Final Report : Data Visualization

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1. Introduction

Background and Objectives

Understanding the impact of different economic sectors on CO_2 emissions is crucial for developing effective environmental policies. This project aims to visualize the relationship between CO_2 emissions and GDP across U.S. states, analyzing how emissions evolve over time. By leveraging interactive visualizations, we provide insights into how economic activity correlates with environmental impact.

2. Method

Data Sources

The data used in this project come from two main sources:

- GDP by State dataset from the Bureau of Economic Analysis (BEA), offering a detailed view of economic activity at the state level (througth csv).
- CO_2 Emissions by State dataset from the Energy Information Administration (EIA), which tracks emissions data across different economic sectors (througth API).

Visual Components

The visualization employs two primary components to represent the data:

- **Scatterplot with dual curves**: This chart displays the relationship between GDP and CO_2 emissions over time. The x-axis represents the timeline in years, while the y-axis includes two curves that depict GDP and CO_2 emissions for a specific state and economic sector.
- **Choropleth map of the United States**: This map illustrates CO_2 emissions by state using a color gradient from yellow to red, indicating the intensity of emissions for a given year.

Interactions and Linked Views

To enhance user interaction and data exploration, several interactive features have been implemented:

- **Sector Selection**: Users can choose an economic sector using radio buttons. This selection updates both the scatterplot and the map to reflect the relevant data.
- **State Selection**: Clicking on a state in the choropleth map highlights its borders and simultaneously updates the scatterplot to display data for the selected state.
- **Year Selection**: A slider allows users to choose a specific year, dynamically updating the emissions data displayed on the map.
- **Tooltips**: For both visuals, you can display more precise information by hovering over a state or a point.

These interactions create a linked view system, allowing users to seamlessly explore relationships between economic activity and environmental impact. The combination of these views enables a multi-faceted analysis where users can track how emissions change over time while correlating them with economic growth.

3. Result

Data Description and Experimental Results

The visualization effectively provides a comparative analysis of CO_2 emissions and GDP trends across states and sectors over time. Users can:

- Identify high-emission states.
- Observe geographical trends in emissions.
- Explore temporal changes using the interactive tools.
- Visualize correlation between GDP and CO2 emissions for a state and a sector

The initial findings reveal that:

- States with strong commercial and industrial activity tend to have higher emissions, with some exhibiting a strong correlation between GDP growth and increased CO_2 emissions.
- Emission reduction efforts vary significantly across different states over time (likely to be correlated to state policies).

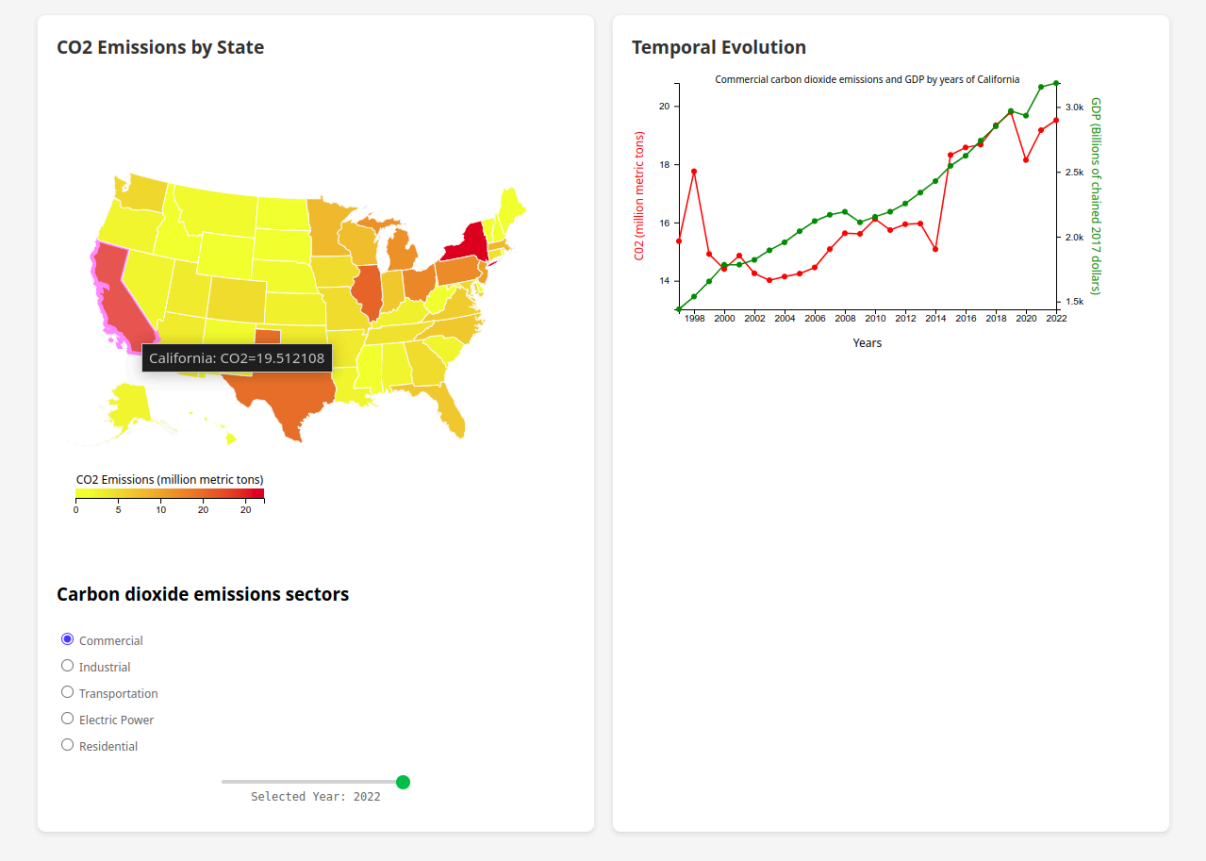

Fig 1. Visualization of CO2 emissions and GDP in United States regarding emissions sectors and year

4. Discussion

The interactive approach improves the comprehension of complex data relationships by allowing users to dynamically filter and analyze emissions and economic data. By selecting different sectors and years, users gain a deeper understanding of how emissions sources fluctuate over time.

However, some limitations exist:

- **Data granularity**: Annual values may not capture short-term fluctuations.
- **Sector classification**: A more detailed breakdown could refine insights.
- **Map readability**: Color choices must balance clarity and accessibility to ensure an intuitive user experience.
- **Sectors impact comparison**: The current visualization does not allow for a direct comparison of sectoral impacts within a single state. A stacked bar chart could address this issue by providing a clear view of how

emissions are distributed across sectors for each state, enabling users to compare the relative contributions of different industries both within and between states.

Despite these challenges, the visualization effectively communicates key trends and relationships, making it a valuable tool for policymakers, researchers, and the public.

5. Conclusion

This project demonstrates how interactive visualizations can enhance the understanding of CO_2 emissions trends in relation to economic activity. By integrating scatterplots and choropleth maps, users can dynamically explore historical data and uncover trends in emissions across different sectors.

Future improvements could include:

- A more detailed sectoral breakdown.
- Incorporation of additional socio-economic factors for a more comprehensive analysis.
- Refinement of color schemes and accessibility features to improve user experience.
- Implementation of a correlation matrix heatmap to visually highlight the strength of the relationship between GDP, emissions, and other potential influencing factors.
- Addition of a parallel coordinates plot to compare multiple variables, such as economic sector contributions, emissions intensity, and GDP per capita across states.
- Integration of time series small multiples, allowing users to observe variations across different states in a compact and comparative manner.

The interactive approach proves to be an effective means of engaging users with complex datasets, ultimately fostering a better understanding of environmental and economic dynamics. Expanding the variety of visual representations and refining interactivity will further enhance the analytical capabilities of this tool, making it more useful for decision-makers and researchers.

6. References

- Tamara Munzner. *Visualization Analysis and Design.* A K Peters Visualization Series, CRC Press, 2014.
- D3 Geomap
- BEA (for GDP open data) (source)
- EIA (for CO_2 emission open data) (source)