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The Role of Corruption in the Implementation of Environmental Regulations

Rola korupcji we wdrażaniu środowiskowych przepisów

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Abstract
The necessity for politicians to take action to prevent environmental pollution and combat environmental pollution and corruption is made clear by the rise in environmental pollution and corruption that results from growing economic activity and development in emerging countries. The correlation between economic growth, corruption, and environmental harm has been studied for groupings of high-income emerging countries for this reason. The inverted U-shaped correlation between economic growth and environmental pollution is valid for MIST but not for BRCS because of empirical studies taking cross-section dependency into account and assessing the long-term relationship. Additionally, corruption has been demonstrated to worsen environmental contamination.

Key words: economic growth; corruption; environmental pollution; environmental regulations

Streszczenie
Konieczność podejmowania przez polityków działań mających na celu zapobieganie zanieczyszczeniu środowiska oraz zwalczanie zanieczyszczenia środowiska i korupcji jest konieczne wobec wzrostu poziomu zanieczyszczeń i korupcji, które wynikają z rosnącej aktywności gospodarczej i rozwoju krajów rozwijających się. Dlatego zbadano korelację między wzrostem gospodarczym, korupcją i szkodami dla środowiska w grupach krajów rozwijających się o wysokich dochodach. Korelacja w kształcie odwróconej litery U między wzrostem gospodarczym a zanieczyszczeniem środowiska jest ważna dla krajów MIST, ale nie dla krajów BRCS, co wynika z badań empirycznych uwzględniających zależność przekrojową i oceniających zależność długoterminową. Ponadto wykazano, że korupcja zwiększa poziom zanieczyszczenia środowiska.

Słowa kluczowe: wzrost gospodarczy; korupcja; zanieczyszczenie środowiska; regulacje środowiskowe

1. Introduction

The problem of environmental pollution in the world is a complex result of various interrelated factors. The causes of environmental destruction cannot be grouped under a single heading. Therefore, there are various studies and opinions on what could be the reasons underlying the environmental degradation. One of the main causes of environmental pollution is population growth. Natural resources have been overutilized due to the increase in population. Moreover, increased migration and urbanization have led to various environmental problems, which are multiplier effects of population growth. All economic and individual activities require the use of natural resources. In addition, rapid industrial development, an increase in economic activities, trade openness, and inefficiency in energy consumption may also affect environmental quality unless necessary precautions have been taken. The most prominent feature of the Paris Agreement (2015) is a system based on the contributions of all countries. The agreement divides its parties into developed and developing countries in the fight against climate change. All countries work for a common purpose, but the responsibilities of each differ in this mechanism. As regards emission reduction, the agreement requires developed countries to pursue their absolute emission reduction targets. It encourages developing countries to adopt new targets that will cover all sectors over time by raising their emission reduction targets (Gladun and Ahsan, 2016; Graham, 2018). BRICS and MIST countries are known as high-income developing countries. In addition, they are also very important countries in terms of environmental pollution, economic growth, sustainable development, and corruption. As of 2018, according to the report of the International Social Security Association, BRICS and MIST countries comprise almost 31% of the world's GDP. BRICS and MIST countries also made up over 47% of the world's carbon emissions in 2021 (World Bank, 2023). The rapid economic growth and industrialization in China are known to cause environmental damage. China is confronted with various environmental pollution issues, including urban and industrial pollution, desertification caused by missing agricultural practices, and water scarcity (Ploberger, 2011). Moreover, increasing dependence on non-renewable fossil fuels has also contributed to environmental pollution in China (Zhou, 2013). South Africa, the 13th largest greenhouse gas diffuser in the world, is considered the largest pollutant on the African continent. The coal-based electricity generation company is located in South Africa and is the second largest electricity company emitting carbon dioxide at an international level (Greenpeace, 2012). Moreover, 13 out of 20 of the world's most greenhouse gas-emitting cities are in India; Brazil and Russia are the leading countries that emit the highest number of greenhouse gases per capita in the world (Graham, 2018). Greenhouse gas emissions in Mexico have been increasing since 1990. These emissions have shifted from agricultural sources to energy-based sources. In 1990, agricultural emissions accounted for 31% of greenhouse gas emissions in Mexico, while in 2015 they dropped to 18%. During the same period, energy-related emissions increased significantly, by almost 40%. Indonesia, a fossil fuel exporter, encourages the use of domestic coal production in industrial production to reduce its dependence on international fossil fuel demand. This situation increases environmental damage because of the continuous use of coal. Moreover, between 1990 and 2014, South Korea's emissions more than doubled, and this increase in emissions causes environmental damage. In Turkey, it is expected to meet the increasing energy demand with the establishment of new coal-based power stations. However, this contradicts the goal of reducing coal use in electricity and causes environmental destruction (Climate Action Tracker, 2019). BRICS and MIST countries are highly affected by political uncertainties, political instability, mismanagement, and corruption. The common characteristics of MIST countries are the fight against corruption and bribery, as well as environmental damage. All the MIST countries received the worst score from the international corruption index (Mastsangou, 2015). In countries facing high levels of corruption, democratic institutions and political rights are ineffective. Moreover, the high level of corruption restrains governments' effective controls over environmental quality, delays the implementation of strict environmental policy laws, and postpones controlling stricter environmental regulations. Figure 1 shows the corruption index in BRICS and MIST countries.

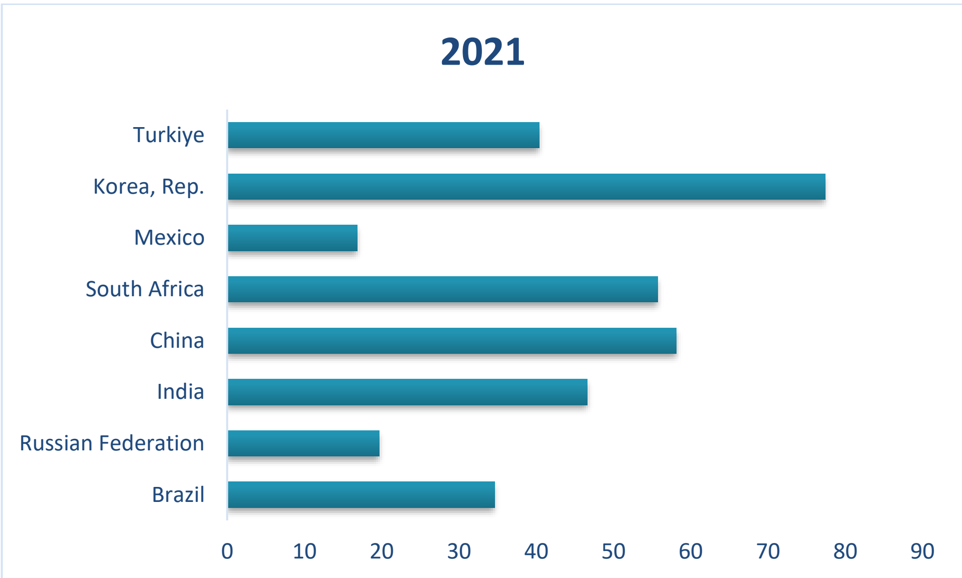

Figure 1. The control of corruption in the public and private sectors rank for BRICS and MIST countries (Transparency International (2023))

Figure 1 shows the control of corruption in the public and private sectors rank for BRICS and MIST countries. It is rated from zero to hundred. While the country with the best performance in this field is Korea, it is seen that the control of corruption is low in Mexico and Russia. Therefore, the concept of corruption has become important in many countries. In the literature, the corruption and environmental pollution nexus has two approaches, such as the direct effect and the indirect effect (Welsch, 2019; Cole, 2019). The direct effect is that corruption leads to inefficiency in the implementation of environmental regulations and thus to a deterioration of environmental quality. The indirect impact of corruption on a clean environment is related to its impact on income levels. The indirect effects of corruption on the Environmental Kuznets Curve (EKC) are also revealed, as corruption reduces per capita income and economic growth (Ehrlich and Lui, 1999). Firstly, corruption will reduce economic growth, and then its negative effects on economic growth and income will affect environmental quality (Drury et al., 2019). On the other hand, good governance is one of the most effective ways to achieve Sustainable Development Goals. At this point, Sustainable Development Goals (SDG)-16 (peace, justice, and strong institutions) can be given as an example. Accordingly, when the subheadings of the objectives are examined, the following subheadings attract attention. SDG 16.4: Strengthen the recovery and return of stolen assets, significantly restrict illicit financial and armament flows, and combat all types of organized crime; SDG 16.5: Significantly lower all types of bribery and corruption; SDG 16.6: Establish transparent, responsible, and efficient institutions at all levels; SDG 16.10: Protect fundamental freedoms and guarantee public access to information. (Jenkins, 2021). In order to achieve long-term sustainable development, the effectiveness of government institutions should be ensured, practices should be carried out efficiently, ethical principles should not be deviated from, and actions in this direction should be supported. Otherwise, an uncontrolled society and institutional structure will lead to the emergence of corruption, which is a global problem that can affect all countries (Sekrafi and Sghaier, 2017). According to Muslihudin et al. (2018), corruption may occur, and this may harm the environment as follows: The authors stated that the problem of corruption may be encountered when licensing entrepreneurs to regional managers, issuing environmental impact analysis licenses, and especially when imposing fees that may cause higher costs to entrepreneurs. In an environment where corruption exists, it can be expected to cause further exploitation of natural resources and, as a result, great environmental damage. As is well known, there are many studies in the literature about the factors affecting environmental pollution. Although many countries face a dramatic corruption problem, the impact of corruption on pollution is generally ignored. Therefore, we focus on the literature about corruption and environmental pollution. It's known that BRICS and MIST countries are high-income developing countries. Consequently, the main research question is, *If these countries' groups continue to struggle with environmental and corruption problems, can they render leadership in the international arena in any case?* The rest of the paper can be expressed as follows: Firstly, it briefly reviews the literature on the subject of the study and summarizes the nexus between economic growth, renewable energy consumption, corruption, trade openness, and environmental destruction. The next sections express the empirical strategy and give the empirical findings and their discussion. Finally, the last section offers results and policy implications.

2. Literature Review

In economics literature, there are many studies about the factors affecting environmental pollution. The most important feature of these studies is the examination of the EKC hypothesis in general. The main purpose of this study is to observe the effect of corruption on environmental deterioration and test the EKC pattern. Thus, this study incorporates an interaction between corruption and economic growth on environmental degradation, trying to examine it with a reinforced model that covers this topic. In this section, a literature review about the following sub-sections will be given: a) EKC pattern between real GDP and carbon emissions; b) impact of renewable energy consumption and trade openness on carbon emissions; and c) relationship between corruption and environmental quality.

2.1. EKC hypothesis

The association between economic growth and environmental deterioration is explained in the economic literature by the hypothesis developed mainly based on Kuznets' (1955) study (Tsurumi v. D., 2010). The inverted U-shape Kuznets hypothesis based on economic growth and income inequality has led to the development of the EKC hypothesis based on an inverted U-shaped nexus between economic growth and environmental deterioration. According to the EKC hypothesis adopted by Grossman and Krueger (1991), environmental pollution will increase in the first stages of economic growth; after a certain level, in the stages of maturity where economic growth exceeds a certain threshold, environmental degradation will decrease with the effect of structural and technological developments. In pre-industrial society, agriculture and farming are the primary sources of income for people, and in this period, environmental damage based on industrial resources is not encountered. However, with the increase in industrialization and economic growth, the inefficiency in resource utilization of societies whose income levels increase also causes environmental destruction problems. After this period, environmental quality increases. Environmental destruction starts to improve with awareness of a clean environment after a certain income level, and environmental degradation is prevented by the introduction of information-intensive industries and clean technologies (Cialani, 2007; Stern, 2001). Iwata et al. (2010) support the evidence for the EKC hypothesis during 1960-2003 in France. Similarly, Tiwari et al. (2013) report the EKC association between real GDP and carbon emissions in India, and Ahmed (2014) finds empirical evidence of EKC in Mongolia. Alam et al. (2016) analyze the validity of the EKC pattern and find inverse U-shape relations for some countries. Sarkodie and Strezov (2018) examine China along with three other countries using economic growth and CO_2 emissions data and find the validity of EKC in China. Uzar and Eyuboglu (2019) test the nexus between income inequality and carbon emissions in the case of Turkey for 1984-2010 and find the EKC pattern between variables. Danish et al. (2019) evaluate the association between real GDP and carbon emissions for BRICS countries in the years 1990-2015 and find that the EKC hypothesis is verified for Brazil, China, Russia, and South Africa, excluding India. Rahman et al. (2019) probe the income-carbon emissions nexus and find the EKC pattern in NAFTA and BRIC nations. Moreover, Balsalobre-Lorente et al. (2019) report that econometric results exhibit the EKC relationship for MINT countries. For the same country, Shahbaz et al. (2020) tested the validity of EKC, and the obtained findings confirmed the validity of the hypothesis. Gessesse and He (2020) explore the relationship between economic growth and carbon emissions by using the ARDL approach in China, and the obtained result supports the EKC hypothesis. Chang et al. (2021) also use CO_2 emissions in testing the EKC for 284 Chinese cities and corroborate the EKC. Using the ARDL approach, Pata and Kartal (2023) corroborate the EKC in South Korea. Mahmood (2023) also tested the validity of EKC in Latin America, and the obtained findings confirmed the validity of the hypothesis. In addition, Wang et al. (2023) also report finding the same relationship between income level and carbon emissions in 208 countries. Leito et al. (2023) used economic growth and carbon emissions data to examine the validity of EKC for Visegrad countries and concluded that the results support the theory in the short term. On the other hand, He and Richard (2010) find that there is no evidence for an EKC pattern in Canada from 1948 to 2004. This study concludes that there is a monotonic increase between income and environmental degradation. Hailemariam et al. (2019) search for the validity of the EKC pattern in OECD countries and find a nonlinear nexus between real GDP and carbon emissions, whereas Sharker et al. (2010) test the nexus between GDP growth and carbon emissions in Bangladesh and find a linear relationship between variables. In addition, Al-Mulali et al. (2015) analyzed the EKC pattern using the ARDL bound test for 1981-2011 in Vietnam, and their findings do not support EKC. Ozturk and Al-Mulali (2015) conclude that economic growth has no adverse U-shaped impact on environmental quality in Cambodia. Moreover, Ozokcu and Ozdemir (2017) researched whether the EKC pattern was supported in 26 OECD and 52 emerging countries between 1980 and 2010. The empirical results depict that the EKC pattern is not valid in both country groups, and these countries show inverted N-shape behavior. Inglesi-Lotz and Dogan (2018) note the existence of the U-shaped EKC hypothesis for Sub-Saharan Africa during 1980–2011. In addition, Hasanov et al. (2019) do not find any EKC relationships in Kazakhstani for the period from 1992 to 2013. There is a monotonic nexus between real GDP and carbon emissions in the long run. Danish and Wang (2019) find an N-shaped nexus between income and carbon for 1992-2013 in the case of BRICS countries. Mesagan et al. (2019) examine the EKC for BRICS countries using dynamic OLS (DOLS), and it has been concluded that the hypothesis is not valid in other countries other than China. Using panel data analysis, Murshed and Dao (2022) test the validity of the EKC hypothesis in South Asia and report that the EKC hypothesis is valid for Bangladesh and India, whereas a U-shaped relationship is valid between economic growth and carbon dioxide emissions in Pakistan. On the other hand, it can be concluded that Nepal and Sri Lanka monotonically reduce carbon dioxide emissions. Using the ARDL model, Massagony and Budiono (2022) examine whether the EKC hypothesis is valid or not in Indonesia. As a result of the findings, it is concluded that the EKC hypothesis is not valid. Wang et al. (2023) test the validity of EKC by using the data of 56 countries, and their findings show that the relationship between economic growth and carbon emissions changes from an inverted U shape to an N shape over time. Ali et al. (2023) use carbon emissions and economic growth data to test the validity of EKC in selected emerging Asian economies using the AMG estimation technique and find that the N-shaped EKC hypothesis is valid.

2.2. The link between renewable energy consumption, trade openness and carbon emissions

There is unanimity on the impact of renewable energy consumption on environmental pollution. It is known that renewable energy consumption has an important place in the SDGs (Antonakakis et al., 2017). These goals can be stated as SDG 7-affordable and clean energy, SDG 12- responsible consumption and production and SDG 13-climate action. According to SDG 7.2 (renewable energy), expanding the deployment of renewable energy sources and enhancing energy efficiency are essential to achieving the global objective of lowering greenhouse gas emissions (United Nations, 2023). According to the International Energy Agency (2021) report, even the fact that fossil fuels represent 80% of the total energy supply globally is a clear indication of the importance given to renewable energy. Thus, one of the most effective measures for reducing carbon emissions will be taken. However, there are different views on trade openness in the literature. Trade openness, which is one of the key factors in environmental pollution (Nasir et al., 2021), plays an important role in increasing economic output and economic growth (Wang and Zhang, 2021). Looking at the factors that cause global carbon emissions, it is seen that more than a quarter of trade-related carbon emissions cause this pollution (Zhang et al., 2017). In addition, with the development and diffusion of the global value chain, the environmental losses of open economies are starting to spread all over the world (Wang et al., 2021). For this reason, because of increasing commercial activities and relations, more industrial production, consumption, and energy use occur and may cause more carbon emissions (Pata, 2019). For this reason, it is very important to examine the effect of trade openness on carbon emissions. Menyah and Wolde-Rufael (2010) examine the carbon emissions, renewable energy, and real GDP nexus using the Granger causality test for the US spanning the period of 1960-2007. According to the results of the study, there is no causality from renewable energy consumption to carbon emissions, whereas there is a unidirectional causality running from carbon emissions to renewable energy consumption. Tiwari (2011) examines the linkages among variables in India, and the results indicate that an increase in renewable energy consumption improves environmental quality. Moreover, the author finds an increase in economic growth to be positively influencing carbon emissions. Shahbaz et al. (2012) in Pakistan for 1971-2009 and Shahbaz et al. (2013) in South Africa for 1965-2008 find that trade openness causes a clean environment. Jebi et al. (2013) report that the square of GDP, renewable energy consumption, and carbon emissions were negatively affected by trade openness for 25 OECD countries in 1980-2009. Shahbaz et al. (2013) collected the data for Indonesia in 1975 Q1-2011 Q4 using the ARDL bounds test, and the authors found that the real GDP and energy consumption were negatively influencing environmental pollution, while trade openness decreased carbon emissions. Jebli and Youssef (2016) find that there is a positive impact of trade openness on carbon emissions, while renewable energy has a weakly negative impact for Tunisia during 1980-2009. Bento and Mountinho (2016) research the carbon emissions, renewable electricity production, trade openness, and real GDP nexus using ARDL bounds testing in Italy from 1960 to 2011. Empirical results show that renewable electricity production increases environmental pollution both in the short and long run. However, trade openness enhances environmental pollution in the long run. Al-Mulali and Ozturk (2015) reveal that the real GDP increased carbon emissions while renewable energy consumption and trade openness decreased them for 27 advanced economies in 1990-2012. Ali et al. (2016) use the same variables as Al-Mulali and Ozturk (2015) in Nigeria during 1971-2011 and find the real GDP and energy consumption to be positively influencing environmental pollution, but trade openness decreases environmental quality in Europe. Moreover, Dogan and Seker (2016) report that there was an inverse nexus between these variables during 1985-2011 in the top renewable energy countries. Jebli et al. (2016) reveal that there was a negative effect of renewable energy consumption and trade openness on carbon emissions for 25 OECD countries in the 1980-2010 period. Inglesi-Lotz and Dogan (2018) explore the same relationship and report that increases in renewable energy consumption and trade openness reduce carbon emissions. Jebli et al. (2019) conclude that renewable energy is positively influencing carbon emissions, while economic growth and trade openness cause higher carbon emissions. Kahia et al. (2019) reveal that economic growth causes environmental pollution, whereas trade openness and renewable energy consumption increased environmental quality in Pakistan during 1975-2016. Zafar et al. (2019) report that renewable energy consumption decreases pollution while trade openness increases environmental degradation in emerging countries. In addition, Leito et al. (2020) evaluate the link between renewable energy, trade openness, and carbon emissions in the EU-28. The econometric results show that trade openness improves environmental quality, while renewable energy sources are beneficial for environmental quality. Adebayo (2022) examines the relationship between trade openness and renewable energy consumption on CO_2 emissions and finds that trade openness and renewable energy have a negative effect on carbon emissions in Sweden. Usman et al. (2022) concluded that while trade openness causes an increase in environmental pollution in the short term, renewable energy sources increased environmental quality in Pakistan from 1990 to 2017. Wang et al. (2023) report that renewable energy consumption has a reducing effect on carbon emissions in most countries at pre- and post-EKC turn points. It also concluded that the mitigating effect of trade openness on carbon emissions is valid only in high-income countries (208 countries from 1990 to 2018). Using the panel ARDL estimator and the Dumitrescu-Hurlin panel causality test, Pata et al. (2023) examine the relationship between trade openness and renewable energy consumption on carbon emissions during 1995-2018 and find that trade openness decreases environmental pollution and renewable energy increases environmental quality by reducing carbon emissions in the short term.

2.3. Relationship between corruption and environmental quality

Environmental degradation is not only caused by excessive natural resource consumption or increased trade openness but also by corruption. Especially in literature, it is possible to come across studies that support this discourse and express the relationship between corruption and environmental sustainability (Ganda, 2020). Looking at the studies, the general view is that corruption can cause environmental destruction directly or indirectly (Wang, Zhao, and Chen, 2020). Lippe (1999) examines the corruption and environmental pollution nexus and finds that corruption may diminish the efficacy of environmental laws in implementation and cause higher environmental pollution. Lopez and Mitra (2000) show that corruption certainly exists all over the world. However, government institutions in developing countries are generally not effective in achieving economic efficiency; bribe-taking and corruption practices are mostly experienced, and these cause weak effectiveness in the government institutions. Industry owners prefer cheaper ways to avoid environmental cost increases, and therefore, the increase in corruption practices is a major obstacle to pollution control laws. Moreover, they probe the effect of corruption on environmental quality following the EKC framework and find validity in the EKC hypothesis despite corruption. Fredriksson and Svensson (2003) examine the relationship between political instability, corruption, and environmental policy for 63 countries, and the results show that corruption decreases strict environmental regulations. Damania et al. (2003) research the trade openness, corruption, and environmental pollution nexus in both developed and developing countries in 1982-1992 and find that an increase in trade openness causes stricter environmental policies, such as an increase in the pollution tax, if the corruption of the government is high. Damania et al. (2003) also find the same results as Lopez and Mitra (2000), namely, that corruption may decrease the strict laws and regulations on environmental pollution and may cause higher pollution. Fredriksson et al. (2004) analyze the association between corruption and energy efficiency between 1982 and 1996, and the empirical results reveal that higher corruption is related to lower energy efficiency in 12 OECD countries. Welsch (2004) investigates the impacts of corruption on pollution and the validity of the EKC pattern for 122 countries within the period 1980-1997. Empirical results show that environmental pollution increases monotonically during periods of corruption. The direct effect is mostly consolidated by the indirect effect. This means that corruption reduces the income level, while low income leads to increased environmental pollution. Cole et al. (2006) examine the effects of corruption on environmental pollution in 1987-2000, and the results show that there is a positive direct effect between corruption and pollution, while there is a negative indirect impact of corruption on environmental deterioration. Moreover, Cole (2007) reports that corruption directly enhances pollutant emissions per capita. On the other hand, there is an indirect negative effect on pollution. Corruption leads to a lower income level, and a decreasing per capita income level also increases environmental pollution. Leito (2010) examines how corruption affects the relationship between environmental degradation and income following the EKC pattern framework. According to the results, the EKC pattern is valid for 94 countries that were divided into different income groups during 1981-2000. When there is an increase in the level of corruption in the country, it enhances an increase in per capita income at the turning point. Chen et al. (2018) stresses the effect of corruption on environmental degradation in China from 1998 to 2012. An increase in corruption may decrease the effectiveness of the implementation of environmental regulations. Because of weakening environmental regulations, illegal production will increase and cause pollutant emissions. Sinha et al. (2019) analyze the effect of corruption on environmental pollution in BRICS and the next 11 countries for the period of 1990-2017 and report that corruption increases carbon emissions and causes environmental degradation. Balsalobre-Lorente et al. (2019) probe the impact of corruption and energy innovation on carbon emissions for 16 selected OECD countries in 1995-2016, and the results show that corruption affects clean environments negatively in the long run. According to Habib et al. (2020), they examined the relationship between corruption and carbon emissions for African countries by using the panel quantile regression approach and GMM. As a result of the findings obtained, i) corruption has a negative impact on CO_2 emissions in low-emission countries, whereas it becomes insignificant in high-emission countries. ii) It is concluded that the indirect effect of corruption on CO_2 emissions is positive. iii) However, the positive effect of corruption on environmental quality outweighs its negative effect. iv) It was concluded that corruption is high in all African economies, and as a result, serious ecological problems are encountered. Hao et al. (2022) conducted a study for 30 provincial administrative regions of China between 2005 and 2016 and concluded that as the degree of corruption in a region increases environmental decentralization in limiting environmental emergencies decreases. Using the ARDL method, Pujiati et al. (2023) concluded that corruption increases environmental degradation in the short run in Indonesia in 1984-2020 but positively affects environmental degradation in the long run. In addition, Zhao et al. (2023) examined the relationship between corruption and haze pollution for 30 provinces in China using the GMM method. As a result of the findings, it was concluded that corruption, especially environmental corruption, both caused a direct increase in haze pollution and that the effect of corruption on haze pollution in different regions and different periods showed heterogeneity.

3. Empirical strategy

In this study, the relationship between carbon emissions, real GDP per capita, renewable energy consumption, trade openness, and corruption index is examined for the BRICS (Brazil, Russia, India, China, and South Africa) and MIST (Mexico, Indonesia, South Korea, and Turkey) countries. The annual period of 1995–2021, the carbon emissions (metric tons per capita), real GDP per capita (constant 2010 US$), renewable energy consumption (% of total final energy consumption), and trade openness (% of GDP) are collected from World Development Indicators published by the World Bank. The corruption perceptions index is obtained from Transparency International.

$$InCO_{i,t} = \delta_0 + \delta_1 InGDP_{i,t} + \delta_2 InGDP^2{}_{i,t} + \delta_3 InREN_{i,t} + \delta_4 InTRA_{i,t} + \delta_5 InCOR_{i,t} + \mu_{i,t} \quad (1)$$

where, t refers year during 1995-2021, i denotes cross-section, and μ_{it} refers the stochastic error, respectively. In addition, $lnCO_{it}$ is log of carbon emissions metric tons per capita, $InGDP_{it}$ is log of real GDP per capita, $InGDP^2_{it}$ is square of log-transformed real GDP per capita, $lnREN_{it}$ is log-transformed renewable energy consumption per capita, $lnTRA_{it}$ is log of trade openness and $InCOR_{it}$ is the log of corruption index. Renewable energy consumption variable is obtained by dividing into populations. In the literature, the effect of the coefficients for the variables on carbon emissions in the model, $\delta_1, \delta_2, \delta_3$, δ_4 and δ_5 are not clear. Destek and Ozsoy (2015) find the inverted U-shaped Kuznets Curve in Turkey for the period from 1970 to 2010. In addition, Sarkodie and Ozturk (2020) test the validity of EKC pattern in Kenya during 1971-2013 and the results support the EKC. On the other hand, Arminen and Menegaki (2019) examine the EKC hypothesis, and their results show the invalidity of the EKC for high and upper middle-income economies. Arminen and Menegaki (2019) also report that corruption has a statistically insignificant relation on environmental pollution.

Table 1. Descriptive Statistics for BRICS and MIST

Countries		$INCO_2$	INGDP	INREN	INTRA	INCOR
BRICS						
Brazil	Mean	0.260	3.889	3.799	1.390	3.185
	Max.	0.375	3.964	3.891	1.593	4.300
	Min.	0.148	3.814	3.691	1.194	1.544
	Std. Dev.	0.057	0.053	0.060	0.092	1.036
Russia	Mean	1.021	3.873	3.526	1.720	2.205
	Max.	1.055	4.009	3.598	1.841	2.800
	Min.	0.978	3.654	3.488	1.663	1.447
	Std. Dev.	0.020	0.124	0.027	0.049	0.492
India	Mean	0.052	3.045	2.521	1.572	2.699
	Max.	0.233	3.288	2.813	1.760	3.800
	Min.	0.136	2.791	2.304	1.341	1.590
	Std. Dev.	0.128	0.164	0.159	0.133	0.732
China	Mean	0.647	3.624	3.111	1.635	2.901
	Max.	0.854	4.048	3.661	1.809	4.000
	Min.	0.367	2.659	2.659	1.510	1.568
	Std. Dev.	0.192	0.340	0.340	0.094	0.864
South Africa	Mean	0.865	3.741	2.228	1.706	3.957
	Max.	0.927	3.796	2.899	1.819	5.680
	Min.	0.791	3.642	1.550	1.596	1.633
	Std. Dev.	0.040	0.055	0.367	0.054	1.442
Panel	Mean	0.569	3.638	3.037	1.604	2.898
	Max.	1.055	4.048	3.891	1.841	5.680
	Min.	0.136	2.791	1.550	1.194	1.447
	Std. Dev.	0.380	0.348	0.637	0.149	1.116
MIST						
Mexico	Mean	0.552	3.957	3.031	1.775	2.869
	Max.	0.597	4.005	3.194	1.992	3.700
	Min.	0.441	3.876	2.882	1.665	1.447
	Std. Dev.	0.039	0.030	0.065	0.080	0.865
Indonesia	Mean	0.180	3.408	2.444	1.712	2.197
	Max.	0.324	3.590	2.942	1.983	3.400
	Min.	0.006	3.251	2.088	1.518	1.556
	Std. Dev.	0.090	0.216	0.216	0.100	0.592
South Korea	Mean	0.998	4.352	2.711	1.867	4.040
	Max.	1.069	4.514	3.399	2.023	5.600
	Min.	0.870	4.127	2.183	1.719	1.724
	Std. Dev.	0.058	0.121	0.394	0.086	1.471
Turkey	Mean	0.548	3.922	3.316	1.702	3.310
	Max.	0.673	4.125	3.626	1.850	5.000
	Min.	0.411	3.756	3.041	1.575	1.576
	Std. Dev.	0.080	0.115	0.467	0.059	1.145
Panel	Mean	0.569	3.910	2.876	1.764	3.104
	Max.	1.069	4.514	3.626	2.023	5.600
	Min.	0.006	3.251	2.088	1.518	1.447
	Std. Dev.	0.299	0.351	0.405	0.105	1.251

However, some researchers state that corruption increases environmental destruction, such as Chen et al. (2018), Sinha et al. (2019), and Balsalobre-Lorente et al. (2019). Jebli et al. (2020) reveal that renewable energy consumption led to a decrease in pollution in 102 countries classified by income levels in 1990-2015. On the other hand, Apergis et al. (2010) report that renewable energy consumption does not reduce carbon emissions for selected 19 developed or developing countries during 1984-2007. There are also conflicting results in the empirical literature about the effect of trade openness on carbon emissions. Grether et al. (2007) probe that trade openness has a beneficial effect on the environment, while Cole et al. (2000) express that trade openness has negative effects. In addition, the finding results of Jalil and Mahmud (2009) indicate trade openness to be insignificantly influencing carbon emissions for China in 1975-2005.

The results obtained in the analysis without considering the cross-sectional dependence might be deviant and inconsistent. Therefore, it is necessary to test this dependence among the series before starting the analysis. In methodology, we use the panel data methodology to review the possible dependency using the Pesaran (2004) CD test among observed countries. The formulation of the CD test is as follows:

$$CD = \sqrt{\left(\frac{2T}{N(N-1)}\right)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (\hat{\rho}_{ij}) \sim N(0,1) \quad (2)$$

where, *N* refers the countries; *T* refers the period of observation. $\hat{\rho}_{ij}$ denotes correlation of the residuals. Therefore, the unit root test, allows dependency between the series, developed by Pesaran (2007) has been used. The cross-sectional ADF (CADF) unit root test is as below:

$$\Delta y_{it} = a_i + \rho_i y_{it-1} + \beta_i \bar{y}_{t-1} + \sum_{j=0}^{k} \gamma_{ij} \Delta \bar{y}_{it-1} + \sum_{j=0}^{k} \delta_{ij}\, y_{it-1} + \varepsilon_{it} \quad (3)$$

where a_i is constant, k refers the lag order, $\bar{y}_t$ shows the cross-sectional mean of time *t*. After equation (3), in order to obtain t-statistics, individual ADF statistics should be computed. Cross-sectional IPS (CIPS) is acquired by the mean of CADF values for all *i* is as below:

$$CIPS = \left(\frac{1}{N}\right) \sum_{i=1}^{N} t_i(N,T) \quad (4)$$

The critical values of cross-sectional IPS for various deterministic terms can be obtained from Pedroni (2007). The next step is to analyze the long-term coefficients of the variables. The long-run parameters of independent variables on carbon emission are estimated with fully modified ordinary least squares (FMOLS) estimation, which Pedroni developed (2000), DOLS developed by Pedroni (2021), and the Augmented Mean Group (AMG) estimator developed by Eberhardt and Bond (2009) and Bond and Eberhardt (2013). Before the results and discussion, the summary of descriptive statistics with the average of the variables of the BRICS and MIST countries has been given in Table 1. According to a summary of BRICS countries' statistics, the mean of carbon emissions ranges from 0.136 in India to 1.055 in Russia. According to trade openness, the highest value belongs to Russia (1.841), and the lowest value is in Brazil (1.194). South Africa has the lowest number (1.150) for renewable energy consumption, while Brazil has the highest number (3.891). In terms of real GDP per capita, Russia and China are the leading countries among the BRICS countries. In addition, Russia has the lowest number (1.447) for corruption, while South Africa has the highest number (5.680). Based on Table 1, which is evaluated for MIST countries, the mean carbon emissions range from 0.006 in Indonesia to 1.069 in South Korea. According to trade openness, the lowest value belongs to Indonesia (1.518), and the highest value is in South Korea (2.023). Indonesia has the lowest number (2.088) for renewable energy consumption, while Turkey has the highest number (3.626). In terms of real GDP per capita, South Korea is the leading country among MIST countries. In addition, Mexico has the lowest number (1.477) for corruption, while South Korea has the highest number (5.600).

4. **Empirical results and their discussion**

In this study, the relationship between real GDP, renewable energy consumption, trade openness, corruption in public, and carbon emissions is examined for the period from 1995 to 2021 in BRICS and MIST countries. Firstly, the cross-sectional dependence of the variables is analyzed by the CD test. The results are displayed in Table 2 for both country groups. No cross-sectional dependence is rejected according to the findings in the BRICS and MIST countries. There is a cross-sectional dependency between countries, which means that the shock in one country may easily spread to other countries.

Table 2. Cross-sectional Dependence Analysis

	BRICS: Stat (Prob)	**MIST: Stat (Prob)**
Breusch-Pagan LM	114.2501 (0.0000)	65.6622 (0.0000)
Pesaran scaled LM	22.192 (0.0000)	16.0683 (0.0000)
Pesaran CD	10.4085 (0.0000)	7.8452 (0.0000)

The cointegration relationship among variables would be calculated through a test that considered cross-sectional dependence. However, the stability of the variables had to be tested before the cointegration tests. For this purpose, the CIPS unit root test of Pesaran (2007) was applied, which considered cross-sectional dependence. The empirical results in Table 3 and Table 4 illustrate the results for BRICS and MIST countries, respectively.

Table 3. CIPS for BRICS

	Level		First	
Variables	**Constant**	**Constant&Trend**	**Constant**	**Constant&Trend**
InCO_2	-2.565	-2.219	-3.433**	-3.291***
lnGDP	-2.142	-2.219	-3.781**	-3.621***
InREN	-1.717	-3.062***	-5.338***	-5.320***
InTRA	-1.605	-1.913	-3.637***	-3.603***
lnCPI	-2.637**	-2.731*	-4.254***	-4.375***

Note: Critical values for constant: *10%; -2.12; **%5; -2.25, ***%1; -2.51, Critical values for constant and trend: *10%; -2.67; **%5; -2.82, ***%1; -3.1

In empirical analysis, we should first observe the stationary properties of variables. In table 3, CIPS unit root test which permits cross-sectional dependence results can be seen for BRICS. Results from Table 3 presents that InCO_2, InREN, InGDP and InTRA are stationary at I(1), while INCPI is level stationary.

Table 4. CIPS for MIST

	Level		First	
Variables	**Constant**	**Constant&Trend**	**Constant**	**Constant&Trend**
InCO_2	-2.301*	-2.340*	-4.670***	-4.855***
lnGDP	-1.750	-2.324*	-3.673***	-4.015***
InREN	-1.152	-3.648***	-5.002***	-5.020***
InTRA	-1.222	-2.109	-3.403***	-3.312**
lnCPI	-1.960	-2.318*	-2.960***	-3.318***

Note: Critical values for constant: *10%; -2.18; **%5; -2.33, ***%1; -2.64, Critical values for constant and trend: *10%; -2.70; **%5; -2.94, ***%1; -3.33

Table 4 depicts CIPS unit root test results for MIST countries and illustrates that InCO_2 stationary at level. The null hypothesis of unit root process is clearly rejected for InTRA, InGDP, InCPI and InREN, and they become stationary at first differenced form. According to the results of Table 3 and Table 4, all variables are integrated at different forms I(1) and I(0) in case of cross-sectional dependence. Because of the different stationary level, we couldn't analyze the cointegration among variables. In this step of the analysis, we search the long-run effect of variables on environment by using FMOLS, DOLS and AMG that allow non-cointegrations.

Table 5. Estimation Results

	BRICS	**MIST**
Variables	**FMOLS**	**FMOLS**
INGDP	-1.5675***	1.1433***
INGDP^2	0.3503***	-0.0656*
INREN	-0.1907**	0.00021
INTRA	1.4175**	-0.3247*
INCPI	-0.03444*	0.0102***
	DOLS	**DOLS**
INGDP	-0.8704**	4.4389***
INGDP^2	0.2064**	-0.4802**
INREN	-0.1185*	0.1248***
INTRA	0.9988***	-0.1152*
INCPI	-0.0512**	0.0104**
	AMG	**AMG**
INGDP	0.2415	-0.9809
INGDP^2	-0.0164	1.4136
INREN	-0.0264**	-0.7780**
INTRA	0.2146**	-0.0018
INCPI	0.112***	0.00415**

Note: Prop. values; *10%; **%5; ***%1

According to the results of FMOLS, DOLS, and AMG, the EKC hypothesis is supported because GDP has a positive effect on carbon emissions, and the square of GDP has a negative effect on carbon emissions in MIST countries but not in BRICS countries. Balsalobre-Lorente et al. (2019) and Rahman et al. (2019) obtain an inverted U-shaped connection between carbon emissions and real GDP. In addition, renewable energy consumption reduces environmental pollution in BRICS and MIST (Baloch et al., 2019; Zhang and Wang, 2019). Further, trade openness improves environmental quality for both country groups. It can be said that international trade increases emissions. These countries have an economic advantage for growth because of their capital accumulations. Therefore, the growth targets of these countries are often kept above environmental targets. Considering that international trade has a significant growth effect on countries, this result is expected. In these countries, it can be said that they do not have a lot of dirty industries with a heavy share of pollutants. Usman et al. (2022) investigate the trade openness and carbon emissions nexus, and the results show that trade openness has significant effects on pollution. However, these findings are inconsistent with the findings of Mahmood et al. (2019). According to the results of this study, they find trade openness to be positively influencing carbon emissions for BRICS countries in the long run. Finally, it can be seen that increasing corruption deteriorates environmental quality in both country groups, according to AMG. The findings related to corruption are consistent with previous findings (Damania et al., 2003; Cole et al., 2006; Chen et al., 2018; Sinha et al., 2019; Balsalobre-Lorente et al., 2019, Zhao et al., 2023).

Conclusions

This paper investigates the impact of corruption in public on carbon emissions and examines the validity of the EKC pattern in BRICS and MIST countries over the period of 1995–2021. In doing so, the real GDP, renewable energy consumption, and trade openness are included in the model. Although many studies have recently examined the economic growth-trade openness-renewable energy consumption-carbon emissions nexus, there is no evidence of the existence of a study that has conducted this relationship using corruption in BRICS and MIST countries. In this study, FMOLS, DOLS, and AMG estimators are used to investigate the cross-sectional dependence between countries and the long-term relationship. As a result of the study, the evidence shows that the inverted U-shape of the Kuznets Curve (Balsalobre-Lorente et al., 2019; Rahman et al., 2019) is valid for MIST countries but not BRICS such as He and Richard 2010, Massagony and Budiono 2022, and Ali et al. 2023. In addition, trade openness is significant for these countries. The other result of the study is that renewable energy consumption decreases environmental pollution in BRICS and MIST countries. This result is compatible with the results of Baloch et al. (2019) and Zhang and Wang (2019). Increasing the importance of trade openness in BRICS and MIST countries may lead to more investment in renewable energy sectors in these countries. In this way, the transfer of clean technologies to these countries can be facilitated.

To ensure environmental activity and sustainable development, a set of measures must be taken: The countries can

- apply environmental taxes effectively,
- adjust emission levels in the country with emission trading systems,
- attach importance to the transfer of green technologies,
- transfer clean technologies through trade openness.

On the other hand, corruption causes environmental degradation, and this finding is supported by previous studies by Lopez and Mitra, 2000; Damania et al., 2003; Cole et al., 2006; Chen et al., 2018; Sinha et al. 2019; Balsalobre-Lorente et al., 2019, Hao et al., 2022, Pujiati et al., 2023, and Zhao et al., 2023. Although investments to reduce environmental pollution and protect environmental quality have increased, in cases where corruption is not under control, the effectiveness of environmental regulations decreases and environmental damage increases. The anti-corruption campaign will be beneficial for the quality of the environment because the steps taken to combat corruption will put pressure on the officials and reduce the arrangements made in return for bribery. Moreover, due to the negative impact of corruption on environmental efficiency, corruption can limit the enforcement and control of environmental regulations. Although the fight against corruption may seem difficult, the negative impacts on the economy and the environment can be mitigated by taking measures. Implementing environmentally inappropriate practices for economic development may seem cheaper and more profitable in the short term, but long-term environmental destruction is inevitable. The main purpose of the study is to focus on the impact of corruption on the environment, and our policy implications are mostly based on this nexus. So, we can say that the policymakers in these countries should increase criminal sanctions through administrative and legal means,

- strengthen the institutional structure,
- take the necessary measures to create environmental awareness.

The findings show that developing nations should prioritize investments in renewable energy for their production and expansion. Additionally, the right policy choices for advancing the renewable energy sector and ultimately for developing countries to develop include offering tax exemptions, subsidies, and tariff guarantees. However, it is crucial for nations to implement public and private corruption control for these effects to produce positive results.

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