Advanced Statistics: Final Project

Global Emissions

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# Introduction

Our research project, which served as our final project for the Advanced Statistics course, investigated worldwide CO2 emissions in great detail with the goal of breaking down the complex relationships between variables that affect environmental responsibility. We used a thorough statistical approach to determine the complicated links between a country's economic power, industry makeup, and matching environmental commitments.

# Methodology

In our methodology, we employed various statistical tests and regression analyses to explore different facets of global CO2 emissions. Firstly, we utilized the **World Bank's income categorization to examine the impact of a country's economic strength on CO2 emissions**. Employing an ANOVA test, we tested the hypothesis that there is indeed a significant difference in CO2 emissions between income categories. Log transformation was applied to achieve a more symmetric distribution of total CO2 emissions, revealing **skewed patterns in CO2 contributions**.

Next, **we investigated the impact of greenhouse gases**, specifically N2O and CH4, on CO2 emissions using **Ordinary Least Squares** (OLS) regression. The results **demonstrated a significant correlation of N2O on CO2 emissions**, while **CH4 failed to show a statistically significant effect**.

We then **explored regional and continental disparities in CO2 emissions**, employing a hypothesis test to determine whether different continents exhibit significant differences in mean total CO2 emissions.

For **CO2 prediction, we employed Partial Least Squares** (PLS) regression with **dimensionality reduction**. While it is an overkill, in general, to bring down 6 dimensions, **our aim was to separate and show significant sources of CO2 emissions**. The model, decided on two major components (emissions from coal and oil) that allow for an **effective approximation of a country's total CO2 emissions**.

Lastly, our project **contextualized the statistical findings within the realm of climate action**, discussing the **Kyoto Protocol and the Paris Agreement**. The methodology culminated in an **analysis of policy implications**, emphasizing the importance of **informed decision-making for policymakers**, including **identifying key sources of CO2 emissions** and contributing to the ongoing global dialogue on climate change mitigation.

# Results

**1. ANOVA Results:**

The analysis of variance (ANOVA) results revealed a consistent rejection of the null hypothesis (H0) for all years, providing substantial evidence to suggest that income categories significantly affect CO2 emissions. This implies that, across various temporal contexts, a country's economic strength plays a crucial role in influencing its carbon emissions.

**2. OLS Results on N2O:**

The Ordinary Least Squares (OLS) regression results for N2O demonstrated a statistically significant impact on CO2 emissions. The rejection of the null hypothesis, supported by substantial coefficient values and a high R-squared, underscores the influential role of N2O in contributing to overall CO2 emissions.

**3. OLS Results on CH4:**

In contrast, the OLS regression results for CH4 indicated a failure to reject the null hypothesis, with the coefficient of CH4 being insignificantly close to 0. This suggests that, in the context of our analysis, the production of CH4 did not have a statistically significant impact on CO2 emissions.

**4. Regional/Continental Disparities:**

The ANOVA results for regional/continental disparities successfully rejected the null hypothesis, indicating that different continents exhibit significant differences in mean total CO2 emissions. The implications of these disparities can inform targeted policy interventions and international collaboration efforts to address varying contributions to global CO2 levels.

5. Dimensionality Reduction and CO2 Prediction:

The reduction of components from 6 to 2, guided by the knee observed in the R-squared plot, allowed for an effective model to predict total CO2 emissions. The resulting equation, involving CO2 emissions from coal (x1) and oil (x2), provides a simplified yet accurate approximation of a country's total CO2 emissions, aiding in a more efficient understanding of contributing factors.

**6. Climate Agreements:**

Our analysis delved into the historical context of climate agreements, highlighting the Kyoto Protocol and the Paris Agreement. The Kyoto Protocol, with its commitment to a 5.2% reduction in greenhouse gas emissions by developed countries, laid a crucial foundation for subsequent global climate discussions. The Paris Agreement, emphasizing the limitation of global temperature increase and Nationally Determined Contributions (NDCs), represents a contemporary framework for international cooperation in combating climate change.

**7. Policy Implications**:

The culmination of our findings underscores the importance of informed policymaking. By identifying key sources and temporal patterns of CO2 emissions, our analysis provides valuable insights for policymakers to develop effective strategies. This includes mitigating climate change, promoting sustainable practices, and meeting international commitments outlined in agreements like the Kyoto Protocol and Paris Agreement. The ability to prioritize efforts based on major emission sources facilitates targeted regulatory measures, technological innovation, and sustainable practices for a more impactful approach toward emission reduction.

**Verification of findings:**

@Udhav please do this one, also please give the citations, write a short thing

# Discussion/Conclusion

In conclusion, our statistical exploration provides a nuanced understanding of global CO2 emissions, linking economic factors, greenhouse gas impacts, regional disparities, and predictive modeling. These findings offer valuable insights for policymakers, enabling them to formulate informed strategies for mitigating climate change, fostering sustainability, and navigating the complex landscape of international climate agreements. As we confront the challenges of a changing climate, the knowledge gleaned from this analysis serves as a foundation for shaping effective and impactful environmental policies on a global scale.

# Incorporating Feedback

1. We removed the section on SARiMA because there was no motivation to do sarima with our current understanding.
2. We have added more detailed explanation of requiring PCA and PLS