CO2 Emissions and Energy Consumption Analysis

A Comparative Study Across Ten Countries

Presented by: Mahmoud Moursi
Matriculation number: 23285941

The Importance of CO2 Emissions Analysis

Since 1990, global CO2 emissions have shot up by over 60%.[1] This dramatic rise paints a concerning picture. It signifies an acceleration of greenhouse gas accumulation in the atmosphere, further escalating the threat of climate change. This ever-growing blanket of heat-trapping gas is pushing our planet towards a tipping point, potentially leading to more extreme weather events, rising sea levels, and mass extinctions. Curbing these emissions is no longer just an environmental goal, it's a critical step to ensure a habitable planet for future generations.

[1]: https://www.mpg.de/6678112/carbon-dioxide-climate-change

Analyzing CO2 Emissions and Energy Consumption

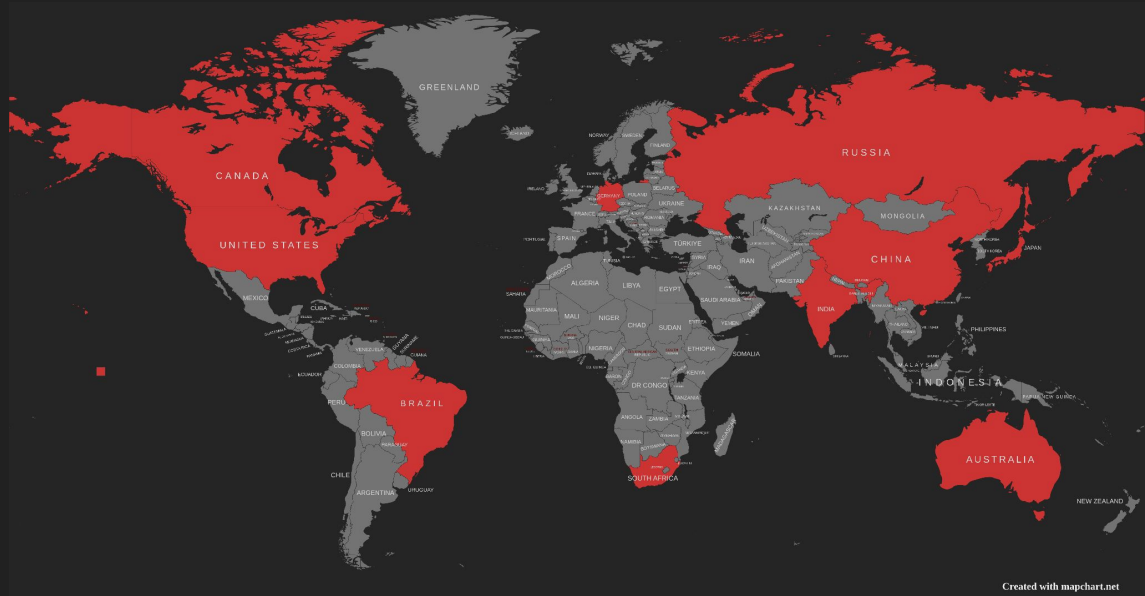
This study attempts to answer the question:
What is the relationship between greenhouse gas emissions and energy production across 10 different countries, and how does it vary based on regional, economic, and climatic factors?

Study Objectives:

Analyze patterns in CO2 emissions and energy consumption.

Identify crucial factors impacting CO2 emissions.

Deliver actionable insights for policymakers.



Understanding Key Terms

- Correlation Analysis: "Measures the relationship between two variables."
- Variance Inflation Factor: "Identifies multicollinearity issues in regression models."
- Principal Component Analysis: "Reduces data dimensionality while retaining key information."
- Time Series Analysis: "Analyzes data points collected or recorded at specific time intervals."

Data Sources and Features

We merged data from two datasets spanning 2007 to 2016, including features such as:

- Year
- Country
- CO2 emissions
- Primary energy consumption
- GDP
- CO2 emissions from coal, oil, gas
- population

Data Preprocessing Steps

Handling Missing Values: Addressing null or empty entries to maintain data integrity and accuracy.

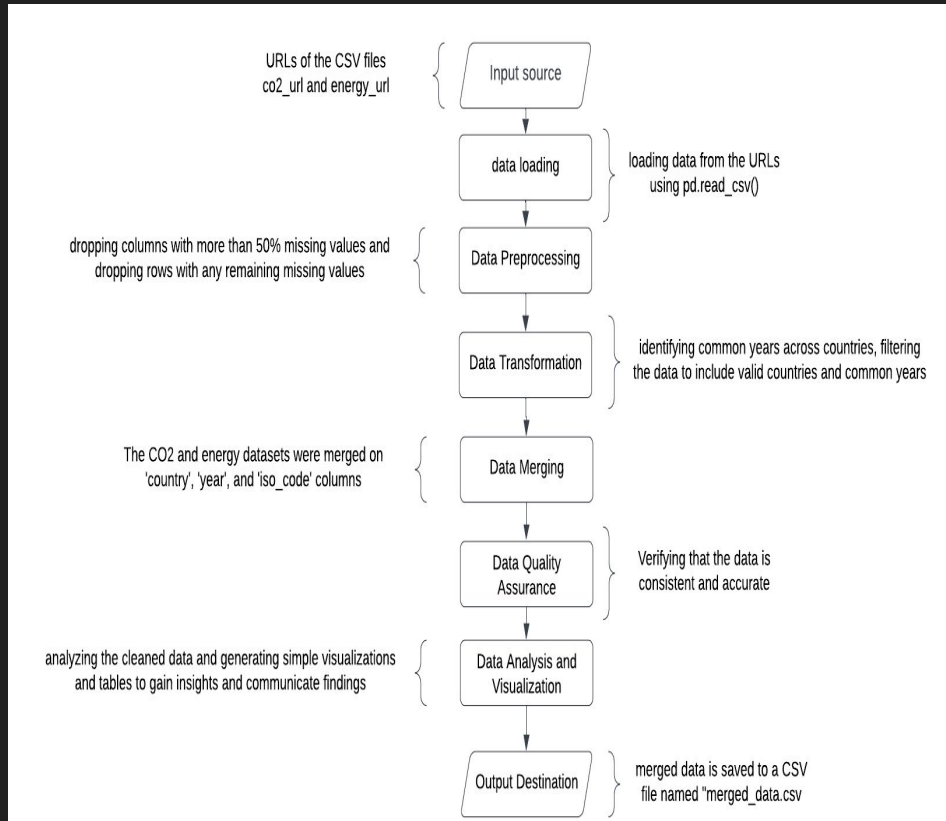
Normalization: Scaling and standardizing data to ensure all variables contribute equally to the analysis.

Correlation Analysis: Evaluating relationships between variables to identify patterns and dependencies within the dataset.

VIF Calculation: Identifying multicollinearity issues in regression models.

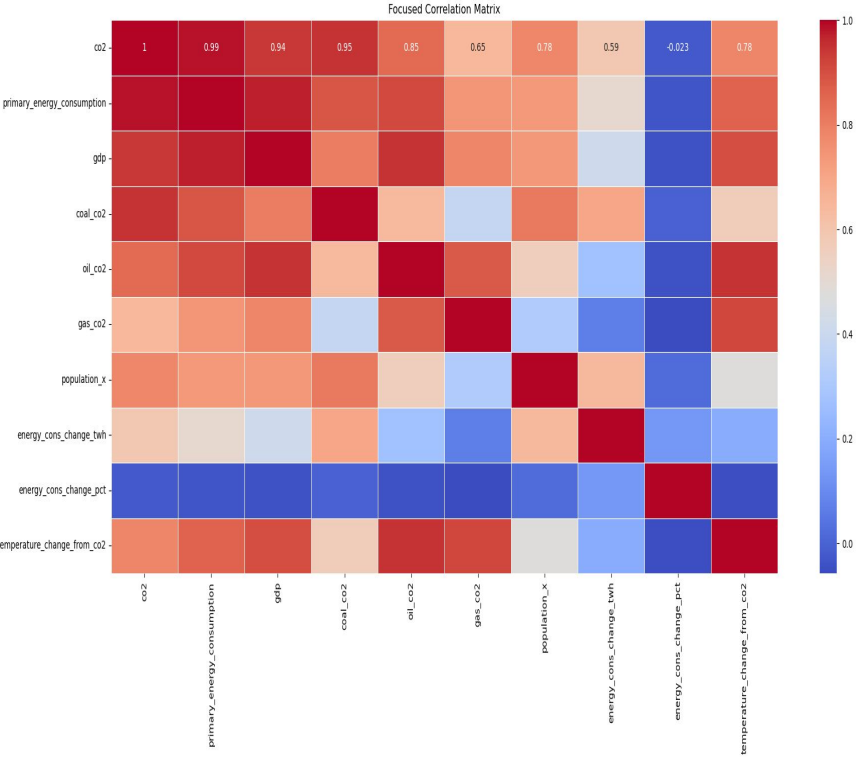
PCA for Dimensionality Reduction: Reducing the number of dimensions in the dataset while preserving essential information.

Outlier Detection: Identifying and addressing data points that deviate significantly from the rest of the dataset.

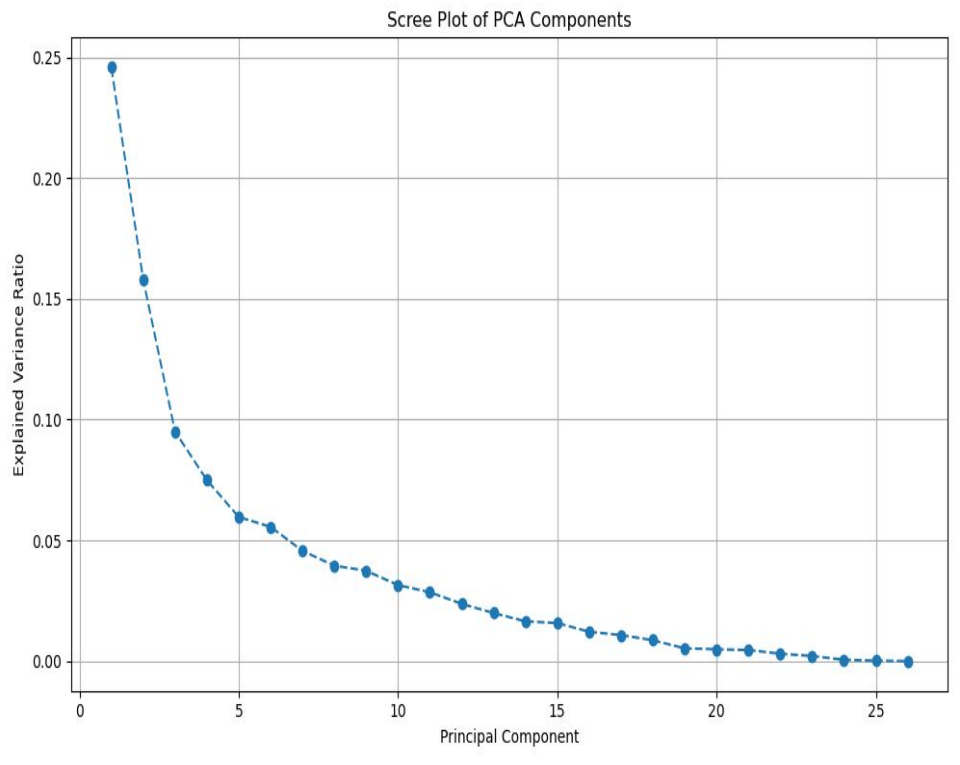


Data Preprocessing Steps

Correlation Analysis

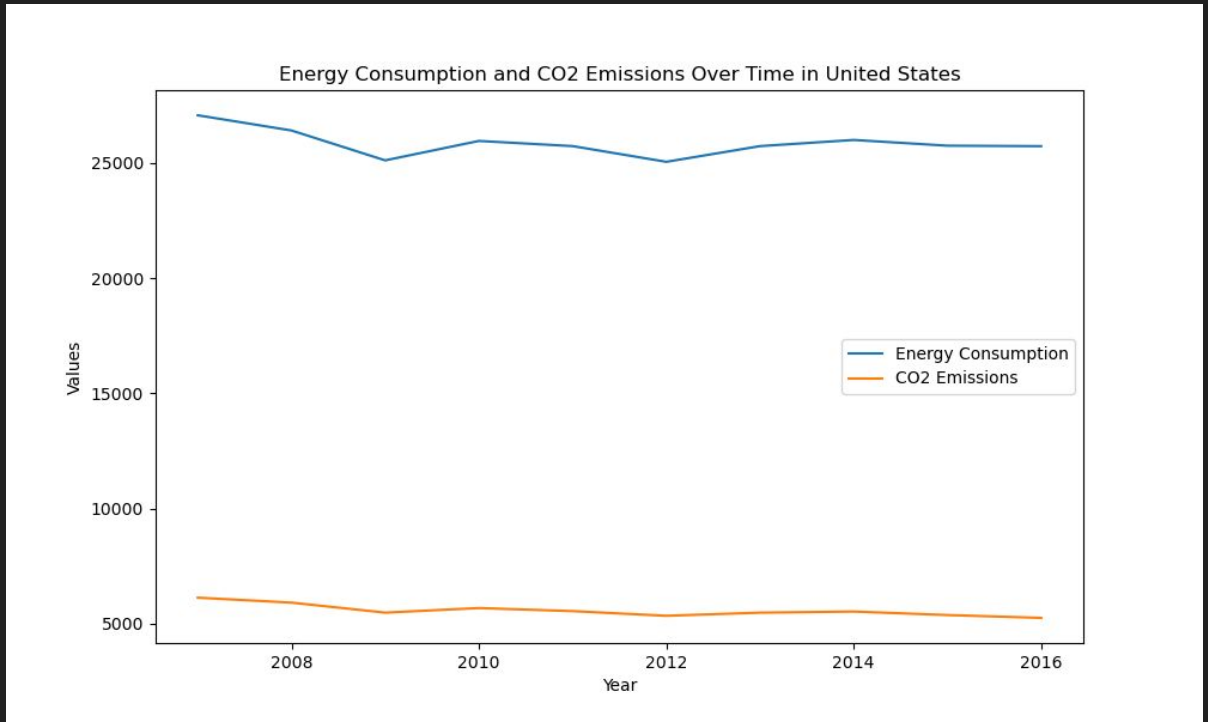


Principal Component Analysis



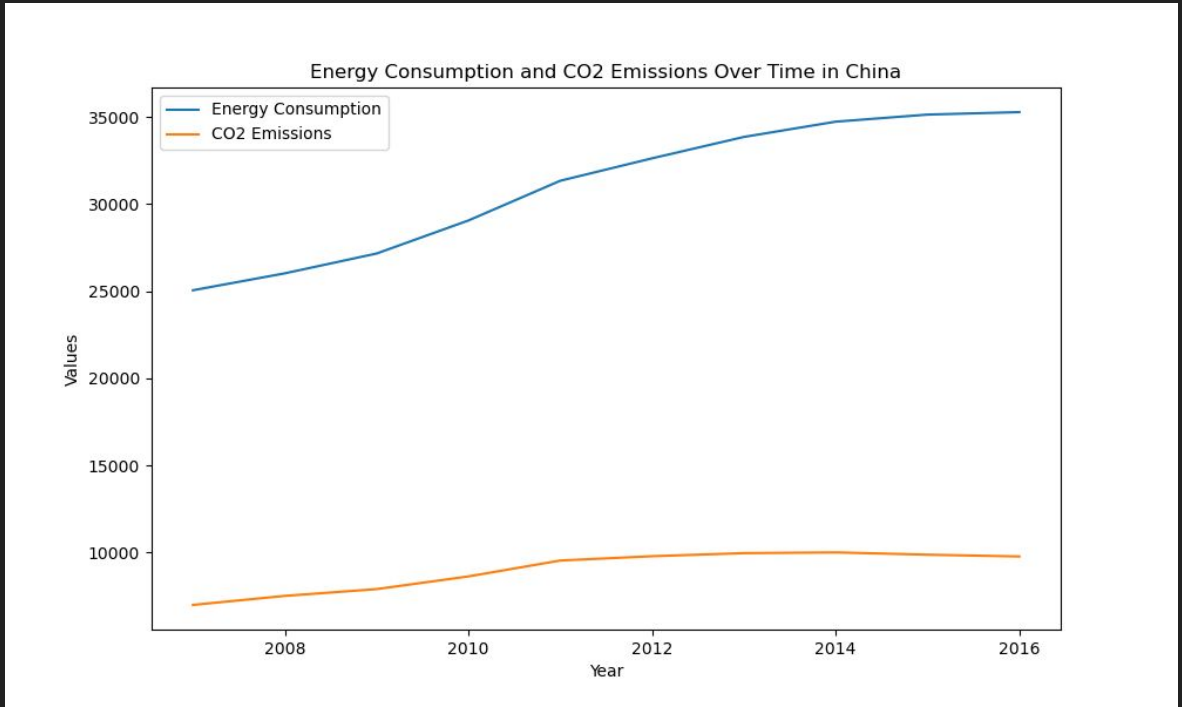
Time Series Analysis - United States VS China

Energy consumption and CO2 emissions dynamics in the United States reveal a sustainability narrative.



Time Series Analysis - United States VS China

China's rapid industrialization sets the stage for a dynamic interplay between energy consumption and CO2 emissions.



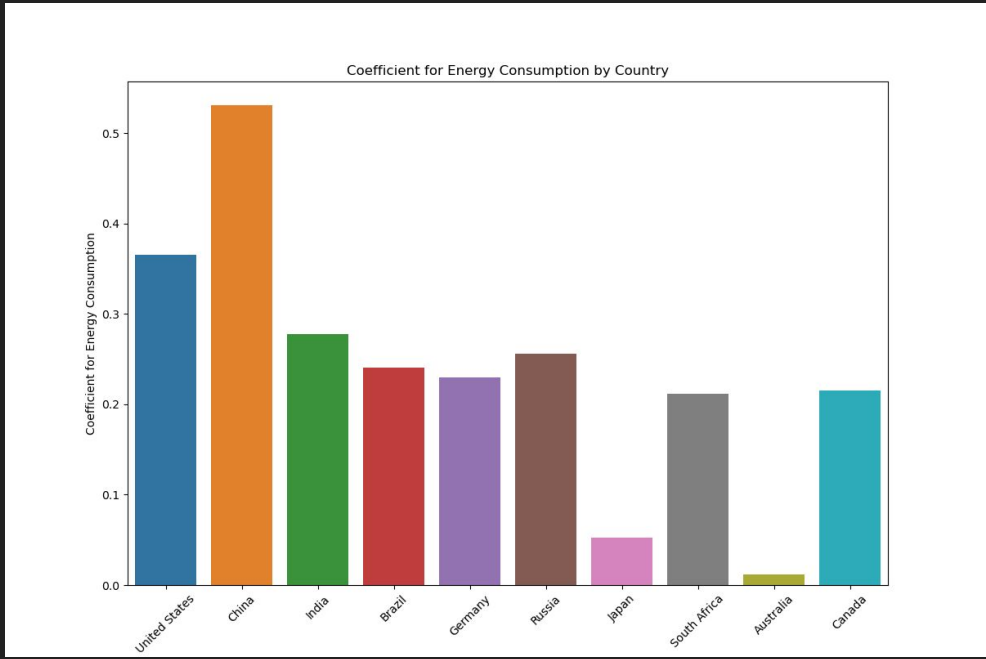
Energy Consumption Coefficient

In China, CO2 emissions are strongly correlated with energy consumption. CO2 emissions increase significantly when energy consumption increases.

United States, Russia, India: CO2 emissions are significantly influenced by energy consumption.

Brazil, Germany, South Africa, Canada: CO2 emissions moderately affected by coefficients.

Japan, Australia: smaller impact on CO2 emissions, likely due to efficient energy use or cleaner energy sources.

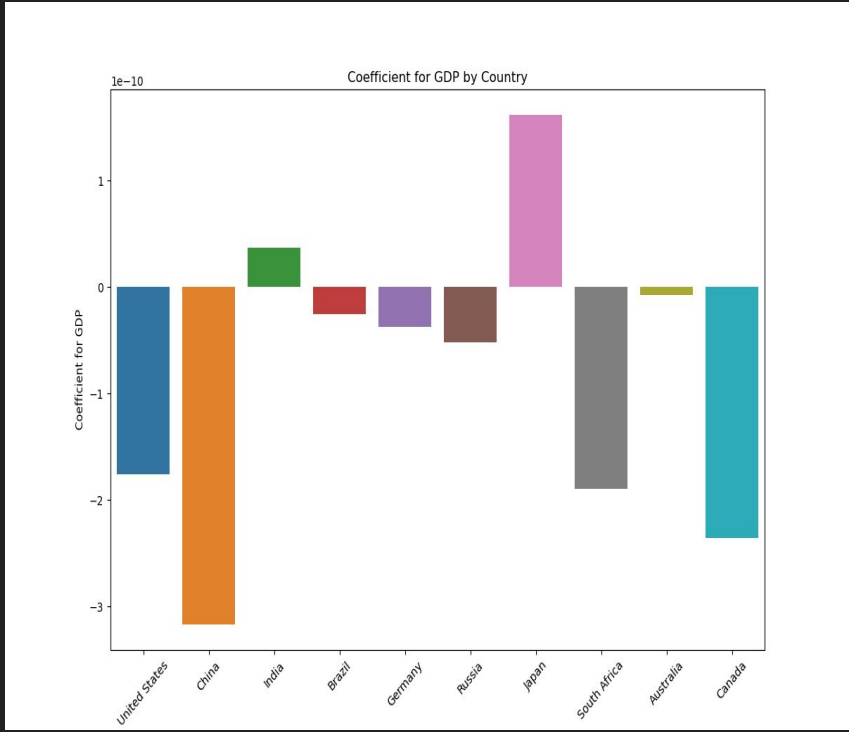


GDP Coefficient Comparison

Japan and India show positive GDP coefficients, linking higher GDP to increased CO2 emissions and economic growth.

The rest exhibit negative GDP coefficients, indicating that higher GDP is associated with lower CO2 emissions.

This suggests that in these countries, economic growth is linked to more efficient or cleaner energy use, resulting in reduced emissions.



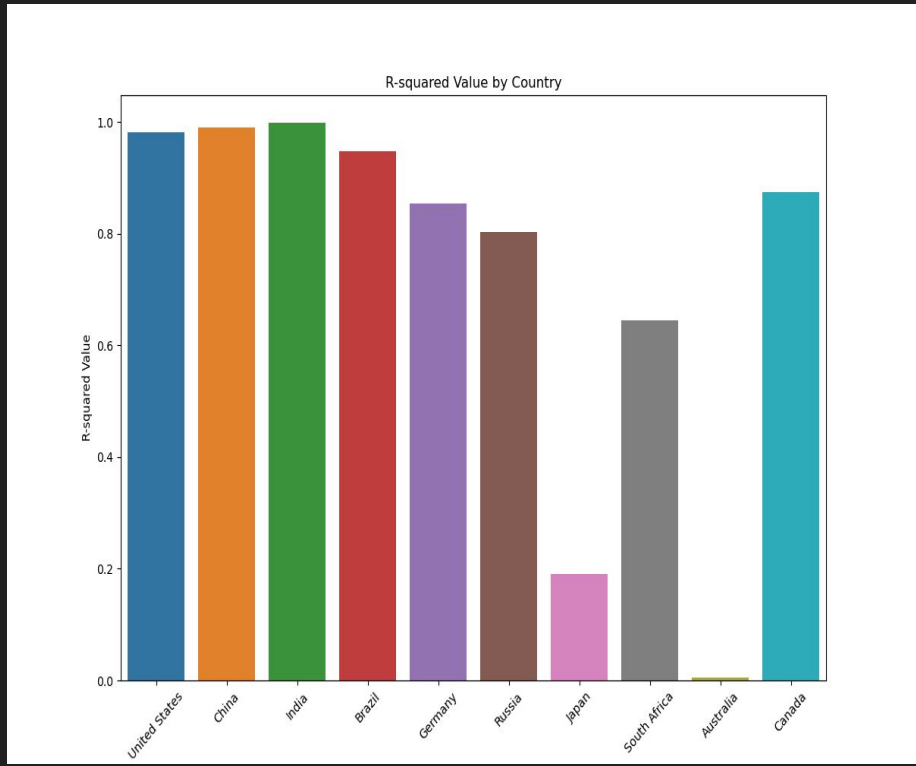
R-squared Value Comparison

Most show High R-squared values; primary energy consumption and GDP are strong predictors of CO2 emissions.

Others show Moderate R-squared values; other factors may influence emissions.

Japan has Low R-squared value; energy efficiency, renewable energy, or other factors may play a role.

Australia: Lowest R-squared value.



Key Findings

- Strong positive correlation between primary energy consumption and CO2 emissions.
- Significant variation in coefficients for energy consumption and GDP across countries.
- China shows the highest energy consumption coefficient, while Japan and Australia have much lower coefficients, indicating more efficient energy use or reliance on cleaner energy.
- The United States shows stable energy consumption and emissions, while China exhibits consistent increases, emphasizing the need for efficiency measures.

Limitations and Future Research

- Analysis may not account for all factors influencing CO2 emissions and energy consumption, such as technological advancements, energy policies, and socio-economic conditions.
- Future research should consider more granular data and explore specific policies, technological changes, and economic factors on emissions.
- Examining renewable energy adoption and energy transition policies could provide deeper insights.

Moving Forward

- Policymakers should focus on renewable energy and improving energy efficiency.
- Future research should explore the impact of specific policies and technological advancements.
- Collective action is essential to mitigate climate change.