Final Report

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Introduction and Data

Climate change is one of the world's most pressing issues, and it is unique in the way it will affect every country in the world, regardless of their contribution to the issue. Because of this, questions of who should pay for carbon abatement, climate mitigation and adaptation inevitably arise during international climate negotiations. To inform these decisions, we sought to answer the question: Is economic development correlated with increased greenhouse gas emissions? To answer this central question, we explored the relationship between key indicators of economic development and countries' greenhouse gas (GHG) emissions using descriptive statistics and hypothesis testing.

The data used in our analysis is from the World Bank's public datasets: the World Bank Corporate Scorecard and the World Development Indicators. The four variables analyzed in our research were GHG emissions per capita – our outcome variable, and gross domestic product (GDP) per capita, GDP per capita growth (over one year), and countries' Gini Index – our predictor variables. All data used is from 2022, as this was the year with the most data points for all four variables. GDP per capita is measured in 2025 US dollars. GDP per capita growth is measured as the percent change in a country's GDP per capita from 2021 to 2022. The Gini Index provides relative scores of economic inequality ranging from 1 to 100, with 100 indicating perfect inequality and 1, perfect equality. GHG emissions per capita are measured as a country's total emissions (in tons) per person of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphurhexafluoride emissions standardized to CO equivalent values.

Initial data analysis and scatter plot visualization indicated a possible, very weak, negative linear relationship between the Gini index and GHG emissions, as shown in Figure 1 below. Figure 2 shows an apparent positive correlation between GDP per capita and GHG emissions per capita. Intuitively, you would expect that if GHG emissions per capita increase as GDP per capita increases, then emissions will also increase as GDP growth increases. However, Figure 3 shows no clear linear relationship between GHG emissions per capita and the percent change in GDP per capita.

Figure 1: Gini Index vs GHG Emissions Per Capita

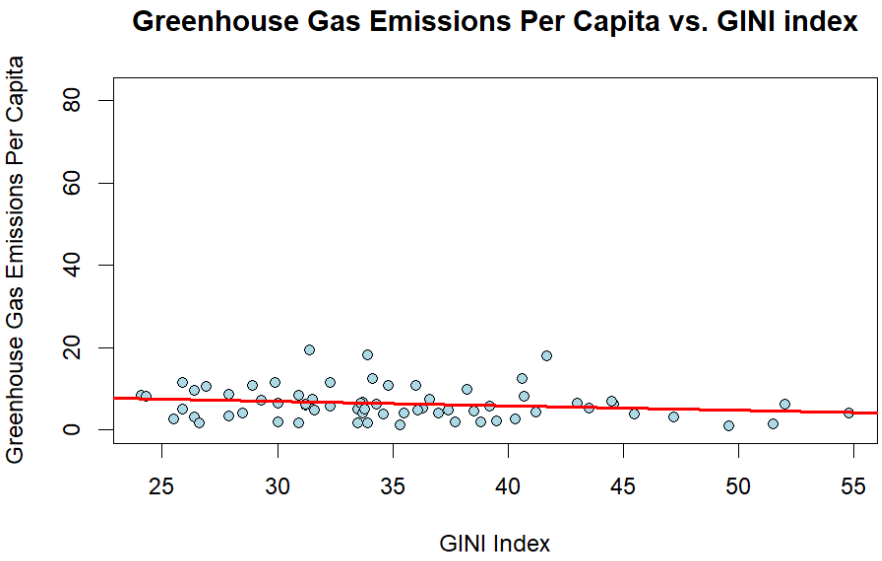


Figure 2: GDP Per Capita vs GHG Emissions Per Capita

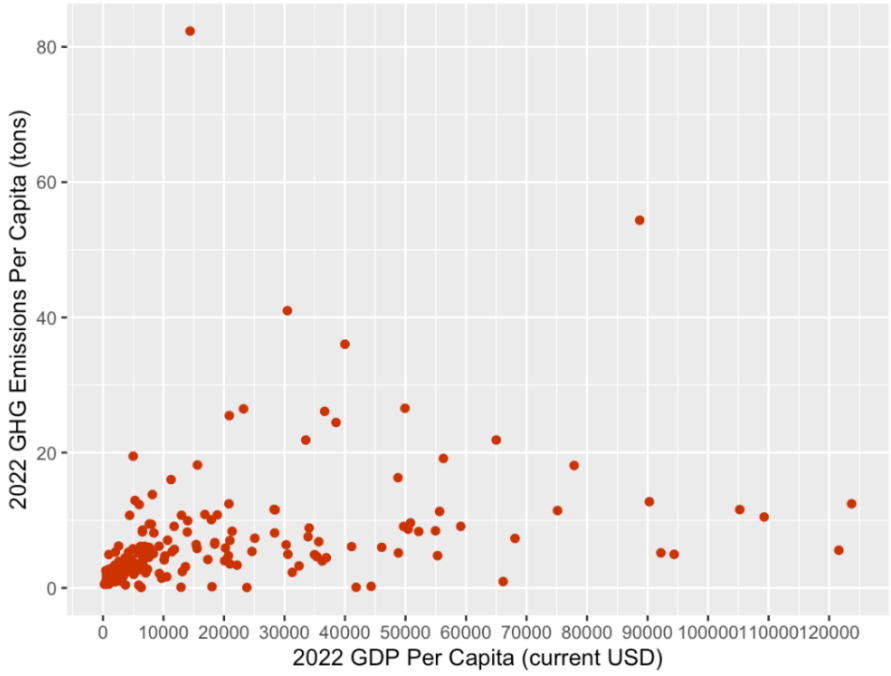
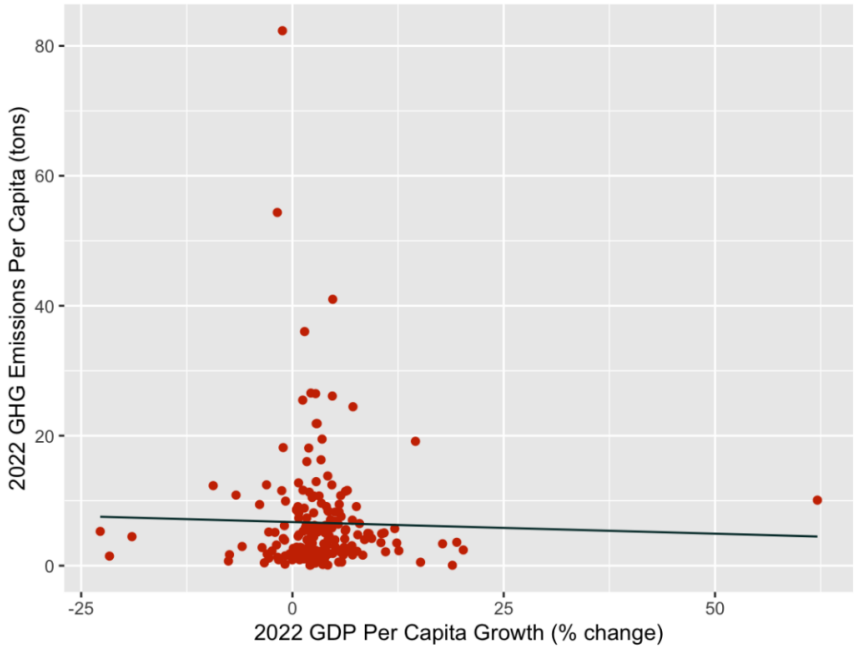


Figure 3: GDP Per Capita Growth vs GHG Emissions Per Capita



Methodology

The first part of the process in hypothesis testing was to create the data set with all the variables. Initially, there were three original data sets for each of the variables to be tested: GINI index, GDP per capita, and GDP per capita growth. To be as current as possible but also consistent, for each variable only the data from the year 2022 was selected. The data was then cleaned, filtered to remove any invalid or missing entries, and then merged into a new Excel file that was used to perform the hypothesis tests and linear regressions.

The hypothesis test used for this research was a one-tailed t-test which uses the t-statistic to determine id the correlation differs significantly from zero. This test assumes that the data/observations are randomly sampled, independent, continuous, and normally distributed. For each of the variables the following hypotheses were used:

- **Null hypothesis**: (H0 = 0) There is no correlation between the variable and the greenhouse gas emissions per capita.
- **Alternative hypothesis**: (H0 > 0) There is a positive correlation between the variable and greenhouse gas emissions per capita.

More specifically, a right-tailed t-test was chosen because the expectation was for there to be a positive relation between the independent variables and greenhouse gas emissions per capita. This aligns with the premise of this research project which was to determine whether countries with more wealth also tend to produce higher levels greenhouse gas emissions.

Results

After running our 3 linear regression statistical tests, our group discovered various results in terms of our data. Looking at the raw data, conclusions were hard to draw due to the complexity and abundance of information being displayed. However, with the 3 tests we were able to narrow down our information into more understandable terms and depictions.

As seen in Figure 1, our first test utilized the GINI index and GHG emissions variables to show the correlation between the two. Our results gave us a p-value of .7081 and a correlation coefficient of -.1806. In addition to the values, we can observe a weak negative correlation in the graph, as would be expected from the data we received. Moving on to Figure 2, the data shows some different results in regard to the GDP per capita and GHG emissions variables. As seen in the graph, there is an upward sloping line that runs through the points of the data in the scatter plot. This observed trend makes sense as it is further supported with the derived values from the test, being that there is a p-value of 4.33×10 , and a correlation coefficient of .3508. Finally, looking at Figure 3 there appears to be no real trend or line that can be drawn through the various points. The results drawn from this test gave us a p-value of .7081 with a correlation coefficient of -.0267.

Discussion & Conclusion

From our results and graphs, it can first be concluded that there is no statistically significant relationship between income inequality and greenhouse gas emissions. While there is an estimated correlation value that is slightly negative, the results are not significant enough to reject our null hypothesis. These results suggest that differences in distribution of income do not effect the production of greenhouse gas emissions at least as a solo factor. This can be interpreted in the case that greenhouse gas emissions are more so affected by consumption patterns and energy systems. To add, there were limitations within this data including limited GINI index information which posed an issue in differing sample sizes and determining a meaningful relationship.

Moving forward, we find that there is a statistical significance between GDP per capita and GHG emissions per capita, which is positive. This is an understandable finding considering it follows along with the general thought process that wealthier countries produce and consume more per person, resulting in greater energy use and increased emissions. However, with

the moderate level of correlation, it can be assumed that this factor alone is not what determines GHG emissions and instead there must be some other variables that play a role in the production.

Finally, when comparing GDP growth per capita and GHG emissions per capita, we found no statistically significant relationship. There also appears to be slightly to no correlation between the data points as shown in Figure 3 and our resulting data. This gives us the information that short-run output growth does not effect emissions output in a given year which can be related to the idea that emissions are a more long-run trending factor. With this result, we can see the importance of distinguishing between types of growth rates and development when analyzing these outcomes.

Overall, our results show that there may be more extensive and informational findings if focused on long-term growth and consumption pattern strategies as opposed to short-run growth or income distribution. Future research could strengthen our data through using a panel over multiple years or running various types of tests to see other factors of statistical significance. Our next steps into this research are considerably combining the data into one model to compare variables, moving forward to compare countries of high and low income with their GHG emissions, and using our information to further interpret magnitudes and inequalities within economies.