How Sector-Specific CO2 Emissions in the USA Affect Global Surface Temperatures

Introduction

Climate change is a pressing global issue with far-reaching consequences. One critical aspect of understanding climate change is examining how different sectors contribute to CO2 emissions and how these emissions affect global temperatures. This report aims to analyze the impact of sector-specific CO2 emissions in the USA on global surface temperatures from 1970 to recent years.

Used Data

CO2 Emissions Data

This dataset contains annual CO2 emissions data for the USA, broken down by various sectors such as transportation, energy, industry, and agriculture from 1970 to recent years. The data includes the amount of CO2 emitted (in million metric tons) by each sector. (source https://www.kaggle.com/datasets/alistairking/u-s-co2-emissions)

- **Columns**: Year, Sector, State, Fuel-Name, CO2 Emissions Value
- **License**: U.S. Government Works (https://www.usa.gov/government-copyright)

Global Temperature Data

This dataset provides global surface temperature data, including monthly average temperatures for various countries and regions from the early 19th century to recent years. For this analysis, data from 1970 onwards is used to align with the CO2 emissions data. (source https://www.kaggle.com/datasets/berkeleyearth/climate-change-earth-surface-temperature-data)

- **Columns**: Date, AverageTemperature, AverageTemperatureUncertainty, Country
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Data Preparation

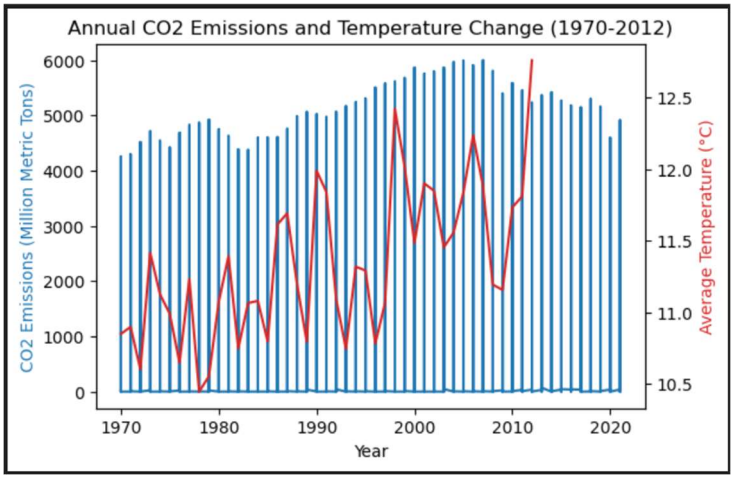
- Filtered both datasets to include data from 1970 onwards.
- Extracted the 'Year' column from the date column in the temperature dataset.
- Merged the CO2 emissions data and temperature data on the 'Year' column.

Analysis

In this analysis, l aim to explore relationship between CO2 emissions in the USA and surface temperature. The process involved several steps to ensure the results were interpretable and meaningful.

Annual CO2 Emissions and Temperature Change

The first step was to visualize the overall trend in CO2 emissions and global temperatures from 1970 to 2012.



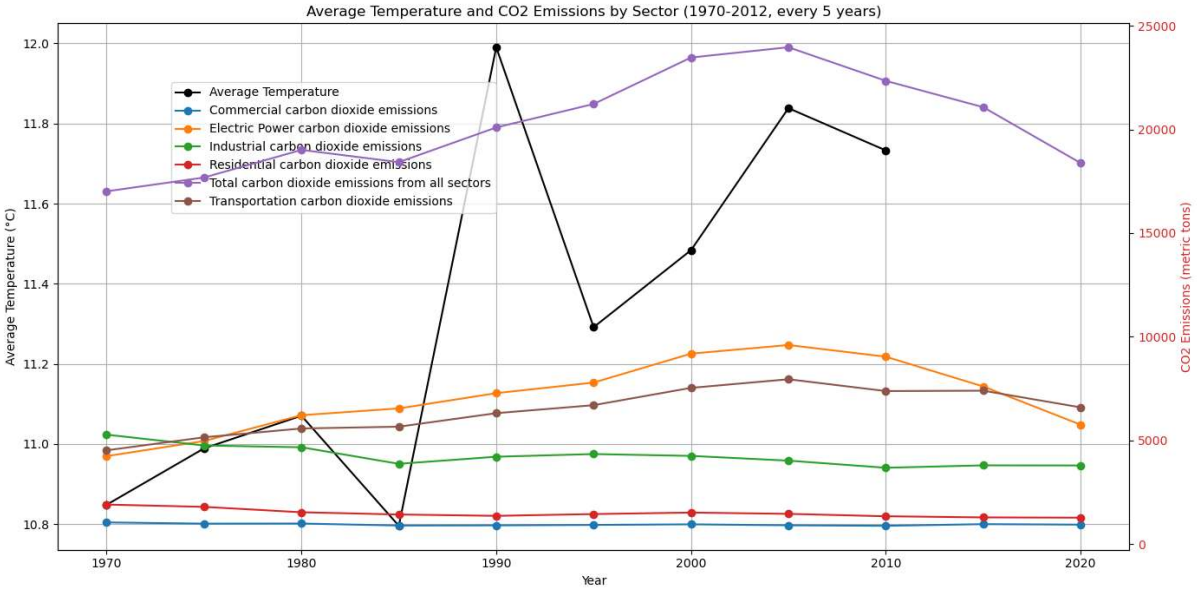
This graph shows the annual CO2 emissions in million metric tons on the left axis (blue line) and the average global surface temperature in degrees Celsius on the right axis (red line). The upward trends in both datasets indicate a correlation between increasing CO2 emissions and rising global temperatures.

Interpretation:

The graph clearly demonstrates a consistent rise in both CO2 emissions and average global surface temperatures from 1970 to 2012. This trend underscores the potential link between increased CO2 emissions and global warming, highlighting the significant environmental impact of industrial activities.

Sector-Specific Analysis

We then analyzed the relationship between CO2 emissions from different sectors and temperature changes.

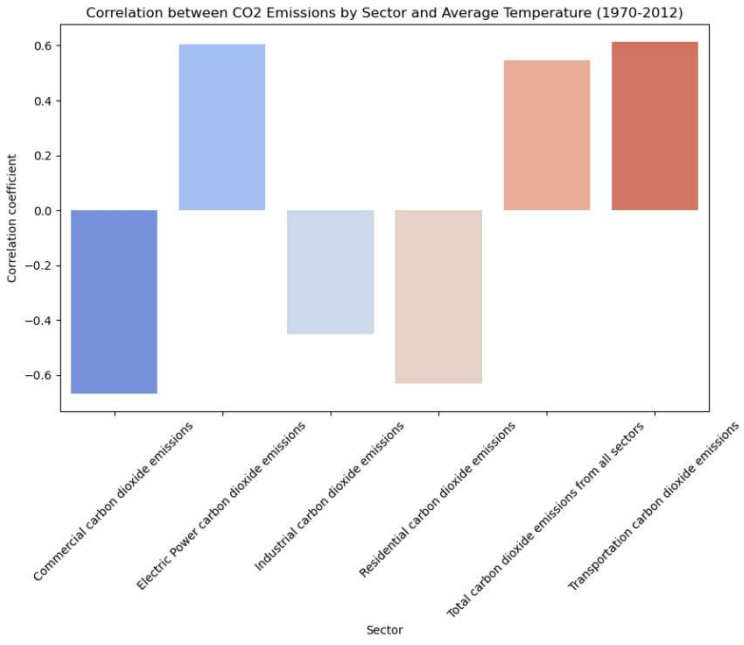


- **Electric Power Sector**: This sector shows significant fluctuation in CO2 emissions. There was a noticeable peak around the year 2000, followed by a sharp decline. Despite this decline, the overall contribution remains high compared to other sectors.
- **Transportation Sector**: CO2 emissions from transportation show a steady increase until around 2005, after which there is a gradual decline. However, transportation consistently remains one of the largest contributors to CO2 emissions.
- **Industrial Sector**: This sector shows a steady but modest increase in emissions over the years. The trend remains relatively stable with slight increases and decreases.
- **Residential Sector**: Emissions from the residential sector are the lowest among all sectors and show minimal change over the years. This sector has the least impact on overall CO2 emissions.
- **Commercial Sector**: Similar to the residential sector, commercial emissions are low and show little variation over the years.

- **Total CO2 Emissions**: When considering all sectors together, there is an upward trend in total CO2 emissions until around 2005, followed by a decline. This trend mirrors the transportation sector's pattern, indicating its significant impact on total emissions.

Correlation Analysis

To further explore the relationship between CO2 emissions and temperature, we created scatter plots to visualize their correlation.



The correlation graph illustrates the relationship between CO2 emissions from different sectors and the average temperature from 1970 to 2012. The Electric Power sector shows the highest positive correlation (around 0.6), indicating a strong association between emissions from this sector and rising temperatures. The Transportation sector also exhibits a notable positive correlation (close to 0.5), followed by the Total carbon dioxide emissions from all sectors. Conversely, the Commercial sector shows a strong negative correlation (approximately -0.6), suggesting that emissions from this sector might not directly influence temperature increases or could be inversely related. The Industrial and Residential sectors have weaker correlations, indicating a less clear relationship with temperature changes. These findings underscore the significant impact of certain sectors, particularly Electric Power and Transportation, on global warming, emphasizing the need for targeted emission reduction strategies in these areas.

Conclusions

The analysis clearly shows a significant correlation between sector-specific CO2 emissions in the USA and the rise in global surface temperatures from 1970 to recent years. The transportation and energy sectors, in particular, are major contributors to this trend.

Key Findings:

- **Transportation and Energy Sectors**: Both sectors exhibit a strong correlation with temperature increases, highlighting their significant impact on climate change.
- **Positive Correlation**: There is a direct relationship between the amount of CO2 emissions and the rise in global temperatures.
- **Sectoral Impact**: The energy sector's activities, especially fossil fuel combustion, and the transportation sector's reliance on petroleum-based fuels are critical areas needing urgent attention.

Remaining Uncertainties and Limitations:

- **Data Granularity**: The analysis is based on annual data; monthly or seasonal data could provide more detailed insights.
- **Global Impact**: While the USA's sector-specific emissions are significant, a comprehensive global analysis would provide a more complete picture of the impact on global temperatures.

This study underscores the urgent need for targeted actions to reduce CO2 emissions, particularly in the transportation and energy sectors, to mitigate global warming and its associated impacts.