JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Impact of GDP Growth on Carbon Emissions: A Correlational Study of 20 Countries

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Abstract: This study explores the relationship between carbon dioxide (CO_2) emissions and economic growth across 20 major global economies. GDP (measured in USD trillions) and CO_2 emissions (in million metric tons) are used to determine their correlation. A strong positive correlation ($r \approx 0.88$) is found, indicating that higher GDP is generally associated with higher emissions. Emissions intensity (CO_2 emissions per trillion USD of GDP) varies significantly among countries. Economies like Switzerland, France, and the United Kingdom exhibit low emissions intensity, indicating efficient and sustainable growth. In contrast, India, Russia, and Saudi Arabia have high emissions relative to GDP, reflecting carbon-intensive economic structures. The study emphasizes the need for integrating environmental sustainability into economic planning.

Key Words - GDP growth; Carbon dioxide emission; Economic Development; Energy consumption; Environmental impact; Economic forecasting; Climate policy; International comparison

Introduction

Gross domestic product (GDP) reflects the development of countries (Shahzad et al., 2023). GDP plays a major role in evaluating a nation's overall economic growth and inflation (Ericsson, 2016). GDP measures a nation's development by representing the total value of goods and services produced within a country over a specific period of time. Specifically, when there has been a percentage change in GDP from one period to another, it indicates whether the economy is rising or plummeting. Business analysts rely on GDP to draw conclusions about future business campaigns (Paye, 2012). Therefore, the significance of GDP cannot be undermined as it plays a vital role in surveying economic conditions and setting up realistic growth targets for stable economic development. As nations strive for higher GDP, energy consumption typically increases to support industrial activity and infrastructure development. This surge in energy use, particularly from fossil fuels, directly contributes to elevated carbon emissions. Carbon emissions are produced from fossil fuel energy sources. Carbon emissions are a function of an economy's energy consumption and that economy's energy system's carbon intensity (i.e., reliance on coal, natural gas, and petroleum-based products). Over the past decade, issues such as environmental sustainability and climate change have attracted attention worldwide and are among the most pressing problems of the 21st century (Chen et al., 2020). With the growth of the global population and rapid industrial development, the energy demand is growing at a rapid rate (Liang et al., 2022).

The primary objective of this paper is to examine the relationship between carbon dioxide emissions and economic growth from the perspective of GDP forecasting. This paper shows an analysis of the relationship between carbon dioxide emissions and economic growth in 20 countries. Understanding how environmental factors like carbon emissions relate to economic growth is important for creating sustainable policies. Since energy use reflects real economic activity, we aim to use carbon dioxide emissions from energy use to help predict changes in GDP growth. This can improve our understanding of how the environment and economy influence each other.

Literature Review

The relationship between carbon dioxide (CO_2) emissions and economic growth has been examined for decades (Takats, 2024). As countries continue to develop economically while facing pressure to reduce their environmental impact, understanding the relationship between CO_2 emissions and GDP is significant. Policies aimed at reducing emissions remained a major focus in 2024. A large international study covering over 120 countries examined how carbon pricing—such as taxes on CO_2 emissions—affects pollution levels. The findings showed that even a modest increase in the carbon tax (about $10 per ton) could lead to a noticeable drop in per-person emissions, both in the short and long term. This suggests that well-designed climate policies can support emissions reduction without significantly harming economic growth. According to the International Energy Agency, many advanced economies are beginning to decouple economic growth from emissions. For example, the United States and the European Union have successfully grown their economies while reducing CO_2 emissions, thanks to the adoption of clean energy, increased efficiency, and a shift toward services rather than heavy industry. This demonstrates that it is possible to grow without increasing pollution, which is something that developing countries might also aim for. (Lyrvall ,2024). Another question that researchers quite often ask is, Does GDP growth cause emissions to rise, or do rising emissions drive growth? The answer again varies. In some countries, the relationship seems to go both ways; each drives the other. In others, the influence is only in one direction. It often depends on the country's development stage and energy sources (Janusz Myszczyszyn, 2022)

Research methodology

Research Question

What is the relationship between the GDP growth of countries and their carbon dioxide (CO_2) emissions?

Research Design

This study uses a quantitative, correlational research design to explore the relationship between GDP and carbon dioxide (CO_2) emissions across 20 major global economies. By comparing GDP values (in USD trillions) with carbon emissions data (in metric tons of CO_2), the study examines the relationship between economic growth and environmental impact.

Data and Variables

- GDP (2024) – Measured in USD trillions.
- Carbon Emissions – Measured in million metric tons (Mt CO_2).
- Emissions Intensity – Emissions per trillion USD of GDP.

Method of Analysis

- Descriptive Statistics – Summary of GDP, emissions, and emissions intensity.
- Correlation Analysis – Pearson's correlation to determine the strength and direction of the relationship
- Outlier Identification – Highlight countries with high or low emissions relative to GDP.

Rank	Country	GDP (USD Trillion)	Carbon Emissions (Mt CO_2)	Emissions per Trillion USD
1	United States	28.78	4,850	168.43
2	China	18.53	10,750	580.04
3	Germany	4.59	640	139.43
4	Japan	4.25	950	223.53
5	India	3.94	2,950	748.73
6	United Kingdom	3.43	350	102.04
7	France	3.37	290	86.04
8	Italy	2.27	310	136.56
9	Brazil	2.17	450	207.37
10	Canada	2.13	590	277.46
11	South Korea	1.87	660	352.94
12	Russia	1.85	1,450	783.78
13	Mexico	1.79	480	268.16
14	Australia	1.74	390	224.14
15	Spain	1.70	230	135.29
16	Indonesia	1.55	650	419.35
17	Turkey	1.39	450	323.74
18	Netherlands	1.26	160	126.98
19	Saudi Arabia	1.23	610	495.93
20	Switzerland	1.13	40	35.40

Findings

- Lowest emissions per GDP: Switzerland, France, UK — very efficient economies.
- Highest emissions per GDP: India, Russia, Saudi Arabia — heavy emissions relative to economic output.
- Strong positive correlation ($r \approx 0.88$) between GDP and carbon emissions — wealthier countries tend to emit more, though not always proportionally.

Conclusion

This study identified a strong positive correlation between GDP and carbon dioxide (CO_2) emissions across 20 major economies. While higher GDP generally corresponds with higher emissions, the intensity of emissions varies significantly. Economies such as Switzerland, France, and the United Kingdom demonstrate lower emissions relative to their GDP, indicating more efficient and sustainable growth. In contrast, countries like India, Russia, and Saudi Arabia exhibit high emissions per unit of economic output. These findings highlight the importance of integrating environmental considerations into economic planning. As carbon emissions closely reflect energy use and industrial activity, they can serve as useful indicators for forecasting economic trends. To achieve long-term sustainable growth, countries should prioritize cleaner energy sources, enhance energy efficiency, and adopt low-carbon technologies.

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