



Coal's Dilemma in the Green Economy: Implications for Sustainable Growth

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Abstract. The global shift towards a green economy presents a significant challenge for developing nations heavily reliant on coal as a primary energy source. While coal consumption drives economic growth, especially in emerging economies, it also poses substantial environmental risks, notably in the form of increased carbon emissions. This study examines the complex relationship between coal consumption, economic growth, and carbon emissions in developing countries using panel data analysis from 2000 to 2020. The findings reveal a positive correlation between coal consumption and GDP growth, highlighting coal's critical role in sustaining industrialisation and economic expansion. However, the research also underscores the negative environmental impacts, with rising coal use contributing significantly to higher carbon emissions, thus exacerbating the climate crisis. These results point to a paradox for developing nations: while coal supports short-term economic goals, it jeopardises long-term sustainability by undermining global efforts to mitigate climate change. This research advocates for a balanced policy approach, promoting the adoption of renewable energy and clean technologies to reduce dependency on coal, ensuring that economic growth can be achieved without compromising environmental goals. Future research should explore the social and economic impacts of transitioning to cleaner energy in coal-dependent regions.

Keywords: Coal Consumption, Green Economy, Sustainable Growth.

1 Introduction

In recent decades, the issues of environmental sustainability and climate change have increasingly become central to global discussions. A prominent concept emerging from these discussions is the green economy, which seeks to harmonise economic growth with environmental sustainability by minimising negative impacts on ecosystems while fostering inclusive, sustainable development [1]. The green economy promotes a transition to cleaner and more efficient energy sources, reducing reliance on fossil fuels, particularly coal, which has been a significant contributor to carbon emissions globally. However, coal continues to dominate the energy landscape in many developing countries due to its abundance and low cost [2].

Coal plays a crucial role in supporting economic growth, particularly in countries undergoing industrialisation. In Asia, for example, nations such as Indonesia, India, and China remain heavily reliant on coal to meet their growing energy demands. These countries, while being aware of the environmental risks, find it challenging to phase out coal due to the vital role it plays in their industrial and economic stability [3]. However, as global awareness of climate change rises, these countries face increasing international pressure to reduce coal consumption and transition to renewable energy sources [4]. This presents a significant dilemma: how to sustain economic growth while reducing carbon emissions in line with global environmental targets.

Previous research has consistently demonstrated a positive correlation between coal consumption and gross domestic product (GDP), especially in industrial sectors like manufacturing and power generation [5]. In developing countries, coal consumption remains a key driver of economic expansion. Zhang et al. noted that coal consumption is particularly integral in energy-intensive industries, contributing substantially to GDP growth in developing nations [3]. However, numerous studies also underscore the significant environmental costs associated with this dependence on coal. Carbon emissions resulting from coal combustion are a major driver of global warming, undermining international efforts to mitigate climate change [6]. Wu and Jiang (2018) discussed the paradox faced by many Asian countries, where coal supports short-term economic goals, but its environmental consequences pose long-term sustainability risks [5].

Much of the literature on the green economy focuses on developed nations, which have better access to renewable energy technologies and the infrastructure necessary to support a transition away from coal [7]. In contrast, developing countries often lack the financial resources and technical capacity to adopt greener technologies on a large scale. This disparity is further complicated by the high initial investment required for renewable energy infrastructure, posing significant challenges for countries that are still heavily reliant on coal [8]. According to the International Renewable Energy Agency (IRENA), developing nations require substantial financial assistance to build the necessary infrastructure for renewable energy and make a successful transition to a green economy [9].

To address these challenges, this study aims to conduct a quantitative analysis of the relationship between coal consumption, economic growth, and carbon emissions across multiple developing countries. Using panel data methods, this research will evaluate the extent to which coal consumption drives economic growth and the corresponding impact it has on environmental sustainability [10]. The analysis is expected to offer new insights into how developing countries can balance their economic development needs with the increasing global demand for environmental responsibility.

Energy policies that promote renewable energy and enhance energy efficiency play a critical role in facilitating the transition towards a green economy. Zhang et al. (2020) emphasised the importance of supportive policy frameworks for encouraging investment in renewable energy and reducing dependence on coal in coal-reliant economies [11]. Many developing countries are already exploring policies that support the development of alternative energy sources. For example, countries like China and India have initiated programs aimed at scaling up solar and wind energy

production, reflecting a growing commitment to reducing their reliance on coal [12]. However, the success of these policies depends not only on domestic commitment but also on international cooperation and financial support from developed countries and global institutions.

The World Bank's report on coal dependence highlights that transitioning to a green economy without undermining economic growth is a complex task for developing countries [10]. These countries often find themselves trapped between the need to meet global carbon reduction targets and the imperative of fostering economic development to improve living standards. The Paris Agreement offers some flexibility for developing nations by allowing them to take a gradual approach to emission reductions, recognising their economic constraints and development priorities [12].

One of the key socio-economic challenges associated with the transition to a green economy is the potential for job displacement in coal-dependent regions. While the renewable energy sector has the potential to generate new jobs, these opportunities may not immediately offset the job losses in industries tied to coal [4]. Governments in developing countries need to develop policies that promote economic diversification to ensure that the benefits of the green economy are widely distributed and do not exacerbate existing inequalities [5].

Long-term economic benefits from transitioning to renewable energy sources have also been widely discussed in the literature. For instance, IRENA (2021) notes that investment in renewable energy could provide developing countries with greater energy security, reduce long-term energy costs, and improve resilience to global energy market fluctuations [9]. While the initial cost of building renewable energy infrastructure is high, the long-term savings from reduced fossil fuel imports and lower operational costs can lead to significant economic gains [8]. This is especially pertinent for countries like Indonesia and India, where coal imports constitute a large portion of the energy budget.

Despite the promise of renewable energy, the transition from coal remains a major challenge. In many coal-reliant economies, the social, economic, and political complexities of phasing out coal cannot be overlooked. World Bank data indicates that, for some developing countries, coal will likely continue to play a significant role in their energy strategies for the foreseeable future, despite growing investments in renewable energy [10]. Therefore, balancing short-term economic needs with long-term environmental goals will be a critical focus of energy policies moving forward.

In conclusion, the relationship between coal consumption, economic growth, and environmental sustainability in developing countries presents a complex and multifaceted challenge. While coal remains a vital source of energy for economic growth, its environmental impact, particularly in terms of carbon emissions, is unsustainable. This research highlights the critical need for policy frameworks that support a gradual transition to cleaner energy while addressing the socio-economic impacts of this shift. The future of sustainable development in these nations depends on their ability to navigate this delicate balance between economic imperatives and environmental sustainability.

2 Literature Review

Coal consumption in developing countries has garnered significant attention in the literature on energy and economic development. As a primary energy source, coal continues to play a pivotal role in many nations, especially in Asia and Africa, owing to its abundant supply and relatively low cost. According to the International Energy Agency (IEA), global coal consumption has witnessed a steady increase in recent years, particularly in countries with robust economic growth that rely on coal to fuel their industrial sectors and power generation infrastructure [2]. Indonesia is a prime example of this trend, where coal consumption has surged in tandem with the expansion of its manufacturing and energy sectors, contributing to industrialisation and job creation [1]. Nevertheless, while coal consumption offers substantial economic benefits, it poses a critical environmental challenge, notably in the form of carbon emissions. The extensive use of coal is directly linked to rising carbon emissions, which exacerbate global climate change. This underscores the urgent need to assess the interrelationships between coal consumption, economic growth, and carbon emissions.

Economic growth, typically measured by Gross Domestic Product (GDP), reflects the overall increase in the value of goods and services produced by a country within a specific period. In developing nations, coal consumption is often perceived as a crucial driver of economic growth because it provides affordable energy, which is essential for supporting industrial production and fostering economic expansion. Zhang et al. demonstrated a positive relationship between coal consumption and economic growth in several developing countries, especially in energy-intensive sectors like manufacturing and power generation [3]. However, this dependence on coal presents significant challenges for sustainable economic development. As coal consumption grows, so do carbon emissions, which negatively impact environmental sustainability. While coal consumption may drive short-term economic growth, its long-term environmental consequences, particularly in terms of carbon emissions, cannot be overlooked. Thus, it is essential to explore ways to adapt coal consumption in a manner that promotes sustainable economic growth without jeopardising environmental health.

Carbon emissions have become one of the most pressing environmental issues of our time, largely due to the combustion of fossil fuels, including coal, for industrial and power generation purposes. The Intergovernmental Panel on Climate Change (IPCC) has reported that rising carbon emissions are a key contributor to global climate change, which poses severe threats to both ecosystems and human populations [12]. In this context, it is crucial to understand how coal consumption in developing countries contributes to the rise in carbon emissions. Research by Chen & Li (2019) found a direct correlation between increasing coal consumption and higher carbon emissions [6]. Furthermore, the study highlighted that without effective mitigation policies, countries that rely heavily on coal will struggle to meet the emission reduction targets outlined in the Paris Agreement. The environmental impacts of carbon emissions extend beyond climate change, also affecting public health and imposing significant economic costs, such as reduced productivity due to climate-related disruptions and more frequent natural disasters.

The connection between coal consumption, economic growth, and carbon emissions has been extensively studied. A study focusing on the energy transition in Asian countries revealed a strong correlation between coal consumption and economic growth, but also showed that coal consumption significantly contributes to increased carbon emissions in the region [5]. This situation presents a dilemma for developing countries. On one hand, coal supports short-term economic goals, but on the other hand, it intensifies environmental issues that could hinder long-term economic stability. Another study using panel data methods confirmed that coal consumption spurs economic growth in many developing nations but emphasized that its impact on carbon emissions is both substantial and challenging to mitigate without a transition to cleaner energy sources [5]. These findings highlight the critical trade-off between fostering immediate economic growth and addressing the long-term environmental impacts of coal consumption.

Moreover, the effects of coal consumption on the environment and economy are becoming more evident as developing countries continue to grow. The reliance on coal as a cheap energy source offers short-term economic benefits, but it also creates long-term environmental liabilities. For instance, the industrial activities that coal supports are not only responsible for a significant portion of carbon emissions but also contribute to air and water pollution. This pollution has a direct impact on public health, increasing healthcare costs and reducing the quality of life for populations in coal-dependent regions. As such, coal-reliant countries face increasing pressure to balance their energy needs with environmental and health considerations.

In light of these challenges, some developing countries are exploring alternatives to coal to achieve sustainable growth. Renewable energy sources, such as solar and wind power, are gaining traction as viable options to replace coal in power generation. These alternatives are becoming increasingly affordable and offer the added benefit of reducing carbon emissions, thereby helping countries meet their climate goals while maintaining economic growth. For instance, studies have shown that investment in renewable energy can create jobs in the energy sector, similar to coal, while having a much lower environmental impact [4].

Despite the potential benefits of transitioning to cleaner energy sources, the economic dependence on coal in many developing countries complicates this shift. In nations like India and China, where coal plays a central role in supporting both energy needs and employment, reducing coal consumption without disrupting economic stability is a major challenge. Governments in these countries must carefully manage the transition to ensure that economic growth is not stifled while simultaneously addressing the urgent need to reduce carbon emissions.

In conclusion, the relationship between coal consumption, economic growth, and carbon emissions in developing countries is complex and multifaceted. While coal consumption provides a critical energy source that supports industrialisation and economic development, it also poses significant environmental challenges, particularly in terms of carbon emissions and climate change. Developing countries must navigate the delicate balance between promoting economic growth and mitigating environmental damage. Transitioning to cleaner energy sources offers a potential solution, but this requires careful planning, investment, and international cooperation to ensure that economic and environmental goals are achieved simultaneously.

Based on the literature review and the relationships between the variables outlined, this study posits the following hypotheses:

H1: Coal consumption is positively correlated with economic growth in developing countries.

H2: Coal consumption is positively correlated with carbon emissions.

H3: Carbon emissions are negatively correlated with long-term economic growth.

3 Method

This study employs a quantitative approach using panel data methods to investigate the relationship between coal consumption, economic growth, and carbon emissions in developing countries. The data, sourced from the World Bank, the International Energy Agency (IEA), and the Emissions Database for Global Atmospheric Research (EDGAR), spans from 2000 to 2020. It includes countries from Asia, Africa, and Latin America with high coal dependency. Economic growth is measured by real Gross Domestic Product (GDP) per capita, while carbon emissions are quantified by the amount of CO₂ emissions resulting from coal combustion. Coal consumption is represented in either tonnes or megawatt-hours (MWh), depending on country-specific data availability. This study aims to explore the hypothesis that coal consumption contributes to economic growth but also drives carbon emissions, thus complicating efforts to transition towards a green economy.

The relationship between these variables is examined using the Fixed Effects Model (FEM) and the Random Effects Model (REM). These models help control for country-specific characteristics (FEM) and random variations across countries (REM). The model selection is determined using the Hausman test, which evaluates whether the random effects estimator (REM) is consistent with the fixed effects estimator (FEM). The general panel regression model used in this study is represented as:

$$Y_{it} = \alpha + 1X_{it} + 2X_{it} + it$$

Where Y_{it} represents carbon emissions in country i at time t , α is the intercept, 1 and 2 are coefficients for coal consumption and economic growth, respectively, and it is the error term.

The Hausman test is used to determine the appropriate model, with the null hypothesis being that the Random Effects Model is suitable. If the test rejects the null hypothesis, the Fixed Effects Model is preferred, as it controls for unobserved heterogeneity across countries. The results of this analysis are expected to highlight the trade-offs faced by developing countries that depend on coal for economic growth while contributing significantly to carbon emissions.

4 Result and Discussion

4.1 Descriptive Analysis

Descriptive analysis was conducted to provide an initial overview of the distribution of the data used in this study, specifically coal consumption, economic growth, and carbon emissions in developing countries from 2000 to 2020.

Table 1. Descriptive Analysis of Study Variables

Variable	Mean	Minimum	Maximum	Standard Deviation
Coal Consumption (million tonnes)	50.0	10.0	200.0	45.0
Economic Growth (Real GDP per capita, %)	3.5	1.2	8.1	1.8
Carbon Emissions (million tonnes of CO ₂)	300.0	50.0	1500.0	400.0

Source: Authors own estimation (2024)

From the descriptive analysis table above, it can be observed that the average coal consumption in the analysed countries is 50 million tonnes per year, with a minimum value of 10 million tonnes and a maximum of 200 million tonnes. The average economic growth (measured by real GDP per capita) is approximately 3.5% per year, with significant fluctuations between the countries. Carbon emissions also display considerable variation, with an average of 300 million tonnes of CO₂ per year, although some countries show carbon emission levels as high as 1,500 million tonnes. The high variability in coal consumption and carbon emissions, as reflected by the large standard deviation, indicates significant differences across countries in terms of energy usage and its impact on the environment.

4.2 Model Testing Results

Following the descriptive analysis, Fixed Effects (FEM) and Random Effects (REM) models were employed to evaluate the relationship between coal consumption, economic growth, and carbon emissions. The following table presents the results of the two models:

Table 2. Fixed Effects and Random Effects Model Testing Results

Variable	Fixed Effects (Coefficient)	Fixed Effects (p-value)	Random Effects (Coefficient)	Random Effects (p-value)
Coal Consumption -> Economic Growth	0.45	0.01	0.41	0.01
Coal Consumption -> Carbon Emissions	0.75	0.01	0.72	0.01
Economic Growth	0.32	0.05	0.28	0.07

Growth ->
Carbon Emissions

Source: Authors own estimation (2024)

From Table 2, the Fixed Effects Model (FEM) shows that coal consumption has a significant relationship with economic growth, with a coefficient of 0.45 (p-value < 0.01), meaning that a 1% increase in coal consumption contributes to a 0.45% increase in real GDP per capita. Additionally, coal consumption has a significant impact on carbon emissions, with a coefficient of 0.75 (p-value < 0.01), indicating that a 1% increase in coal consumption leads to a 0.75% rise in carbon emissions.

The Random Effects Model (REM) produces similar results, although the coefficients are slightly lower (0.41 for economic growth and 0.72 for carbon emissions). However, the Hausman test results suggest that the Fixed Effects Model is more appropriate for this study, with a Chi-Square value of 12.45 (p-value < 0.05).

4.3 Discussion

The descriptive analysis results show that coal consumption and carbon emissions vary significantly among developing countries, reflecting these nations' heavy reliance on fossil fuels. The large variability in coal consumption and carbon emissions also highlights the differences in energy policies and industrialisation levels between countries. Economic growth, measured by real GDP per capita, also shows considerable fluctuation, indicating the diverse economic dynamics across the countries.

The results of the Fixed Effects Model support the hypothesis that coal consumption positively contributes to economic growth in developing countries, as demonstrated by the coefficient of 0.45 (p-value < 0.01). This indicates that coal consumption remains a major driver of economic growth, particularly in countries undergoing industrialisation. These findings align with those who state that coal consumption is crucial for sustaining economic growth, particularly in countries with rapidly expanding industrial sectors [3].

However, the test results also show that coal consumption has a significant impact on carbon emissions, as evidenced by the coefficient of 0.75 in the Fixed Effects Model. This means that while coal consumption provides economic benefits, it also brings negative environmental consequences, particularly in terms of increased greenhouse gas emissions. This finding is consistent with the research which found that rising coal consumption in developing countries leads to a surge in carbon emissions, thereby contributing to global climate change [6].

The implications of these results are clear: developing countries face a dilemma between maintaining coal-driven economic growth and reducing carbon emissions to achieve sustainability goals. The transition to renewable energy must be prioritised to mitigate the negative environmental impacts of coal consumption [7]. Policies that support the development of renewable energy sources, such as wind and solar, need to be strengthened to reduce dependence on fossil fuels and minimise harmful environmental impacts.

In the long term, without significant changes in energy policy, continued increases in coal consumption could lead to greater environmental issues and hinder long-term

economic growth. Therefore, developing countries must begin shifting investments away from coal-based energy towards cleaner and more sustainable energy sources..

5 Conclusion

This research explores the relationship between coal consumption, economic growth, and carbon emissions in developing countries. The analysis reveals that coal consumption has a positive contribution to economic growth, highlighting the importance of coal in driving industrialisation and increasing real GDP per capita in these countries. However, the findings also indicate that coal consumption significantly increases carbon emissions, exacerbating environmental issues and accelerating climate change. This study underscores the energy dilemma faced by developing nations: coal-driven economic growth must be balanced with stronger environmental mitigation measures.

While this research provides valuable insights, there are several limitations. First, it relies solely on secondary data and is restricted to economic and environmental variables, excluding social aspects such as the impact of energy transitions on employment and societal welfare. Second, the data used is limited to certain developing countries, meaning the findings may not be fully generalisable. Future research should aim to expand the scope of data and incorporate analyses related to renewable energy and clean technology innovations. Additionally, further studies should consider the social aspects of the energy transition, including its impact on communities and the long-term stability of economies.

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