# Effects of Macroeconomic Trade Variables on Carbon Emissions – An Empirical Study of BRICS Nations

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**Abstract**

"At present, we are stealing the future, selling it in the present and calling it gross domestic product" – Paul Hawken. The time has arrived when climate change isn't just a fantasy but a reality. Environmental sustainability should be the golden trump card as we awaken ourselves to work on suitable action against climate change. This research study emphasizes the effects of macroeconomic trade variables on carbon emissions in BRICS nations. Carbon Emissions (CO2) were chosen as the dependent variable, with Gross Domestic Product (GDP), Exports (EXP), and Imports (IMP) as the independent variables. An attempt has been made to study this effect using panel data regression analysis. Using the fixed effects model, we have been able to identify that GDP and Carbon Emissions have a negative relationship. In contrast, Exports and Imports have a positive relationship with Carbon Emissions. Furthermore, the findings from the research study imply that an enhanced methodology of policymaking, including the promotion of trade reforms and environmental sustainability, should be formulated in alignment with the Sustainable Development Goals. The BRICS nations play a paramount role in the global GDP and trade. Hence it is of utmost importance and relevance that the macroeconomic indicators don't cause environmental imbalance and prove to threaten sustainability.

*Keywords – Climate Change, Environmental Sustainability, Carbon Emissions, Gross Domestic Product, Exports, Imports, Panel Data Regression, Fixed Effects Model, Trade Reforms, Sustainable Development Goals*

## Introduction

Primarily, the hazardous concern of climate change is slowly and gradually asking more questions from policymakers worldwide as it has become the issue of the hour and much more in the foreseeable future. The release of carbon emissions into the atmosphere, mainly due to human activities like burning fossil fuels, deforestation, and industrial processes, is one of the primary causes of climate change. Although traditionally developed nations have been the most significant carbon polluters, developing economies

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like the BRICS (Brazil, Russia, India, China, and South Africa) have significantly increased their share of global carbon emissions due to their fast economic development and rising trade quantities.

The most significant greenhouse gas emitted by human activity, carbon dioxide, accounts for about 76% of all greenhouse gas emissions, according to the Intergovernmental Panel on Climate Change (IPCC, 2014). China and India are the world's top two and third most significant emitters of carbon dioxide, respectively, among the BRICS countries (Le Quéré et al., 2018). As assessed by Gross Domestic Product, carbon emissions and economic growth are closely correlated. Energy consumption rises along with economies, which causes a rise in carbon pollution. According to research in the Journal of Energy Economics, BRICS nations' average CO2 emissions increase by 0.46 percent for every 1% growth in GDP. (Wang et al., 2017)

Globally, trade-intensive nations typically have more significant carbon emissions. This is a result of the increased exportation of products, which requires more energy to create. In BRICS nations, openness to trade (measured as the ratio of exports + imports to GDP) substantially affected CO2 emissions, according to research published in the journal Energy Policy. (Moutinho et al., 2020). Similar to exports, imports may influence carbon pollution. By essentially outsourcing some of their carbon emissions to the nations where the goods were made, countries that import goods do so. Embodied carbon emissions refer to such. According to the Journal of Environmental Science and Policy research, imports significantly reduced CO2 emissions in the BRICS nations. (Shi et al., 2018).

In the BRICS nations, carbon pollutants come from various sources. The most significant source of carbon pollution in China and India is the energy sector, followed by transportation and manufacturing. While business and transit are the main contributors to carbon emissions in Russia, deforestation and farmland are the most significant contributors in Brazil. The petroleum industry in South Africa is the primary source of carbon pollution.

On the other hand, a significant effect of the BRICS on climate change is anticipated. Since they are major partners in any regional or international discussions relating to climate change or the production and consumption of energy due to the size and rate of growth of their economies, their energy demand, their energy imports (for example, in the case of China and India), and their atmospheric emissions of various types. (Arcas, 2013)

Finance, technology, and international collaboration are the critical drivers for accelerating climate action. Finance for both adaptation and prevention would need to multiply many-fold to meet climate objectives. There is enough money in the world to fill the funding shortages, but it is difficult to divert money to climate change initiatives. Accelerating the general adoption of technologies and practices requires improving technology innovation processes. There are numerous ways to improve foreign collaboration. (AR 6 Synthesis Report ,Climate Change 2023, 2023)

The current research uses a descriptive method to document the BRICS country's climate change efforts and policies. Despite focusing on and reiterating the same aim at their summits, BRICS nations still need to catch up to OECD, non-OECD, and EU member states in achieving climate change and sustainable development objectives. The nine BRICS summits have strengthened the nation's resolve to implement climate change policies. (Rahman & Turay, 2018)

In the BRICS countries, a significant portion of carbon emissions is caused by creating products and services for export. For example, the UN Conference on Trade and Development reports that BRICS shipments rose from $782 billion in 2000 to $4.6 trillion in 2018. As a result, there has been a rise in energy use and carbon emissions, as well as extra emissions from the movement of products across borders. The Organisation for

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Economic Co-operation and Development (OECD) conducted research that revealed a 56% rise in the carbon impact of BRICS shipments between 2004 and 2014. Nevertheless, this increase in exports has prompted a rise in output and transportation, raising carbon emissions. According to a study by Wang et al. (2018), China's growing export tendency has caused a significant rise in carbon emissions. Similar findings were made by Malla and Timilsina (2017), who discovered that India's increased shipments have increased carbon emissions.

BRICS nations heavily depend on imports to meet their consumption requirements because they are unable to meet domestic demand through domestic production alone. Due to this, there has been a rise in the transportation of goods and products, raising carbon emissions. Additionally, the import of goods that require much energy, like fossil fuels, also considerably increases carbon emissions. For instance, crude oil and petroleum goods, which are important sources of carbon emissions, are imported by India at the third-largest rate in the world. China is also the biggest importer of coal, which contributes significantly to carbon emissions.

Sustainable Development Goals, one of the most pioneer and prominent goals of the United Nations, are intended to make this world a better place to live in. It is through the implementation of the 17 developmental goals and 169 targets that the organization attempts to make transformative changes through the three dimensions of sustainable development, which are economic, social, and environmental. (Nations) Since carbon emissions are a major contributor to climate change and have a variety of negative effects on the ecosystem and society, they are a serious worry for the entire world community. As a result, lowering carbon emissions is crucial for accomplishing sustainable development objectives like lowering poverty, fostering economic growth, and maintaining the ecosystem.

It can be difficult to strike a balance between economic growth and environmental sustainability while still achieving sustainable development objectives. In conclusion, lowering carbon emissions is crucial for reaching sustainable development objectives and necessitates a variety of governmental changes, technical advancements, and behavioral changes in society. Governments, the business sector, civic society, and local groups must work together to achieve these objectives, and both economic growth and environmental sustainability must be balanced.

## Review Of Literature

### *GDP and Carbon Emissions*

Growing economic activity may have very mixed natural effects, which need to be considered individually. The economic development in Brazil and Russia is the primary factor causing an increase in CO2 emissions. We discover that CO2 emissions are variables explained by their lag in a year for China, India, and South Africa, i.e., there is no discernible correlation between economic development and CO2 emissions. It does not, however, imply that the amounts of CO2 emissions have decreased (G., Sartori, & Campos, 2018). (Kais & Sami, 2016), put forward that a 1% increase in the per capita GDP leads to a 0.927% rise in carbon emissions. Along with it is found that a 1% decrease in trade openness leads to a 0.0011% decrease in carbon emissions, and a 1 % increase in per capita energy use leads to a 0.843% increase in carbon emissions. Furthermore, the paper affirms that energy production is a major factor in the generation of carbon emissions, and it can have a direct impact on various macroeconomic variables.

According to (Akalpler & Hove, 2018), it was discovered that the short-term impacts of the previous value, Gross Fixed Capital Formation, Energy Consumption, Carbon Emissions, and Imports on the Indian economy's Real Gross Domestic Product per Capita were identified. Also Gross Fixed Capital Formation and Exports did, however, play a major role over the long term. Along with it, Carbon dioxide emissions, energy use, gross fixed capital formation, real GDP per capita, exports, and imports were cointegrated in

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the Indian economy. The paper also puts forward that the Indian government authorities must show a real commitment to cutting carbon dioxide emissions if it hopes to achieve sustainable development and a healthy environment. As per the long-term capital stocks and return rates, capital is considered to be mobile between nations. The BRICS economies saw greater increases in real GDP over time, according to a comparison of the short- and long-term impacts of opening intra-BRICS trade. These larger real GDP growth rates were mainly brought on by rising capital stock levels within the BRICS economies. Accordingly, depending on the strength of scale effects, a greater rise in real GDP causes an increase in carbon emissions. (Aydin, 2016)

(Huang, Lee, & Wu, 2007), investigated The Kyoto Protocol aims to steer the Greenhouse Gas (GHG) emissions of participating industrialized nations from a positive growing tendency to a peak point (or turning point) and then be lowered to a negative growth through political talks. This supports the idea of the Environmental Kuznets Curve (EKC) theory, according to which the connection between declining GHG emissions and economic development may be represented by an inverted-U curve (also known as a bell-shaped curve). This study found that the economic growth and GHG emissions in Economies in Transition (EITs) show a hockey-stick curve trend (also known as a quasi-L-shape curve), which also produces a lot of "hot air" and is important for the Kyoto Protocol's application.

As per (Sebri & Ben-Salha, 2014) BRICS nations have been acknowledged as being important forces behind the economic expansion in developing markets, and predictions indicate that they may soon rank among the most powerful economies. Also, the growth of the renewable energy sector is largely driven by an increase in income, which goes to demonstrate how important renewable energy is becoming in promoting economic growth in the BRICS nations. Additionally, empirical findings highlight the impact of economic openness and CO2 pollution while encouraging the use of renewable energy. On the one hand, trade openness allows BRICS nations to gain more from the transfer of "green technologies," which encourages investment in the field of renewable energy.

For the energy-dependent BRIC countries, increasing both energy supply investment and energy efficiency, as well as stepping up energy conservation policies to reduce unnecessary energy waste, can be started in order to reduce emissions without negatively affecting economic development. (Pao & Tsai, 2010)

### Financial Development , Economic Trade and Carbon Emissions

(Boutabba, 2014) investigated the impact of financial development, income, energy and trade on Carbon emissions with evidence from the Indian economy. It was found that there are a long-run and causal relationships between per capita CO2 emissions, financial development, per capita real GDP, the square of per capita real GDP, per capita energy use, and trade openness, with financial development having a long-run positive impact on per capita CO2 emissions. This indicates that environmental degradation happens when financial development improves. The information seems to indicate that emission reduction policies won't impede economic expansion and might be a workable tool for India's long-term sustainable development.

Based on data from 182 nations between 1990 and 2015, the heterogeneous effects of trade openness on carbon emissions show that trade openness reduced emissions in high-income and upper-middle-income nations while having little to no effect on emissions in lower-middle-income nations. Worse yet, trade openness increased emissions in low-income nations. An important policy implication denotes that while manufacturing trade products, developing nations should use clean and environmentally friendly technologies. Additionally, increasing the proportion of the tertiary sector in foreign direct investment is a workable method to contribute to reducing environmental pollution as global trade is liberalized (Wang & Zhang, 2020).

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(Dogan & Seker, 2016) investigated the influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in top renewable energy countries. From their studies, they have found out that increase in renewable energy consumption, trade openness, and financial development decrease carbon emissions. In contrast, increases in non-renewable energy consumption contribute to the level of emissions. The research also suggests that the net environmental impact of trade openness and financial development is positive, implying reductions in environmental deterioration.

The BRICS nations have a comparative edge in dirty manufacturing of dirty products as evidenced by the positive coefficient of liberalisation effect that is represented by the sum of imports and exports as a share of total GDP. This finding strongly suggests that BRICS countries' CO2 emissions per person rise by 1.08% for every 1% increase in trade liberalisation. Free commerce is, therefore, detrimental to the environment (Mehrara & Rezaei, 2013). The BRICS countries' poor air quality was made worse by industrial development, a less diversified export base, a low concentration on traditional exports, and a high concentration on new exports. On the other side, the chosen countries find that technological advancement has a negative effect on carbon emissions. The computed findings allow for the possibility that technological advancement and a greater focus on traditional exportable goods could strengthen the environmental quality in the BRICS countries(Sharma, Sinha, & Kautish, 2021).

The BRICS countries are currently exploring plans to introduce an innovative currency that could be advantageous for their macroeconomic operations as they work to become one of the most powerful global powers. The plan is to transition to using domestic currencies in transactions at first and then introduce and circulate a digital or alternative form of a ground-breaking currency in the near future (Merchant, 2023).

## Sustainable Development Goals and BRICS

Assessments of the effects of Carbon Dioxide Removal (CDR) on the SDGs should become more transparent in terms of their factual foundation and increasingly incorporate trial activity experiences as they start to materialise. As part of the periodic planning processes required by the Paris Agreement for revising NDCs, domestic CDR policies or actions should be evaluated with respect to their possible risks and advantages in national settings. Updating long-term low GHG pollution growth plans every five years would enable a comprehensive evaluation of the local applicability of CDR and emissions reductions measure portfolios, preventing the absence and overlap mistakes that are all too frequent for concurrent policy planning processes. (Honegger, Michaelowa, & Roy, 2020)

The reality that the present economic system significantly depends on economic growth is the primary cause of the conflict between the different SDGs. Both spending and development. However, when concentrating on expenditures in health programs, education, and sustainable technologies (like green energy generation) rather than on pure economic development, there are methods to prevent the clash between environmental and social SDGs. However, reducing consumption can also reduce the impact of GDP per capita, which in turn could have an impact on rising consumption-based emissions (Spaiser, Scott, Owen, & Holland, 2018). (Sezgin, Bayar, Herta, & Gavriletea, 2021) noted that environmental viability depends on human growth and strict environmental regulations. Environmentally strict policies, however, can have a negative impact on jobs and economic development by driving up initial costs. However, the \ nations cannot accomplish their environmental goals without having consistent environmental policies. Therefore, each nation should create a blend of environmental policies that take into account its unique features.

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## Research Gap

International trade constitutes a huge share of economic transactions between nations. BRICS nations being one of the largest shareholders of Gross Domestic Product and international trade, contribute heavily into the production and consumption framework globally. It is of greater importance to understand that there has not been much of an exploratory analysis regarding the effect of these variables on the carbon emissions in BRICS nations. As many variables are inter-linked with each other, the effect of exports and imports on environmental sustainability is less discussed as of now. Consequently, it has been noted that the current studies on the mentioned areas have provided with limited scope for policy recommendations.

## Research Objectives

The aim of this paper is triple fold:

To individually analyse the effect of GDP, Exports and Imports on Carbon Emissions in BRICS nations.

To explore the macroeconomic policy implications regarding the environmental sustainability in BRICS nations.

To provide suggestions and alternatives which will boost the prospect of Sustainable Development Goals.

## Area of Study

The strong alliance of the world's major developing market economies—Brazil, Russia, India, China, and South Africa—goes by the abbreviation BRICS. The BRICS mechanism seeks to advance collaboration, growth, security, and harmony. It also seeks to create a world that is more equitable and just while making a major contribution to the advancement of humankind. In the last 15 years, BRICS nations have tripled their portion of the global GDP. According to market exchange rates, the proportion of the BRICS in global production will rise from 18% to 25% to 26% over the following ten years and even to one-third by 2030.This group of nations is now the dominant force in the development of the global economy thanks to their 50% addition to the rise of the global economy over the past ten years.

BRICS nations play an indispensable role in world trade, with 17% of global trade occurring within these nations. (Fifth BRICS Summit - general background, n.d.)Along with economic development, the perspective of environmental sustainability and conservation is also a pivotal topic to be discussed. The statistics of these nations regarding the environmental threat of carbon emissions are also of no lesser significance. China is the biggest carbon dioxide emitter in the world, contributing about 28% of all carbon pollution. With about 7% of the world's carbon pollution, India is the third-largest carbon dioxide producer. About 4% of the world's carbon pollutants are produced by Russia, Brazil, and South Africa.

BRICS nations being one of the powerful alliances in the world economy and simultaneously contributing heavily to showcase these factors, proves to be suitable for conducting this research study. It also enables a prolific viewpoint of the evolving environmental and economic scenario to establish the findings of this study.

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## Data – Variables, Sources and Description

For the proposed research study, we have taken the following variables into account.

***Carbon Dioxide Emissions***

Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. (Bank, Metadata Glossary, n.d.). Carbon dioxide (CO2) makes up the largest share of manmade greenhouse gases. The addition of man-made greenhouse gases to the atmosphere disturbs the earth's radiative balance (i.e., the balance between the solar energy that the earth absorbs and radiates back into space). This is leading to an increase in the earth's surface temperature and to related effects on climate, sea level and world agriculture (OECD, 2016).

***Gross Domestic Product***

Gross Domestic Product (GDP), a widely used indicator, refers to the total gross value added by all resident producers in the economy. Growth in the economy is measured by the change in GDP at a constant price. Many WDI indicators use GDP or GDP per capita as a denominator to enable cross-country comparisons of socioeconomic and other data. (BANK, n.d.)

***Exports***

Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. (Bank, Metadata Glossary, n.d.)

**Imports**

Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. (Bank, Metadata Glossary, n.d.)

These variables are studied across the economies of BRICS, which constitutes the nations of Brazil, Russia, India, China and South Africa for a time period of 1992-2021. The data for carbon emissions were extracted from ourworldindata.org and the data regarding GDP, exports and imports were extracted from worldbank.org.

**Table 1**

| Variable | Notation | Unit | Source |
|---|---|---|---|
| Carbon Dioxide Emissions | CO2 | Annual Global Share (Percentage) | https://ourworldindata.org/co2-emissions |
| Gross Domestic Product | GDP | Current US Dollar | https://data.worldbank.org/indicator/NY.GDP.MKTP.CD |
| Exports | EXP | Current US Dollar | https://data.worldbank.org/indicator/NE.EXP.GNFS.CD |
| Imports | IMP | Current US Dollar | https://data.worldbank.org/indicator/NE.IMP.GNFS.CD |

Source- compiled by author

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## Research Methodology

In this research study, we employ a quantitative methodology. Since the data is a mixture of cross-sectional and time series data, we apply the panel data regression model to examine the relationship between the variables. The regression is performed with estimation techniques such as Pooled OLS Estimator, Fixed Effects Estimator and Random Effects Estimator.

Consequently, the Lagrange-Multiplier Test is used to choose the best model from Random Effects Estimator and Pooled OLS Estimator, F-test to choose the best model from Fixed Effects Estimator and Pooled OLS Estimator and Hausman test to choose the best model from Fixed Effects Estimator and Random Effects Estimator. All the mathematical and econometric analysis of the panel data analysis are examined using R software.

## Empirical Model

The model for panel data regression analysis is represented by:

$CO2it = ϐ0+ϐ1GDPit+ϐ2EXPit+ϐ3IMPit+ε.$

Here CO2, is carbon dioxide emissions represented as a share of annual global emissions which is the dependent variable in our study. β0 is the intercept term which signifies the value of CO2, when GDP, EXP and IMP are zero. Here we have GDP as the Gross Domestic Product, EXP as the volume of Exports, and IMP as the volume of imports. Likewise, β1, β2, and β3 are coefficients of GDP, EXP, and IMP, respectively.

## Results

***Pooled OLS Estimator***

**Table 2**

| Coefficients | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| Intercept | 2.4520e+00 | 3.6451e-01 | 6.7269 | 3.662e-10 *** |
| XGDP | -2.0804e-12 | 5.4138e-13 | -3.8428 | 0.000181 *** |
| XEXP | 2.1046e-11 | 4.5009e-12 | 4.6759 | 6.602e-06 *** |
| XIMP | -8.3295e-13 | 5.8120e-12 | -0.1433 | 0.886238 |

Source- calculated by author

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**Random Effects Estimator**

**Table 3**

| Coefficients | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| Intercept | 2.4520e+00 | 3.6451e-01 | 6.7269 | 1.734e-11 *** |
| XGDP | -2.0804e-12 | 5.4138e-13 | -3.8428 | 0.0001217 *** |
| XEXP | 2.1046e-11 | 4.5009e-12 | 4.6759 | 2.927e-06 *** |
| XIMP | -8.3295e-13 | 5.8120e-12 | -0.1433 | 0.8860403 |

Source- calculated by author

**Effects**

**Table 4**

| | Variance | Std.dev | share |
|---|---|---|---|
| Idiosyncratic | 1.195 | 1.093 | 1 |
| Individual | 0.000 | 0.000 | 0 |
| Theta | 0 | | |

Source- calculated by author

**Fixed Effects Estimator**

**Table 5**

| Coefficients | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| XGDP | -6.1338e-13 | 1.7661e-13 | -3.4730 | 0.0006824 *** |
| XEXP | 4.0728e-12 | 1.7664e-12 | 2.3057 | 0.0225778 * |
| XIMP | 5.0448e-12 | 2.1265e-12 | 2.3723 | 0.0190165 * |

Source- calculated by author

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## Comparison of Different Estimators

**Table 6**

| | **Pooled OLS Estimator** | **Random Effects Estimator** | **Fixed Effects Estimator** |
|---|---|---|---|
| Total Sum of Squares | 9669.2 | 9669.2 | 1340 |
| Residual Sum of Squares | 2039.5 | 2039.5 | 169.68 |
| R – Squared | 0.78908 | 0.78908 | 0.87338 |
| Adj. R - Squared | 0.78474 | 0.78474 | 0.86714 |
| | F - statistics: 182.065 on 3 and 146 DF, p – value: < 2.22e-16 | Chisq: 546.195 on 3 DF, p-value: < 2.22e-16 | F – statistics: 326.481 on 3 and 142 DF, p–value: < 2.22e-16 |
| Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | |

Source- calculated by author

**Table 7**

| **Lagrange Multiplier Test (OLS vs Random Effects)** |
|---|
| data: Y ~ X |
| normal = 21.673, p-value < 2.2e-16 |
| alternative hypothesis: significant effects |
| |
| **F -test for Individual Effects (Fixed Effects vs OLS)** |
| data: Y ~ X |
| F = 391.19, df1 = 4, df2 = 142, p-value < 2.2e-16 |
| alternative hypothesis: significant effects |
| |
| **Hausman Test (Fixed Effects vs Random Effects)** |
| data: Y ~ X |
| chisq = 156.71, df = 3, p-value < 2.2e-16 |
| alternative hypothesis: one model is inconsistent |

Source- calculated by author

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## Analysis And Discussion

### *Pooled OLS Estimator*

Table 2 demonstrates the results which are derived as a result of Pooled OLS Estimator. According to Table 2 all the variables excluding IMP (Imports) are significant with a p-value less than 0.05. The intercept term is also significant with the estimated value of the coefficient is found to be 2.4520e+00. This indicates that when all the independent variables are equal to zero, the expected value of the dependent variable (CO2 emissions) will be 2.4520e+00. Also, all other things being equal, the coefficient for GDP is 2.0804e-12, showing that there is a negative relationship between GDP and CO2 emissions. A one-unit increase in GDP will result in a 2.0804e-12 unit decline in CO2 emissions. Along with it, the coefficient for EXP is 2.1046e-11, showing a positive relationship between Exports and CO2 emissions. A one-unit increase in Exports will result in a 2.1046e-11 unit increase in CO2 emissions. The R- square value for the model, according to Table 6 is 0.78908 which proves that 78.91% of the variation in the model can be explained by the independent variables.

### Random Effects Estimator

The results of the panel data regression analysis using the Random Effects Estimator are shown in the Table 3. Here as well, the intercept term is significant, with the estimated value of the coefficient to be 2.4520e+00, which shows that when all the independent variables are equal to zero, the expected value of CO2 emissions will be 2.4520e+00. While the coefficient for IMP is not significant at the 5% level, the coefficients for GDP and EXP are statistically significant. This suggests that while import is not a very good predictor of CO2 emissions, GDP and export are favorably related to CO2 emissions. According to the R-squared value, the model accounts for 78.9% of all the variation in CO2 emissions.

The variance, standard deviation, and share of variation for the idiosyncratic and individual effects are shown in the Effects table (Table 4). The individual variance reflects the variance of the individual effects, whereas the idiosyncratic variance represents the variance of the error term within each individual. Since the individual variance in this situation is considered to be zero, the individual effects are not variable. This implies that a fixed effects approach might be more suitable.

### Fixed Effects Estimator

Table 5 specifies the results regarding the panel data regression analysis using Fixed Effects Estimator. As per Table 5, all the independent variables including GDP, EXP (Exports) and IMP(Imports) are statistically significant with a p-value of less than 0.05. GDP, EXP, and IMP coefficient values are -6.1338e-13, 4.0728e-12, and 5.0448e-12, respectively. This indicates that, when individual-specific effects are held constant, an increase in GDP of one unit is associated with a decrease in CO2 emissions of -6.1338e-13. Similarly, it takes into consideration that, while holding individual-specific effects constant, a one-unit increase in EXP denotes a 4.0728e-12 increase in CO2 emissions and a one-unit increase in IMP denotes a 5.0448e-12 increase in CO2 emissions.

The null hypothesis that the actual coefficient is zero is tested by the t-values for each coefficient estimate. The dependent variable's variation is explained by the model 87.34% of the time, according to the R-squared value of 0.87338. The addition of the time-varying variables GDP, EXP, and IMP enhances the model's goodness of fit, according to the adjusted R-squared value of 0.86714. With a p-value of less than 0.001, the F-statistic, which assesses the model's overall significance, indicates that the current study is extremely significant.

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### Lagrange Multiplier Test (OLS vs Random Effects) (Table 7)

The Lagrange Multiplier Test is used to determine whether the Ordinary Least Squares method or the Random Effects method is more accurate for panel data analysis. Here, the null hypothesis denotes that random effects is preferred over the OLS method and the alternate hypothesis is that there are significant effects that makes random effects a better fit for the data we have chosen.

With higher values showing a better fit for the random effects model, the test statistic is a measurement of the difference in the residual sum of squares between the random effects and OLS models. The LM test statistic in this output is 21.673, and the p-value is less than 2.2e-16, which indicates strong proof supporting the alternative hypothesis over the null hypothesis. As a result, we can say that the random effects model fits the data more accurately than the OLS model. This indicates that the dependent variable is being influenced by unknown individual-specific effects, which the random effects model is better able to account for.

### F -test for Individual Effects (Fixed Effects vs OLS) (Table 7)

To determine whether the individual (entity) specific fixed effects in the panel data model have a statistically significant impact, the F-test for individual effects is used. The alternative hypothesis is that there are substantial individual effects, while the null hypothesis is that there are no individual effects at all.

The test statistic in this instance is F = 391.19, with df1 = 4 and df2 = 142 degrees of freedom, and the p-value is less than 2.2e-16. (Essentially 0). We reject the null hypothesis because the p-value is so small and come to the conclusion that there are significant individual effects. This indicates that the outcome variable is influenced by unobserved variables that differ across the entities in the panel. Therefore, the fixed effects model is more suitable than the pooling model.

### Hausman Test (Fixed Effects vs Random Effects) (Table 7)

The Hausman test is used to determine whether a particular dataset is better suited for the fixed effects model or the random effects model. The fixed effects model is favored, contrary to the alternative hypothesis, which states that the random effects model is preferred.

The test statistic in the data given has a chi-squared value of 156.71, three degrees of freedom, and a p-value lower than 2.2e-16. We reject the null hypothesis because the p-value is less than the significance threshold of 0.05, and we come to the conclusion that the fixed effects model is preferable to the random effects model. As a result, the individual-specific effects that are unique to each person are correlated with the regressors and cannot be regarded as random. Instead, it is best to consider the individual-specific effects as fixed and analyse the data using the fixed effects model.

### Conclusion

Climate change isn't a just a mere responsibility anymore, it has become the most indispensable necessity of the world currently. Extensive coverage in the field of research and development should be carried over across countries to reduce the hazardous effect of carbon emissions, which contribute heavily towards climate change around the globe. This research study attempts to study the effect of macroeconomic trade variables on carbon emissions in BRICS nations. It explores the consequences of macroeconomic variables that can contribute to environmental sustainability. In this research study, we have attempted to analyse the relationship between GDP, Exports and Imports on Carbon Emissions using different econometric techniques and models like Pooled OLS Estimator, Random Effects Estimator and Fixed Effects Estimator. Using the results from, Hausman Test we have found that Fixed Effects Estimator is the most appropriate

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model in this scenario. According to the Fixed Effects Estimator, we can conclude that the estimated coefficient of GDP has a negative effect on Carbon Emissions. In contrast, the estimated coefficients of Export and Import have a positive effect on Carbon Emissions.

Carbon emissions' detrimental impact on GDP can be viewed as the financial expense of these environmental externalities. Therefore, promoting economic growth and attaining sustainable development in these nations may depend on policies that cut carbon emissions and lessen the negative effects of environmental externalities. As an alternative to the West, the BRICS countries are establishing themselves as economic superpowers and building a new world order. Additionally, with desire from countries like Mexico, Saudi Arabia, Argentina, Egypt, and others, interest in the BRICS group has increased dramatically on a global scale. (WELLE, 2023) Therefore, policymakers must consider both the short-term economic benefits of trade and the long-term environmental effects of carbon emissions in order to support these countries' sustainable growth.

## Policy Implications

**Carbon Tax**: Since carbon emissions have a negative impact on GDP, implementing carbon tax policies may be a good method to lower emissions and lessen those emissions' adverse effects on economic growth. Additionally, SDG 13—which calls for taking immediate action to combat climate change and its effects—could be supported by this strategy.

**Investment in Green Technology**: For the BRICS nations to accomplish sustainable development, encourage economic growth, and reduce carbon emissions, investment in green technology could prove to be a crucial policy. Additionally, SDG 7—which aims to guarantee that everyone has access to affordable, dependable, sustainable, and modern energy—could be supported by this policy.

**Sustainable Trade Agreements:** Trade agreements should be created to encourage green trade and lower carbon emissions. Such agreements might assist SDG 12's goal of ensuring sustainable output and consumption patterns**.**

**Promotion of Sustainable Development:** Policymakers should prioritize promoting sustainable development by putting in place measures that strike a balance between environmental protection and economic growth. Several SDGs, including SDG 8—which seeks to advance sustained, inclusive, and sustainable economic development, full and productive employment, and decent work for all - could be aided by this.

**Carbon Credits:** Through investing in initiatives that lower emissions elsewhere, nations or businesses can use carbon credits, a market-based mechanism, to offset their own carbon emissions. The BRICS countries are able to generate money by curbing their carbon pollution and selling carbon credits to other nations or businesses by taking part in the carbon market. As a source of financing for sustainable development projects, this can encourage investments in renewable energy and other technologies that lower emissions. Additionally, BRICS countries may be able to benefit financially from lowering their carbon emissions through the use of international carbon markets, such as the Clean Development Mechanism (CDM) established by the UNFCCC. Through the CDM, developing nations can generate carbon credits by funding initiatives that reduce emissions. These credits can then be sold to developed nations that need to mitigate their emissions.

**Reducing Carbon Footprints:** Carbon footprints are an instrument that policymakers can use to monitor and assess how their policies and programmes are affecting the reduction of carbon emissions. This procedure can benefit from modern technologies like geo-mapping, image decoding from satellite images, and night lights that indicate the level of economic activity in specific areas. Carbon footprints can also be

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used by policymakers to pinpoint places where emissions can be reduced and could spread awareness and education regarding the same.

## Limitations of the Study

***The major limitations of this research study include***

The data for this research study was chosen for a time period from 1992-2021. There are chances that the results of this research study can fluctuate along with the trends and patterns, if the time period for this research study is increased and on basis of the accuracy of the data available.

Although the research shows a relationship between carbon emissions and macroeconomic trade variables, it might not establish causality. When interpreting the findings, it is important to take into account other variables, such as population development and technological advancements, which may also have an impact on carbon emissions.

Since economic and environmental circumstances can differ greatly between regions and countries, the study's conclusions might not be applicable to other nations or regions outside of the BRICS.

The model's variable relationships might not be linear, and the research might not have taken into account the nonlinear impacts of macroeconomic trade variables on carbon emissions.

The variables used in the study might be endogenous, which means that external forces outside the scope of the model may be responsible for their determination. For instance, other variables, such as energy efficiency regulations or technological advancements, may have an impact on the relationship between GDP and carbon emissions.

The study may not have taken into consideration all the factors that could have an impact on carbon emissions, such as energy policies, urbanization, or infrastructure development.

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