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Capturing The Dynamics of Environmental Degradation and Economic Growth in Selected Developing Countries: Using Simultaneous Equation Approach

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ABSTRACT

The current study aims to investigate the dynamic nexus between environmental degradation and economic growth in selected developing countries. To analyze the impact of control of corruption as a measure of governance, FDI, renewable energy and urbanization on economic growth and carbon emissions, the simultaneous equation modeling is applied. A panel of 18 selected developing countries for the time period 1995-2022 is taken for empirical verification of the relationship. This study employs descriptive analysis and for diagnostic checking the normality of residual is also tested for the possibility of any model misspecification. Correlation matrix is used to check the degree of multicollinearity among the independent variables. The nature of study indicates the use of simultaneous equation model where economic growth and carbon emission, as a measure of environmental degradation are indigenous variables. The statistical package EVIEWS is used in estimation and obtaining results. In the long run estimation model of CE, URBAN and PG are positively correlated with CE, and GDP, REEC, COC are inversely related to CE in selected developing countries. In model of GDP, CE, FDI and COC are positively correlating with GDP and REEC and PG are negatively affecting the GDP.

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1. Introduction

Today, the world's top priority is the preservation of resources in order to save the environment and ensure sustainability (Nathaniel, Anyanwu, & Shah, 2020). In addition, it is believed that many economies, throughout the world are looking for strategies to stop environmental degradation while maintaining growth for sustainability (Abbas et al., 2017; H. S. Ali et al., 2019; Madrid-Guijarro & Duréndez, 2024). This study also focuses on the many types of corruption, as well as the effects and costs that corruption has on the environment and economic progress, particularly in emerging nations that are wealthy in resources (El-shbrawy, Radwan, & Hamdi Amin, 2024; Sadiq, Hassan, Khan, & Rahman, 2023). This article examines a few real-world examples that have been picked from these nations because of the connections between corrupt environmental governance and poor environmental governance (El-shbrawy, Radwan, & Hamdi Amin, 2024). The degree to which corruption exists in a country is directly proportional to the institutional structure of that nation, including the features of its political and judicial systems. The concept of transparency has been referred to as a remedy for corruption in this particular setting. Putting an end to the devastation that corruption has caused to the environment may be accomplished via the implementation of good governance, which includes a wide commitment to the rule of law. This is an essential component of environmental sustainability (Bilgili, Alsanusi, Kabir, & Awan, 2024; Usman, Iorember, Ozturk,

& Bekun, 2022). Numerous empirical and theoretical studies have spent a significant amount of time on the subject of whether or not corruption hinders the growth and development of economies. However, there is very little agreement among economists regarding the significance of corruption in order to control environmental losses, carbon emissions and economic growth (Kesar, Jena, Kamaiah, Bekun, & Dehury, 2024; Nguyen & Bui, 2022). On the other hand, over this time period, the nations have also been plagued by a significant amount of corrupt behavior in order to deplete the environment. The fact that certain nations have had significant levels of economic growth while also maintaining high levels of corruption compels us to question the generalization of these researches (Mahmood, Tanveer, & Furqan, 2021; Sultana, Rahman, Khanam, & Kabir, 2022).

There have been several nations' economies that have been subjected to significant environmental pressures brought about by manmade carbon emissions that are a consequence of the utilization of natural resources. These emissions have led to climatic difficulties, which in turn have hampered the well-being of all living beings on earth (Brennan, 2024; Adger, 2010). In the beginning, the urgent need for these afflicted economies to increase their economic production was the driving force behind the extraction and use of resources that were formed in nature. These materials included minerals, oils, coal, and natural gas. This comes at a cost to the environment, and it is a significant signal of environmental strain that over consumption of natural resources is a significant contributor to the problem (Hunjra et al., 2023). Developing countries have had a prolonged and rapid economic growth since the late 20th century. The rapid economic growth of developing countries has been facilitated by the industrialization process inside these nations, as well as the transfer of technology from more advanced economies (Schacht, 2012). The burgeoning economic activity provided a multitude of advantages to the emerging nations, including a decrease in poverty, enhancements in education and healthcare facilities, the establishment of infrastructure, technological progress, and more. Conversely, higher rates of economic growth have been associated with some negative consequences for countries, such as the exhaustion of natural resources, the degradation of the environment, the expansion of income disparities, and the deterioration of health outcomes (Dashkevych & Portnov, 2023).

There have been a number of academics that have discussed the function that the government plays in the expansion of the economy (for example,(Azam, 2022; Emara & El Said, 2021). Moreover, the theoretical discussion shown Solow (1956); Wagner (1958) neoclassical growth model assert that fiscal policies involving taxes and government expenditures can affect economic growth. On the other hand, the endogenous growth model, which was developed by Barro (1990); Lucas Jr (1988); Romer (1986), proposes that the government can influence economic growth because transition and steady-state growth rates (as well as the government itself) are considered to be endogenous. The fact that governments have such a major influence on the economy is demonstrated by this (Chien, Sadiq, Nawaz, Hussain, Tran, & Le Thanh, 2021; Fazal & Azam, 2023; Ibrahim, Huang, Mohammed, & Adebayo, 2023; Satrovic, Cetindas, Akben, & Damrah, 2024). Despite the fact that policy advocates are focusing on the most innovative nations, which are also at the top of the list in terms of income and resource consumption, the policies that are being proposed here are applicable to other high-income countries that are responsible for environmental degradation as a result of excessive consumption of natural resources (Fazal, 2020; Mohsin, Kamran, Nawaz, Hussain, & Dahri, 2021; Vishal et al., 2022). As per the studies by Bukhari, Pervaiz, Zafar, Sadiq, and Bashir (2023); Jena, Mujtaba, Joshi, Satrovic, and Adeleye (2022), advanced and developed nations are increasing their use of renewable energy sources, which resulted a decrease in the rate of environmental degradation. Degradation of the environment is one of the most important elements that contribute to health problems. According to Naz, Khan, Masood, Baig, Siddique, and Haq (2021), the majority of researchers agree that the degradation of the environment that is caused by emissions of greenhouse gases has a negative effect on people's health. The pace of economic expansion has direct and indirect effects on the health condition of humans, mostly through the moderating function of the deterioration of the natural environment.

Matthew et al. (2020) conducted research not too long ago that investigated the direct and indirect effects of economic expansion on health performance in Nigeria by examining the function that air pollution had as a mediator. The authors have included the amount of money spent by the government on healthcare as a moderator in the relationship between air pollution

and health outcomes (Angell et al., 2022; Roberman, Emeto, & Adegboye, 2021). The findings were achieved by using time series data ranging from 1980 to 2015 and the results of the model indicated that rising economic activity contributes to rising levels of air pollution. However, as the process of economic development in a developing nation continues, it inevitably leads to a number of negative outcomes, Shahbaz, Sherafatian-Jahromi, Malik, Shabbir, and Jam (2016) and Hailemariam, Dzhumashev, and Shahbaz (2020) such as increased inequality, deterioration of the natural environment, and depletion of natural resources. Researchers and economists are focusing a lot of their attention on environmental deterioration since it is the threat that poses the greatest risk to both humanity and nature. According to the findings of a number of research by Murshed and Dao, (2020), a faster pace of population expansion is also contributing to environmental pollution in Pakistan. Current study aims to

1. Use the simultaneous equation system to estimate the relationship between carbon emission and economic growth in selected developing countries.
2. Analyze the impact of control of corruption, FDI, renewable energy and urbanization on economic growth and carbon emissions.

Research by Xie, Cui, Ren, and Li (2023) indicates that emerging Asian countries such as China, India, and others are witnessing a significant increase in energy consumption. In these countries, the rise in prosperity and better living standards has resulted in a higher energy consumption per person (Dogan, 2016). Few research pieces indicated that international tourists have a beneficial effect on economic growth, along with promoting trade openness and foreign direct investment. The empirical investigations of Acheampong (2018); Chen et al. (2022); Khan, Zhong, Khan, Dong, and Nuţă (2023) discovered an inverse association between CO2 emissions and economic growth. Hence, the authors concluded that the growth of economic activity did not lead to rise the environmental harm in such region. Paramati, Alam, and Chen (2017) conducted a research that investigated the relationship between the tourist industry and economic development in the top 10 nations from 1995 to 2013. They employed an econometric approach called FMOLS to analyze this association. The econometric research findings indicated a clear correlation between the growth of tourism and factors such as income per capita, trade openness, and the number of international visitors entering the country, these results are also consistent with Shan & Ren, 2023. After analyzing empirically, it was evident that there was a positive correlation between population and income per capita and CO2 emissions (Agyeiwaah & McKercher, 2024).

2. Data and Methodology

2.1. Data Description

This research examines the association between environmental deterioration and economic growth in a number of developing nations, by using the simultaneous equation method as an estimation tool on the panel data set for the period 1995-2022. These variables included GDP, URBAN, REEC, CE, FDI, PG, and COC. The data for GDP came from the World Development Indicator (WDI), while the data for COC came from the World Governance Indicator (WGI). The study chose 18 developing nations from the panel and cannot include more due to lack of data for other nations led to their exclusion from the list. Afghanistan, Indonesia, Laos, Brunei, Timor-Lest, and Qatar are some of the countries that have been left out.

Table 1: Name of developing countries

Developing countries		
Malaysia	India	Sri Lanka
Thailand	china	Maldives
Cambodia	Bangladesh	Magnolia
philipiness	Bhutan	Krygystan
Myanmar	Nepal	Turkemenistan
Vietnam	pakistan	Bahrain

2.2. Specification of Econometric Models

In model specification, distinct models each have their own set of variables that are stated. It is necessary to specify those variables, together with their respective units of

measurement, data sources, and the anticipated relationships with the variables that are dependent. This section is structured to provide all of the description that is associated with each variable in its own distinct part, which can be found further down in this article.

$CE = F(GDP, REEC, URBAN, PG, COC)$….. Function 1
$EC = f\ (CE, REEC, PG, FDI, COC)$…. Function 2
The econometric models can be written as per following system of equations.

$$CE = C_1 + \alpha_1 GDP_{it} + \alpha_2 REEC_{it} + \alpha_3 URBAN_{it} + \alpha_4 PG_{it} + \alpha_5 COC_{it} + \epsilon_{it} \quad (1$$
$$GDP = C_2 + \beta_1 CE_{it} + \beta_2 REEC_{it} + \beta_3 PG_{it} + \beta_{it} FDI_{it} + \beta_{it} COC_{it} + \varepsilon_{it} \quad (2$$

While applying the identification process of the above system of equations, the G is number of equations that are 2 and M is number of missing variables from each equation. As per the Hall and Asteriou (2016), the identification process has the following condition:

$$G - 1 = M$$

For Equation 1, M= 1 and therefore it is exactly identified and same for equation 2. The table 1 is explaining the variable and data sources and their expected relations.

Table 2: Description of Variables and Sources

Variable Name	Acronyms	Data Source	Expected Relationship	
			Equation 1	Equation 2
Carbon Emissions	CE	World Development	Dependent Variable	Positive
Economic Growth	GDP	Indicator	Negative	Dependent Variable
Renewable Energy Consumption	REEC			Negative
Population Growth	PG		Positive	
Urbanization	URBAN			Not Included
Foreign direct investment	FDI		Not Included	Positive
Control of Corruption	COC	World Governance Indicators	Negative	

2.3. Descriptive Analysis

Table 3: Data Description and Source of Data

	CE Thousand kt	GDP	REEC	PG	URBAN	FDI	COC
Mean	550.084.	6.347	35.568	1.560	2.832	4.108	-0.419
Median	463.815	6.143	32.025	1.397	2.660	2.839	-0.489
Maximum	10707.223	42.745	94.370	7.895	7.921	43.912	4.823
Minimum	162.725	-10.010	0.000	0.004	0.040	-0.990	-1.673
Std. Dev.	1792.705	4.196	30.814	0.970	1.330	4.838	0.744
Skewness	2.441	1.180	0.403	1.413	0.842	1.444	2.090
Kurtosis	2.672	2.005	1.838	3.493	4.200	2.728	1.748
Barque-Bera	973.574*	139.390*	42.045*	2801.499*	89.862*	831.549*	173.993*

2.4. Correlation Matrix

A table that illustrates the correlation coefficients between a number of different variables is referred to as a correlation matrix (Dziuban & Shirkey, 1974). In the fields of statistics and data analysis, it is utilized rather frequently to establish the link between the various variables. Correlation coefficient is a useful tool for quantifying the strength as well as the direction of a linear relationship that exists between two variables.

Table 4: Correlation Matrix

	CE	GDP	REEC	PG	URBAN	FDI	COC
CE	1.00						
GDP	0.09	1.00					
REEC	-0.15	-0.04	1.00				
PG	-0.24	-0.02	-0.23	1.00			
URBAN	0.02	0.06	0.09	0.58	1.00		
FDI	-0.08	0.21	-0.34	0.17	-0.01	1.00	
COC	0.05	-0.14	0.06	0.08	0.20	-0.05	1.00

2.5. Kao Cointegration

It is essential to select the appropriate panel cointegration test for your data in accordance with the characteristics of those data. The existence of a cross-sectional

dependence, the order of integrating the variables, and any other features that are relevant are all included in these criteria kao cointegration test is suitable (Kao, 1999). In accession in order to ensure the correctness of findings, it is strongly advised to do sensitivity studies and read relevant econometric literature. The empirical results recommend the rejection of null hypothesis that no cointegration exist between the selected variables.

Table 5: Kao Cointegration results

	t-Statistic	Prob.	
ADF	-1.634948	0.0262	Reject Ho

2.6. Simultaneous Equation System

The current study uses the simultaneous equation system in which the economic growth and carbon emission are intrinsically linked in the relation. The specification of econometric model is explained in previous chapter and the results of system of equations are given in table 5 and 6. The results are obtained by using EVIEWS and equations are written manually in system of equation. Although it is often used to gauge economic activity and success, the Gross Domestic Product (GDP) may also have a detrimental effect on the amount of carbon emissions produced. There is a confusing link between GDP and carbon emissions. The negative impact of GDP on carbon emissions is caused by several different processes working together (Zhang & Zhang, 2018). When the GDP goes up, which is a sign of economic growth, energy use almost always goes up as well. A higher GDP usually means that more energy is needed. A lot of different businesses and fields need energy to run. A lot of the time, this need is met by burning fossil fuels, which releases carbon dioxide (CO2). Often, for the economy to grow, more industry operations are needed. These operations may use a lot of energy and produce pollution. When powered by fossil fuels, industries like manufacturing, building, and using heavy machinery release carbon into the air (Deka, Ozdeser, & Seraj, 2023). A growing GDP means that people are spending more money, which makes more goods and services being made. The making and selling of these things might lead to more carbon emissions, especially if a lot of energy is needed for the processes involved (Choudhury, Kayani, Gul, Haider, & Ahmad, 2023).

Renewable energy sources, such as solar, wind, and water power, are generally thought to be better for the climate than fossil fuels. They also help cut down on carbon emissions (U. Ali, Guo, Kartal, Nurgazina, Khan, & Sharif, 2022). But the growth and use of green energy sources may be linked to some negative effects, even though these effects are usually much smaller and different from those caused by fossil fuels. According to Deng et al. (2024); Mukhtarov, Aliyev, Aliyev, and Ajayi (2022), carbon emissions may be made when green energy equipment is made, shipped, and put in place. But these emissions are usually a lot less than the emissions made by fossil fuel-powered power plants over the life of the green energy system (Yang, Zhang, Liu, & Zhou, 2022). The number of people living in a country or area may have a big effect on the amount of carbon dioxide that is released into the air because it changes how much energy, resources, and greenhouse gases that specific place uses. Rehman and Rehman (2022) say that the link between a growing population and more carbon emissions could be difficult and depend on a number of factors. Energy needs usually go up when the population does. This is because more people means more homes, businesses, factories, and vehicles that need energy. According to Minh, Ngoc, and Van (2023), the total amount of energy used is likely to rise because more people are using it for heating, cooling, lights, transportation, and tools. The fight against crime in a country may have carbon pollution effects that aren't directly seen or felt. There isn't a clear link between fighting corruption and lowering carbon emissions, but there are a lot of things that can change emissions in a country that doesn't properly fight corruption. These things are linked to each other. Good environmental laws are more likely to be followed and kept up in countries with strong anti-corruption measures and open government systems (Xie et al., 2023). Some of the things that these rules might include are limits on emissions, ways to stop waste, and long-term management of resources that can all help lower carbon emissions. Investors from both inside and outside the country are more likely to put money into sustainable building projects and green energy technology when there is less corruption. These efforts could lead to the development and wide use of technologies and methods that produce less carbon.

Carbon emissions are mostly caused by burning fossil fuels. These emissions play a big role in making greenhouse gases and speeding up climate change (Sikder et al., 2022). The link between carbon emissions and GDP is complicated. The positive impact of carbon emissions on GDP may be looked by keeping environmental degradation and sustainable practices (Razzaq, Fatima, & Murshed, 2023). Economic activities that are boosting economic growth like manufacturing, building, mechanization, also lead to increase carbon emission. This growth contributes further deterioration of environment and this effect can be reduced by shifting to renewable energy industries that are energy efficient with better job choices (Candra, Chammam, Alvarez, Muda, & Aybar, 2023; Ślusarczyk, Żegleń, Kluczek, Nizioł, & Górka, 2022).

A country's resources, like its ability to grow food and water, make energy, and maintain its facilities, can be put under a lot of stress when its population grows quickly. Providing people with their basic needs becomes harder as the population grows, leading to a lack of resources and higher costs (Islami, Prasetyanto, & Kurniasari, 2022). A growing population can put a strain on social structures and public services, like schools, hospitals, and transportation, especially if the population keeps growing. It might be hard for governments to provide enough services to meet the needs of a growing population, which could lead to waste and a drop in the level of services generally (Alam, Nur Alam, & Hoque, 2020). FDI is a source to open the economy for investment opportunities from global world (Chaudhury, Nanda, & Tyagi, 2020; Chike, Oguanobi, Mbamalu, & Egbunike, 2023). Foreign direct investment can assist local firms expand their global sales. Foreign companies can market local products and services using their worldwide connections. Increased exports and a favorable trade balance may follow. GDP would benefit from both. FDI initiatives provide locals with training and job advancement. This investment in people might lead to a more trained and productive workforce, which is crucial for economic growth and GDP. The mitigation of corruption inside a nation can provide several advantageous outcomes for the country's Gross Domestic Product (GDP) and overall economic expansion. A link exists between less corruption and more transparency, stronger governance, and a business-friendly environment. Each of these things has the potential to contribute to a rise in GDP (Uddin & Rahman, 2023). Businesses exhibit more confidence in their operations when there is a reduced prevalence of corruption. When businesses think that they can engage in fair competition, win contracts without resorting to bribery, and depend on the rule of law to preserve their interests, they are more likely to be prepared to make investments and expand their operations (Spyromitros & Panagiotidis, 2022). The Gross Domestic Product (GDP) benefits from increased levels of corporate activity and growth. Corruption often results in the addition of expenditures that are not required to corporate operations. The price of doing business may be decreased if corrupt practices such as bribery and extortion were done away with. Having lower operating expenses may have a positive impact on the profitability of a corporation and even contribute to GDP.

Table 6: Results of Equation 1

	Coefficient	Std. Error	t-Statistic	Prob.
Constant 1	13.456	0.285	47.200	0.000
GDP	-0.070	0.022	-3.226	0.001
REEC	-0.038	0.003	-12.103	0.000
URBAN	0.039	0.088	0.443	0.658
PG	0.839	0.121	6.943	0.000
COC	-0.345	0.125	-2.765	0.006

Table 7: Results of Equation 2

	Coefficient	Std. Error	t-Statistic	Prob.
Constant 2	8.083	1.351	5.981	0.000
CE	0.201	0.092	2.180	0.030
REEC	-0.004	0.007	-0.538	0.591
PG	-0.314	0.206	-1.527	0.127
FDI	0.172	0.041	4.181	0.000
COC	0.770	0.247	3.121	0.002

3. Conclusion and Recommendation for Public Policy

The current study intended to capture the indigenous behaviour of two main variables of the study that are carbon emission and economic growth. Both variables are interconnected with one another along with some supporting variables like urbanization, FDI, renewable

energy consumption, population growth and control of corruption as a measure of government effectiveness in selected 18 developing countries. The study conducted in a systematic manner started from descriptive analysis of the variables of the study and then panel unit roots tests and Kao cointegration tests are applied and results suggested the presence of long run relationship among the selected variables and it showed the path to apply the empirics of the relations. The system of equations is comprised of two equation and results shows that the empiric support the strong relationship among the variables. In the end the direction of causality is obtained through Dumitrescu and Hurlin test of causality. It is essential to keep in mind that the relationship between GDP and carbon emissions does not follow a linear pattern, and it is possible to achieve economic development while simultaneously reducing emissions of carbon. Investing in energy efficiency, shifting to renewable energy sources, adopting sustainable practices, and putting in place price mechanisms for carbon are all examples of strategies that may be used to decouple the development of GDP from emissions. Policymakers and governments play an essential part in the process of establishing policies that encourage sustainable economic development while also lowering carbon emissions and other negative consequences on the environment.

It is essential to emphasis that, despite the fact that these unfavorable effects do take place, they are, on average, far less severe and easier to deal with than the environmental and carbon emissions repercussions that are caused by energy sources that rely on fossil fuels. In addition, many of these problems may be solved by adopting more environmentally friendly business practices, acquiring more advanced equipment, and engaging in thorough strategic planning. The shift towards the use of renewable energy sources is an essential component of any climate change mitigation and carbon emission reduction plan. It is vital to apply laws and practices that promote sustainability, energy efficiency, and responsible land use in the development and deployment of technologies related to renewable energy in order to maximize the advantages of renewable energy while minimizing its negative effects. This will allow us to maximize the positive effects of renewable energy while minimizing the negative effects of renewable energy. However, it is essential to keep in mind that the connection between rising numbers of people living in a given area and increased carbon emissions is not a deterministic one. The effect that an expanding population has on emissions is contingent upon a number of variables, including the sources of Energy that the carbon intensity of the various sources of energy that are utilized (such as fossil fuels vs renewable). Efficiency refers to how well buildings, modes of transportation, and manufacturing processes use energy. The effectiveness of urban planning and the operation of public transport networks is referred to as urban planning.

To reduce carbon emissions related to population growth, sustainable development, energy efficiency, renewable energy adoption, responsible land use, and consumption are crucial. Policymakers, governments, and organizations play a crucial role in establishing policies that support sustainable development while reducing carbon emissions and environmental impacts. Preventing corruption is not enough to tackle climate change, and a holistic strategy involving policy formulation, technical advancement, public education, and international collaboration is essential. Measures to reduce corruption can indirectly influence carbon emissions by cultivating a culture of transparency, accountability, and responsible governance. The global movement towards sustainability and low-carbon economies emphasizes the need to transition away from businesses producing large levels of carbon emissions and relying on fossil fuels. Large-scale renewable energy projects can impact land use and ecosystems, but selecting suitable locations and taking preventative measures can help mitigate these effects.

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