HIGH SCHOOL EDITION
Journal of Student Research
Volume 12 Issue 1 (2023)

The Correlation of Various Economic and Political Variables on Carbon Emissions

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ABSTRACT

With the sea levels and surface temperatures steadily rising, many scientists have warned of an oncoming global climate crisis. Currently, most studies point towards greenhouse gas emissions as being the main contributor for this climate crisis. In this study, we will investigate the correlation between various political and economic factors with carbon emissions. We run correlations among GDP and environmental policy stringency with the carbon dioxide emissions per capita to see the way the trends change over the scales of these variables. We also observe the trends of total population and total carbon emissions over time to analyze any occurring patterns. The goal of finding the correlations between these factors is that they may shed light on other potential elements that are commonly overlooked when attempting to minimize the global climate crisis. Our analysis also shows some inconsistencies between the intended and actual effects of the policy.

Introduction

Research Questions

(1) Does the degree to which climate change laws are enforced correlate to the ideal trend?
(2) In what way does GDP correlate towards the carbon dioxide emissions per capita over time?
(3) How does the total population trend over time relate to the total carbon dioxide emissions trend over time?

Previous Work

Datasets

All our data is sourced from open-source data sets. We read data from an Environmental Policy Stringency dataset published by the OECD (2022). This dataset provides us with a country on each row and 26 columns with an environmental stringency value for each year from 1990-2015. We referenced an open-sourced dataset on population density which gave us the population density of countries from the 19th century to 2100 (the values for the future years being estimations) (Roser et al., 2013). Another dataset which provided us with values for carbon dioxide per capita is maintained by Our World in Data and it includes data for the carbon dioxide emissions per capita from the early 20th century all the way to 2020 (Hannah Ritchie and Rosado, 2020). For our second investigation, we found an open-sourced data set about GDP which gives us the GDP values for countries from 1960 to 2020 (Tas, 2022). For our final investigation, we sourced a dataset from the World Bank which gave us the total population for each country over a period of 62 years (1960-2021). We also used the previous data of carbon dioxide emissions per capita to get our total emissions data in this investigation.

Previous Literature

Previous literature regarding our first question (Does the degree to which climate change laws are enforced correlate to the ideal trend?) has been investigated in the past when Wang et al. (2020) used the same dataset as us by Botta and Kozluk (2014) to come to their conclusion. They determined trends between the Environmental Policy Stringency (EPS) with the carbon dioxide emissions while setting many other variables as control variables. Their conclusion is that higher EPS did not always result in better carbon dioxide emissions per capita. Our first section will use another method and test if we are able to come to a similar conclusion. We then look at the correlations of a few of the variables (GDP, Total Population) they set as control to see their correlation with CO2 emissions.

Do the Environmental Policy Results Correlate with their Stringency?

Context

Our first question asks whether the degree of strictness for countries' environmental policies is directly correlated to their intended results. In the data set, we are given values for each country every year from 1990 to 2015. These values indicate the degree of stringency to which the country is enforcing their environmental policy. Thus, a higher number would indicate a stricter policy and a lower number would indicate a less strict environmental policy. Environmental policies are put in place to help protect the environment to which global warming poses a major threat. This allows us to infer that a stricter environmental policy should cause less carbon dioxide emissions as they are proven to trap heat, causing surface temperatures to rise at unnatural rates around the world. It also allows us to infer the opposite: countries with less strict environmental policies should not outperform countries with stricter policies in the amount of carbon dioxide emissions per capita.

Evidence

To test this hypothesis, we used a data set that we merged with the carbon dioxide emissions data set and then rounded the values given by the environmental stringency data set to the nearest integer. This allowed us to plot the distribution of emissions data for each rounded value (x) such that $x \in \{0, 1, 2, 3, 4\}$. In Figure 1 we see a box plot of these distributions.

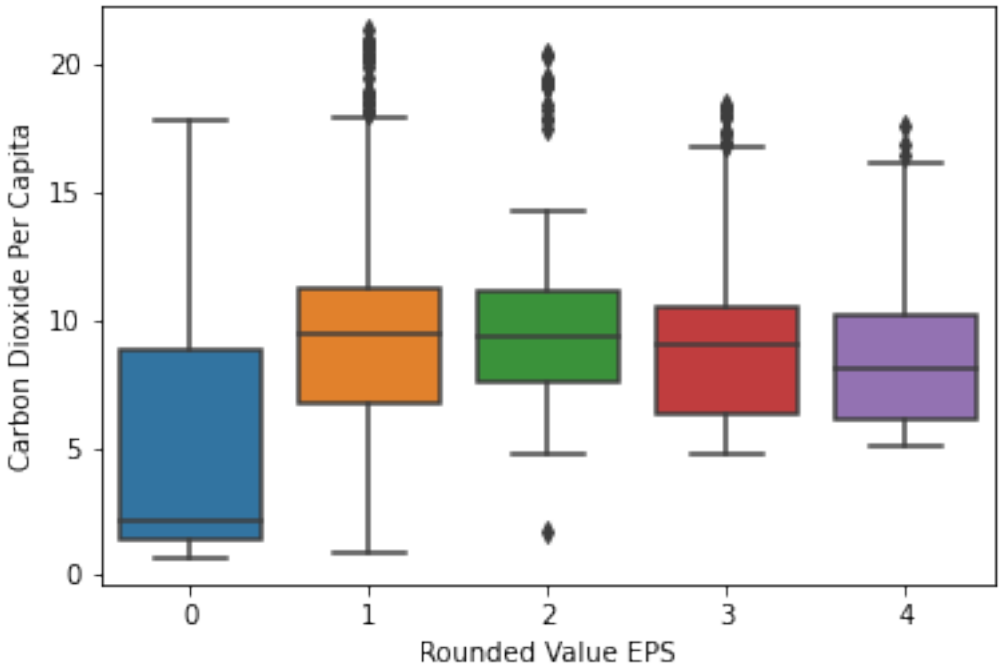

Figure 1. Box plot of each the distribution of carbon emissions per capita for each country whose economic policy stringency rounds to the value.

We can see in this box plot that the stringency of countries' environmental policies does not have the intended correlation for which they were enforced. We can see through the box plots that the center of the carbon emissions data for the value 0 is a lot lower than for the greater values. This refutes our hypothesis as 0 signifies a less strict environmental policy which we hypothesized to lead to higher carbon emissions per capita. We can also analyze the lower quartile of each box plot and we can see that 0 and 1 have a first quartile value much lower than that of the box plots for values 2, 3, and 4. Lastly, we see very small, unsubstantial differences in performance for the values of 2, 3, and 4. All of these observations may shed light on just how efficient our environmental policies are. We can also look at them in the form of histograms to see a clearer shape of the data.

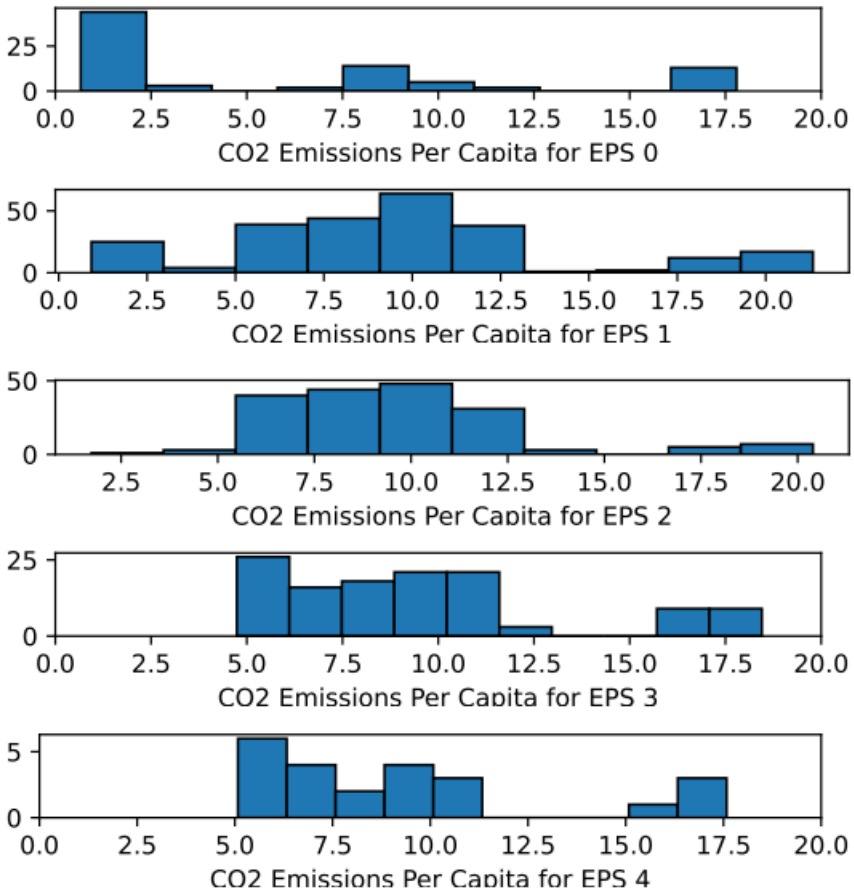

Figure 2. Distribution of carbon dioxide emissions per capita for EPS Values of 0 to 4 in that order.

GDP Correlation with Carbon Dioxide Emissions Per Capita

Context

In this section, we begin our next step of looking at the relationship between the variables that the previous paper held constant. Our first investigation surrounds the relationship between GDP and the carbon dioxide emissions per capita. We investigate the correlation over time to see whether a good economy benefits climate change or makes it worse over time. We then dig deeper into the significance of our findings to see the certainty of our results.

Evidence

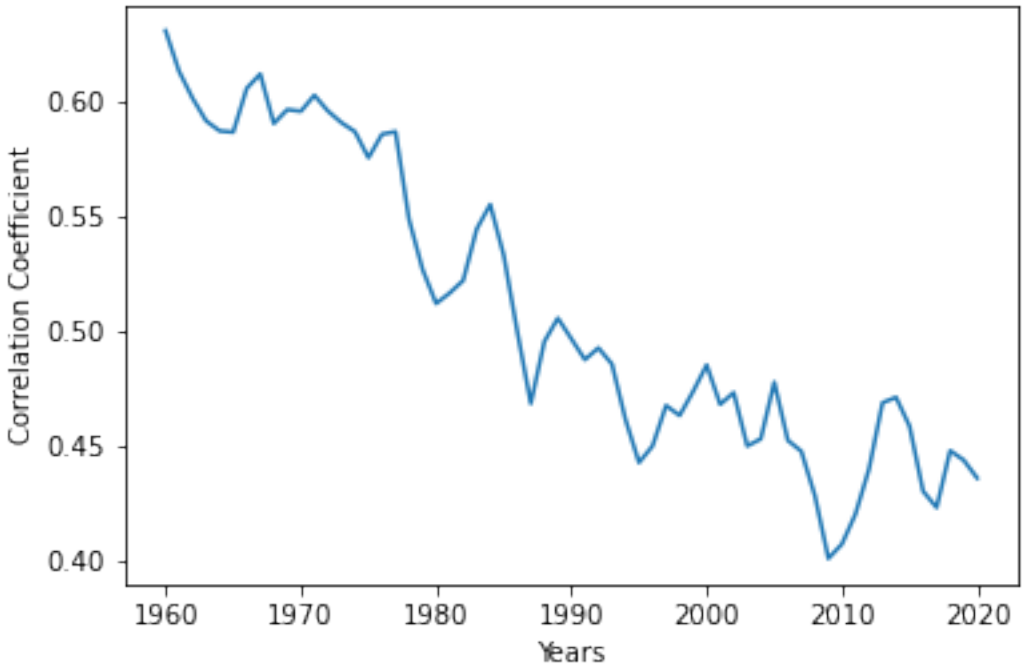

Figure 3. Correlation between GDP and carbon dioxide emissions over time in years

In Figure 3, we tracked the correlations of GDP and carbon dioxide emissions per capita over a period of time ranging from 1960 to 2020. We can see that the correlation between these two variables decreases over time dropping from 0.60 in 1960 all the way to 0.40 in 2020. This is quite important as it shows that the economy is relying less on carbon emissions in order to profit and if the trend keeps continuing the same way, we might begin to see an inverse relationship between GDP and CO2 per capita. This is important as better profits may result in a better atmosphere. Although this chart seems promising, it is important to see how significant this data is. When looking at the p-values over time, we noticed that the p-values indicated that the data was significant until 2010.

Total Population Correlation with Total Carbon Dioxide Emissions

Context

Our world's population has skyrocketed since the beginning of the 20th century with 2 billion people in 1900 to close to 8 billion people living on Earth today. With such a large increase in population and a generally fixed surface area, it is important to understand the way this affects carbon dioxide emissions. In this section, we investigate whether there is a substantial enough correlation between the total population over time and the carbon dioxide emissions to make a strong claim about total population's impact on carbon dioxide emissions.

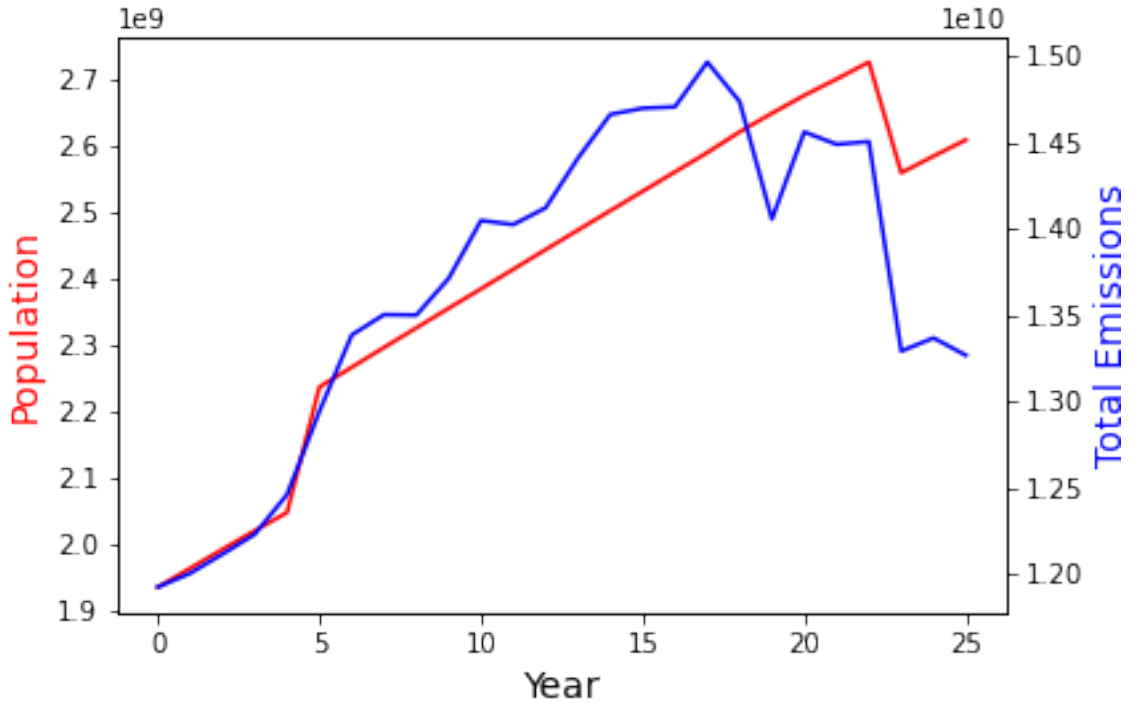

Figure 4. Graph of total population over time and total emissions over time.

Evidence

To gather this data, we created a line graph with two variables versus time in years after 1990 (Figure 4), one on the left and one on the right. The left scale is for total population data and the right scale is for total emissions data. We can see that originally, both total population and carbon dioxide emissions per capita had a similar rising trend but sometime around 2005, the total carbon dioxide emissions dropped. This is promising as it shows us that the human population can continue to grow without having a major negative effect on carbon dioxide emissions. It is important to notice that there is a significant drop around 2010 which we believe is because many countries stopped reporting their data. Although this may be the case, it is important to know that the carbon dioxide trend stopped correlating to the population trend before 2010 and we can continue to see the lack of correlation after 2010.

Conclusion

In Section 2, based on our evidence we were able to conclude that EPS values did not always follow the ideal trend which mirrored the results provided in our reference article. Although the EPS values of 1 and onward did perform ideally (Figure 2), the EPS value of 0 seems to contradict the ideal trend. In Section 3, we do see a decreasing correlation between GDP and carbon dioxide emissions and the data has low p-values making it significant in our investigation. In Section 4, we see a generally similar trend initially between total carbon dioxide emissions and total population, but at around 2005, we see a switch in this trend. Even though the total population continues to increase, the total carbon dioxide emissions started to lower. At around 2010, we mention a potential reason for the steep drop as countries stopped reporting around that time. Regardless, the negative carbon dioxide trend continued after this drop in the data which further supports the fact that carbon dioxide emissions are not positively correlated with total population.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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