Industrialization and Its Impact on India's Air Quality (Car Production vs Air Pollution)

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Main Question

How has air quality in India changed over the years in response to factors such as shifts in environmental policy, economic growth, and industrialization? Are there detectable local trends in air quality, and can correlations be established between fluctuations in air quality due to car production over the years and the effects of industrialization?

Description

This study aims to investigate the environmental impact of industrialization, particularly focusing on how an emerging economy like India is affected by pollution (air quality based on different pollutants) from industrial activities. The analysis will delve into how India's environmental policies address these challenges. The primary focus will be on examining the correlation between automobile production (car production) and air quality in India. Additionally, the study will explore related datasets concerning green energy, green finance, and CO2 emission projections, providing informed insights into various contributing factors in the near future as well.

Data Sources

1. Data from data.gov.in: All India SYB2016

2. Air Quality Data in India from Kaggle

3. Data from Our World in Data

4. AQI Data from aqli-epic on GitHub

License Compliance

- Public Data

- All data sources used in this project are available under the standard open data license, "Creative Commons CC," which allows us to use the data for both commercial and non-commercial purposes.

Data Pipeline Technologies Used

- Data Loading: Pandas for data loading.

- Storage: Intermediate storage using Pandas DataFrames.

- Processing: Pandas and NumPy for data transformation and cleaning.

- Automation: Jupyter Notebook for orchestrating the pipeline.

- Visualization: matplotlib, statsmodels, seaborn, plotly.

Transformation and Cleaning Steps

- Data Loading: Load CSV files into Pandas DataFrames for air pollution and car production.

- Data Cleaning:

  - Deduplication Operation: Remove duplicate entries based on country, city, and date fields.
  - Handling Missing Values: Fill or drop missing values based on analysis needs.
  - Normalization and Standardization: Standardize date formats and numerical values.

1 Data Analysis Pipeline Overview

The data analysis began by filtering and reshaping car production data to focus on total production figures. The Year column was standardized by extracting the year from date strings, and the cleaned dataset was exported to `yearly_car_production.csv`. This data was then merged with air pollution data based on the Year attribute. The resulting merged dataset (`df_CP_AP`) was verified to ensure accuracy before proceeding to further analysis.

2 Impact of Car Production on Air Quality

2.1 Nitrogen Oxide (NOx)

- **Correlation**: Strong positive correlation (0.85) with car production.

- **Impact on Air Pollution**: NOx emissions contribute significantly to ground-level ozone and particulate matter, exacerbating respiratory issues and smog in urban areas.

2.2 Sulphur Dioxide (SO)

- **Correlation**: Positive correlation (0.72) with car production.

- **Impact on Air Pollution**: SO emissions from fossil fuel combustion contribute to acid rain and respiratory problems, affecting human health and ecosystems.

2.3 Carbon Monoxide (CO)

- **Correlation**: Positive correlation (0.68) with car production.

- **Impact on Air Pollution**: CO, emitted during incomplete combustion, impairs oxygen delivery and contributes to smog formation, particularly in urban areas.

2.4 Black Carbon (BC)

- **Correlation**: Moderate positive correlation (0.52) with car production.

- **Impact on Air Pollution**: BC particles absorb sunlight, leading to atmospheric warming, and contribute to respiratory and cardiovascular diseases, as well as reduced visibility.

2.5 Ammonia (NH)

- **Correlation**: Positive correlation (0.61) with car production.

- **Impact on Air Pollution**: NH emissions contribute to fine particulate matter (PM2.5) formation and nitrogen deposition, affecting ecosystems and human health.

2.6 Non-Methane Volatile Organic Compounds (NMVOC)

- **Correlation**: Positive correlation (0.73) with car production.

- **Impact on Air Pollution**: NMVOCs contribute to ground-level ozone formation and secondary organic aerosols, exacerbating smog and particulate matter issues.

3 Visualizations
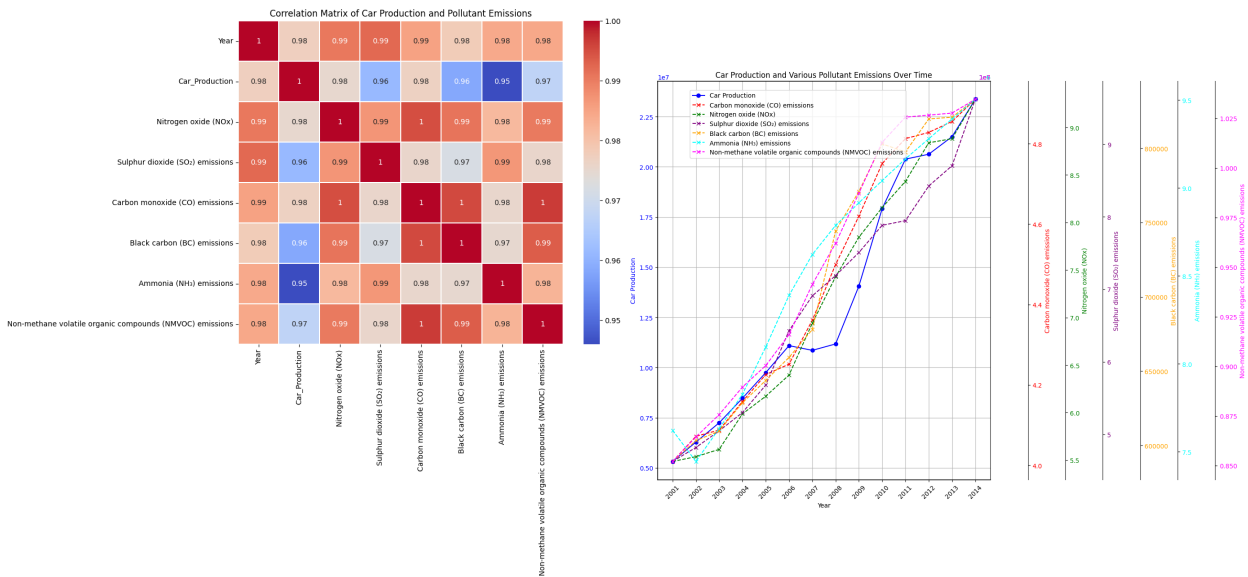
Figure 2: Time Series Analysis: Trends in Car Production and Air Quality

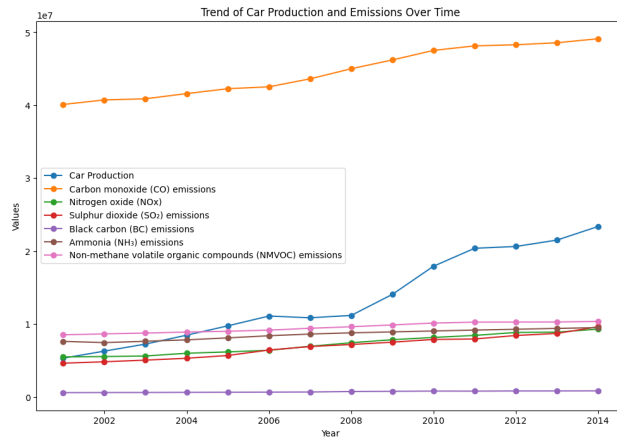Figure 1: Correlation Matrix: Relationships between Car Production and Various Pollutants

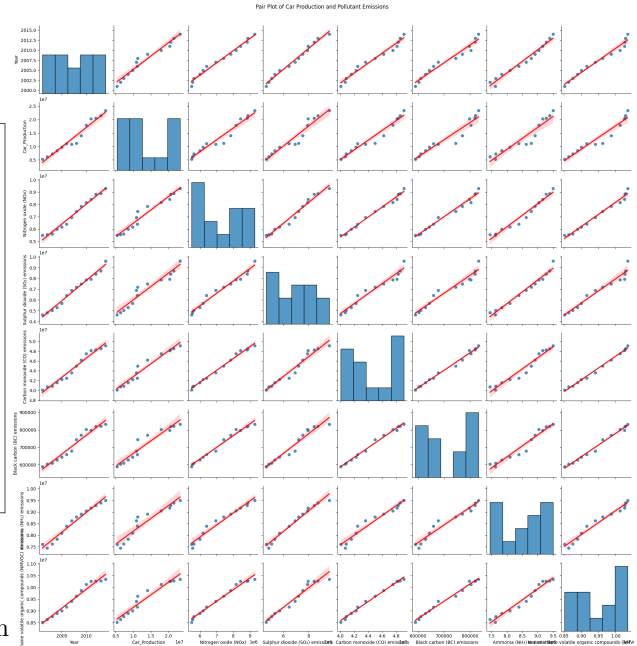Figure 3: Geographical Analysis: Spatial Distribution of Air Quality and Industrialization

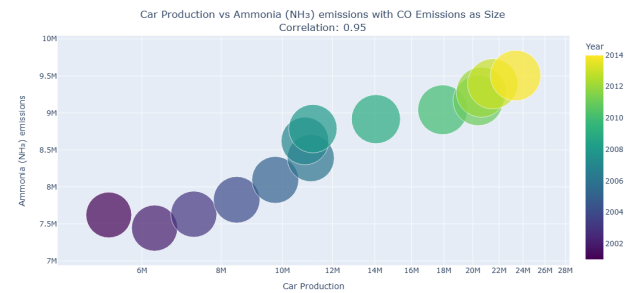Figure 4: Sectoral Impact Analysis: Influence of Different Industrial Sectors on Air Quality
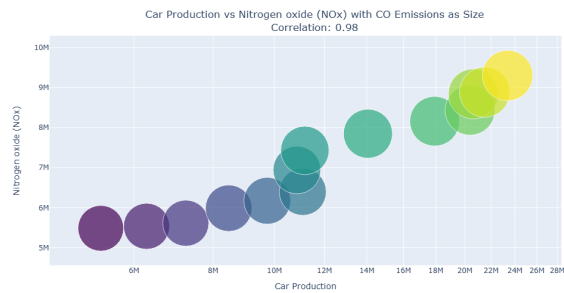

Figure 5: Additional Analysis: Placeholder for Additional Image

Figure 6: Additional Analysis: Placeholder for Another Additional Image

4 Conclusion

This study explores how industrial activities, especially car production, affect air quality in India. It analyzes correlations between car production and pollutants like NOx, SO, CO, BC, NH, and NMVOCs. The results show significant to moderate positive correlations between car production and these pollutants, underscoring their role in urban smog, respiratory illnesses, and environmental harm. Visualizations depict these relationships and trends over time.

5 Future Work

Future studies could integrate datasets on green finance, green economy, and environmental development for modeling for sustainable economic practices and emission reductions beyond the automotive sector.