CO$_2$ Emissions

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The issue of environmental degradation has emerged as a pervasive global concern. Consequently, authors have expanded their investigations into environmental studies to mitigate the adverse repercussions and safeguard the integrity of the planet's ecosystem. In the context of national priorities, the fundamental goal of any nation is to enhance its economic progress (GDP) rate to foster social welfare. In this scenario, the occurrence of swift GDP can lead to the reduction of resources and the exacerbation of the environment. Sustainable GDP in developing nations improves society. Trade, development, foreign direct investment (FDI), and natural resource (NAT) development have been used to achieve this goal. Production increases energy use and CO$_2$ emissions (CO$_2$em). GDP must not harm future generations.

green investments   renewable energy   education

1. CO$_2$em and Renewable Energy

Since renewable energy (RE) technology is long-lasting and widely available, the authors of [1] recommended using it to reduce environmental degradation. Ref. [1] found that RE reduces environmental degradation and is sustainable. Countries need to increase RE consumption to reduce environmental damage. RE fuels industrialization, potentially improving the environment [2]. RE is more environmentally friendly than fossils [3]. The exponential growth in the utilization of RE sources plays a crucial role in mitigating the adverse environmental consequences [4]. Prior research has examined the relationship between RE consumption and its impact on CO$_2$ emissions, economic progress (GDP), and environmental pollution [5].

The topic of RE has been extensively discussed and analyzed in various academic studies [6]. For example, Ref. [7] have demonstrated a significant positive relationship between carbon dioxide (CO$_2$) and RE.

In a similar vein, Ref. [8] conducted an empirical examination of the relationship between RE and CO$_2$em in China. The study utilized a dataset spanning the years 1980 to 2016, employing the Environmental Kuznets Curve (EKC) framework. The findings of the study indicate that the implementation of RE leads to a significant reduction in carbon dioxide emissions. Ref. [9] examined RE and CO$_2$em in the countries by using the Fourier autoregressive distributed lag (ARDL) cointegration, and found that RE lowers CO$_2$ in the BRICS economies. Ref. [10] used GS2SLS to examine RE and CO$_2$ emissions from 1995 to 2014, and found that RE predicts CO$_2$ emissions because RE causes them. Ref. [11] used a novel QQ approach to study CO$_2$ and RE in the US. They found that RE reduces CO$_2$ emissions. Finally, Ref. [12] found that RE reduces CO$_2$ emissions in Argentina while non-RE increases them.

While these research studies highlight the significant importance of RE for fostering GDP, several other research studies argue that the utilization of RE sources hinders GDP. Abbasi et al., 2020 and Baz et al., 2021 [13][14] conducted empirical investigations on various groups, including developed and developing economies, across different time periods. Their data analysis indicated that the slower GDP rate in these areas could be attributed to the utilization of RE sources. The relationship has generated conflicting arguments, leading to a renewed examination of this connection in emerging economies like BRICS.

2. CO$_2$em and Economic Progress

The increase in global carbon dioxide (CO$_2$) emissions is significantly influenced by recent economic development [15]. The E-7 countries are experiencing a significant transformation in their economic structure, resulting in a detrimental rise in CO$_2$em. Coal is the predominant source of energy in South Africa, thereby presenting a substantial risk to air quality. Similarly, Russia is heavily dependent on the steel, oil, and coal sectors, resulting in a significant escalation of CO$_2$em across the nation. Russia is positioned as the fifth highest emitter of greenhouse gases per capita globally.

Numerous contemporary studies have investigated the correlation between GDP and CO$_2$em. Hence, the empirical findings exhibit inconsistency when considering various factors such as the countries under investigation, the timeframe of the study, the approaches employed, and the techniques utilized. Ref. [16] utilized the wavelet method to investigate the relationship between CO$_2$em and economic progress. A positive linkage was observed between the levels of CO$_2$ emissions in Indonesia and the country's economic development. Similarly, Ref. [17] gathered data spanning from 1971 to 2016 to analyze the influence of CO$_2$em on the GDP of China. The researchers discovered that there is a positive correlation between GDP and CO$_2$em across quantiles (0.1–0.95) when employing the QQR technique. This suggests that the rapid GDP in China has detrimental effects on the environment. In a similar vein, Ref. [18] conducted a study utilizing data spanning from 1971 to 2017. They employed a unique two-gap methodology to examine the relationship between GDP and CO$_2$ emissions in Turkey. The researchers discovered that the pro-growth policy implemented in Turkey is responsible for the environmental degradation observed within the nation.

Furthermore, Ref. [19] utilized frequency domain causality and innovative two-gap methodologies to examine the relationship between CO$_2$em and GDP in Mexico. The findings demonstrate a positive correlation between the growth of Mexico's economy and the escalation of environmental degradation within the country. In contrast, several research findings indicate a negative correlation between GDP and CO$_2$em. Ref. [20] utilized a novel quantile-on-quantile methodology to investigate the association between GDP and CO$_2$ emissions in Sweden, using a dataset spanning the years 1965 to 2019. The researchers discovered that the economic expansion observed in Sweden is associated with a reduction in CO$_2$em, suggesting the presence of sustainable growth within the nation.

3. CO$_2$em and Green Investments

The term "green investments (GF)" refers to services and goods that have an impact on the environment. According to [21], the implementation of GF has been found to reduce energy limitations, leading to favorable outcomes in terms of CO_2em and economic progress. Countries across the globe have commenced allocating financial resources towards diverse green initiatives to facilitate the realization of green GDP. The implementation of these initiatives is closely linked to the preservation of the environment and the achievement of desired outcomes [22]. Ref. [23] proposes the implementation of various advanced technologies to ensure sustainable development. The implementation of green financing for diverse projects can facilitate stakeholders in allocating their research and development funds towards matters pertaining to environmental sustainability [24]. Additionally, the implementation of green financing can help mitigate the financial constraints, enabling stakeholders to make investments in sustainable practices.

GF facilities can help private firms meet these goals [25]. Thus, green financing may make balancing economic development and environmental protection harder. Although important, the relationship between GF and environmental degradation is unexplored. Stakeholders (regulators/governments/organizations) who profit from environmental policies may strategically participate in green financing. Stakeholders must understand GF's benefits. Green financing may depend on environmental improvement [26]. Ref. [27] predicted that GF could reduce fossil fuel consumption by 2.5% by 2030. They also found that RE will generate 46% of global electricity. The authors of [28] used a fixed-effects model to study the association between digital finance and innovation in urban areas utilizing city-level panel data collected in 268 Chinese cities from 2011 to 2019. They found that urban innovation can be effectively increased by digital finance, yet there are notable variations in several areas. Moreover, towns with varying degrees of commercial attractiveness exhibit varied effects of financial technology on urban innovation. The promotional effect of digital money on urban innovation is moderated by the availability of traditional finance. Moreover, in [29] the authors developed a comprehensive measurement for assessing the level of corporate environmental responsibility (CER) engagement. This measurement is utilized to investigate the correlation between CER engagement and firm value. Additionally, the researchers aimed to explore the potential mediating role of corporate innovation in this relationship. The study was conducted using a sample of 496 companies listed on China's A-share market, spanning the period from 2008 to 2016. The findings indicate that the implementation of environmental rules by enterprises initially leads to a decrease in firm value. However, at a certain threshold, the adoption of these policies begins to have a beneficial impact on firm value. Furthermore, it is worth noting that corporate innovation serves as a mediator in the correlation between corporate environmental responsibility (CER) and business value. The implementation of corporate innovation initiatives has been found to have a greater positive impact on the overall value of organizations that possess a Corporate Entrepreneurship Readiness (CER) compared to firms that lack such readiness.

GF includes any production-efficiency-boosting expenditure. Unexpectedly little research has been done on the association between GF and the environment. The impact of GF on CO_2 emissions and RE, however, is rarely highlighted in research. For instance, GF significantly affects sustainable development [30]. According to [31], CO_2 emissions are decreased by private investment in environmentally friendly projects. Additionally, such investment aids developing nations in embracing a green mindset [32]. According to [33], the contemporary media landscape has the potential to incentivize environmentally detrimental firms to address the expectations of their stakeholders

and make substantial advancements in their adoption of sustainable technology. The utilization of diverse environmental regulatory instruments, such as pollution charges and environmental protection subsidies, can have a collective positive impact on the advancement of green technological innovation within corporations. This is achieved through the combined influence of pushback and compensation effects. Furthermore, the implementation of effective environmental regulation tools can strengthen the relationship between the government and enterprises, and enhance the preparedness of heavily polluting enterprises in terms of resources and dynamic capabilities to effectively address public opinion crises. Consequently, this can serve as a moderating factor in the promotion of new media environments, ultimately fostering corporate green technological innovation. Additionally, the impact of the digital economy on national-level industrial eco-efficiency is predominantly positive, with a decrease in marginal returns. The impact of the internet economy on industrial eco-efficiency exhibits considerable variation across different regions. The impact of the digital economy on corporate eco-efficiency is found to be notably good in eastern regions, but it is observed to be detrimental in western regions. The impact of the digital economy on corporate eco-efficiency in China is shown to be negligible, suggesting the presence of digital isolation [34]. The concept of green finance encompasses various interconnected principles. This research provides a concise description of the global events that have contributed to the evolution of green finance, the common forms and instruments utilized in this field, the regulatory framework and issuance process associated with these instruments, and the diverse international agencies and organizations involved in the development and implementation of green finance schemes for specific beneficiary projects [35].

4. CO$_2$em and Foreign Direct Investment

In a recent study by [36], it has been proposed that world economics aims to enhance its economic prospects through the adoption of a multidimensional approach to globalization. Financial globalization and GDP are closely associated with various forms of globalization.

Hence, it can be argued that financial globalization is accountable for the concurrent escalation of GDP and environmental degradation, as evidenced by the increased influx of foreign direct investment (FDI) [37]. According to [38], financial globalization emerges as a prominent factor in the examination of environmental quality. Nevertheless, it is worth noting that financial investments can serve as a catalyst for industrialization, which in turn may result in adverse environmental consequences such as increased degradation and pollution [39].

In [40], among other recent studies, the authors contend that FDI promotes GDP. Additionally, it generates employment opportunities and makes international technology transfers easier. Moreover, international trade activities raise CO$_2$ emissions globally despite environmental agreements [41]. Furthermore, many nations that support financial globalization strategies to achieve globalization-driven GDP view the global FDI data as a significant predictor of CO$_2$ emissions). However, one of the major worries about FDI investments is the potential harm to environmental quality [42]. Since the negative impacts of FDI investments on environmental degradation are disregarded, the economic prospects associated with FDI investments are not maintainable [43]. FDI inflow, mostly via technology routes, positively impacts the climate [44]. Ref. [44] found that FDI boosts GDP and reduces

CO$_2$em. Current research shows that GDP and energy use degrade the environment, but RE and trade via FDI may mitigate these effects.

More usage of RE and FDI information reduce environmental pollution in the American and Asian regions. Ref. [45] conducted an empirical investigation of the association between FDI and environment in China. They found that GDP brought on by FDI enhances the environment by reducing fossil fuel consumption and increasing efficiency. Therefore, one can discuss the economic impact of FDI information on the environment.

5. CO$_2$em and Education

Because education has so many implications for the advancement of knowledge and technology, many people think that the growth of a nation is inversely correlated with the caliber of its education arrangement. Previous findings from research studies already conducted represent two distinct areas of investigation.

While the later feature of the research work bases the positive effect of education in lowering CO$_2$em, the first aspect emphasizes performances that create high CO$_2$em. The first group of proponents argues that because higher education institutions offer a wide range of academic activities, education is to blame for rising CO$_2$em.

Ref. [46] conducted a recent study in Spain wherein they developed a metric to quantify emission activities within a university campus. The study conducted by the researchers revealed that the average CO$_2$em produced by individuals attending educational institutions in the United States amounted to approximately 41 metric tons per person, specifically attributed to transportation activities on campus. Ref. [47] conducted a study in Spain utilizing a dataset spanning from 2011 to 2014. Their findings revealed a consistent trend in CO$_2$ emissions, with approximately 0.55t CO$_2$ attributed to various on-campus activities within higher education institutions. Ref. [48] argue that the implementation of online education is imperative to mitigate CO$_2$ emissions within the higher education sector, thereby reducing the global and regional carbon footprint. This phenomenon occurs because of the significant carbon dioxide emissions stemming from the frequent transportation undertaken by employees and students within the Dutch institutions under examination. The average CO$_2$em per person resulting from housing, mobility, air transportation, food, and consumption were approximately 10.9 metric tons of CO$_2$. Nevertheless, the heat emissions produced by students were minimal.

The 2nd part of the investigation confirms education's positive impact on CO$_2$ emissions using various methods tailored to individual nations. Ref. [49] estimated China's education's CO$_2$ emissions percentage. Higher education affects national and regional environments along with other demographic structures. In another Chinese region, higher education was negatively correlated with CO$_2$ emissions. The ratio was calculated from the 6+ student percentage. Ref. [50] examined education, environmental pollution, and poverty in 22 developing countries using panel data. Their results show that education reduced the negative impacts of the environment. Ref. [51] found that a year of environmental programs reduced CO$_2$em by 2.86 tons. They stressed environmental efforts.

After discussing the research, it is evident that very few studies investigated the impacts of education, renewable energy, and green investment on CO$_2$ emissions in E-7 countries. Most of studies have considered human capital and very few of them consider education expenditures for other regions. Therefore, to contribute to the literature and for updated evidence, this research adds education as a moderator in the linkages of green investment, renewable energy, FDI, GDP, and CO$_2$ emissions in E-7 nations.

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