Clustering and Fitting

Exploring Global Trends: Clustering Countries by CO2 Emissions and GDP, with Fitted Models for Insightful Predictions.

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https://github.com/Diya-Amith/Clustering-and-fiting-assignment.git

Abstract

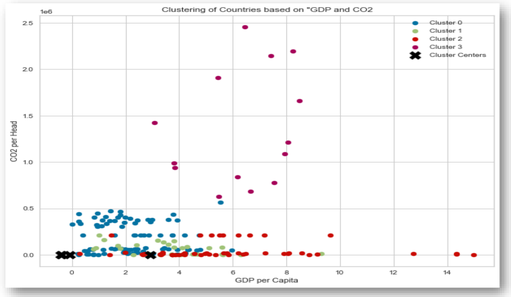
Environmental concerns and sustainable development have become critical topics in today's world. In this analysis, we explore the relationship between a country's economic indicators, specifically GDP growth, and its environmental impact measured by CO2 emissions. The dataset, sourced from diverse countries, provides insights into how nations cluster based on these variables.

We begin by preprocessing the data, addressing missing values through imputation and normalizing the numeric features. Utilizing the K-means clustering algorithm, we categorize countries into distinct groups, shedding light on similarities or differences in their economic and environmental profiles.

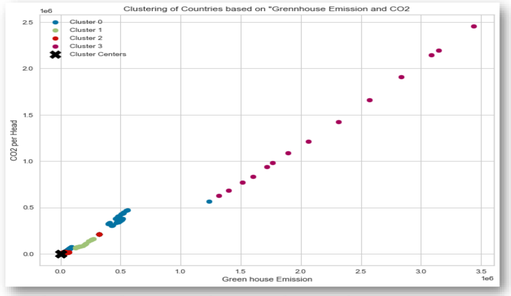
The visualizations, including cluster plots and silhouette analyses, play a crucial role in interpreting the clustering results. The silhouette analysis provides a quantitative measure of the clustering effectiveness, offering insights into the coherence of the identified clusters.

As part of a case study, we focus our attention on India and France, two nations with diverse economic and environmental profiles. Through curve fitting analysis, we model the trajectory of greenhouse gas emissions over the years for these countries. This predictive approach enables us to anticipate potential future trends, contributing to a more comprehensive understanding of their environmental dynamics.

Clustering

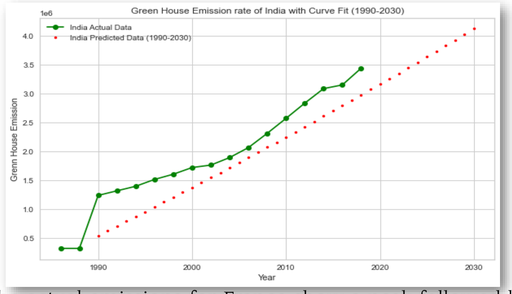


GDP and CO2 Cluster Analysis: The clustering reveals four distinct groups, ranging from low-income, low-emission countries to high-income, high-emission countries. The majority fall into a cluster with low GDP and low CO2 emissions, suggesting that most countries have not reached a level of economic growth associated with high environmental impact. A small yet significant cluster represents economically advanced countries with substantial CO2 emissions, posing questions about sustainability practices within these nations.

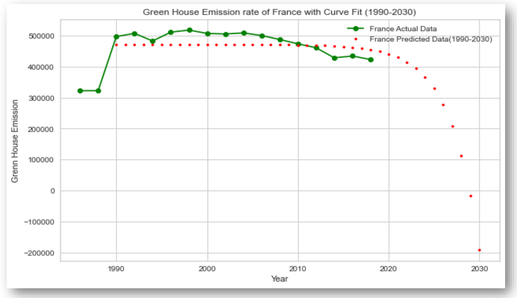


CO2 and Greenhouse: This analysis shows a more linear relationship, indicating that CO2 emissions per capita increase with overall greenhouse gas emissions. The implication is a direct correlation between the two, reinforcing the global challenge of reducing greenhouse gases. Environmental Policy Indicator: The tight clustering along the trendline suggests that a universal factor, possibly industrialization level is influencing both greenhouse and CO2 emission. A silhouette score of 0.3768 indicates a moderate to strong level of separation between the clusters, affirming that the chosen features, GDP growth, and CO2 emissions, effectively contribute to the distinctiveness of the identified clusters.

Fitting and Prediction



- The actual emissions for France show a peak followed by a decline, suggesting effective measures in reducing greenhouse gases.
- The curve fit for France portrays a robust alignment with historical data up to 2010. Post-2010, the model predicts a continued decline in emissions, intriguingly projecting negative emissions by 2030 which could imply carbon neutrality or net-positive environmental efforts.
- The fitting suggests France may be moving towards a sustainable future, likely through aggressive environmental policies, technological advancements, or a combination o. both.



- India's emissions have been consistently increasing since 1990, reflecting the country's rapid industrialization and economic growth.
- The predictive curve for India extrapolates the upward trend, indicating a rise in emissions without a plateau in sight. This is consistent with India's developing status and growing energy demands.
- The fit indicates an urgent need for policy intervention to manage India's environmental impact as it continues to develop economically.

Conclusion

The analysis concludes that global CO2 emissions are closely tied to a country's economic development, with wealthier nations typically having higher emissions. Case studies of India and France reveal differing trajectories, with India's emissions rising steadily due to rapid industrialization, and France's emissions declining, suggesting successful implementation of environmental policies. The study underscores the importance of strategic policy interventions that are aligned with a country's economic development stage to mitigate environmental impact while supporting growth.