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ISQA 8086
Final Presentation Summary
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Air and Greenhouse Gas Emissions

Educators have the power to impact the thinking and decision making of the next generation. Rachel Green is a theology professor at Creighton University in Omaha, Nebraska. One of Dr. Green's strongly held beliefs is that climate change is a moral and ethical issue. She has studied policy, theological teachings, and scriptural sources to support this position. She is now preparing to present to other theology professors at a conference. Our analysis of greenhouse gas emissions is designed to give historical context and accurate information from trusted sources with which she can share her message that addressing climate change is a moral and ethical issue facing all people today.

Our main data set was produced by the Organisation for Economic Cooperation and Development, an international organization whose mission is "to promote policies that will improve the economic and social well-being of people around the world." (OECD)

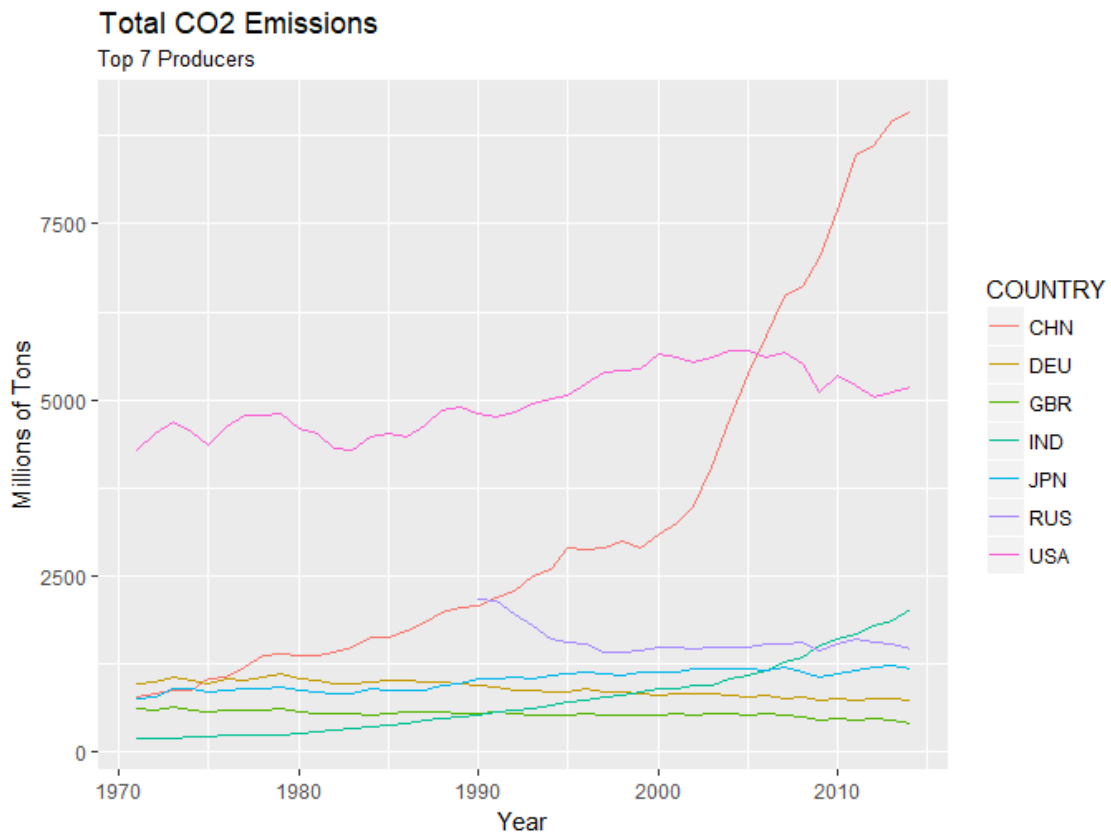
This data set consisted eight columns and 24,950 lines of data. These are records of greenhouse gases, carbon dioxide (CO2), sulfur oxide (SOX), and nitrous oxide (NOX) emissions for 180 countries since 1960. Not all countries have complete data. Most of our analysis begins with 1971 because few countries had data prior to that. Few countries had compiled greenhouse gas data, so we focused on CO2, NOX, and SOX. The data set contains the country code, which emission type, the year, the total emissions, the unit of measure, a frequency column (all A, which we believe is Annual), and a Flag Code. There were 3693 flag codes of "L" with no metadata to explain what this meant. We observed that these were all CO2 records, and the amounts were missing. We deleted all of these records. Additionally there were 30 flag codes of "B." We did not know what this stood for, these were limited to NOX and SOX records, which we used in our analysis.

In order to complete our analysis, we needed to supplement our data with Population and Urbanization rates for the countries and years of our analysis. Fortunately, we found that World Bank had this data available on their website. We appended this information to our dataset in Excel before uploading to use in the R analysis.

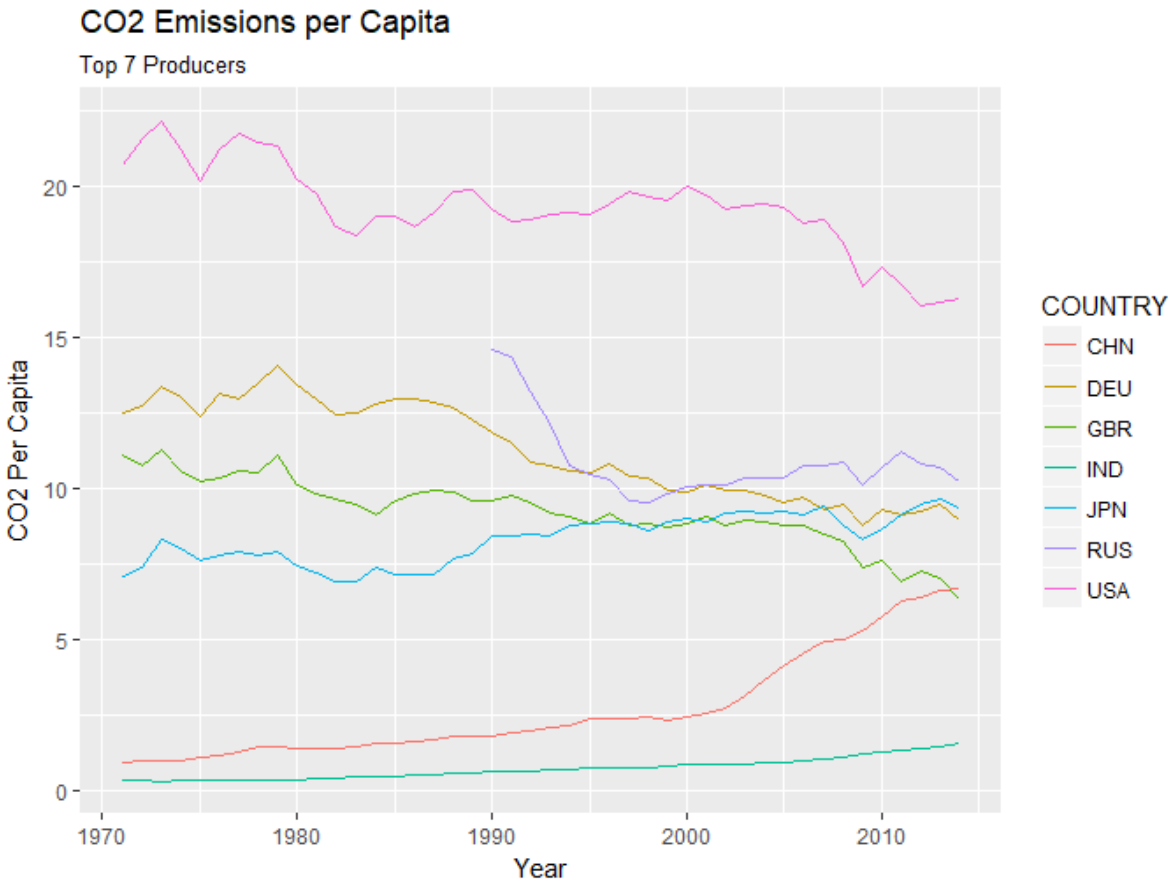
Our analysis focused on three questions:

1. Which countries and regions contribute the most CO2 emissions, both on a total volume basis and from a per capita perspective? Do the top offenders have similar patterns of increasing an decreasing emissions?
2. Are urbanization rates correlated to carbon dioxide emissions?
3. Are Nitrogen Oxides and Sulfur Oxide emissions highest from OECD member countries? Are these emissions correlated to urbanization?

To answer the first question, we sorted the data into subsets by year and looked at the top producers for each year starting in 1971, then years ending in 5 or 0, and ending in 2014, the last year included in the OECD dataset. We looked at which countries were in the top five for total emissions in each of these years. The data was fairly consistent, there were seven countries that made up the top five for the years surveyed: USA, China, Russia, Germany, the United Kingdom, Japan, and India. We produced a time series graph of total CO2 emissions for these countries and one for per capita emissions over the same time period.

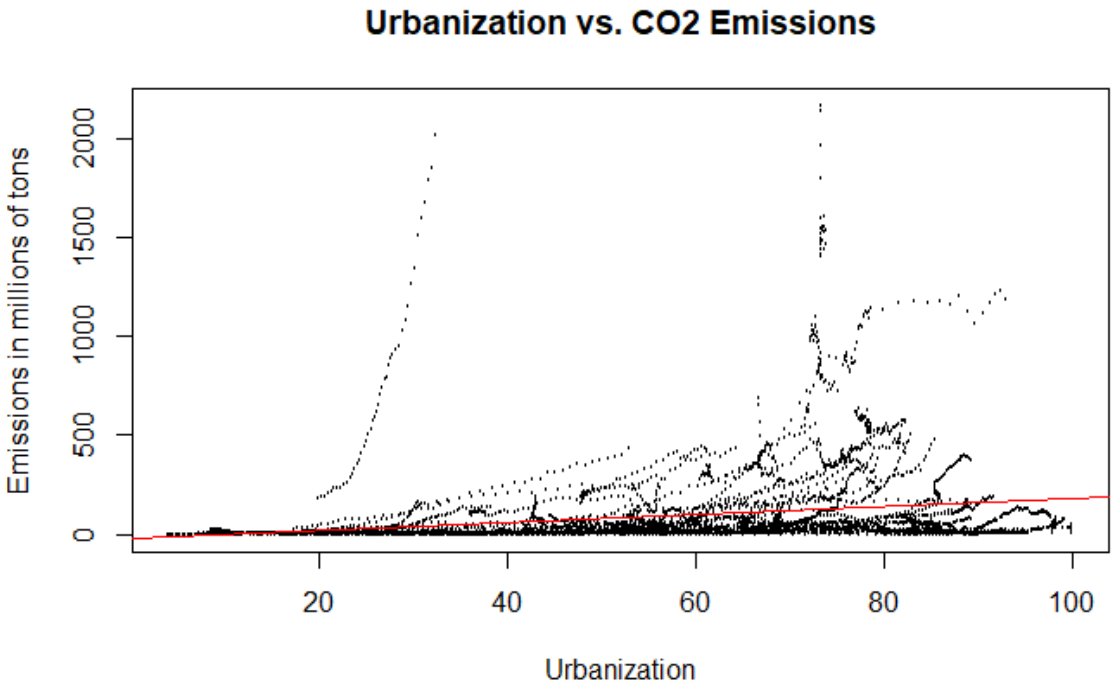


This plot shows that China's CO2 production has seen a sharp increase in the last decade and they produce, by far, the most CO2 emissions. China's growth looks like a steep exponential curve until approximately 2009, and for the last five years, while they are still exhibiting growth, the concavity of the curve changed direction, indicating a slower growth rate. Recent reports indicate that China's CO2 emissions are expected to peak by 2030. (Bloomberg) The chart also shows that the USA's emissions are consistently much higher than the other countries in the top seven, although they have seen a decline since approximately 2005. India is seeing rapid growth in CO2 emissions, going from 7th place in 1970 to third in 2014. Russia's data starts in 1990, after the collapse of communism in 1989. Japan, Germany, and Great Britain have similar and relatively consistent emissions patterns, though Japan had a slight increase while Germany had a decrease, causing them to switch places in the rankings. Despite being the top polluters, all countries but India seem to be trending down in more recent years, due to international recognition of the dangers of continued emissions growth.

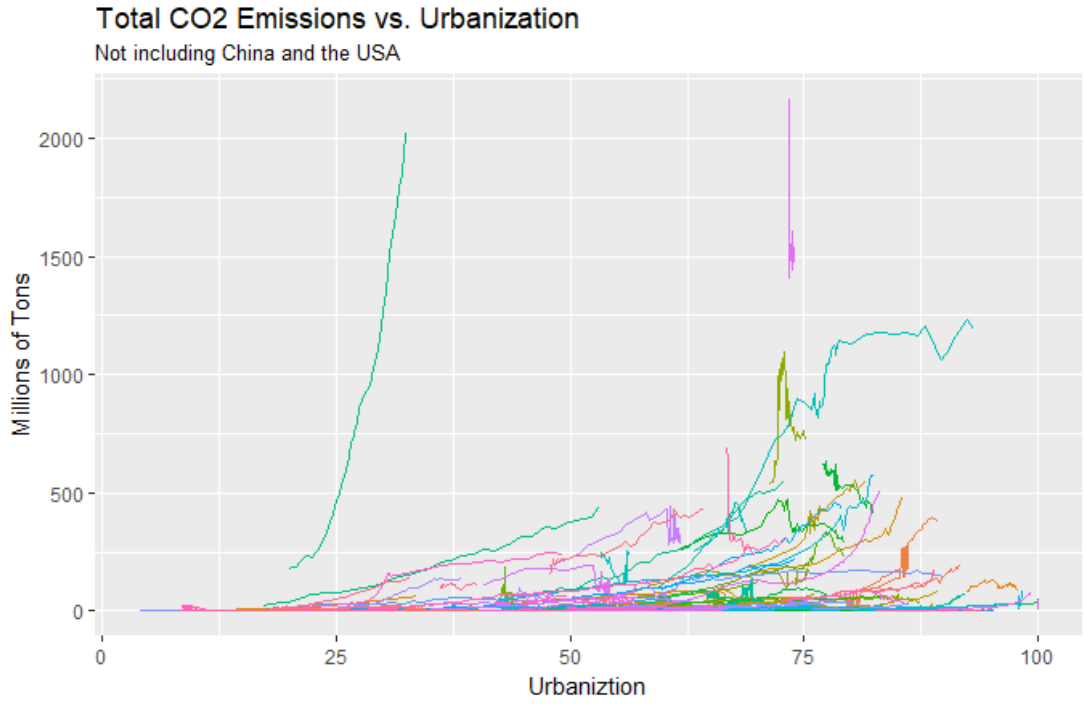


When considering per capita CO2 emissions, the USA is consistently significantly higher than any other country of the top 7 CO2 emissions producing countries. The USA, Germany, and Great Britain exhibit decreasing trend over time, while Japan and India are growing slowly, and China grew quite rapidly in the last two decades. Russia has not exhibited a consistent pattern, but their CO2 emissions per capita are consistently among the highest. We also considered regional consumption patterns. North America and Eastern Asia were dominated by the data from USA and China, as expected. Africa shows little CO2 emissions, and does not appear to be experiencing growth in this area.

The second question we explored was whether or not there was a correlation between urbanization and CO2 emissions worldwide. We started with a graph that plotted urbanization rates against total CO2 emissions. There appeared to be a correlation, but China and the USA had such high rates (with positive sloping relationships) that all other data points were very compressed at the bottom of the graph. For that reason, we graphed again without China and the USA. We also added a best fit line, which indeed showed a positive slope, with a correlation coefficient of 0.22. For the initial analysis, we did not distinguish between different countries. All points are black to show the overall correlation.

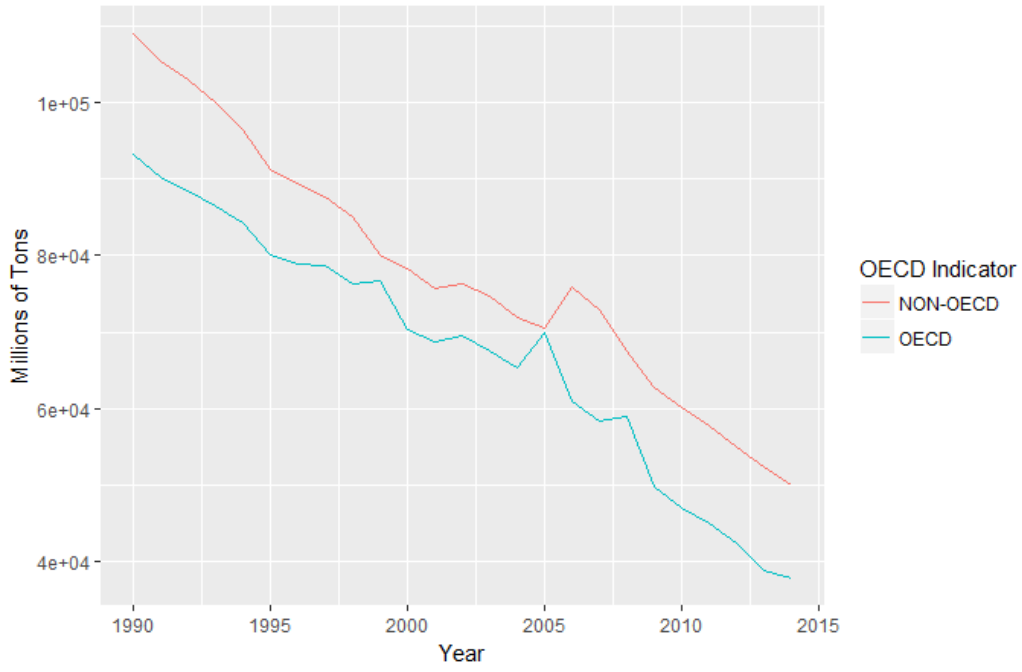


We then looked at Urbanization vs. Emissions for individual countries, graphing lines instead of points, and making each a different color, which shows that, with the exception of a few interesting squiggles, most countries exhibit increasing emissions as urbanization increases. Here again, China and USA were such outliers that the pattern was easier to see with them eliminated from the graph.



The final question we analyzed was whether OECD member nations had lower emissions of Nitrous Oxide and Sulfur Oxide emissions, and how these emissions rates were related to urbanization in the member and non-member countries. To address these questions, we had to add a flag indicator for which countries were OECD members. Then, to address the urbanization portion of the question, we multiplied each country's population times its urbanization rate to get the number of people living in urban areas for each year. We then had to sum all urban people and total populations for member and non-member countries by year. Once we had these totals, we could divide to get the urbanization rate for all OECD member nations together, and all non-member nations.

Because NOX and SOX gases were identified as dangerous pollutants for human health many decades ago, there has been a relatively consistent decline in these emissions. For example, the USA mandated reducing these pollutants in the 1970 EPA Clean Air act (EPA).



We also considered urbanization rates for OECD vs Non OECD countries. As observed above, both exhibit similar patterns of decreasing NOX and SOX emissions. But Non-OECD countries tend to have significantly lower urbanization rates. Over the 25 year period considered, member nations urbanization rate grew from approximately 14 to 16% , where non-OECD countries saw increases from approximately 2 to 6%.

The results of our analysis show that a combination of public awareness and regulation can make a significant difference when it comes to reducing our toxic emissions. The human suffering and environmental devastation caused by climate change make this a moral and ethical issue for all persons on earth. But those in the countries that are the greatest offenders bear the biggest responsibility to enact swift change and support policies and politicians who prioritize responsible stewardship and minimal damage to our environmental resources.

Word Count: 1357

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