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Impact Of Gross Domestic Product On Carbon Emissions

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ABSTRACT

The complex interplay of economic growth and the endeavour for environmental sustainability continues to be a major challenge in the 21st century. The present study investigates the objective of Gross Domestic Product (GDP) and carbon emissions in India, where fossil fuels account for about 73% of the energy mix, is a rapidly developing economy. The research, based on the premise that growth in GDP leads to a proportional rise in carbon emissions, relies entirely on secondary data from the Worldometer Databases over 2001–2016, with cross-validation against Macroeconomic Trends archives.

The methodology employs a quantitative design integrating inferential statistics and correlation analysis. First, a Student's t-test was applied at a 0.05 significance threshold to test the existence of a relationship between GDP and carbon emissions. Second, Pearson correlation analysis was conducted to quantify the strength of association between the two variables. Ethical considerations were addressed through systematic source verification, including the CRAAP framework for currency, relevance, authority, accuracy, and purpose.

The results demonstrate a highly significant statistical relationship ($p < 0.001$) between GDP and carbon emissions. The correlation coefficient ($r = 0.9822$) reveals a very strong positive linear association, affirming that increments in India's GDP are accompanied by nearly proportionate increases in carbon emissions. These findings validate the hypothesis and corroborate earlier scholarship that links economic expansion with intensified environmental degradation, particularly through greenhouse gas accumulation.

The discussion situates these findings within global sustainability debates, emphasizing that India's trajectory exemplifies the environmental costs of growth reliant on non-renewable energy. While economic expansion has delivered enhanced productivity and industrialization, it has simultaneously entrenched pathways of carbon dependency that exacerbate global warming and ecological deterioration. The study acknowledges limitations, particularly the exclusion of confounding variables such as urbanization, technological innovation, and trade openness, which may also influence emissions dynamics.

Policy implications are twofold: (i) stricter regulatory frameworks to curtail carbon-intensive energy consumption, including vehicular emissions and industrial fuel use, and (ii) accelerated integration of renewable energy technologies to decouple growth from environmental harm. This research underscores the urgent need for multivariable, interdisciplinary approaches to environmental economics that move beyond GDP as the sole explanatory factor and advance frameworks for sustainable growth in developing economies.

INTRODUCTION

Context and Background

Natural-based based-fuels account for approximately 73% of the energy mix, and their consumption leads to a rise in carbon emissions released to the environment (Tejvan, 2019). These fossils are usually composed of hydrogen and carbon. Importantly, whenever the fuels are combusted, air combines with carbon, leading to the formation of carbon dioxide in the environment. On the other hand, hydrogen will combine with oxygen, leading to water formation. The production of heat energy characterizes the combustion and combination reactions involved. This energy is consumed and used in industrial operations. Importantly, the total amounts of carbon dioxide gas produced depends on the carbon content in the fuel used. The content of carbon dioxide produced from natural gases is less compared to other fossil fuels, such as petroleum and coal (Tejvan, 2019).

India is one of the wealthiest countries in the world. According to Trading Economics (2023), the country stands at the 5th position in the world's richest countries, with an estimated economic growth of $ 3.38 trillion. Economic growth entails the real, measurable gross domestic product (GDP). Whenever there is an increase in GDP in the country, there is an idealized rise in consumption and real output, with a tentative cost imposition on the environment. The environmental impacts of improved GDP include increased consumption of non-renewable resources, an increase in pollution levels, global warming, and deterioration of environmental habits, among others. In accordance with the scientific study of Ibrahim and Ajide (2021), not all forms of GDP will have a direct negative environmental impact. Importantly, however, the same study has recommended greater responsibility in devoting resources towards ensuring environmental protection and mitigating factors of harmful pollution effects as economic growth increases.

This investigation will examine the impact of India's GDP on the amounts of carbon emissions released in the same country. Secondary database sources will be used to carry out the investigation. Once the data has been collected, it will be subjected to different statistical tools, including a t-test and Pearson correlation for analysis. The analysis will be aligned to past reviewed scientific literature before concluding.

THE HYPOTHESIS OF THE STUDY

It is hypothesized that there will be a strong relationship between India's GDP and the amounts of carbon emissions. It is expected that a change in the country's GDP level will lead to a corresponding change in the amounts of carbon emissions. This hypothesis is supported by the study of Tejvan (2019) supposes that a positive variation in the economic growth of a country is a serious threat to global warming and environmental degradation.

Variables

Independent Variable

The independent variable in this environmental study will be taken as India's yearly gross domestic product (GDP). The data of this variable will be obtained from an online database for a period varying from 2001 to 2016.

Dependent Variable

The dependent variable in this investigation will be taken as the yearly amounts of carbon emissions in India. This variable will be obtained from an online database and then compared and analyzed with GDP data.

Control Variables

Two main variables will need to be controlled in this investigation to ensure consistency, accuracy, and reliability assessment of the dependent variable with respect to the independent variable.

- **Source of Data:** All data values will be obtained from the same online platforms, the worldometers site for the GDPs of India and the worldometers site for the amounts of carbon emissions of India, respectively.
- **Period of Study:** The data will be collected for 16 years for the independent and dependent variables.

METHODOLOGY

A secondary approach was adopted in investigating the impact of India's GDP on the amounts of carbon emissions released in the same country. Two online database platforms were used to find the data for the carbon emissions and GDP of the country for sixteen years https://www.worldometers.info/co2-emissions/india-co2-emissions/, and https://www.worldometers.info/gdp/india-gdp/, respectively. The data obtained were recorded in Table 1 below.

Ethics and Approach

Special consideration was given to the reliability and accuracy of data sources. To achieve this credibility, similar data sources, including the macro trends databases, were used to check whether the data compared with the world meter sources. Additionally, a CRAAP test was conducted on the data sources to assess the level of currency, relevance, authority, accuracy, and purposefulness of the data sources.

Data Overview and Treatment

Data Collected

Table 1: Carbon Emissions and GDP in India

Year	Carbon Emissions (Tons)	GDP ($ USD)
2001	1,082,142,730	485,441,026,156
2002	1,116,841,480	514,937,961,194
2003	1,209,890,700	607,699,299,977
2004	1,262,993,900	709,148,531,775
2005	1,358,357,200	820,381,672,148
2006	1,443,280,400	940,259,892,375
2007	1,741,058,900	1,216,735,426,855
2008	1,843,399,100	1,198,895,498,504
2009	1,741,058,900	1,341,886,699,393
2010	1,843,399,100	1,675,615,312,693
2011	1,958,193,900	1,823,049,927,772
2012	2,086,788,400	1,827,637,859,136
2013	2,157,168,200	1,856,722,121,394
2014	2,328,013,400	2,039,127,446,299
2015	2,419,637,200	2,103,587,813,812
2016	2,583,638,100	2,290,432,075,244

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Graphical Presentations

The data presented in table 1 above was used to generate graphical plots of Gross Domestic Products against time factors for the 16 years and carbon emissions against time for the same period, as presented in graphs 1 and 2 below.

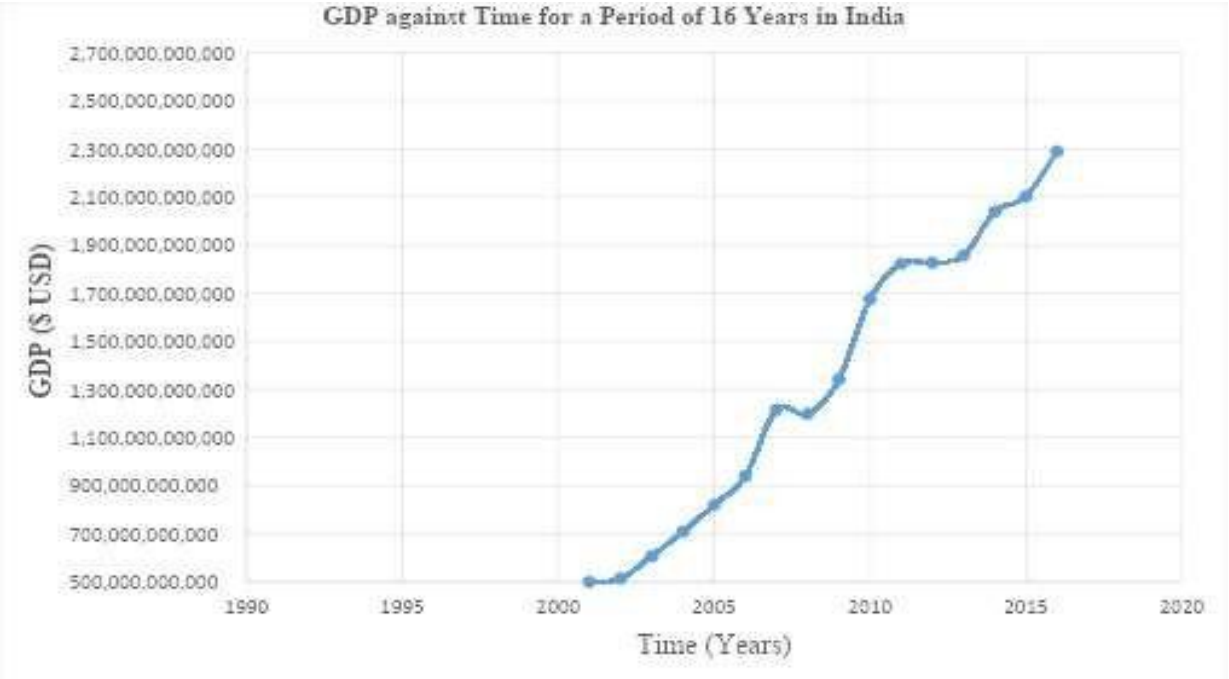

Figure 1: A Graph of GDP against Time for 16 Years in India

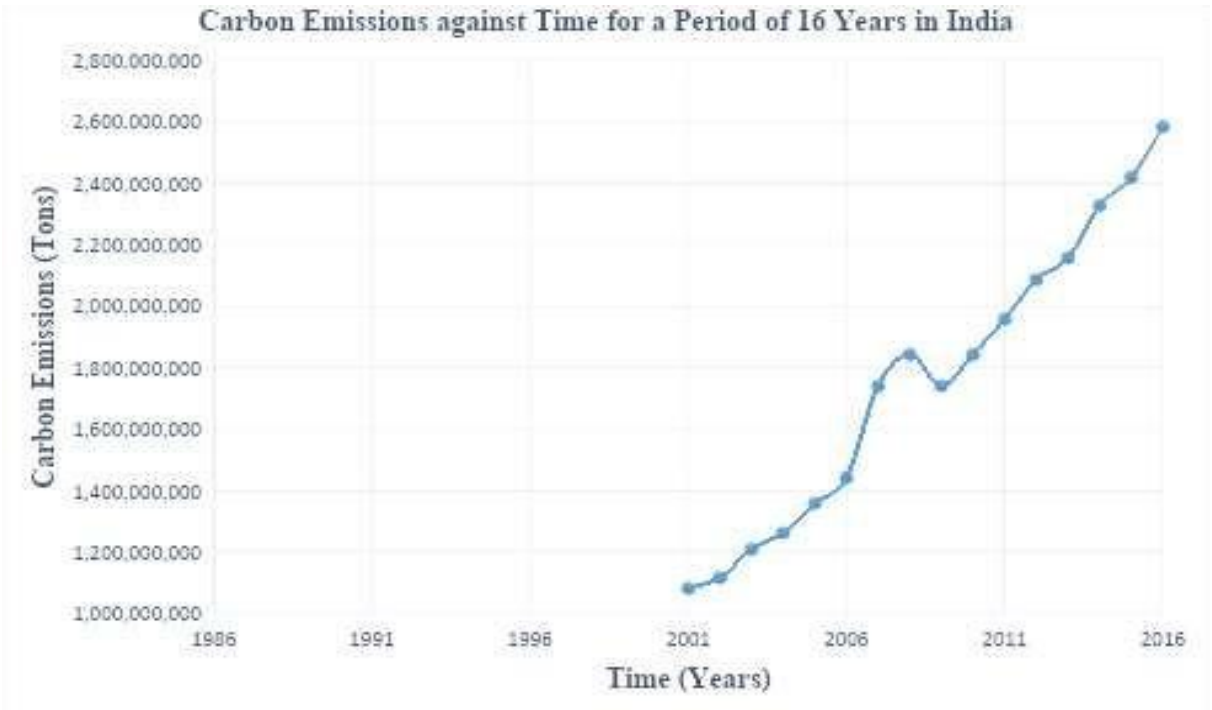

Figure 2: A Graph of Carbon Emissions against Time for 16 Years in India

The graph in figure 1 above clearly demonstrates that India's GDP has been on an upward trajectory over the last 16 years considered in this investigation. Ideally, the GDP of the country has been rising from 485,441,026,194 USD in 2001 to 2,290,432,075,244 USD in 2016; approximately 78.81% rise without any remarkable drop. The later years were excluded from the investigation due to the effects of the inflation rates that had hit the country and the recent pandemic of Coronavirus. On the other hand, the graph in the figure demonstrates that the production of carbon emissions in the country has also been

on an upward trajectory. Essentially, in 2001, carbon emissions were, 1,082,142,730 tons, rising to 2, 583,638,100 tons, approximately 58.12 % increase. Thus, the two variables have been increasing over the study period. However, to determine whether improvement in GDP has had any significant effect on the rates of carbon emissions in India, there was a need for statistical tests.

Student T-test for GDP and Carbon Emission Amounts

This test involves a comparison of mean values of the two variables (μ) to determine the existence of a statistical relationship between them. A significance level has to be specified. For this investigation, a significance level of 0.05 will be assumed for the country's carbon emissions and GDP levels. The p-value obtained from the t-test will then be compared with the significance level. The hypotheses for this test were defined as follows;

Null Hypothesis, H0: There is no significant relationship between Gross Domestic Product and carbon emissions in India ($\mu>0.05$).

Alternative Hypothesis, H1: There is a significant relationship between Gross Domestic Product and carbon emissions in India ($\mu\leq0.05$).

Once the variables had been defined, the raw data presented in Table 1 were used to carry out the Student t-test in MS Excel, and the output results were tabulated as in Table 2 below.

Table 2: t-Test Output, Assuming Unequal Variance

	GDP Variable	Carbon Emission Variable
Mean	1.34072E+12	1760991351
Variance	3.75738E+23	2.29265E+17
Observations	16	16
Hypothesized Mean Difference	0	
Df	15	
t Stat	8.737466768	
P(T<=t) one-tail	1.42986E-07	
t Critical one-tailed	1.753050356	
P(T<=t) two-tail	2.85973E-07	
t Critical two-tail	2.131449546	

From the results output, the p-value was found to be 2.85973E-07, a value smaller than the assumed significance level of 0.05. Based on this observation, the alternative hypothesis was satisfied, indicating a significant relationship between Gross Domestic Product and carbon emissions in India.

Statistical Correlation between GDP and Carbon Emissions

The precise level of correlation between the variables was to be determined after ascertaining that there is a significant relationship between Gross Domestic Product and carbon emissions in India. Different statistical approaches can be used to work on the correlation. However, for this investigation, the Pearson correlation method was found to be most appropriate since the formula finds the exact degree of correlation, in accordance with the study of Turney (2022). The Pearson correlation is deemed fair if it is greater than 0.5 (or -0.5) and very strong if it is found to be greater than 0.7 (or -0.7).

Where;
x_i=Values of the first variable; Gross Domestic Product, with respect to this investigation
y_i=Values of the second variable; carbon emissions, with respect to this investigation
x=The mean of the Gross domestic product of India in the period considered
y=The mean of carbon emissions in India in the study period
n=Number of values in the datasets;16 for this investigation
Using the data values in table 1; a table of processed data was developed to obtain the coefficient.

Table 7: GDP and Amounts of Carbon Emission for Pearson Determination

-855,281,384,139	-678,848,621	7.31506E+23	4.60835E+17	5.80607E+20
-825,784,449,101	-644,149,871	6.8192E+23	4.14929E+17	5.31929E+20
-733,023,110,318	-551,100,651	5.37323E+23	3.03712E+17	4.0397E+20
-631,573,878,520	-497,997,451	3.98886E+23	2.48001E+17	3.14522E+20
-520,340,738,147	-402,634,151	2.70754E+23	1.62114E+17	2.09507E+20
-400,462,517,920	-317,710,951	1.6037E+23	1.0094E+17	1.27231E+20
-123,986,983,440	-19,932,451	1.53728E+22	3.97303E+14	2.47136E+18
-141,826,911,791	82,407,749	2.01149E+22	6.79104E+15	-1.16876E+19
1,164,289,098	-19,932,451	1.35557E+18	3.97303E+14	-2.32071E+16
334,892,902,398	82,407,749	1.12153E+23	6.79104E+15	2.75978E+19
482,327,517,477	197,202,549	2.3264E+23	3.88888E+16	9.51162E+19
486,915,448,841	325,797,049	2.37087E+23	1.06144E+17	1.58636E+20
515,999,711,099	396,176,849	2.66256E+23	1.56956E+17	2.04427E+20
698,405,036,004	567,022,049	4.8777E+23	3.21514E+17	3.96011E+20
762,865,403,517	658,645,849	5.81964E+23	4.33814E+17	5.02458E+20
949,709,664,949	822,646,749	9.01948E+23	6.76748E+17	7.81276E+20

The mathematical value of Pearson correlation would therefore be;
The coefficient of correlation value of 0.9822 was indicative that, yes, there is a very strong and positive relationship between the two variables. A change in the country's GDP level will lead to a corresponding change in the amounts of carbon emissions.

DISCUSSION AND CONCLUSION

This environmental investigative study was designed to examine the impact of India's GDP on the amounts of carbon emissions released in the same country. It had been hypothesized that there would be a strong relationship between India's GDP and the amounts of carbon emissions. It had been expected that a change in the country's GDP level would lead to a corresponding change in the amounts of carbon emissions. Data was collected from worldometers sources. For analysis, the data were subjected to two statistical tools, the t-test and Pearson correlation. The t-test tool used revealed a significant relationship between Gross Domestic Product and carbon emissions in India. Pearson correlation was used to test the level of identified correlation or relationship between the two variables. The strong correlation coefficient (0.9822) obtained between the variables of this investigation identifies that the improvement of Indian GDP has had a direct impact on the deterioration of global warming through carbon emissions (greenhouse gases) and a sufficient confirmation of the pre-defined variable. In addition, and of more importance, is the strong correlation coefficient. This finding was in line with the scientific study of Tejvan (2019), which established that a rise in the positive economic growth of a country is a serious threat to global warming and environmental degradation. Essentially, when the economy is improving, there will be a corresponding increase in economic activities in the country. As a result of increased economic activities, there will be a tentative rise in energy consumption and utilization of natural resources. Since natural fuels account for approximately 73% of the energy mix, their consumption increases carbon emissions released to the environment.

EVALUATION OF THE STUDY

There were several remarkable strengths in this investigation. First, a large sample of data was used to develop and analyze the effect of GDP on the number of carbon emissions (sixteen years). Using a large sample ensured there was control over the risk of either false-positive or false-negative findings. In addition, the large sample size of data significantly contributed to the validity of the final results. Despite all these strengths, there was a notable limitation. Ideally, there exist several other factors that may have a direct impact on carbon emissions besides the GDP. These factors include industrialization, progress in technology, and urbanization. Therefore, it would be important to consider at least two more factors in addition to GDP on the amounts of carbon emission in India through a multivariable approach for a comprehensive analysis.

Suggested Solutions of the Study

This environmental investigation proposes a few recommendations for reducing carbon emissions in India and beyond. The country needs to develop laws to control carbon-based energy sources, despite the continued rise in GDP. These measures are suggested both at individual and industrial levels. In addition, the country's administration can ban or lower the number of vehicles consuming carbon-based fuels. These recommendations, if evaluated and adopted, would encourage people and industries to reduce the amounts of carbon dioxide released, hence the measurable amounts of carbon emission. This scientific study was developed with the realization that India, like many other countries, has implemented renewable energy, including sun, biomass, and wind. The renewable energy uses do not run out. However, there is a need to incorporate more technological research and increase such sources' use to reduce carbon emissions further.

AUTHOR'S NOTE

This paper was independently conceived, researched, and authored during the author's higher secondary education (Grades 11-12), undertaken as part of the Internal Assessment (IA) in Environmental Systems and Societies (ESS) at Standard Level (SL), a core component of the International Baccalaureate Diploma Programme (IBDP).

The subject matter of the investigation aligns with the author's current undergraduate academic trajectory at Jain (Deemed-to-be University), where he is enrolled in the Bachelor of Business Administration (BBA) programme with a specialization in Data Science and Analytics.

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