	3.52	4.86	10%	1.9	3.01	Cointegration
		5%	2.86	4.01		5%	2.26	3.48	
		2.5%	3.25	4.49		2.5%	2.62	3.9	
		1%	3.74	5.06		1%	3.07	4.44	

Table 3 shows the results of ARDL bound test. First, we explain the results of un decomposed model and we find cointegration in case of Brazil, China, India, Russia and South Africa as calculated F-statistic in equation 5 are 7.76, 5.13, 6.88. 5.73 and 5.59 and are above upper bound critical values (5.72, 5.05, 5.72.5.72 and 5.06).

On the other hand, results of decomposed model also show cointegration as calculated F-statistic are 6.60, 5.55, 5.29, 4.83 and 4.86 are greater than 5.72, 4.44, 5.06, 4.44 and 4.44 (upper bound critical values) respectively. The results of un decomposed and decomposed models confirm cointegration. Hence, we can use ARDL models to estimate long run coefficients. The results are given in table 4.

Table 4
Long Run Coefficients

	Un-decomposition				Decomposition		
	Variables	Coefficient	t-Statistic	Prob	Coefficient	t-Statistic	Prob
Brazil	**FFECt**	1.58	22.19	0.00	1.67	13.40	0.00
	RECt	-0.59	-4.24	0.003	-0.04	-1.09	0.28
	GPCt	0.23	4.90	0.001			
	GPCt2	-0.01	-4.28	0.003			
	GPCt +				0.28	2.267	0.03
	GPCt2+				-0.74	-2.05	0.06

	Chi-square value	Prob.	Jarque Bera	Prob	Chi-square value	Prob	Jarque Bera	Prob
Normality			0.99	0,60			0.85	0.65
Hetroskedasticity	4.86	0.30			1.52	0.21		
Auto correlation	20.85	0.14			27.93	0.17		
	Variables	**Coefficient**	**t-Statistic**	**Prob**	**Coefficient**		**t-Statistic**	**Prob**
China	**FFECt**	0.03	0.04	0.96	1.30		1.88	0.07
	RECt	-0.35	-2.51	0.03	-0.31		-2.02	0.05
	GPCt	3.26	2.32	0.04				
	GPCt2	-0.18	-1.98	0.07				
	GPCt +				1.13		2.43	0.02
	GPCt2+				-2.91		-1.84	0.07
	Chi-square value	Prob.	Jarque Bera	Prob	Chi-square value	Prob	Jarque Bera	Prob
Normality			1.06	0.58			0.79	0.67
Hetroskedasticity	11.38	0.32			6.42	0.69		
Auto correlation	28.94	0.18			1.55	0.45		
	Variables	**Coefficient**	**t-Statistic**	**Prob**	**Coefficient**		**t-Statistic**	**Prob**
India	**FFECt**	1.11	1.98	0.06	1.09		3.26	0.004
	RECt	-1.23	-1.99	0.05	-0.87		-2.92	0.009
	GPCt	1.08	2.13	0.04				
	GPCt2	-0.08	-2.16	0.04				
	GPCt +				0.56		1.85	0.08
	GPCt2+				-0.88		-3.94	0.00
	Chi-square value	Prob.	Jarque Bera	Prob	Chi-square value	Prob	Jarque Bera	Prob
Normality			3.50	0.17			2.36	0.30
Hetroskedasticity	0.48	0.48			8.92	0.34		
Auto correlation	0.85	0.65			0.75	0.68		
	Variables	**Coefficient**	**t-Statistic**	**Prob**	**Coefficient**		**t-Statistic**	**Prob**
Russia	**FFECt**	1.02	0.93	0.36	1.06		23.75	0.00
	RECt	-0.33	-2.07	0.05	-1.84		-11.16	0.00
	GPCt	-0.62	-2.22	0.04				
	GPCt2	0.04	2.48	0.02				
	GPCt +				0.54		1.97	0.08
	GPCt2+				-0.59		-3.05	0.01
	Chi-square value	Prob.	Jarque Bera	Prob	Chi-square value	Prob	Jarque Bera	Prob
Normality			0.70	0.70			0.92	0.63

Hetroskedasticity		0.11	0.73			0.90	0.34		
Auto correlation		4.11	0.12			14.40	0.15		
	Variables	**Coefficient**	**t-Statistic**		**Prob**	**Coefficient**		**t-Statistic**	**Prob**
South Africa	**FFECt**	1.67	1.51		0.15	0.94		76.67	0.00
	RECt	0.56	1.90		0.07	0.71		37.98	0.00
	GPCt	8.48	2.67		0.01				
	GPCt2	-0.50	-2.68		0.01				
	GPCt +					0.29		3.41	0.009
	GPCt2+					-1.08		-3.38	0.009
	Chi-square value		Prob.	Jarque Bera	Prob	Chi-square value	Prob	Jarque Bera	Prob
Normality				2.62	0.26			2.22	0.32
Hetroskedasticity		0.17	0,73			0.09	0.76		
Auto correlation		3.96	0.13			2.78	0.24		

Results show that there is the no evidence of EKC hypothesis in case of Russia in un-decomposed model while the rest of the cases there is the evidence of EKC hypothesis. On the other hand, in decomposed model, the coefficients of GPC and GPC^2 have significant negative and positive signs respectively in all countries of the region having clear evidence of the hypothesis. Moreover, increase in renewable energy consumption in most of BRICS countries tends to decrease CO2 emissions while, a rise in fossil fuel energy causes an increase in environmental degradation. China and India are large energy importers and they can decrease their reliance on imported energy by fulfilling their energy demand from indigenously produced renewable energy resources. It will help them in further improving balance of trade and energy protection. Both countries have even now invested more in wind and solar than in fossil fuel-based energy ([IEA], 2019).

4 Conclusion and Policy Implications

We focus on BRICS as a group of countries that is considered as significant part of world economy and energy markets. In addition, the clean energy shift has also influenced the BRICS through global climate obligations. the reducing expenditures of renewables and local dynamisms to develop energy security, energy efficiency and regional air quality.

This study examines the EKC hypothesis for the BRICS based on a technique that distinguishes it from past studies. For this purpose, per-capita income of each country in the group is decomposed into two series, increases and decreases and only income increase series has been used for analysis. The logic of decomposition, including positive series and ignoring the negative series is based on the statement that EKC hypothesis just considers income increase. This hypothesis assumes that initially rise in per-capita income leads to increase in environmental degradation, whereas, after a certain point income rises, degradation falls.

Although, both increase and decrease are assumed as apart of un decomposed model due to economic ups and down and this may hide the actual connection between carbon emissions and GPC. Thus, decomposition may grant more realistic analysis of the EKC theory.

Different diagnostic tests are used to check the validity of the model. Results show that there is no problem of "Heteroscedasticity and Serial Correlation" in the data.

Empirical results of both (un decomposed and decomposed) models show that there is no indication of EKC theory in case of Russia in un decomposed model while in decomposed model the coefficients of GPC and GPC^2 have significant negative and positive signs respectively in all countries of the region having clear evidence of the hypothesis. So, we can interpret that the decomposed model finds theoretically existing but disguised rationality of the EKC theory, which is unidentified by un decomposed model. Therefore, the use of method is important in current study in EKC hypothesis testing models.

Finally, Results implies that BRICS governments should focus on falling their exceedingly substantial dependence on fossil fuels through state-owned enterprises and public finance. The clean energy evolution can lead to the abandoning of fossil fuel assets, including those retained or supported by policy makers.

In various respects the results of the present investigation both support and contradict earlier studies on the Environmental Kuznets Curve (EKC) proposal. Like previous research this study shows evidence in favor of the EKC hypothesis especially when income is broken down into positive and negative series. This strategy draws attention to the asymmetrical relationship between environmental quality and income growth a nuance that has been echoed in recent research by Armstrong et al. (2015) as well as Armstrong and Tessier (2015). Particularly in BRICS nations the decomposed model effectively detects EKC patterns that the un decomposed model was unable to offering a more sophisticated comprehension of the relationship between income and environment. Nevertheless, the outcomes also deviate from earlier research that used symmetric models as many of those studies yielded contradictory or negligible results (e. g. G. Ajmi and colleagues. Burnett and colleagues (2013). (2013). Notably the study uses the decomposed income model to uncover EKC patterns challenging previous inconclusive results for nations like Russia. This emphasizes how crucial methodological developments are since conventional models might mask important connections between environmental results and economic growth. While policy implications are in line with earlier suggestions which emphasize a move away from reliance on fossil fuels to promote sustainable development it also distinctively shows how decomposed analysis can be used to inform more sensible climate policies.

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