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NEW INSIGHT INTO AN OLD ISSUE: REVISITING THE ENVIRONMENT KUZNETS CURVE HYPOTHESIS IN MINT COUNTRIES

Abstract. *The Environmental Kuznets Curve (EKC) hypothesis is a theoretical concept that explains the association between income and environmental degradation. Prior research assessed the current association using a constant parameter. Nonetheless, as a result of political and global economic conditions changes, implemented policies, technological shocks, and natural disasters, the linkage between economic growth and CO_2 emissions is about to change. Thus, this research assesses the economic growth-emission nexus for MINT nations—Mexico, Indonesia, Nigeria, and Turkey—between 1960 and 2019*

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utilizing a novel approach: bootstrap panel rolling window causality. In this sense, rather than assuming an unchanging parameter, this method is beneficial for deciding the relationship between income and CO_2 emissions level in sub-sample cycles, and it catches the invisible causal linkages between environmental pollution and economic growth. Based on the results, policy implications are suggested.

***Keywords**: Economic Growth; Bootstrap Rolling Window Causality; CO_2 Emissions; MINT Countries.*

JEL Classification : C22, O13, O47

1. Introduction

Environmental degradation has been one of the most pressing issues confronting modern society. The topic of environmental pollution has sparked the interest of scholars and policymakers due to its link to billions of human lives (Pan et al., 2022; Zhang et al., 2022). Despite the fact that the Kyoto Protocol and Paris Agreement and many other summits have developed several policies to minimize CO_2 emissions, fossil fuel burning with the goal of accomplishing rapid economic growth has raised CO_2 emissions (Alola et al., 2021; Kirikkaleli et al., 2021). As a result, one of the most hotly discussed topics by economists and environmentalists is the effect of economic growth on environmental degradation (Adebayo et al., 2022; Alola et al., 2019; Gyamfi et al., 2022; Sinha et al., 2020). The environmental Kuznets curve (EKC) hypothesis has been widely used to establish a connection between environmental destruction and economic activities in existing studies. The groundbreaking work of Grossman and Krueger (Grossman & Krueger, 1991) established the EKC hypothesis which is an inverted U-shaped curve between income and environmental degradation.

In accordance with this hypothesis, an increase in income will initially cause destruction of the environment but after a certain threshold of income is reached, an increase in invome will reduce the environmental degradation. This inverted U-shaped connection is widely explained by claiming that at first, people are more concerned with economic growth at the expense of degradation of the environment because the goal is to achieve a higher standard of life. People prefer to have a favorable ecological condition than achieving economic prosperity after they have improved their living habits (Adebayo & Kirikkaleli, 2021). As a result, economic development is conducive to achieving a higher level of environmental sustainability. For this basic reasoning, the EKC hypothesis has been extensively investigated for different nations and time periods using different econometrics. Nevertheless, the logic of this hypothesis remains a contentious topic in the literature, especially as the interaction spans a long period. There are a few explanations for the inconsistent evidence about the EKC hypothesis's validity. A quadratic functional version of the CO_2 model is used in the majority of studies examining this relationship. Nevertheless, while studying the aforementioned

nexus, different studies use a cubic or quadratic functional form (Alola et al., 2021; Shan et al., 2021). Another explanation for the contentious findings of the EKC hypothesis is the lack of research conducted over much extended periods of time. Utilizing individual nation historical data instead of a cross-section of brief history provides a benefit in considering the complexities of the EKC hypothesis. Thus, this present study assesses the EKC hypothesis in the MINT nations using data spanning between 1960 and 2019. To the understanding of the researchers, no existing studies have been conducted utilizing MINT nations as a case study using the proposed methodology.

Furthermore, it has been reported that examining the growth-degradation nexus utilizing long time series shows more reliable results than short time series. As a result, utilizing a long dataset with suitable methods is an excellent concept that provides both continuity and consistency, as we demonstrate in this paper. For these purposes, our research contributes to the existing environmental and energy economics literature in three ways: (i) It reassesses the connection between CO_2 emissions and GDP for MINT nations between 1960 and 2019. Mexico, Indonesia, Nigeria, and Turkey are among the countries represented on our panel.

The MINT is a relatively young community of emerging market economies that has gained little recognition so far. (ii) MINT nations are characterized as prime investment destinations as well as the second wave of fast-growing emerging nations (Al-mulali et al., 2015; Dogan & Inglesi-Lotz, 2020). With a population of about 700 million people, and increasing economic growth, including a substantial number of young people, the nation has the capacity for strong economic growth, a geographic advantage that allows access to large markets, and policies that promote the private sector. Furthermore, these nations have a bad track record when it comes to emissions. MINT nations are an excellent sample to study the nexus between CO_2 and economic growth because of both of these considerations. (iii) The bootstrap-rolling window estimation method is used, which helps one to evaluate complex EKC hypothesis behavior patterns over a long period. When analyzing the interaction between long-sample series, assuming parameter stability will result in inaccurate policy recommendations. Recursive estimates, rolling or Time-varying parameters are often utilized in these situations. The justification for the approach used in this analysis is based on (Balcilar et al., 2010) claim that rolling window estimations provide more reliable outcomes than recursive and time-varying estimates. In particular, the results of the rolling estimate disclosed that n Turkey and Mexico, the EKC hypothesis is validated, while in Nigeria and Indonesia, the EKC hypothesis is not validated.

The next section presents past studies summary. Section 3 presents the empirical method and Section 4 presents the findings and discussion. The conclusion and recommendation are depicted in Section 5.

2. Literature review

The first strands of researchers to ascertain the EKC hypothesis validity were (Panayotou, 1997), and (Grossman & Krueger, 1991). Nonetheless, only (Grossman & Krueger, 1991) assessed the interconnection between GDP and different measures of air pollution and their findings disclosed a U-shaped association. Later, utilizing 10 different measures of air pollution, (16) assessed income-pollution linkage in 149 nations from the period 1960 to 1990. Their empirical outcomes disclosed the validity of the EKC hypothesis in 2 out of 10 measures of pollution. Furthermore, the study of (Panayotou, 1997) using 68 nations found a U-shaped association between income and different metrics of pollution. Following these initial findings, scholars focused further on the linkage between pollution and income, and several studies have been done in the last few decades. Due to various discrepancies in explanatory variables, models, and different country-specific features, the findings of these studies exploring the linkage between pollution and income are inconclusive. The established literature on the viability of the EKC hypothesis is summarized in two different strands namely time-series and panel studies.

The first strand of the study examined time-series studies on the connection between GDP and pollution. For instance, (Minlah & Zhang, 2021) looked at the EKC hypothesis in Ghana between 1971 and 2018 and applied the bootstrap Rowling causality approach. The research uncovered a positive linkage between GDP and CO_2. Furthermore, there is no proof of the EKC hypothesis in Ghana. Furthermore, there is proof of feedback causal linkage between GDP and CO_2. In Rwanda, (Nutakor et al., 2020) explored the GDP-emissions linkage using data stretching from 1960–2014. The investigators utilized a recent econometric technique to capture causal linkage between the series of studies. In Brazil, (Awosusi et al., 2021) assessed the GDP-emissions association in Turkey using data stretching from 1960 to 2018. The FMOLS and DOLS outcomes disclosed a positive association between CO_2 and GDP. The study of (Adebayo & Kirikkaleli, 2021) in Japan on the GDP-CO_2 pollution using quarterly data from 1990 to 2015 disclosed a positive correlation between GDP and pollution. The causality test also revealed that GDP could predict CO_2 pollution.

The second strand of the study examined panel studies on the connection between GDP and pollution. For instance, the study of (Kaufmann et al., 1998) on the connection between income and pollution in 22 nations between 1971 and 1989 established the EKC hypothesis. Furthermore, (Richmond & Kaufmann, 2006) assessed the income-pollution linkage utilizing data stretching from 1973 to 1997 in 16 developing and 20 advanced nations. The investigators applied panel OLS and also incorporated both energy use and renewable energy in their model. Their findings disclosed U-shaped interconnection between GDP and emissions in both advanced and emerging nations. Furthermore, (Song & Woo, 2008) assessed the

EKC hypothesis utilizing 29 Chinese Provinces. The investigators utilized yearly data stretching between 1985 and 2005. The panel OLS techniques were utilized to capture this linkage and the findings affirmed the EKC hypothesis. Likewise, (Bilgili et al., 2016) assessed the EKC hypothesis in OECD nations utilizing data between 1977 and 2010. The authors applied recent econometric techniques to investigate this linkage. The panel cointegration disclosed a long-run association between variables of interest. Furthermore, their outcome validates the existence of the EKC hypothesis. The study of (Liddle & Messinis, 2018) in 21 OECD nations between 1870 and 2010 established a less significant linkage between pollution and GDP. Also, (Yilanci & Ozgur, 2019) assessed the GDP-CO_2 linkage in G7 nations utilizing data spanning from the period 1970 to 2014. The investigators utilized the bootstrap panel causality rolling windows test to ascertain this linkage. Their outcomes confirmed the validity of the EKC hypothesis in Japan and the USA while there is the validity of the EKC hypothesis in Canada, France, Germany, and Italy.

3. Methodology

In this empirical analysis, yearly data stretching between 1960 and 2019 was utilized to capture the causal linkage between economic growth (GDP) and CO_2 emissions in MINT economies. CO_2 emission is measured as metric tons per capita and is obtained from the BP database while GDP per capita constant 2010US$ is used to measure economic growth and is gathered from the database of the World Bank. All the series are transformed into a natural logarithm to reduce skewness. As an initial test, the current study utilized the (Hacker & Hatemi-J, 2006) full sample bootstrap causality test to assess the energy consumption-economic growth association.

The full sample bootstrap causality approach is an amended version of the (Toda & Yamamoto, 1995) causation method which permits the causal link between variables to be investigated whether the variables are cointegrated or not(30). Thus, taking into account the vector auto-regression process in the first phase of this technique as follows;

$$y_t = \varphi_0 + \varphi_1 \gamma_{t-1} + \ldots\ldots \varphi_p \gamma_{t-p} + \varepsilon_t, t = 1, 2 \ldots\ldots, T \quad (1)$$

Where lag order is depicted by p, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})^{\iota}$ is zero-mean white noise mechanism with covariance matrix Σ. Moreover, yt is divided into two vectors; CO_2 (y_{1t}) and GDP (y_{2t}), and eventually derived as follows;

$$\begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} \varphi_{10} \\ \varphi_{20} \end{bmatrix} + \begin{bmatrix} \varphi_{11}(L) & \varphi_{12}(L) \\ \varphi_{21}(L) & \varphi_{22}(L) \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (2)$$

Where $\varphi_{ij}(L) = \sum_{k-1}^{p} \varphi_{ij}, k^{L^k}$, $i, j = 1, 2,$ and the operator is represented by L. The null hypothesis of GDP does not Granger cause CO_2 can be assessed by

imposing zero restrictions $\varphi_{12,i=0 \text{ for } i=1,2\ldots p}$ and the null of CO_2 does not Granger cause GDP can be calculated by imposing zero restrictions $\varphi_{21,i=0}$ for $i = 1,2, \ldots p$. In prior studies, scholars utilize various approaches to evaluate structural changes (divide the sample into bits, use dummy variables, etc.). Therefore, this research utilizes the rolling window causality approach proposed by (Balcilar et al., 2010) to assess the causal linkage between GDP and energy usage for sub-sample times. Moreover, (Balcilar & Ozdemir, 2013) established the causality approach in rolling window sub-samples for $t = t = \tau - 1 + l, \tau - 1, \ldots, \tau, \tau = l, l + 1, \ldots, T,$ to examine the causation of the rolling window is depicted by Eq l. The estimation of LR-statistical rolling bootstrap values in the form of T-1 sub-samples determines possible causal changes between growth and energy usage. In addition, the CO_2 impact of GDP is estimated as $B^{-1} \sum_{k-1}^{p} \widehat{\varphi}_{21,k}^{*}$ with $\widehat{\varphi}_{21,k}^{*}$. The bootstrap repetition number is derived from the bootstrap (VAR) model calculation by Eq.2 and B. Likewise, the energy consumption on GDP is estimated. as $B^{-1} \sum_{k-1}^{p} \widehat{\varphi}_{21,k}^{*}$ where $\widehat{\varphi}_{21,k}^{*}$ is estimated bootstrap VAR illustrated by Eq.2 and B corresponds to the repetition number of bootstrap.

4. Results and Discussion

4.1 Full-sample Granger Causality Results

After assessing the variables' integration order, we utilized the full sample bootstrap causality approach to study the causal linkage between CO_2 and GDP. Table 1 shows the findings of the analysis. For Mexico, Turkey, and Indonesia, the outcomes from the full sample bootstrap causality disclosed that CO_2 does not Granger cause GDP, which illustrates that we fail to reject the null hypothesis that CO_2 does not Granger cause GDP. However, in the case of Nigeria, the outcomes from the full sample bootstrap causality disclosed CO_2 Granger cause GDP, which illustrates that we reject the null hypothesis that CO_2 does not Granger cause GDP. The outcome of causality from CO_2 emissions to GDP is only validated in the case of Nigeria. This outcome complies with the study of (Bekun et al., 2021). In addition, in all the MINT nations, the outcomes from the full sample bootstrap causality disclosed that GDP does not Granger cause CO_2 which illustrates that we fail to reject the null hypothesis that GDP does not Granger cause CO_2.

Table 1. Full-sample Granger causality tests.

Mexico				
Test	Ho: CO_2 does not Granger cause GDP		Ho: GDP does not Granger cause CO_2	
	Statistics	P-value	Statistics	P-value
Bootstrap LR Test	4.284	0.140	0.808	0.669

Indonesia				
Test	Statistics	P-value	Statistics	P-value
Bootstrap LR Test	1.431	0.540	0.770	0.5400
Nigeria				
Test	Statistics	P-value	Statistics	P-value
Bootstrap LR Test	4.563	0.089	3.327	0.240
Turkey				
Test	Statistics	P-value	Statistics	P-value
Bootstrap LR Test	2.585	0.280	1.1989	0.65

Figure 1 shows the direction, size, and bootstrap probability value of the impact of CO_2 on GDP for the MINT (Mexico, Indonesia, Nigeria, and Turkey) nations, respectively. For Mexico, at a significance level of 10%, the null hypothesis that CO_2 does no cause GDP can be rejected in the periods of 1980 and 2010. There are positive impacts (2010) and negative effects (1980) from CO_2 to GDP. For Indonesia, at a significance level of 10%, we fail to reject the null hypothesis that CO_2 does not cause GDP. In the case of Nigeria, at a significance level of 10%, the null hypothesis that CO_2 does not cause GDP can be rejected in the periods of 1978, 1992-1995, and 2016. There is positive causality in the periods 1978 and 2016 while there is negative causality from the periods 1992-1995 from CO_2 to GDP. Lastly, For Turkey, at a significance level of 10%, the null hypothesis that CO_2 does no cause GDP can be rejected in the periods of 1975, 1988, and 2003. There are negative effects (1980) from CO_2 to GDP in the periods 1975, 1988, and 2003.

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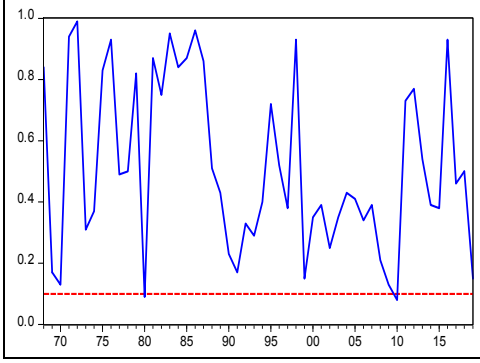
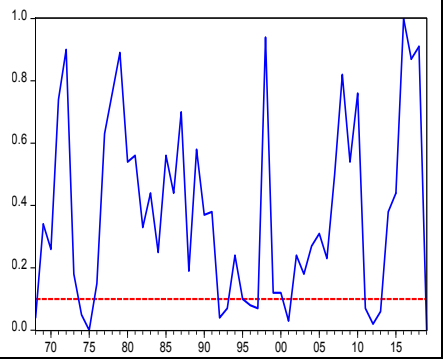
Bootstrap p-values of causality from CO_2 Emissions to Economic Growth	Bootstrap p-values of causality from Economic Growth to CO_2 Emissions
Mexico	





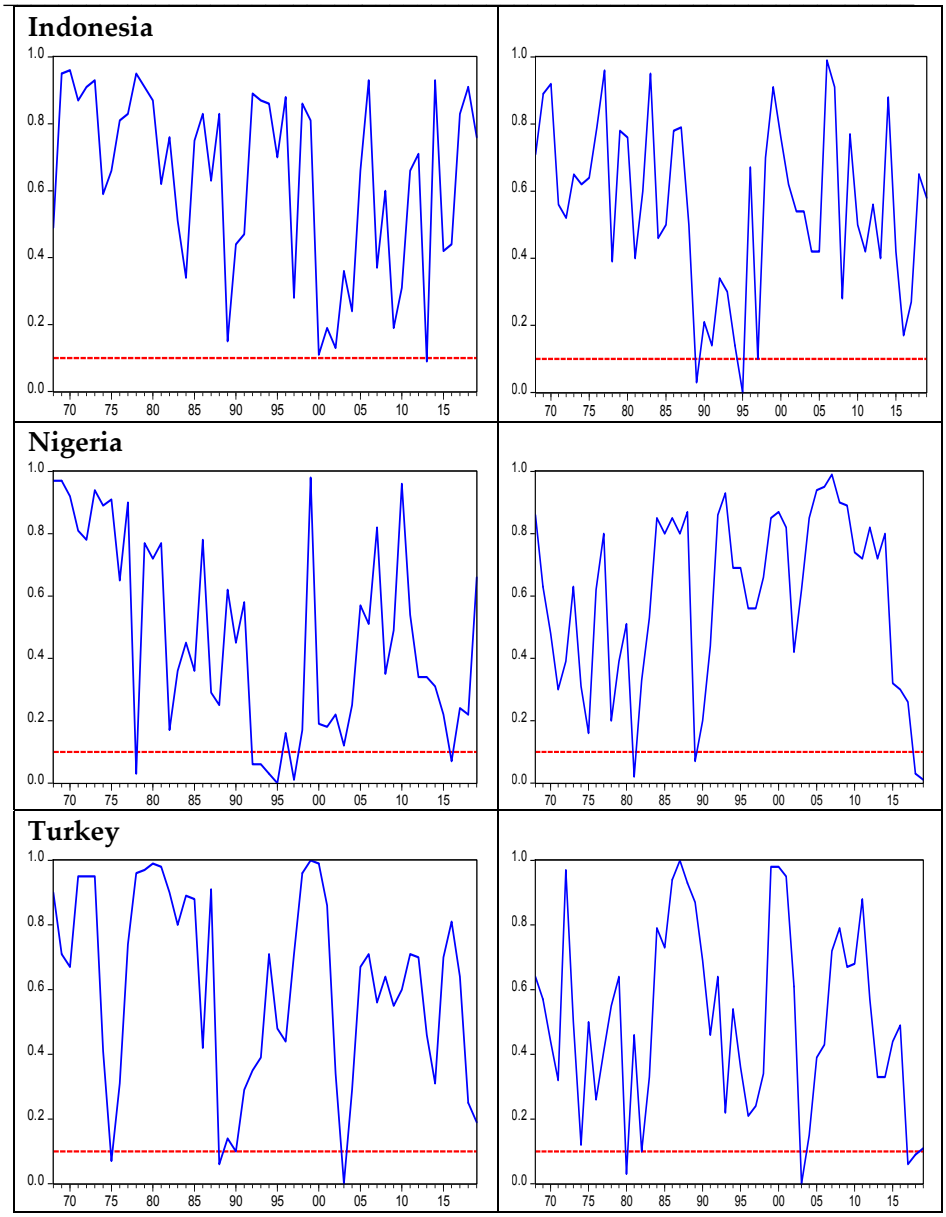


Figure (1)– Bootstrap p-values of causality from CO_2 Emissions to Economic Growth and Bootstrap p-values of causality from Economic Growth to CO_2 Emissions

Figure 2 shows the direction, size, and bootstrap probability value of the impact of GDP on CO_2 for the MINT (Mexico, Indonesia, Nigeria, and Turkey) nations, respectively. For Mexico, at a significance level of 10%, the null hypothesis that GDP does not cause CO_2 can be rejected in the periods of 1973-1978, 1992-1993, 1995-1997, 2001-2002, and 2011-2013. There are positive effects in the periods from 1973-1978, 1992-1993, and 1995-1997 from GDP to CO_2, while there is proof of negative causality from GDP to CO_2 in the periods from 2001-2002 and 2011-2013. Indonesia, at a significance level of 10%, the null hypothesis that GDP does not cause CO_2 can be rejected in the periods of 1989-1990 and 1994-1995. There are positive effects in the periods from 1989-1990 and 1994-1995. For Nigeria, at a significance level of 10%, the null hypothesis that GDP does no cause CO_2 can be rejected in the periods of 1981, 1989, and 2018-2019. There are positive impacts in the periods of 1981 and 2018-2019 and negative impacts in the period 1989 from GDP to CO_2. For the case of Turkey, at a significance level of 10%, the null hypothesis that GDP does not cause CO_2 can be rejected in the periods of 1980, 2003, and 2018-2019. There are positive impacts in the period between 1980 and 2003 and negative impacts in the period of 2018-2019 from GDP to CO_2

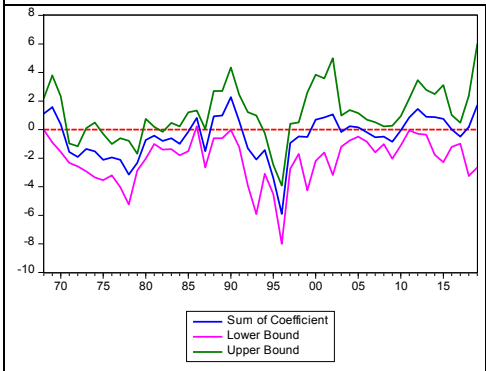
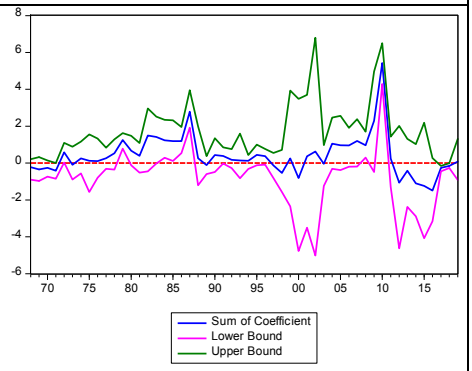
Impact of CO_2 on Economic Growth	Impact of Economic on CO_2 Emissions
Mexico	
	
Indonesia	

Figure 2 – Impact of CO_2 Emissions on Economic Growth (left) and impact of Economic on CO_2 Emissions (right) for Mexico, Indonesia, Nigeria and Turkey

4.2. Discussion of Findings

The outcomes obtained show feedback positive/negative connection between economic growth and CO2 emissions in the MINT nations. These findings show that the MINT nations are not on the path toward sustainable development. Therefore, policymakers in these countries need to deviate from their pro-growth agendas. This scenario affurmthe EKC hypothesis which postulates that at the initial level of development, developing nations such as the MINT nations favour economic growth while giving little attention to their environment. As a result, the MINT nations need to consider their ecosystem when formulating economic growth policies. These outcomes align with the studies of (Katircioglu et al., 2018), and (Gozgor & Can, 2016), who found that economic growth deteriorates the quality of the environment. However, this study contradicts the studies of Adebayo (2022) and Usman et al. (2020), who established that economic growth contributes to environmental sustainability. Generally, it can be said that the MINT countries as emerging nations have not yet achieved the per capita income level beyond which economic growth begins to relieve human strain on the environment. The MINT countries are presently putting pressure on nature to achieve greater economic growth. Nevertheless, achieving a certain level of economic growth should not be used as a justification for environmental deterioration. Furthermore, the researchers concluded that growing levels of environmental degradation (i.e., rising per capita CO_2 levels) appear to be detrimental to the MINT nations' economic growth. As a result, to progress from an emerging to an advanced economy, MINT nations must embark on sustainable development initiatives. Nonetheless, because the MINT nations' growth trends are not yet sustainable, growing levels of environmental degradation and pollution hinder their sustainable economic growth trajectory. As a result, MINT policymakers must restructure their national development policies based on sustainable growth targets that attempt to achieve a balance between the economy and the environment.

5. Conclusion and Policy Recommendations

Using the bootstrap full sample and subsample rolling window Granger causality tests, this analysis assessed the presence of the true essence of the EKC for MINT nations. To ascertain this connection, the present research utilized yearly data stretching between 1960 and 2019. To the understanding of the investigators, no existing studies have been done on MINT nations utilizing these approaches. Thus, the current research fills the gap in the prior studies. The outcomes of the full sample bootstrap Granger causality test disclosed unidirectional causality from GDP to CO_2 in Nigeria which suggests that GDP can predict CO_2 in Nigeria. Furthermore, there is no proof of causality between GDP and CO_2 in Mexico, Indonesia, and Turkey. When the parameter stability tests failed, questions were raised about the reliability and appropriateness of the full sample bootstrap Granger

causality test outcomes. As a result, the present study applied the bootstrap rolling window Granger causality test to capture the linkage between GDP and CO_2.

In the subsample periods in the MINT nations, the rolling window method to the Granger causality test validated the two-way connection between environmental deterioration and economic growth. Furthermore, when the coefficients of the influence of economic growth on environmental degradation were analyzed, economic growth proved to put some pressure on the environment, with a gradually growing pattern. Based on these findings, it may be claimed that Mexico, Nigeria, Indonesia, and Turkey have yet to reach the income turning point, after which economic growth will begin to alleviate environmental degradation. This finding suggests that growing environmental pressure from human activities, such as rising CO_2 emissions, may be damaging to the economic growth of Mexico, Nigeria, Indonesia, and Turkey. There is a destructive circle between pollution and expansion in this regard. Economic growth exacerbates environmental deterioration caused by human activities, whereas growing environmental pressure causes economic growth to decrease.

To break free from this vicious cycle, policymakers in Mexico, Nigeria, Indonesia, and Turkey must use the sustainable growth approach to achieve a balance between economic growth and environmental sustainability. As a result, policymakers in Indonesia, Mexico, Nigeria, and Turkey must restructure and expand their national growth strategies to include environmental protection. Since it implies a harmonious cohabitation between economic growth and the environment rather than a trade-off connection, sustainable growth is now the foundation for environmental policy in several nations across the world. The fundamental objective of a sustainable growth process is to achieve long-term economic and environmental sustainability. Furthermore, integrating and acknowledging environmental, social, and economic issues throughout the decision-making process is recognized as a prerequisite for achieving sustainable growth goals. Furthermore, eco-friendly technologies should be integrated into the MINT economies' consumption and production trends to reduce the impact of human activities on the environment. Furthermore, specific courses in educational environments, seminars, written and visual media, and other methods should be used to improve people's environmental awareness. In this way, People will pollute the environment less, utilize less land for grazing, protect forests from destruction, hunt fewer fish, and so on. Furthermore, with suitable energy policies, all MINT nations can increase their share of renewable energy output in overall energy production, since they are advantageous nations for renewable energy sources including biomass, geothermal, and hydro energy. Therefore, as a policy recommendation, the renewable energy industries in Indonesia, Mexico, Nigeria, and Turkey should be strengthened by both the private and public sectors through increased investments and economic incentives including lower taxe. Further

researches should be conducted in different developing advanced nations on this connection using different environmental degradation proxies.

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