IDS 702 Team Project

Part I: Exploratory Data Analysis

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Data Overview

Upon deciding on the World Inequality Database as our source (https://wid.world/data/), our group quickly realized not only its vastness but the variation in data points that are collected to answer key economic and social inequality questions. These key characteristics of the database are important to understand as the database is open-access, compiling valid data from national databases, surveys, fiscal data, and wealth rankings. This combination of data imports is key to ensuring the validity of the available data.

For our project, the key resultant that our group wants to analyze is a nation's carbon footprint (The Total National CO2 Footprint). A nation's total carbon footprint is equal to the combination of CO2 footprint and the footprint of other greenhouse gases. This leads to 2 distinct research questions:

1. How do income brackets affect a nation's carbon footprint? (top 10%, middle 40%, bottom 50%)
2. How have changes in a nation's average wealth affected their carbon footprint?

During the duration of our study, our main objective is to understand how the different economic status groups affect a nation's carbon footprint. Our assumptions or hypotheses leading to these questions is that there are no CO2 changes between any of the income brackets and changes within a country's average wealth over time have not had an impact on it's respective carbon footprint.

While the dataset/database is vast, we have narrowed to the following key variables that will help analyze demographic statistics of a country:

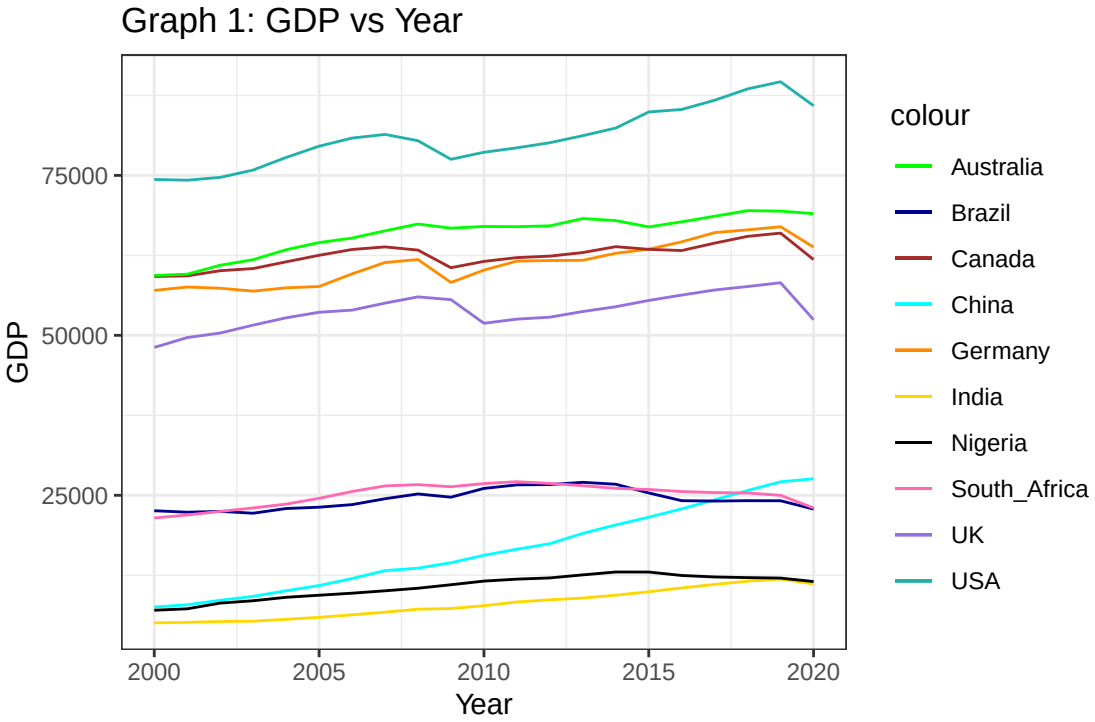
1. The National Income for the Respective Nation - *which according to the World Inequality Database is defined as "National income aims to measure the total income available to the residents of a given country. It is equal to the gross domestic product (the total value of goods and services produced on the territory of a given country during a given year), minus fixed capital used in production processes (e.g. replacement of obsolete machines or maintenance of roads) plus the net foreign income earned by residents in the rest of the world. National income has many limitations. However it is the only income concept that has an internationally agreed definition (established by the United Nations System of National Accounts, see SNA 2008). So we use it as our reference concept (with tax havens correction)."*
2. The respective nation's Gross Domestic Product
3. The Income Inequality within a nation (as determined by the following income brackets: Top 10%, Middle 40%, and Bottom 50%)
4. The respective nation's total population
5. The respective nation's market-value national wealth - *which according to the World Inequality Database is defined as "Net national wealth is the total value of assets (cash, housing, bonds, equities, etc.) owned by the national economy, minus its debts. The national economy - in the national accounts sense - includes all domestic sectors, i.e. all entities that are resident of a given country (in the sense of their economic activity), whether they belong to the private sector, the corporate sector, the governement sector."*

6. The respective nation's wealth-to-income ratio (which assesses the net national wealth to the net national income)
7. Years, from the beginning of the century to 2020 (2000 - 2020)
8. Countries

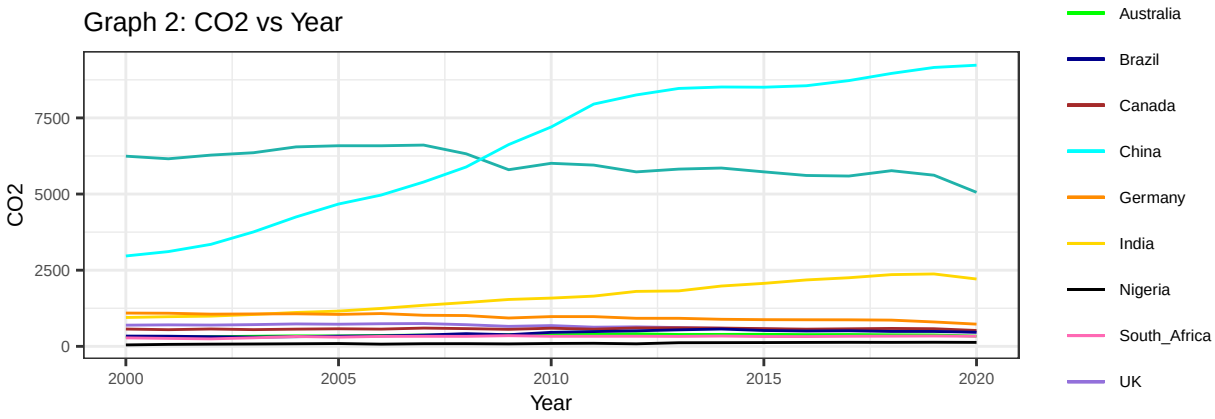
While the world inequality database maintains data for around 300 countries/regions throughout the world, we have narrowed down that total selection/population to a sample size of 10 countries: The United States, China, India, Germany, the United Kingdom, Canada, Australia, Brazil, Nigeria, and South Africa, to effectively analyze and assess these data questions over the 20 year selected period.

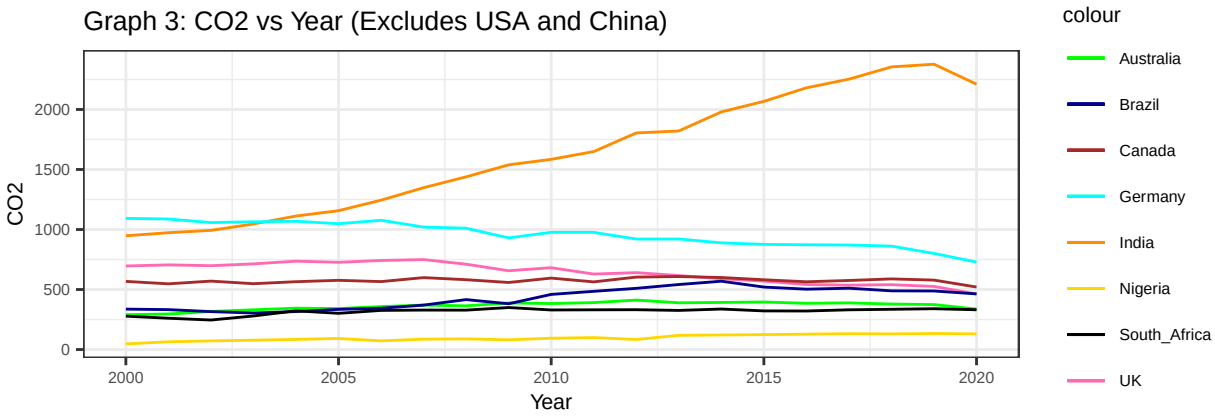
It is important to note: to help standardize the findings for all countries, the US dollar was the currency selected for the appropriate variables

Primary Relationship of Interest



From Graph 1, we have visualized the trend of average income per adult GDP over the years 2000-2020. We see general positive linear trends across all countries with USA, Australia and Canada with the top three highest GDP.

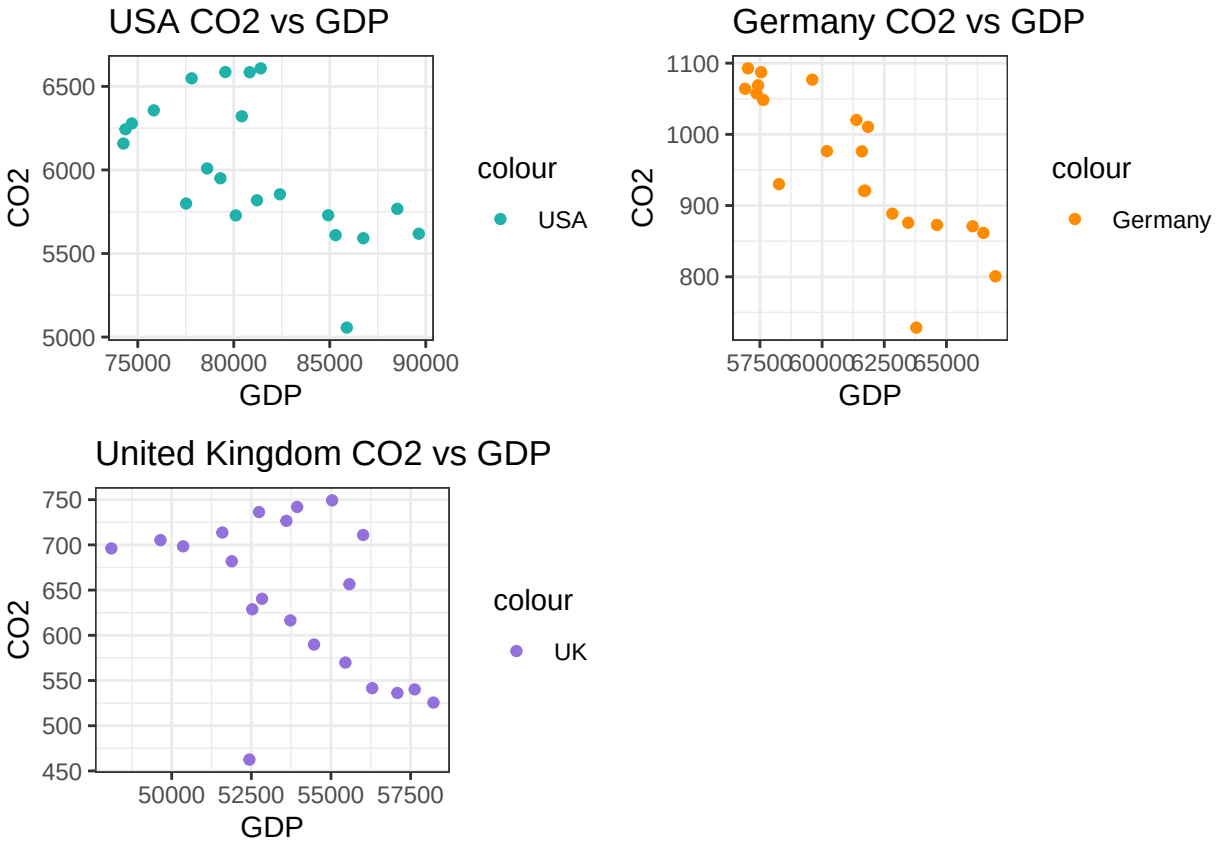




In Graph 2, we visualized the carbon emissions released by each country over the years. The results of the graph show that the USA and China are major contributors of carbon emissions, the other countries are clustered close together towards the bottom of the graph. In order to see the trend among these countries (non-major CO2 contributors), we chose to plot Graph 3 while omitting the two. Most of the countries show a constant trend and some show a slight decrease post-2010, this could be due to reduced coal use and the transition to renewable energy use. The only country that has a contradictory trend is India, which increased in carbon emissions significantly from 2000-2020. India's main source of energy generation is coal-fired and the growth of renewable slowed over the years which explains the spike after 2012. USA, China and India are known as the three major carbon emitters and our data shows parallel results.

	co2_usa	co2_china	co2_india	co2_germany	co2_uk	co2_canada	co2_australia	co2_brazil	co2_nigira	co2 _south africa
wealth_usa	-0.31									
wealth_china		0.94								
wealth_india			0.99							
wealth_germany				-0.91						
wealth_uk					-0.19					
wealth_canada						0.06				
wealth_australia							0.68			
wealth_brazil								0.95		
wealth_nigira									0.89	
wealth_south africa										0.87

Figure 1: Correlation Matrix



From the correlation matrix, we see that all the countries have a generally strong positive correlation between carbon emissions and average wealth. However, USA, Germany and UK have negative correlations. The three graphs above model the relationship between carbon emissions and GDP for those countries and we see the same relationship as we do with wealth. There is not a very strong compared to other countries (see Appendix) but there is an overall negative trend. Based on the similar behavior between GDP and wealth with carbon emissions, we will dive deeper into income brackets and average wealth in our model to infer how significant this relationship is.

Other Characteristics

As mentioned within our data overview, the World Inequality Database is an extensive. For example, the database is comprised of data points within 7 distinct categories:

1. Average and Total Income - This category provides a breakdown of the national and personal income and savings
2. Average and Total Wealth - This category provides a breakdown of the national and personal wealth by assessing assets, liabilities, market valuation of companies, etc.
3. Income Inequality - The income inequality measures the national and personal income/savings between different ranges and can be customized based on the percent range (i.e. top 10% (from 90-100%), etc.)
4. Wealth Inequality - Similar to income, the wealth inequality measures the total value of assets, liabilities, etc. over different ranges and can be customized based on the percent range (i.e. top 10% (from 90-100%), etc.)
5. Carbon Macro and Average - This category assesses carbon emissions and provides breakdowns by national, household, imports, and other territorial groups.
6. Carbon Inequality - The carbon inequality measures the national carbon footprint between different

ranges and can be customized based on the percent range (i.e. top 10% (from 90-100%), etc.)

7. Other data variables available on World Inequality Database - A category that maintains other demographic and financial data points, from market exchange rates and taxes to population size and employed population

From these broad categories, we subset to our variables to answer our two research questions. This consisted of analyzing aggregated views of a nation's income, wealth, carbon footprint, and population size. To see changes over time, we have selected a 20 year timeline (from 2000 - 2020), which, in our opinion, should be a long enough time frame to demonstrate any social or economic changes. Lastly, in selecting our sample size of 10 countries, we wanted to assess the impacts/research questions geographically across the world. For this reason, we selected up to 2 of the largest countries in terms of size, population, income, and other demographic means per continent in order to standardize and have a better understanding throughout the globe.

Potential Challenges

While the World Inequality Database is a great resource and maintains great data, it also has many limitations and presents many challenges. Three of the key constraints we ran into were:

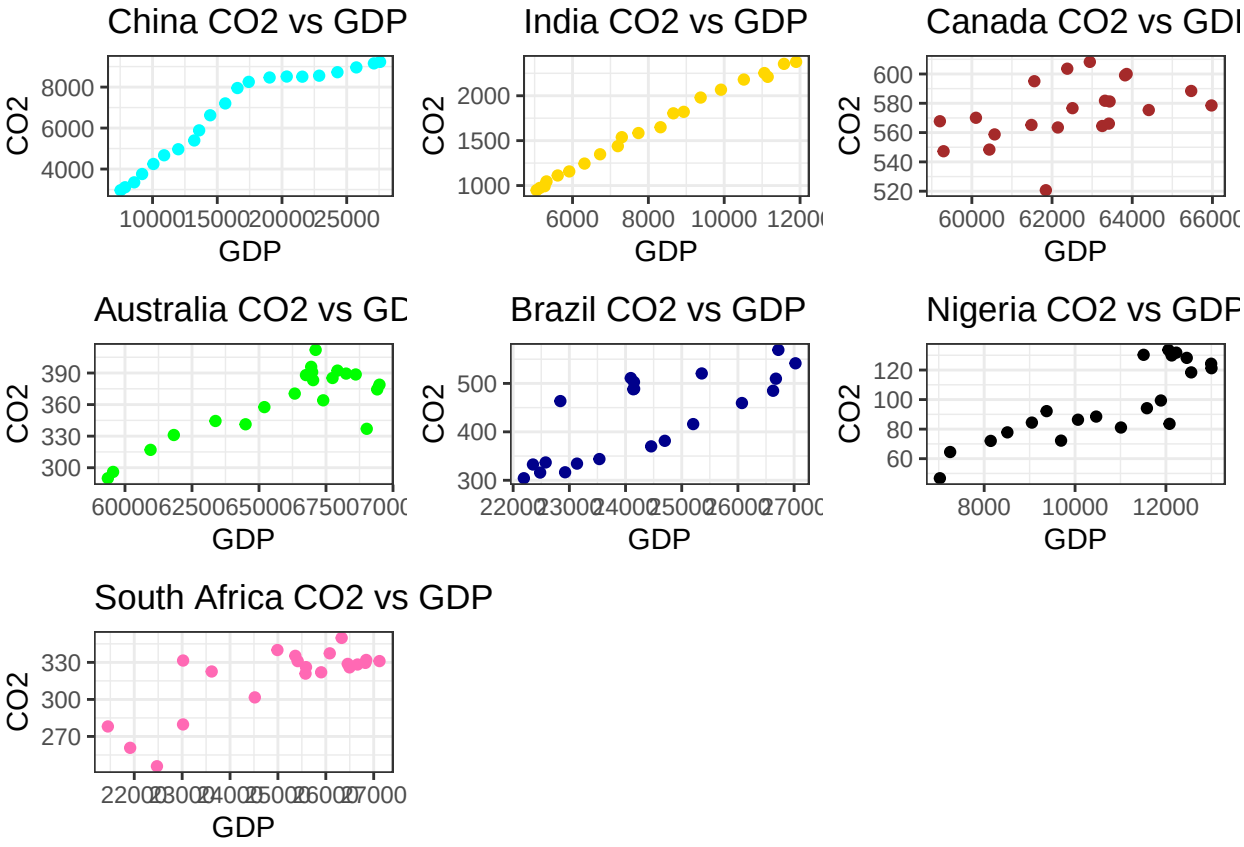
1. The inability to analyze data beyond and/or within our selected 20 year time frame. This was seen from both a country aspect as well as variable aspect. Our decided 20 year window was optimal for most countries and most variables. For example, during our exploratory phase, we found that even for several countries (22 countries to be exact), they did not have basic national income and GDP information. It was important for us to remove these countries that didn't have data within our 20 year window as to not skew/impact our understanding. It can be assumed that for smaller countries, some key data points may not be available due to limited resources. In addition, we found that as the World Inequality Database has become more widely used for research purposes, data collection of interesting data points varies and is only available and can only go as far back based on the sources/when the variable was created. While we may prefer to garner a more significant understanding/trend, we are unable to based on this limitation.

2. The standardization of the data across countries due to multiple factors: population size, currency, etc. While we have tried to control for these factors by including population as a variable and normalizing all financial data to US dollars, this is an important limitation to outline now and remember for future model creation, etc.

3. The resistance to include more variables was due to many variables being dependent on the primary independent variables resulting in collinearity in our model. For example, wealth income is made up of assets and debt so we were unable to include those in our analysis, rather we chose to include the aggregate feature for our model to be more well-rounded.

Appendix

CO2 vs GDP graphs (cont.)



Descriptive Statistics

Table 1: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

year	National_income_USA	GDP_USA	CO2_USA
Min. :2000	Min. :64323	Min. :74252	Min. :5057
1st Qu.:2005	1st Qu.:66668	1st Qu.:77806	1st Qu.:5729
Median :2010	Median :69570	Median :80419	Median :5950
Mean :2010	Mean :69369	Mean :80921	Mean :6010
3rd Qu.:2015	3rd Qu.:72530	3rd Qu.:84920	3rd Qu.:6321
Max. :2020	Max. :76075	Max. :89639	Max. :6608

Table 2: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_China	GDP_China	CO2_China
Min. : 6259	Min. : 7533	Min. :2966
1st Qu.: 9138	1st Qu.:10893	1st Qu.:4672
Median :13275	Median :15618	Median :7202
Mean :13957	Mean :16456	Mean :6595
3rd Qu.:18483	3rd Qu.:21571	3rd Qu.:8514

National_income_China	GDP_China	CO2_China
Max. :23087	Max. :27578	Max. :9229

Table 3: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_India	GDP_India	CO2_India
Min. : 4552	Min. : 5052	Min. : 947.9
1st Qu.: 5283	1st Qu.: 5913	1st Qu.:1157.1
Median : 6855	Median : 7737	Median :1584.6
Mean : 7119	Mean : 8046	Mean :1622.9
3rd Qu.: 8647	3rd Qu.: 9915	3rd Qu.:2067.3
Max. :10503	Max. :11895	Max. :2377.1

Table 4: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_Germany	GDP_Germany	CO2_Germany
Min. :48168	Min. :56905	Min. : 728.6
1st Qu.:49847	1st Qu.:57632	1st Qu.: 875.8
Median :53318	Median :61601	Median : 976.1
Mean :52663	Mean :61162	Mean : 959.5
3rd Qu.:54640	3rd Qu.:63462	3rd Qu.:1057.7
Max. :57716	Max. :66973	Max. :1092.7

Table 5: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_United_Kingdom	GDP_United_Kingdom	CO2_United_Kingdom
Min. :43076	Min. :48108	Min. :462.5
1st Qu.:46503	1st Qu.:52440	1st Qu.:569.8
Median :47626	Median :53726	Median :656.5
Mean :47556	Mean :53771	Mean :641.3
3rd Qu.:49268	3rd Qu.:55579	3rd Qu.:710.9
Max. :50901	Max. :58218	Max. :749.2

Table 6: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_Canada	GDP_Canada	CO2_Canada
Min. :50203	Min. :59203	Min. :520.7
1st Qu.:52204	1st Qu.:61487	1st Qu.:564.5
Median :53779	Median :62511	Median :575.4
Mean :53544	Mean :62450	Mean :574.3
3rd Qu.:55098	3rd Qu.:63435	3rd Qu.:588.4
Max. :56411	Max. :65977	Max. :608.3

Table 7: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_Australia	GDP_Australia	CO2_Australia
Min. :49197	Min. :59361	Min. :290.0
1st Qu.:53336	1st Qu.:64499	1st Qu.:341.3
Median :54886	Median :66983	Median :374.4
Mean :54137	Mean :65894	Mean :363.2
3rd Qu.:55740	3rd Qu.:67929	3rd Qu.:388.6
Max. :56479	Max. :69495	Max. :412.0

Table 8: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_Brazil	GDP_Brazil	CO2_Brazil
Min. :18859	Min. :22191	Min. :304.2
1st Qu.:19574	1st Qu.:22924	1st Qu.:336.8
Median :20612	Median :24150	Median :459.5
Mean :20803	Mean :24353	Mean :428.2
3rd Qu.:21701	3rd Qu.:25356	3rd Qu.:502.9
Max. :23411	Max. :27024	Max. :569.2

Table 9: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_Nigeria	GDP_Nigeria	CO2_Nigeria
Min. : 6475	Min. : 7025	Min. : 46.76
1st Qu.: 8752	1st Qu.: 9374	1st Qu.: 81.08
Median :10450	Median :11509	Median : 92.18
Mean : 9880	Mean :10718	Mean : 98.12
3rd Qu.:11329	3rd Qu.:12127	3rd Qu.:124.26
Max. :12032	Max. :13003	Max. :133.63

Table 10: Exploratory Analysis of National Income, GDP, and CO2 for Countries and Year

National_income_South_Africa	GDP_South_Africa	CO2_South_Africa
Min. :18132	Min. :21449	Min. :245.9
1st Qu.:20314	1st Qu.:23617	1st Qu.:320.9
Median :21278	Median :25577	Median :328.3
Mean :21061	Mean :25032	Mean :317.1
3rd Qu.:22179	3rd Qu.:26459	3rd Qu.:331.5
Max. :22939	Max. :27121	Max. :349.8