

The Nexus Between Economic Development, Democracy, and Environmental Degradation: Testing the EKC Hypothesis in the BRICS + 6 Countries

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Abstract. This study investigates the relationship between economic development, democracy, and carbon emissions in the BRICS + 6 countries, considering the Environmental Kuznets Curve (EKC) Hypothesis. By using the data from 1991 to 2020, it aims to fill the research gap on whether economic development and democratic governance consistently lead to better environmental quality, focusing on carbon emissions as a primary measure. This research is distinctive because it considers the cross-sectional dependency and heterogeneity of the countries involved, employing robust regression models to examine the effects of various factors, including GDP, democracy index, and population, on carbon emissions. The study revisits the EKC hypothesis, which suggests an inverted U-shaped relationship between economic growth and environmental degradation, proposing that environmental quality deteriorates up to a certain income level before improving. However, it also explores critiques of the EKC, recognizing that the trajectory of environmental degradation is influenced by more than just income levels—factors such as technological advancement, economic structure, governmental environmental policies, and the level of democracy also play crucial roles. Expected to provide valuable insights for policy formulation, this research highlights the complex interactions between economic development, democratic governance, and environmental sustainability. It underscores the necessity of integrating democratic processes with economic and environmental planning to foster sustainable development, offering a nuanced perspective on the dynamics between democracy, income, and environmental quality in the BRICS + 6 countries.

Keywords: EKC Hypothesis, Economic Development, Democracy, Environmental Degradation

1 Introduction

Due to the critical problem of greenhouse gas emissions and their contribution to global warming, environmental quality has received increased attention globally in recent years. Carbon emissions are now a major contributing factor to this problem, resulting mostly from human activities. Consequently, there is significant pressure on countries to control and reduce their carbon footprints. It is well-known that a country's political

institutions, which influence its environmental policies, significantly impact the relationship between the country's income and its environmental quality. A significant amount of research has examined how political factors affect the connection between environmental pollution and income. Nevertheless, despite the large number of studies, a thorough and definitive conclusion has yet to be reached.

The connection between democracy and environmental quality is not simple, though. Democracy can enable people to speak out for environmental conservation, but it can also present difficulties in striking a balance between environmental preservation and economic growth. A large amount of study has been conducted because of this complex interaction, but the results are neither comprehensive nor definitive.

In this study, we will examine the relationship between income, democracy, and carbon emissions by revisiting the EKC hypothesis in BRICS (Brazil, Russia, India, China, South Africa) and 6 countries (Argentina, Egypt, Ethiopia, Iran, Saudi Arabia and the United Arab Emirates) that are invited to join as full member of top emerging countries in order to shed more light on this complex relationship. By investigating whether democracy and economic development consistently result in greater environmental quality, particularly regarding carbon emissions, across countries with different emissions levels, the study seeks to address the gap in the existing literature. To examine the complex relationships between many factors and carbon emissions, this study will take cross-sectional dependency and heterogeneity into account and use robust regression models. We can make more informed environmental and policy decisions by investigating this complex relationship. The study will reveal insightful information on how democracy, income, and environmental quality interact, as well as a detailed understanding of how these variables affect carbon emissions. The findings might assist in addressing the problems associated with greenhouse gas emissions and guide policy decisions.

The study's conclusions can offer insightful information for forming policy, especially in the BRICS + 6 countries and elsewhere. These countries have unique approaches to managing the environment and managing government because they are in different phases of development. According to the latest statistics of Freedom House [1], Argentina, South Africa, and Brazil are categorized as free countries, India is considered partly free, while the rest are classified as not free. We can determine whether becoming prosperous initially results in increased pollution, but that pollution can be reduced once countries reach a particular level of wealth or enact specific regulations by examining how their economies develop, how they are governed, and how they manage pollution. This combination of countries allows us to examine the ways in which environmental regulations, political systems, and economic development influence the degree of pollution. This offers an opportunity to draw comparisons between countries with varying forms of government and growth levels. This provides a better understanding of the complicated relationship between pollution, democracy, and economic development. It can be beneficial to policymakers to have a complete awareness of the interrelationships among democracy, economic development, and environmental degradation to develop environmental policies that balance sustainability and growth. By shedding light on the connection between democracy, economic development, and en-

vironmental degradation, this research can assist countries in achieving better environmental sustainability. Given the worldwide environmental issues we face, such as resource conservation and climate change, these kinds of studies are crucial.

This research expands the existing literature by broadening the scope of analysis beyond the BRICS countries to include six additional countries identified as top emerging nations. By incorporating these extra countries, the study offers a more comprehensive understanding of the relationship between environmental quality, economic growth, and democracy across diverse geographical regions. The utilization of data spanning from 1991 to 2020 significantly contributes to the literature by incorporating the most extensive and up-to-date data relevant to the topic. Additionally, the study stands out from previous research by addressing cross-sectional dependency and heterogeneity, ensuring a more robust analysis of the relationships under investigation.

2 Literature Review

The relevant literature includes a broad range of research that look at the connection between environmental degradation and democracy; these studies are frequently presented in the framework of the EKC hypothesis. The study, which is conducted across multiple countries and areas, clarifies the complex relationships that exist between environmental sustainability, income, and democratic government.

According to one viewpoint, people in democratic countries can voice their opinions, obtain information regarding environmental quality, and put pressure on their governments. Thus, democracy can improve the state of the environment [2]. On the other hand, some contend that democracy might make environmental issues worse. For example, they contend that because authoritarian regimes have greater control over demographic dynamics, population increase in democratic countries may be a threat to environmental quality [3]. The impact of democracy on environmental quality is still up for debate, with some studies finding inconclusive evidence. According to the Environmental Kuznets Curve (EKC) hypothesis, there is an inverted U-shaped link between environmental degradation and economic development [4]. This means that when economies expand, environmental quality may first decline but then improve if a particular income threshold is reached. This theory provides a framework that allows us to perceive the sustainability of economic progress and carries significant policy implications. However, according to Perman and Stern [5], a more realistic understanding has emerged, indicating that environmental degradation tends to increase steadily with income, although not as sharply. This trend is influenced by factors beyond income itself, such as the state of technology, the structure of the economy, governmental policies regarding environmental protection, as well as the level of democracy and freedom within a society. Some studies have attempted to expand the EKC model by incorporating variables like political freedom, output structure, or trade. However, the findings lacked robustness due to potential omitted variables bias and insufficient statistical support [6]. Perman and Stern [5] also suggested that a more robust econometric analysis is necessary to examine the EKC.

Ghosh et al. [7] investigated the impact of democracy and renewable energy consumption on environmental quality by using a quantile regression approach. According to the results of the study, a cleaner environment is supported by the utilization of renewable energy sources and the combined effects of GDP and democracy.

Hamid et al. [8] investigated the EKC hypothesis in the BRICS countries, they discovered a positive correlation between carbon dioxide emissions and per capita income. Notably, their research highlighted the function of journalistic freedom and institutional quality as mediators in the association between carbon dioxide emissions and per capita income.

Using the panel quintile regression model, Ren et al. [9] demonstrated the direct and indirect effects of democracy on carbon outflows for the BRICS nations between 1992 and 2018. Overall, the results demonstrated that, while democracy has good indirect impacts in China but negative ones in South Africa and Brazil, democracy could assist reduce carbon dioxide emissions in the BRICS countries. In another study on BRICS countries, panel data regression analysis was applied by Akin [10] to examine the connection between CO₂ emissions, income, and institutional quality using data from 2001 to 2011. The results supported the inverted U-shaped EKC.

Adams and Acheampong [11] examined the effects of democracy on carbon emissions using unbalanced data for 46 sub-Saharan African countries from 1980 to 2015. The study found that democracy and renewable energy both reduce CO₂ emissions. However, the study didn't find a relationship supporting the EKC hypothesis.

Kim et al. [12] applied the least squares method in their analysis, focusing on 78 high-income and 53 low-income countries based on data from the year 2014. Their study investigated the relationship between CO₂ emissions, income, and democracy, revealing an inverted U-shaped EKC relationship.

Sarkodie and Adams [13] investigated the situation in South Africa by applying an ARDL method and found that democracy reduces environmental pollution.

Lv [14] examined the relationship between incomes and carbon outflows in 19 nations between 1997 and 2010 using the quintile regression technique. The findings showed that democracy reduces carbon dioxide emissions only after a country reaches a certain level of income.

Arvin and Lew [15] used a fixed-effects estimator to examine the relationship between democracy and environmental quality for 141 countries between 1976 and 2003 within the scope of the EKC hypothesis. They divided the countries into smaller categories according to income levels and geographic areas. All the subgroups' associations with CO₂ emissions, water pollution, and democracy proved to be significant. On the other hand, the study's conclusion for carbon dioxide emissions defies the EKC hypothesis. It emerged that income levels and carbon emissions were positively correlated, except for Central Asian nations.

3 Data, Model Specification and Methodology

We will utilize data from 1991 to 2020, encompassing the BRICS + 6 countries, which include Brazil, Russia, India, China, South Africa, Argentina, Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates. We will consider carbon dioxide emissions as the dependent variable, and gross domestic product, the democracy index (calculated from civil liberties and political rights), along with population, as independent variables. The democracy index data will be retrieved from Freedom House, while data for the other variables will be obtained from the World Bank database.

The model of the study is as follows:

$$\ln CO_{2it} = \beta_0 + \beta_1 \ln GDP + \beta_2 \ln GDP^2 + \beta_3 DEM + \beta_4 \ln POP + \varepsilon \quad (1)$$

In the above model, where CO_2 , GDP , GDP^2 , DEM , and POP denote carbon dioxide emissions, gross domestic product, the square of gross domestic product, democracy index, and population, respectively, while ε is the random error term. β_1 , β_2 , β_3 , and β_4 are the coefficients of independent variables, and β_0 is used for the intercept. The subscript i and t represent countries and time. \ln denotes the natural logarithms of variables.

We will perform panel data analysis considering cross-sectional dependence and heterogeneity, using data from the BRICS + 6 countries from 1991 to 2022. We will conduct Westerlund cointegration test [16] and use the Augmented Mean Group estimator [17], [18]. These methods have been selected because they are appropriate for addressing specific characteristics of the data and the objectives of the research. When analyzing data from multiple countries over time, like the BRICS + 6 countries, panel data analysis is highly beneficial since it enables the study of both cross-sectional and time-series dimensions. Westerlund [16] advocated the use of Westerlund cointegration tests to investigate possible long-term correlations among variables. As it helps determine whether these variables move together in the long run, this is essential to know when analysing economic phenomena, such as the relationship between economic growth, democracy, and environmental factors. Eberhardt and Bond [17] and Eberhardt and Teal [18] generated the Augmented Mean Group (AMG) estimator, which is useful for heterogeneous panel analysis. Individual heterogeneity and cross-sectional dependence are both allowed, which are frequent in datasets that comprise several nations with various attributes.

All things considered, the combination of these techniques enables an in-depth look that considers individual heterogeneity, long-term relationships, and potential causality among the variables within a panel data framework, offering a nuanced understanding of the dynamics at work in the context of the BRICS + 6 countries.

4 Results and Discussion

Initially, the analysis focuses on examining the variables' cross-sectional dependency. In this study, Pesaran CD [19] test is used for investigating the presence of cross-sectional dependence. The findings outlined in Table 1 clearly indicate that cross-sectional dependency is a notable concern

Table 1. Cross-section dependency test results

| Variables | CD |
|---------------|-----------|
| <i>lnco2</i> | 16.547*** |
| <i>dem</i> | 2.7*** |
| <i>lngdp</i> | 21.289*** |
| <i>lngdp2</i> | 21.291*** |
| <i>lnpop</i> | 26.88*** |

Note: *** denotes significance at the 1% level

Pesaran and Yamagata [20] slope homogeneity test results are shown in Table 2. According to test results, countries have their own features. Therefore, we will consider cross-sectional dependency and heterogeneity issues in the next part of the study. Cross-sectional dependency and the heterogeneity necessitate conducting second generation unit root and cointegration tests.

Table 2. Slope homogeneity test results

| Slope homogeneity | Statistics |
|-------------------|------------|
| Delta | 17.808*** |
| Adj. Delta | 19.910*** |

Note: *** denotes significance at the 1% level

This study employs Pesaran's [21] CIPS test as the second-generation unit root test. The results of the CIPS test statistics are presented in Table 3. The findings suggest that carbon dioxide emissions, gross domestic product, and the square of gross domestic product show unit root behavior at their levels but achieve stationarity after differencing. In contrast, the democracy index and population variables remain stationary at their levels.

Table 3. Results of CIPS of panel unit root test

| Variable | Level | | First Difference | |
|---------------|------------|------------------|------------------|------------------|
| | Constant | Constant & Trend | Constant | Constant & Trend |
| <i>lnco2</i> | -2.027 | -2.223 | -3.914 *** | -3.988 *** |
| <i>dem</i> | -2.351*** | -3.190 *** | -5.066 *** | -5.116 *** |
| <i>lngdp</i> | -2.057 | -2.242 | -3.416 *** | -3.649 *** |
| <i>lngdp2</i> | -2.039 | -2.210 | -3.291 *** | -3.514 *** |
| <i>lnpop</i> | -3.173 *** | -2.691** | -2.076* | -2.645 * |

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels

The Westerlund (2005) cointegration test results presented in Table 4 indicate that the study's model exhibits cointegration. This suggests that the dependent variable, carbon dioxide emissions, and the other variables act together in the long term.

Table 4. Panel cointegration test results

| Test | Value | p-value |
|------|---------|---------|
| DHg | -2.5245 | 0.0058 |
| DHp | -1.4820 | 0.0692 |

Once the cointegration relationship among the variables is confirmed, the Augmented Mean Group (AMG) Estimator is utilized to examine the long-term relationship and coefficients. This estimator corrects for potential cross-sectional dependence and heterogeneity while pooling individual regressions from different entities and time periods. Table 5 presents the results of the Augmented Mean Group estimator.

Table 5. Results of the Augmented Mean Group (AMG) estimator

| Countries | dem | lngdp | lngdp2 | lnpop | Validity of EKC |
|----------------------|---------------|--------------|---------------|---------------|-----------------|
| Brazil | 0.1115146*** | -19.07568* | 1.085047* | 0.282172 | No |
| Russian Federation | -0.0410526*** | 9.208472*** | -0.4968798*** | 2.453869*** | Yes |
| India | 0.0225281 | 4.563412* | -0.2307435 | -2.138926** | No |
| China | -0.0051825 | 4.036016*** | -0.1486123*** | -12.83506*** | Yes |
| South Africa | -0.0141463 | 26.17351** | -1.471169** | -0.8006025*** | Yes |
| Argentina | -0.0127074 | 4.455787 | -0.2079706 | -0.5937756*** | No |
| Egypt | -0.0322294 | -2.73051 | 0.2502782 | -1.216777** | No |
| Iran | -0.0628341 | -10.11479*** | 0.8674927*** | 0.5419257 | Yes |
| Ethiopia | 0.1063695*** | 23.89923** | -1.372578** | 0.306412** | Yes |
| Saudi Arabia | -0.0549815* | -44.49253* | 2.297442* | 0.1746446** | No |
| United Arab Emirates | -0.0016566 | 1.935753 | -0.0799301 | -0.3374706 | No |
| Panel | -0.0105583 | 3.894325 | -0.1337701 | -0.2236558 | No |

Note: ***, **, * denote significance at the 1%, 5%, and 10% levels

Panel results show that there is a negative relationship between the democracy index and carbon dioxide emissions. While there is a positive relationship between gross domestic product and CO₂ emissions, the relationship is negative between the square of gross domestic product and CO₂ emissions, but these results are not statistically significant. According to the country-based results, it is seen that the relationship between the democracy index and carbon dioxide emissions may vary across countries, aligning with findings in the literature. For Brazil and Ethiopia, the coefficient of democracy index is positive and statistically significant, indicating that an increase in the democracy index is associated with a slight increase in carbon dioxide emissions. Conversely, for the Russian Federation and Saudi Arabia, the coefficient for the democracy index is negative and statistically significant, indicating that an increase in the democracy

index is associated with a decrease in carbon dioxide emissions. In countries like Brazil and Ethiopia, democratization may lead to increased political freedom and economic development, which in turn could result in higher industrialization and energy consumption, hence contributing to the environmental degradation. On the other hand, in countries like the Russian Federation and Saudi Arabia, a more authoritarian political regime may have more centralized control over industrial activities and resource allocation, allowing for stricter regulations and enforcement of environmental policies, leading to lower carbon dioxide emissions.

When the coefficient estimation results in Table 5 are evaluated within the framework of the EKC hypothesis, it is seen that carbon dioxide emissions increase when the gross domestic product increases. In the first stage, the hypothesis is that environmental degradation occurs as income increases. According to the hypothesis, after the income level exceeds a certain point; that is, after the point where the environmental degradation is highest, the pollution starts to decrease. In the study, increasing the square of the gross domestic product per capita reduces the CO₂ emissions. Even though coefficients supporting the EKC emerge, the lack of statistical significance prevents us from conclusively affirming their validity. If we examine the results on a country-specific basis, we find that the EKC hypothesis holds true in countries such as Russian Federation, China, South Africa, Iran, and Ethiopia.

5 Conclusion

This analysis of the relationship between democratic governance, economic growth, and environmental degradation in the BRICS + 6 countries provides valuable context to the discussion of sustainable development. With an emphasis on investigating the Environmental Kuznets Curve (EKC) theory, the study was aimed at clarifying the complex relationships among economic growth, democratic states, and carbon emission levels. Using a thorough methodological framework that included the diversity of the countries under study as well as cross-sectional dependency, the research revealed important findings with broad implications for academic circles and policymakers.

Firstly, the study confirmed that the variables under analysis had cross-sectional dependencies, highlighting the complex links between the political, economic, and environmental aspects in the countries that were selected. The utilization of advanced statistical instruments, such as the Augmented Mean Group estimator, highlighted the comprehensiveness of the analysis and enabled a more profound understanding of the involved dynamics. The results showed that, across the countries under study, the link between democracy and carbon emissions varied. A rise in the democracy index was connected to higher carbon emissions in certain cases, and a decrease in carbon emissions in other cases. This variety implies that the relationship between democratic governance and environmental quality is unclear and may depend on other factors including industrialization levels, economic policies, and the efficiency of environmental laws.

The results showed that, across the countries under study, the link between democracy and carbon emissions varied. A rise in the democracy index was connected to

higher carbon emissions in certain cases, and a decrease in carbon emissions in other cases. This variety implies that the relationship between democratic governance and environmental quality is unclear and may depend on other factors including industrialization levels, economic policies, and the efficiency of environmental laws. The results provided some partial support for the EKC concept. It was observed that in some countries, the expected negative U-shaped relationship between economic growth and carbon emissions remained true, suggesting that degradation of the environment increases with income up to a point where it starts to decline. However, the lack of this pattern in a number of nations and the statistical insignificance in certain cases place uncertainty on the validity of the EKC hypothesis, suggesting that other factors such as economic conditions, policy measures, and technological advancements have a significant impact on environmental outcomes.

This study emphasizes how crucial it is to create adapted policy measures, especially for the BRICS + 6 countries, to handle the complex links between democracy, environmental protection, and economic growth. It implies that economic growth and democracy have an inverse effect on environmental results, and in order to promote sustainable development, democratic and economic policies should be integrated with environmental preservation. Further research is necessary to understand the elements that influence the relationship between democracy, economic growth, and environmental quality. Policies that support sustainable goals while considering the unique situations of many countries are also necessary, as highlighted by the research. Overall, the results highlight the necessity of knowing and understanding the complex links between environmental health, governance, and economic development in order to achieve sustainability, and they call for more research and policy.

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