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# From Fossil Fuels to Renewables: Analyzing the Pathways to Carbon Emission Reduction in Developing Nations

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**ABSTRACT**

The present study endeavours to examine the determinants that contribute to the enhancement of environmental quality within specific developing economies while concurrently assessing the validity of transitioning these economies from fossil fuel dependency to renewable energy sources. To achieve this objective, panel data encompassing selected developing economies spanning the period from 2000 to 2022 has been collected from the World Development Indicators database. Fossil fuel consumption is quantified through measures of energy consumption, while renewables are gauged using indicators of renewable energy consumption and renewable electricity consumption. In terms of analytical methodology, both fixed-effect and random-effect models have been employed. The estimated coefficients from the empirical analysis reveal that energy derived from fossil fuels significantly correlates with higher carbon dioxide emissions in the selected developing countries, suggesting that a shift toward renewable energy sources and electricity consumption can serve as an effective strategy for mitigating carbon emissions. Furthermore, the findings indicate that carbon dioxide emissions may be curbed through the facilitation of international trade and the expansion of industrial activities. Conversely, greater levels of foreign direct investment (FDI) and government expenditure appear to be associated with increased carbon dioxide emissions in these developing economies. In light of these findings, it is recommended that the promotion and adoption of renewable energy sources such as solar, wind, hydropower, and geothermal energy be prioritized as a means of effectively reducing carbon emissions and fostering environmental sustainability within these developing nations.



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## 1. Introduction

Renewable energy sources such as wind, solar, hydropower, and geothermal are regarded as environmentally viable alternatives for the creation of electricity because they do not release carbon dioxide during the production process. By directing resources towards renewable energy sources and supporting a direct reduction in emissions, developing countries have the potential to lessen their reliance on carbon-intensive fossil fuels and, as

a result, reduce their overall contribution to global warming. Nations can reduce their emissions of carbon dioxide (CO2) by a significant amount by switching from coal-fired power plants to alternative energy sources such as wind turbines or solar panels.

To fulfil their obligations under international agreements such as the Paris Agreement, developing countries must increase the proportion of renewable energy sources that they use. The use of renewable energy sources makes it easier to cut carbon dioxide emissions, improves air quality, and lowers the risk of health problems associated with pollution. In addition to this, it supports the establishment of employment opportunities and contributes to the increase of economic activity, particularly in rural areas. Reduced reliance on imported fossil fuels and increased use of domestically accessible renewable resources can help developing countries improve their energy security and reduce their vulnerability to the unpredictability of global energy markets. Both of these goals can be accomplished by shifting energy production away from traditional fuel sources.

The association between energy consumption, the implementation of renewable energy sources, and carbon emission might demonstrate fluctuation depending on the specific circumstances, legislation, and resource availability within each developing nation. It is recommended that developing nations give priority to the expansion of renewable energy capacity to maximize the benefits of doing so. Concurrently, these governments should establish regulations and provide incentives that make it easier for people to make the switch to renewable energy sources. In their research, Khizar and Anees (2023) investigated the effects of green finance on environmental sustainability in Pakistan throughout a period spanning from 1980 to 2020. Specifically, they focused on the period between 1980 and 2020. A positive association exists between environmental sustainability and green finance, GDP, and foreign direct investment; however, trade openness was found to have a negative impact on the relationship. In their research, Shahzadi, Ali, Ghafoor, and Rahman (2023) focused on the effects of these factors on countries that are still in the process of industrialization. The research included the years 1991 through 2021 inclusively.

Nasim, Bashir, Munir, and Kiran (2023) investigated the inverse relationship between the value produced by industries and CO2 emissions, which suggests that the expansion of industries is one factor in the degradation of the environment. In addition, research has shown that international direct investment (also known as FDI) harms the natural world. On the other hand, there is an inverse association between CO2 emissions and trade, which suggests that increasing trade activities might lead to a reduction in their negative influence on the environment. The phenomena of population growth have been linked to a positive influence, and the utilization of alternative sources of power has been found to have a positive correlation with carbon dioxide emissions. The research that was carried out by F. Farooq, Tanveer, and Faheem (2023) investigated the non-symmetrical influence that geopolitical risk has on China's efforts to reduce its carbon emissions. The study analyzed annual data from 1990 up until 2018. The results of the research showed that there is a considerable connection between the threat of geopolitical conflict and the environmental viability of a region. The pollution haven hypothesis was proven to be supported by the discovery that higher levels of foreign direct investment were connected to an increase in CO2 emissions.

Zhang, Liu, Wang, and Nazir (2023) examined ecological innovation and green energy investment, together with their dynamic and asymmetrical effects on China's unemployment rate from 1995 to 2020. The Quantile Autoregressive Distribution Lag (QARDL) model was used. The findings indicate that both short- and long-term employment are negatively impacted by investments in clean energy and environmental technology. Nazir, Gillani, and Shafiq (2023) applied structural equation methodology to examine the association between environmental regulations, innovations, and pollution, utilizing data from G7 economies spanning the period from 1990 to 2020. The outcomes of the study confirmed that the implementation of environmental rules has a direct impact on the reduction of emissions. Environmental laws have been found to have a significant and beneficial influence on three key indicators of public health, namely health expenditures, life

expectancy, and infant mortality rates, by F. Wang, Gillani, Nazir, and Razzaq (2023). Farooq, Gillani, Subhani, and Shafiq (2023) found that economic policy uncertainty makes CO2 emissions worse, which can be lowered by working for government stability. Farooq, Subhani, Shafiq, and Gillani (2023) conducted a study utilizing data from 10 industrialized economies around the world spanning the years 2000 to 2019. In their study, positive coefficient values for energy consumption and the volume of trade show that they contribute significantly to environmental degradation. Increased production of goods and the expansion of industrial activities in response to a rise in trade volume increase air pollution. Wang, Laila, Nazir, and Hao (2023) found that trade openness negatively influences renewable energy intensity. Yu, Nazir, Huang, and Li (2023) found that financial development raises the carbon emissions over the long term, while green innovation and the use of renewable energy decrease emissions in Asian countries.

In their research, Ditta, Hashmi, Anis, and Maqbool (2023) analyzed to evaluate the relationship between environmental deterioration and factors such as income growth, urbanization, the size of the working population, and energy use. The consumption of energy in a selection of developed nations was the topic that the researchers concentrated on in great detail. There is a positive association between long-term carbon emissions and income growth. On the other hand, there was found to be a statistically significant negative relationship between energy consumption and environmental health. Tanveer, Ahmad, Asghar, and ur Rehman (2022) used both the ARDL and NARDL methodologies in their research on Pakistan's link between energy consumption and carbon emission. The findings demonstrated increases in CO2 emissions over the short term, declines over the long term, and minor increases. The authors S. Hussain and Yousaf (2022) use MMQR to investigate how the production of renewable energy, the consumption of this energy, the increase in economic activity, and the increase in population all affect CO2 emissions in ASEAN economies. Bhatti and Fazal (2021) explored a selected group of ASEAN states throughout the period from 2000 to 2018 for their study. There is a linkage between energy consumption and carbon emissions; nevertheless, the adoption of trade liberalization assisted reductions in emission levels in economies that were experiencing a decline in environmental deterioration.

Nawab, Bhatti, and Nawaz (2021) looked at the numerous factors that play a role in the deterioration of the natural environment for their study. In particular, they wanted to investigate the effect that the expansion of the economies of the ASEAN nations had on the rate of environmental deterioration as well as the consumption of energy, the utilization of renewable energy sources, and the development of new technologies. The research that was carried out by M. S. Hussain, Nawaz, Ahmad, and Bhatti (2021) looks at the trends of renewable energy usage in Thailand from the years 1980 to 2018. The results of this study demonstrate the existence of a strong and long-lasting link between the consumption of renewable energy, the use of fossil fuels, the expansion of financial markets, the inflow of foreign direct investment, the openness of trade markets, and the GDP per capita. On the other hand, it has been noted that commercial activity and the use of energy sources that do not replenish themselves have a detrimental impact on this connection. The research that was carried out by M. S. Hussain et al. (2021) explores the impact that environmental governance and green energy have on carbon dioxide emissions in the 10 nations that produce the most carbon emissions overall. The research, which used economic growth as a control variable, concluded that these features had a significant influence on the slowing down of the deterioration of the environment.

Salari, Javid, and Noghanibehambari (2021) used time series data from 1997 and 2016 and studied the relationship between carbon emissions and energy consumption in cases of total, non-renewable, industrial, and residential energy consumption that a positive influence can classify; however, a negative association is observed in the context of renewable energy consumption. The research that was carried out by Nawab, Muneza, and Afghan (2021) looked into the connection between economic growth and the deterioration of the natural environment in six different ASEAN countries. They took into consideration a variety of elements, including healthcare costs and renewable energy sources. It was

revealed that a drop in expenditure on the health sector and an increase in consumption of renewable energy sectors were both related to a decrease in environmental deterioration. This relationship between energy consumption and carbon emissions was shown to be a bi-directional one. The objective of the research that was carried out by Khan, Khan, and Rehan (2020) was to investigate the connections that exist between energy consumption, economic expansion, and CO2 emissions in Pakistan. To conduct their study, the researchers made use of annual time series data ranging from 1965 up to 2015. Shafiq, ur Raheem, and Ahmed (2020) found the impact of renewable energy on CO2 emissions by using the GMM for 9 ASEAN economies. The results showed that CO2 emissions go down as the use of green energy and economic growth go up. Carbon dioxide emissions also rise because of growth in the service sector and more people living in cities.

Zhou, Sirisrisakulchai, Liu, and Sriboonchitta (2018) looked at the impact of economic growth and energy consumption on carbon emissions in a sample of 10 significant nations that together contribute to global carbon emissions. These nations were chosen because they are major contributors to carbon emissions. The researchers found a positive association between the consumption of energy and the emissions of carbon dioxide. They saw the most significant impacts at different quantiles within the dataset of sample groups. In their work, Sasana and Putri (2018) did an analysis to investigate the impact on carbon dioxide emissions caused by the use of fossil fuels, the growth of populations, and the use of energy derived from renewable sources. According to the findings, there is a connection between the use of fossil fuels for energy production and the rise in the population as measured by the amount of carbon dioxide emissions in Indonesia.

On the other hand, the research shows that there is an inverse link between the use of renewable energy sources and the total quantity of carbon dioxide emissions in the country. The present study endeavours to examine the determinants that contribute to the enhancement of environmental quality within specific developing economies while concurrently assessing the validity of transitioning these economies from fossil fuel dependency to renewable energy sources. Moreover, the study is organized as the 1st section is about the Introduction, the 2nd section is about data and methodology, the results are discussed in the 3rd section, and the conclusion, along with policy recommendations, is given in the 4th section.

## 2. Data and Methodology

In this research study, panel data from a selected group of developing countries spanning the years 2000 to 2022 has been employed. The study encompasses the following countries: Algeria, Thailand, Angola, Sudan, Argentina, South Africa, Bangladesh, Russia, Belize, Pakistan, Benin, Bhutan, Nepal, Bolivia, Bosnia, Brazil, Lebanon, Cambodia, Cameroon, China, Colombia, Congo, Egypt, Gabon, Ghana, Honduras, India, Indonesia, Iran, Jordan, Kenya, Malaysia, Mexico, Moldova, Morocco, Namibia, Nigeria, Philippines, Rwanda, Sri Lanka, Tanzania and Vanuatu. Data for this research has been sourced from the World Development Indicators database, and we have conducted estimations using both the Fixed Effect (FE) and Random Effect (RE) models. Furthermore, the model specification used in this study is outlined below;

$$CR = a_0 + a_1 ENC + a_2 FDIV + a_3 TROP + a_4 IVAD + a_5 GVEX + a_6 CPFR + u_i \quad (1)$$

For checking the transition from Fossil Fuels to Renewable Energy/ Electricity, there are the following models,

$$CR = b_0 + b_1 RENC + b_2 FDIV + b_3 TROP + b_4 IVAD + b_5 GVEX + b_6 CPFR + v_i \quad (2)$$

$$CR = c_0 + c_1 RELC + c_2 FDIV + c_3 TROP + c_4 IVAD + c_5 GVEX + c_6 CPFR + w_i \quad (3)$$

The detail about the variables used in the above equations is given in Table 1.

**Table 1**
***Description of Variables***

| Variable | Definition | Units of Measurement | Sources of Variable | Expected Relationship |
|---|---|---|---|---|
| CR | Log of Carbon Dioxide Emission | Kilotons | World Development Indicators | Dependent Variable |
| ENC | Log of Fossil Fuels Energy Consumption | Kg of oil equivalent | | Positive |
| RENC | Log of Renewable Energy Consumption | Kg of oil equivalent | | Negative |
| RELC | Log of Renewable Electricity Consumption | kWh | | Negative |
| FDIV | Log of Foreign Direct Investment | Current US $ | | Negative |
| TROP | Log of Trade Openness | Trade Index | | Positive |
| IVAD | Log of Industrial Value Addition | Current US $ | | Negative |
| GVEX | Log of Government Expenditure | Current US $ | | Positive |
| CPFR | Log of Capital Formation | Current US $ | | Positive |

## 3. Results and Discussion

The results of the Fixed Effect and Random Effect models are presented in Table 2. Concerning Fossil fuel energy consumption, a positive linkage is found with carbon emission. The reason may be that the rapid pace of industrialization and economic expansion, which leads to increased demand for energy, is primarily responsible for the increase in carbon emissions that have been recorded in emerging countries. It is common practice to consider fossil fuels, which include coal, oil, and natural gas, to be the most easily accessible and economically advantageous sources of energy. There is a scarcity of access to modern energy sources in developing nations; a sizeable section of the population there is forced to rely on the utilization of fossil fuels as a commercially viable alternative source of energy. In many cases, this necessitates the building of power plants that burn coal for fuel or an increase in the amount of oil that is used for use in transportation.

The use of renewable energy sources in developing countries plays an essential part in reducing carbon dioxide emissions. As a result, an essential strategy for combating climate change and finding solutions to environmental problems. In striking contrast to the usage of fossil fuels, the generation of electricity from renewable sources of energy such as wind, solar, hydropower, and geothermal can occur with low to no direct emissions of carbon dioxide. There is an inverse relationship between the usage of renewable energy sources and the carbon intensity of the generation of electricity. It is common for developing countries to rely on fossil fuels as their primary source of energy; however, the implementation of renewable energy technology can help these countries become less reliant on resources that are not infinite in supply. The proliferation of renewable energy sources in developing countries has been fueled in large part by the improvements in the efficacy and competitiveness of these sources. It is possible that revitalizing regional economies and creating employment possibilities will result from allocating resources towards the development of renewable energy sources. In addition, the satisfaction of global responsibilities such as the Paris Agreement is of great importance concerning the reduction of emissions of greenhouse gases.

Foreign direct investment (FDI) frequently results in increased levels of economic activity and industrialization within the nation that hosts the investment, which may, in turn, result in increased levels of energy consumption and increased levels of carbon dioxide (CO2) emissions. The industries and technology that foreign investors bring in have the potential to affect the emissions. The creation of new infrastructure is another possible outcome of foreign direct investment (FDI), which can contribute to both increased energy consumption as well as the clearing of forest land. Nevertheless, foreign direct investment (FDI) can bring in cutting-edge technologies and optimal procedures, which will make it easier for host nations to improve their energy efficiency and reduce their emissions.

The adoption of trade openness in developing nations in a strategic manner has the potential to offer a significant decrease in carbon dioxide emissions. The promotion of the use of environmentally friendly practices and the guaranteeing of environmental sustainability can both be served by the easing of restrictions placed on the movement of goods and services across international borders. Developing countries can acquire pollution control equipment, energy-efficient technologies, and renewable energy systems, which would result in a drop in emissions. This would be beneficial for the environment. Because it enables countries to specialize in production under their comparative advantages, trade is an extremely important factor in the improvement of resource efficiency. Because of this specialization, there is a greater efficiency in the utilization of resources, which in turn contributes to a reduction in emissions.

**Table 2**
***Panel Data Results***

| Variable | Fossil Fuel Energy Consumption | | Renewable Energy Consumption | | Renewable Electricity Consumption | |
|---|---|---|---|---|---|---|
| | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** | **Coeff.** | **Prob.** |
| **Fixed Effect Model** | | | | | | |
| Fossil Fuel Energy Consumption | 0.280 | 0.000 | | | | |
| Renewable Energy Consumption | | | -0.177 | 0.001 | | |
| Renewable Electricity Consumption | | | | | -0.002 | 0.015 |
| Foreign Direct Investment | 0.400 | 0.000 | 0.396 | 0.000 | 0.392 | 0.000 |
| Trade Openness | -0.100 | 0.018 | -0.088 | 0.037 | -0.069 | 0.103 |
| Industrial Value Addition | -0.202 | 0.002 | -0.167 | 0.011 | -0.199 | 0.002 |
| Government Expenditure | 0.218 | 0.000 | 0.237 | 0.000 | 0.254 | 0.000 |
| Capital Formation | 0.086 | 0.090 | 0.063 | 0.223 | 0.071 | 0.167 |
| Constant | 2.959 | 0.000 | 4.801 | 0.000 | 3.542 | 0.000 |
| **Random Effect Model** | | | | | | |
| Energy Consumption | 0.290 | 0.000 | | | | |
| Renewable Energy Consumption | | | -0.254 | 0.000 | | |
| Renewable Electricity Consumption | | | | | -0.003 | 0.000 |
| Foreign Direct Investment | 0.383 | 0.000 | 0.379 | 0.000 | 0.373 | 0.000 |
| Trade Openness | 0.041 | 0.286 | 0.059 | 0.114 | 0.075 | 0.048 |
| Industrial Value Addition | -0.671 | 0.000 | -0.663 | 0.000 | -0.654 | 0.000 |
| Government Expenditure | 0.347 | 0.000 | 0.374 | 0.000 | 0.393 | 0.000 |
| Capital Formation | 0.292 | 0.000 | 0.277 | 0.000 | 0.264 | 0.000 |
| Constant | -3.492 | 0.000 | -1.575 | 0.015 | -2.924 | 0.000 |

Regarding industrial value addition, the implementation of environmentally conscious practices and legislation in developing nations may have the potential to significantly reduce emissions of carbon dioxide through the process of industrial value addition. This includes the implementation of sustainable practices, the adoption of cutting-edge technologies, the optimization of resource allocation, the investment in emission control systems, the establishment of environmentally friendly supply chains, the allocation of resources towards renewable energy sources, the enforcement of environmental rules, and so on. Industries can reduce the amount of trash they produce, cut their overall energy consumption, and produce goods that are more innovative and valuable if they place a higher priority on the process of adding value. In addition, many businesses are in a position to allot resources

towards the Introduction of emission control technology, the development of ecologically sustainable supply chains, and the execution of eco-certifications.

Talking about government expenditure, the present study concludes a positive relationship between government expenditure and carbon emission. The reason may be that, in a variety of circumstances, the level of government spending in developing nations has the potential to contribute to an increase in carbon emissions. These include the development of substantial infrastructure projects, the provision of subsidies for fossil fuels, and the adoption of policies that emphasize energy efficiency and the utilization of clean energy sources. These projects usually involve the use of materials that need a significant amount of energy in addition to an increase in the number of activities that involve transportation, which results in increased emissions. The expenditures of the government have the potential to result in a lack of effective enforcement of environmental legislation and insufficient investment in monitoring mechanisms, enabling industries to operate with lower adherence to environmental norms. In addition, the absence of emissions standards and pollution abatement measures in programs for the expansion of industrial activity that the government endorses could lead to increased levels of emissions. According to the findings of the study, there is a positive association between capital formation and emissions of carbon dioxide in developing countries; however, this relationship is not statistically significant.

## 4. Conclusion and Policy Implications

The present study aims to see the factors that improve the environmental quality in some developing economies and also to check the validity of the transition of the economy from fossil fuels to renewables. For this purpose, panel data of a few developing economies has been taken from World Development Indicators ranging from 2000 to 2022. The study encompasses the following countries: Algeria, Thailand, Angola, Sudan, Argentina, South Africa, Bangladesh, Russia, Belize, Pakistan, Benin, Bhutan, Nepal, Bolivia, Bosnia, Brazil, Lebanon, Cambodia, Cameroon, China, Colombia, Congo, Egypt, Gabon, Ghana, Honduras, India, Indonesia, Iran, Jordan, Kenya, Malaysia, Mexico, Moldova, Morocco, Namibia, Nigeria, Philippines, Rwanda, Sri Lanka, Tanzania and Vanuatu. Energy Consumption and Renewables measure Fossil Fuels are measured by Renewable Energy Consumption and Renewable Electricity Consumption. For analysis, fixed effect and random effect models have been utilized. The estimated coefficients conclude that Fossil Fuel Energy Consumption is one of the major causes of higher Carbon Dioxide emissions in some selected developing countries that can be reduced by using Renewable energy electricity consumption.

Moreover, Carbon Dioxide emissions may be reduced by opening trade and industrial expansion. Higher FDI and Government Expenditure may be a source of higher Carbon dioxide emissions in these developing countries. To effectively mitigate carbon emissions and promote environmental sustainability in developing nations, it is prudent to prioritize the promotion and adoption of renewable energy sources, such as solar, wind, hydroelectric, and geothermal energy.

Renewable forms of energy, such as solar, wind, hydropower, and geothermal, are extremely important contributors to the reduction of carbon emissions. Implementing insulation practices that are more efficient and making improvements to the efficiency of transportation networks are two ways in which energy efficiency in buildings, industry, and transportation can be improved. Carbon pricing strategies, such as carbon taxes or cap-and-trade systems, can provide economic incentives that encourage both individuals and organizations to take steps to reduce their emissions. These economic incentives can be in the form of tax reductions or reductions in the cost of doing business. To stimulate and promote investment in renewable energy sources, many sorts of economic incentives, such as cash incentives, tax credits, and subsidies, can be utilized as a means of doing so. These incentives can be used. In addition, it is vital to gradually eliminate or redirect government subsidies that are now supporting the fossil fuel industry to set up a fair and equal

environment for the adoption of sustainable energy alternatives. This is necessary to develop a fair and equitable environment for the adoption of alternative energy sources.

**Authors Contribution**
Furrukh Bashir: study design & concept, critical revision, incorporation of intellectual content
Ismat Nasim: data collection, data analysis, data interpretation, drafting

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