FCC DOCUMENTATION

Central Questions:

In this final coding challenge, I aim to manipulate data provided by the Energy Information Administration to graphically demonstrate correlations between CO2 consumption and GDP among developed and developing countries. I then seek to graphically compare CO2 consumption between developing and developed countries. Finally, I graphically demonstrate renewable vs fossil fuel energy reliance in developing and developed countries.

Assumptions:

First, I’d like to explain some assumptions made in my method. The EIA provides data for GDP, CO2 emissions, electric generation from renewable sources, and electric generation from fossil fuel sources data for 228 politically defined regions from 1980-2016. This includes countries that have since fractured into new states and/or countries that have since merged into larger states. Presently, there are 195 countries in the world. For the purposes of this project, I refer to the EIA’s 228 politically defined regions as countries for simplicity. I link the archive for this data below:

<https://www.eia.gov/beta/international/data/browser/#/?pa=000000000000000000000000000000000000000000000000000000001&c=4100000002000060000000000000g000200000000000000001&tl_id=4702-A&vs=INTL.4702-33-AFRC-THP.A&cy=2016&vo=0&v=H&end=2018>

In this project, I selected the “all countries” setting for each dataset and spanned the data from 1980-2016. Please navigate through this site to clarify the parameters and units I included (GDP, population, emissions, electricity, etc.) in my project.

Another assumption I made had to do with addressing missing/unavailable data points. Several of the data sets from the EIA are missing data points for certain countries over certain time frames. The EIA accounts for unavailable data with the label ‘NA’. In order to plot all of the countries provided, the data frames needed to be the same size. As such, rather than removing the rows/columns with ‘NA’ values, I replaced the ‘NA’ values with 0. This is under the assumption that in actuality, no country demonstrates zero carbon emissions, zero GDP, or zero electricity generation from the respective sources between 1980 and 2016. Therefore, in the final plots presented in answer to the project’s central questions, any values of zero are not in fact zero, rather the viewer can interpret this to mean there is no data available for that particular country or year.

To categorize which countries are developing vs developed, I made the general assumption made by economists that developing countries are those with GDP per capita less than $12,000. Doing so, I isolated 76 developing countries and 152 developed countries. The $12,000 GDP per capita threshold comes from the following source:

<https://www.investopedia.com/terms/d/developed-economy.asp>

Finally, I equate emissions and generation to consumption patterns in the data. I assume that any CO2 emitted country-by-country equals the CO2 consumed, i.e. energy consumed, by that country. Similarly, any electricity generated, either renewable or fossil fuel based, is equated to electricity consumed, i.e. energy consumed, country-by-country.

How to Run Code:

My code is organized to run sequentially. Starting with mount drive, run the code step-by-step up until the final plots. I have included the relevant data files in this GitHub repository.

Trends:

Embedded in the code, I plot the total GDP, CO2 emissions, electricity generated from renewable sources, and electricity generated from fossil fuels for all countries as line graphs. These plots are not intended to give explicit answers to the central questions presented at the beginning of the project. Rather, these plots are intended to give the viewer a general sense for the global attitude towards these parameters between 1980 and 2016. These plots do not even show a legend to delineate which country is which, as that is not the point of the graphs. Rather they are meant to demonstrate how the total data in the data frames behaves. In general, there has been an increase in global GDP, CO2 emissions, and electric generation since 2018. This is evident in the general trend presented in the varying graphs embedded in the code.

Conclusions:

1. How does CO2 consumption relate to GDP in both developing and developed countries?

For the developing countries with data available for both CO2 emissions and GDP, the generated subplots of bar graphs demonstrate a positive correlation between CO2 emissions and GDP. Especially in the first section of developing countries explored (American Samoa – Former Yugoslavia), there is a direct relationship between CO2 emissions and GDP, meaning there is some sort of cause and effect relationship between these two parameters.

A similar pattern is seen among the developed countries. For developed countries with data available for CO2 emissions and GDP, there is a positive correlation between the parameters. For example, the US demonstrates a practically identical, i.e. 1:1 ratio, between CO2 emissions and GDP. A similar trend is evident in other major political powers, such as Canada, China, Russia, Japan, and Iran. Again, this direct relationship between CO2 emissions and GDP in developed countries indicates some sort of cause and effect relationship.

The cause and effect relationship between CO2 emissions and GDP is rather intuitive. I completed the “Business of Energy” course this semester in which we explored concepts relating energy consumption to CO2 and GDP. The data manipulation seen in response to the question “How does CO2 consumption relate to GDP in both developing and developed countries?” corroborates what I learned in the Business of Energy. Just as human bodies are fueled by food and plants are fueled by sunlight, economies, both developing and developed, are fueled by energy. Energy consumption promotes growth, and in economies, this growth is seen as increased GDP. As such, the near 1:1 ratio between CO2 emissions, i.e. energy consumption, seen in both developing and developed countries is accurate in the sense that it demonstrates the concept that energy consumption fuels economic development and thus economic growth. The near 1:1 ratio indicates the energy efficiency (energy consumption/GDP) of countries. In countries where CO2 emissions bars are higher than GDP bars, this may indicate that the country has poorer energy efficiency. Visually, developed countries appear to be on average more energy efficient than developing countries

2. How does CO2 consumption differ between developing and developed countries?

Clearly from the first pie chart titled “Global CO2 Consumption”, developed countries account for the majority of global CO2 emissions. This makes sense given that developed countries have higher GDPs than developing countries, ergo developed countries have more active economies requiring more energy. However, from the second pie chart, it becomes clear that developed countries use fossil fuel based, i.e. CO2 emitting energy sources, as a smaller fraction of their total electric energy budget than developing countries do. This indicates that while developed countries emit more CO2 than developing countries, they demonstrate more renewable sources in their electric energy portfolio than developing countries do. If developing countries continue to grow without adjusting their energy budget, they may outpace developed countries in emitting CO2. In fact, as developed countries continue to improve their energy efficiency, their CO2 emissions will begin to level off over time. If developed countries can demonstrate similar renewable consumption outside the electric industry, they will further reduce their share of global CO2 emissions. Developing countries are generally less technologically equipped to demonstrate similar energy efficiency improvements and portfolio shifts, and thus I anticipate their share of global CO2 emissions will increase.

3. Do developing countries rely more on fossil fuel or renewable energy sources? How about developed countries?

To answer this question, I present a bar chart of renewable energy plotted in comparison to fossil fuel energy for all developing and then developed countries. I then provide a summary pie chart to show the total reliance of developing and developed countries on renewable and non-renewable electric energy sources. In general, developing countries rely on renewable sources for 5% of their energy consumption and fossil fuels for 95%. Developed countries rely on renewable sources for 20% of their electric energy consumption and fossil fuels for 80% of their electric energy consumption. Both developing and developed countries rely on fossil fuel sources more than renewable energy sources, although developing countries rely on fossil fuel more than developed countries do. This is likely due to developed countries’ economic and financial ability to explore expensive renewable sources. Natural gas is currently one of the cheapest forms of energy. While solar energy is approaching comparable prices, the technology is more expensive to install compared to natural gas imports. As such, it is expected that developing economies will rely more on cheap fossil fuels than expensive renewables, especially in their more urbanized regions.