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Work From Home, It Helps

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Abstract

The world's population was in lockdown due to COVID 19, accompanied by stringent social measures in 2020. Surprisingly, the outbreak's positive impacts outweigh its adverse effects in terms of environmental well-being as there has been a significant decrease in greenhouse gas emissions at an average of 8% around the world. This study focuses on the relationship between greenhouse gas (GHG) emissions and the strictness level of lockdown measures across the 50 states of the United States of America for the years 2019 and 2020, as the data is retrieved from the U.S federal and Environmental Protection Agency (EPA) websites. We plan to conduct regression analysis to examine whether there is a significance in the relationship between the lockdown measures and the GHG emissions. However, our quantitative analysis may not show conclusive results as the data needed for this study has to be measured over a more extended period of time. This paper aims to provide the first step in analyzing the quantitative data to establish the impact of Covid-19 on climate change. Our findings may support an approach similar to the measures implemented during the outbreak and carry them forward in addition to current efforts to improve our global climate.

Keywords: *Greenhouse gas emissions, Covid-19, Transportation, Measures*

Introduction

Global warming is a significant problem today and it is a fight that needs to be subdued for the population's greater good. The increase in global temperature causes rising sea levels, acidification of the ocean, and melting of ice glaciers (NASA, 2020). The increase in heat-trapping gases, commonly known as greenhouse gases, has led to this rise in temperature (EPA, 2020). Examples of these greenhouse gases are carbon dioxide, methane, nitrous oxide, and mostly water vapor. There are both human-made and natural reasons contributing to the increase in greenhouse gases. Human-made contributions include the burning of fossil fuels that had commenced during the Industrial Revolution, deforestation, landfills, increased populations, fertilizer usage in farming, and meat consumption. The following are natural contributions to global warming: forest fires and volcanic eruptions (Rinkesh, 2019).

Climate change is one of the severe effects of global warming, where there is a change in weather pattern in the longer run. With the increase in the number of Greenhouse gases, the amount of heat trapped also increases, thereby contributing to an overall rise in the earth's temperature (BBC, 2020).

The coronavirus pandemic has taken a toll on the entire world. There has been a devastating loss of lives. From an economic perspective, the global economy has faced an exponential loss. Due to the spread of COVID 19, measures are put in place to mitigate the risks posed to public health. As a result, these measures, such as quarantine and work from home, have disrupted the global supply chain, transportation, and many industries due to the closure of companies, factories, educational institutions, and many other public places.

According to the statements above, the causes of global warming, especially pollution from transportation and factories, human-made activities that increase greenhouse gas emissions,

such as deforestation and landfills, have been interrupted due to the stay-at-home measures. The consequence of these measures helped slow down global warming briefly, although barely significant. Utilizing similar measures even after the pandemic may result in more positive changes to the greenhouse emissions, thereby improving the climate.

Literature Review

Our research paper's main aim is to research and collect evidence in-depth about both the positive and negative impacts of Covid-19 on climate change. The articles help us understand if the positive impacts outweigh the negative impacts of Covid-19. It provides a good overview of the future of environmental studies and focuses on the environmental effects of the Covid-19 outbreak.

Positive Impacts

A study by Forster et al. (2020) wanted to find out how Covid-19 has affected climate change in reducing greenhouse gases produced. The article shows that the implementation of lockdowns across different countries worldwide has led to a decline of 30% in global nitrogen oxides emission, contributing to short-term cooling in 2020. The researchers obtained data through the use of Google and Apple mobility changes, as well as the Le Quéré et al. data (Quéré et al., 2020), which indicates that above half of the world's population has reduced travel by more than 50%. Additionally, the data was compared to a baseline - each country's stated nationally determined contributions (NDCs) by 2030. By estimating the emissions of 125 countries, the research article concludes that the pandemic-driven changes have no significant impact on global warming in the long run. However, with economic recovery tilting towards green stimulus and a continued reduction in fossil fuel investments, it is possible to avoid expected warming levels by 2050. The limitation of data analysis through this method is that the

researchers correlate reduction in travel to lower emission levels produced when many other factors affect emission levels.

Secondly, a study by (Rume & Islam, 2020) also analyzed the positive and negative impacts of Covid-19 on the environment. The researchers found that the lockdown and travel restrictions led to reductions in resource consumption, waste disposal, transportation, and industrial activities. Citing a test done by India's Uttarakhand Pollution Control Board (UPCD, 2020) - where 36 real-time monitoring stations measured water pollution in river Ganga, the article noted that 27 stations' surface water met national drinking water quality standards. Additionally, the reduction of water pollution in beach areas from Bangladesh, Malaysia, Thailand, and Indonesia has caused the reappearance of many aquatic species (Clifford, 2020). The study attributes these effects to the reduction in industrial water consumption, trash generated from manufacturing companies, and merchant ships' movement.

Furthermore, the article states that due to travel restrictions, the number of flights and vehicular movements has drastically reduced worldwide, ultimately reducing the level of noise pollution. The researchers obtained data from the Central Pollution Control Board (CPCB, 2020) of India and found that the noise level of residential areas in Delhi has reduced by 55 dB in the day and 45 dB at night. However, the research article's limitation is that most of the data collected is from India and will not represent the United States or other countries. The tests conducted were also focused on industrialized and city areas where pollution was already high and did not include areas where pollution was minimal.

Negative Impacts

A study conducted by Eroglu (2020) examines the hazardous effects of the Covid-19 outbreak on the environment. The article's objective was to showcase the relationship between

the pandemic, the environment, and the renewable energy sector. Part of his research discusses the adverse environmental effects that had surfaced from the outbreak of the pandemic. The use of medical masks worldwide has grown exponentially and has been made mandatory for everyone to wear when going outdoors. The waste caused by medical masks has raised concerns as these masks are plastic-based and hard to get rid of in nature. His article also states that when the outbreak peaked in Wuhan, an average of 240 tons of medical waste was produced daily in hospitals, and this value was six times higher than the standard value. Lastly, he highlights the negative impact of the Covid-19 outbreak on the renewable energy sector. The outbreak caused severe problems in the renewable energy sector, such as delays in the supply chain, difficulties in tax stock markets, and the risk of not benefiting from government incentives ending this year. Investors act unstable due to the uncertainty in the sector. Therefore, countries need to promote clean energy incentives.

The article has numerous limitations as the writer claims that the article's effects were global. However, the impact of medical waste presented concentrated on the data collected only from Wuhan, China, and not the other parts of the world. It would have been more beneficial to our study if the article included more supporting data from other countries. Additionally, the data presented on the impact of the outbreak on the renewable energy sector lacked to claim that his article discusses the relationships globally. Therefore, it weakens the points and reasoning discussed to support his claims that the data shown presents the global impact.

Secondly, research by Rume and Islam (2020) also highlights the pandemic's negative impacts on the environment. Part of the study discusses the increase in municipal solid waste generation and the decrease in recycling activities, increasing overall environmental pollution. Due to the pandemic, lockdown measures and quarantine policies established in many countries

have resulted in a substantial increase in demand for online shopping and home delivery. This presently increases household waste from shipped packaging materials. This issue raises the importance of recycling the waste as it is an effective method in decreasing pollution, saving energy, and conserving our natural resources. However, the pandemic has caused many government bodies to postpone recycling activities as part of their efforts to prevent the spread of the virus. This is supported by the data collected by the researchers stating that in the USA, recycling programs have been restricted nationwide by nearly 46%, accompanied by the restrictions of many European countries residents to refrain from sorting their waste. On the whole, the restrictions established due to the pandemic have disrupted the routine municipal waste management, waste recovery, recycling activities, which resulted in increased landfills and environmental pollutants worldwide.

The article has limitations as the researchers have only discussed their points briefly, with little evidence. The impacts were not discussed in detail and lacked support on how the disruption of waste management activities has led to increased landfills and environmental pollutants worldwide and how much. In addition, data on the environmental impacts could have included showing and supporting their claim to a greater extent. The researchers should include data showing the negative environmental impact caused by the increase in municipal solid waste and decrease in waste management operations.

Summary

Across the articles, all the data shown has commonly showcased the positive impact of the global pandemic where emissions of Carbon Dioxide (CO_2) had plummeted during the lockdown. This had positive effects on the cause of climate change but only in the short term. However, some contradictions state that the global response to the pandemic was not enough, nor

did it make a dent in the causes of climate change because the concentrations of long-lasting gasses have continued to rise in the atmosphere.

Nonetheless, the past research and studies show irrefutable evidence that the global pandemic had positively impacted the causes of climate, albeit to the degree of it being minute. As such, in this study and research, we will explore the feasibility of continuing work from home measures even after the pandemic has died down for the cause of positively impacting climate change.

Research Question

The COVID-19 pandemic has caused a detrimental effect globally on individuals, the economy, and climate change. As a result, the global pandemic has caused lockdowns globally and has caused employees in the non-essential sectors to take their work home base. Based on the previous studies summarised in the literature review, we believe that the positive outweighs the negative impacts. Our research will look towards working from home being implemented even after the global pandemic to prolong climate change's positive effects.

Theoretical Framework

This section discusses the dependent and the independent variables. The dependent variable is the byproducts of the independent variables, in this case, Greenhouse Gas (GHG) Emissions. Independent variables are classified into two types, namely, key and control. The degree of lockdown measures varies from state to state in the US. The most significant measure is the operational cease in transportation. Therefore, our key independent variables are the degree of lockdown measures and transportation. Also, our control variables are the closure of factories, power plants, companies, educational institutions, agriculture, and landfill waste.

Key Independent Variables

     Lockdown Measures

     In the United States, across the 50 states, the lockdown measures established were of different levels of strictness. The figure below shows each state's containment measures across the start and the peak periods of the corona outbreak. From this, we can see that New Mexico's state had the most robust containment measures ranking first among all the states for imposing the most restrictions having the highest level of strictness.

     Furthermore, presented by a coronavirus containment index in Figure 1, we can witness a relationship between policies. The outbreak's severity has become more evident in each state as the pandemic progresses with time. The index was measured from March 1 to November 16 of 2020 and indicated every state's containment efforts in the country (Leatherby & Harris, 2020). Therefore, each state's different containment efforts will be among the key independent variables in our research.
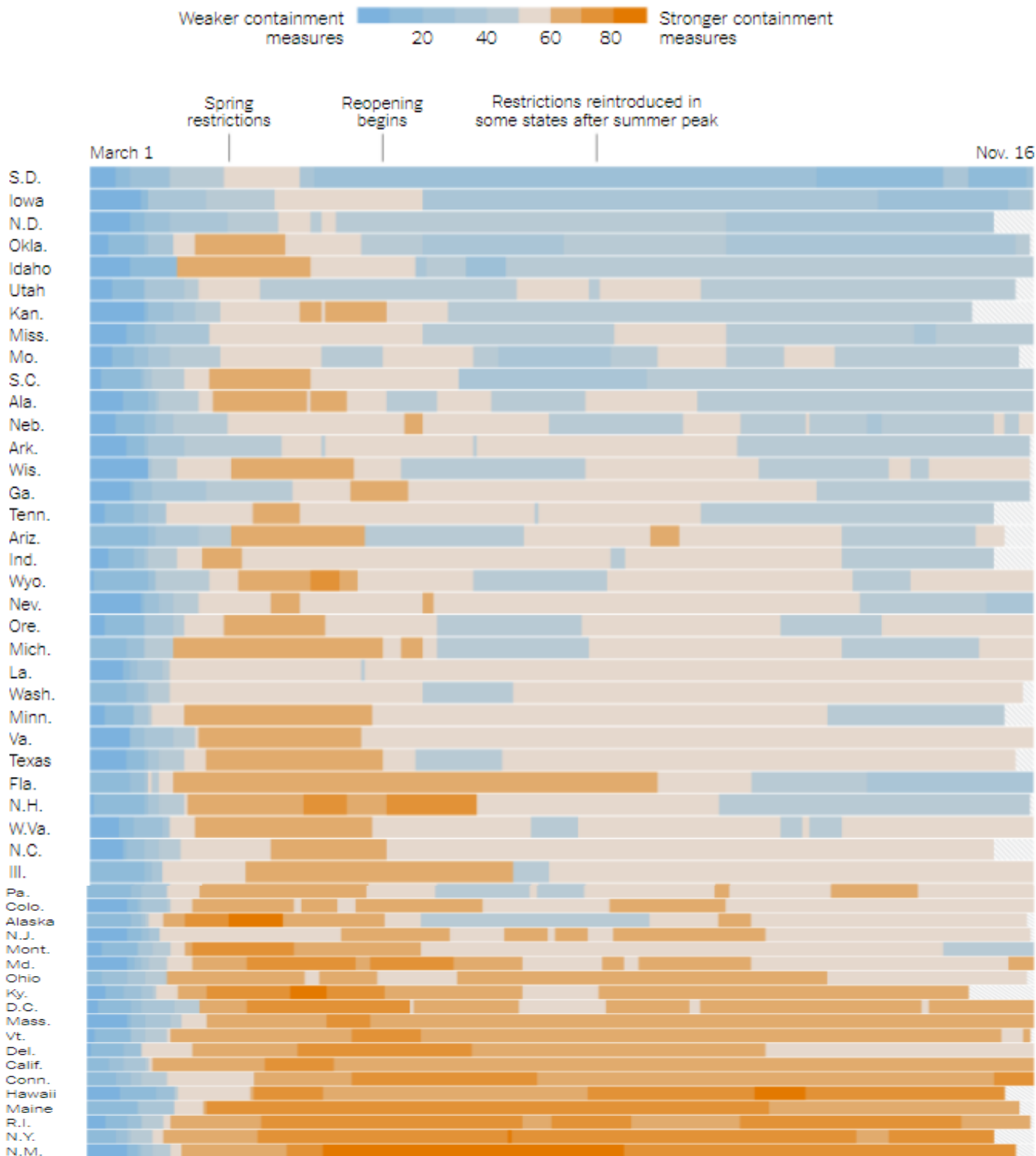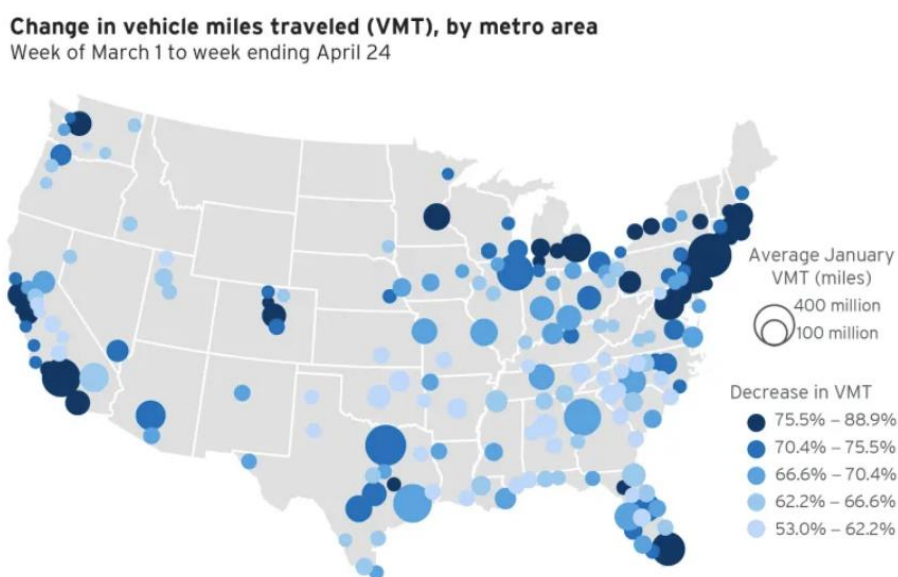
Figure 1: Coronavirus containment index (Leatherby & Harris, 2020)

Transportation

Another key independent variable in this research is the effect of transportation on the dependent variable greenhouse gas (GHG) during the lockdown. GHG emissions from transport account for approximately 28 percent of total U.S. gas emissions ("Carbon Pollution from Transportation," 2020). According to research from (Fishbane, 2020), every metro area in the U.S. has endured a sharp deterioration of at least 53 percent (Figure 2). Our group has selected the transportation sector to be the key variable as it relates closely to our research question. The transportation sector will be measured with the change in vehicle miles collected by metro area (figure 2).

In addition, research from Khan et al. (2020) has also presented data satellite estimates of NO2 over significant Southwest USA cities, which depicts the positive changes of GHG emissions because of the lockdown from March 15(a) to April 15, 2020(b). As a result, it is evident that since the beginning of the lockdown in March, a sharp decline in transportation has posed a positive effect on the amount of GHG.

Change in vehicle miles traveled (VMT), by metro area
Week of March 1 to week ending April 24

Average January VMT (miles)
400 million
100 million

Decrease in VMT
● 75.5% – 88.9%
● 70.4% – 75.5%
● 66.6% – 70.4%
● 62.2% – 66.6%
● 53.0% – 62.2%

Source: Brookings analysis of Streetlight Data and American Community Survey data

R | Metropolitan Policy Program

Figure 2: Change in vehicle miles traveled (VMT), by metro area (Fishbane, 2020)
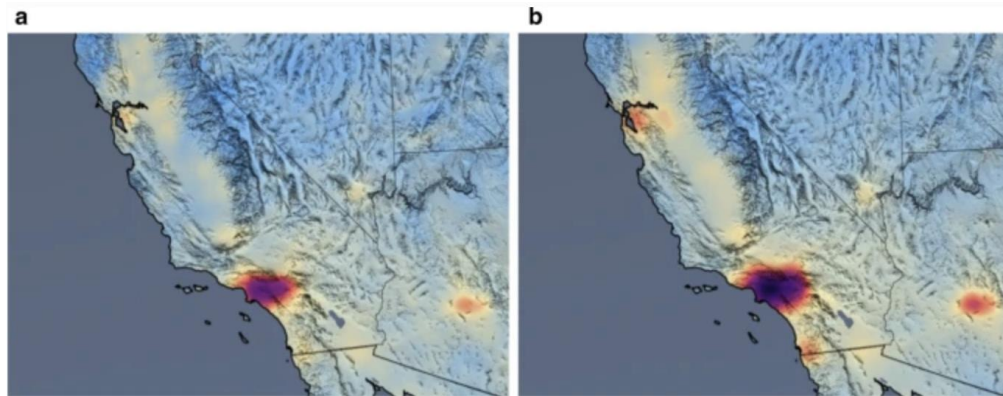

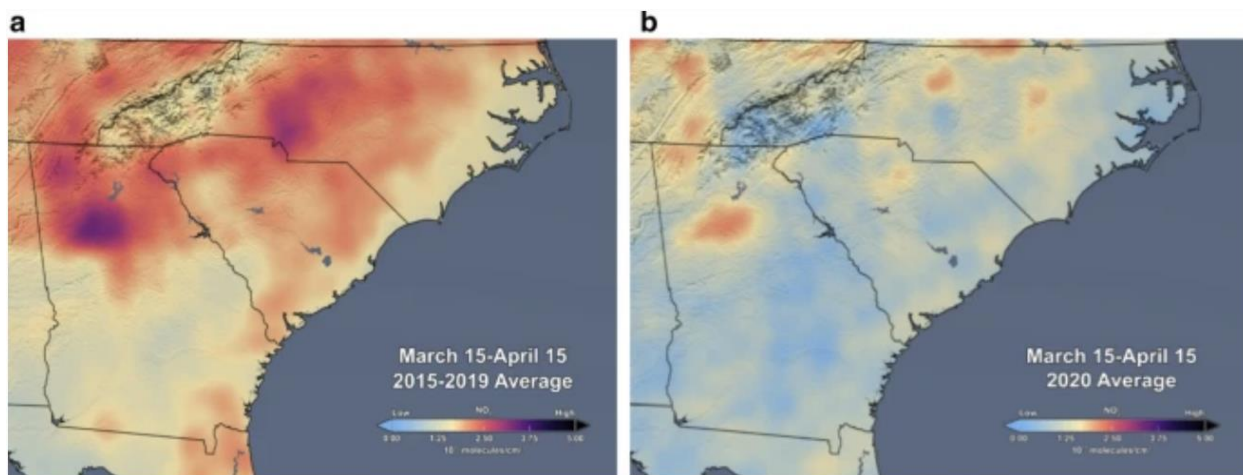*Figure 3:* Satellite estimates of NO$_2$ over Southwest USA (Khan et al., 2020)

Control Variables

Industries and Powerplants

Carbon-di-oxide or CO2 being the second biggest contributor to the greenhouse effect is the most common emission from factories producing raw materials such as plastics. CO2 accounts for about 26% of the greenhouse gas effect (Ahrens & Henson, 2019). According to 2015 data on industrial emissions, plastics emitted up to 1.8 metric tons of CO2 ("Science Daily," 2019). Plastic production includes processes that release CO2, such as disposing of, incinerating, and recycling. Apart from CO2, Methane or CH4 is another greenhouse gas produced most importantly by Fertilizer plants, and its potential to contribute to global warming is greater than that of CO2. According to Science Daily (2019), "We took one small industry that most people have never heard of and found that its methane emissions were three times higher than the Environmental Protection Agency (EPA) assumed was emitted by all industrial production in the United States." There was a 10% reduction in GHG during COVID-19 in the United States due to travel and industrial sectors' restraint. GHG reduction includes the collapse in coal production that led to a 10% reduction in the power sector's operation (Milman, 2021).

Nitrogen Di-Oxide or NO2 is a byproduct of fuel emissions from power plants and transportation ("Environmental Protection Agency," 2019).

Moreover, figure 4 shows the difference in the atmospheric NO2 emission in the Southeast USA between March 2015 - April 2015 and March 2019- April 2019 (Khan et al., 2020). As observed in the legend, there has been a significant decrease in the molecules/cm3. These NO2 molecules are almost zero in 2019.


Figure 4: Satellite estimates of NO_2 over Southeast USA (Khan et al., 2020)

Companies and Educational Institutes

The closure of companies and institutes dramatically impacts the population's energy, leading to a drastic change in carbon dioxide (CO2) emissions. The power sector is the major driving factor for society, providing all other industries with energy. Also, electricity production is mainly based on carbon dioxide, nuclear and wind power, and on the production of combined heat and power (CHP) that is energy efficient. For example, the largest emissions drops occurred in the United States, primarily due to grounded air travel and decreased power, water, and gas use.

However, they come with a considerable economic cost (Yurk, 2020). With more workplaces and schools shut down, the US's overall greenhouse emissions decreased because of decreased power consumption. The exponential increase in individuals operating from home has been a significant improvement in behavior during the lockdown. "According to an April report by the Brookings Institution, a non-profit public policy organization in Washington, DC, nearly half of American employees are telecommuters" (Fong, 2020).

Burning of Fossil Fuels.
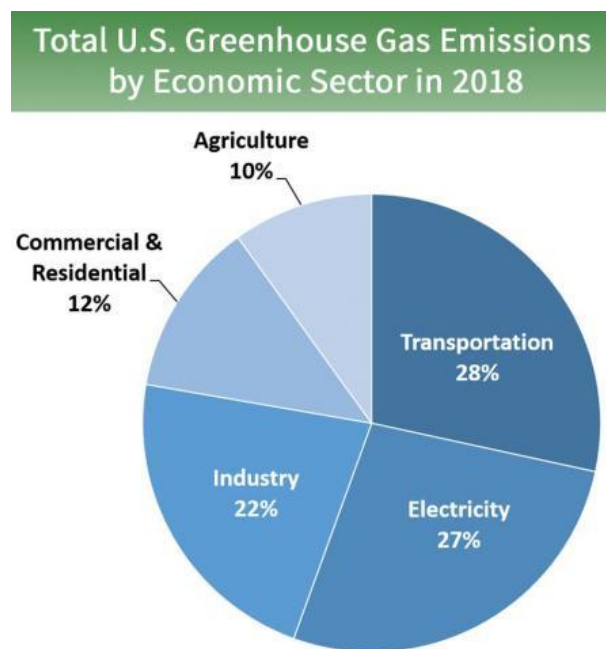
Figure 5: US Greenhouse Gas Emissions by Economic Sector in 2018 (EPA, 2020)
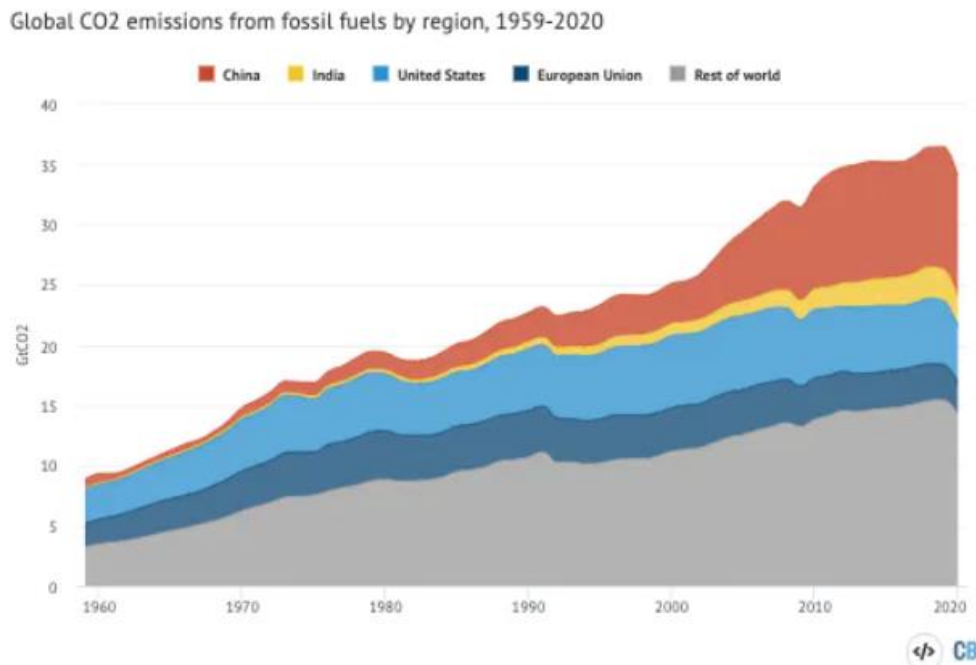
Figure 6: Global Carbon Dioxide emissions from fossil fuels, 1959-2020 (McSweeney &

Tandon, 2020)

The burning of fossil fuels accounts for about 80% of the energy that the world uses.

Common fossil fuels burnt are coal, crude oil, and natural gases, which cause greenhouse gases

such as carbon dioxide, sulfur dioxide, and methane to be produced in enormous amounts. Based

on the United States Environmental Protection Agency (EPA), these burnings contributed to

49% of the greenhouse gas emissions in the United States than other economic sectors for 2018.

Out of the 49%, 22% were used for industries while 27% were used for electricity. This depicts

the detrimental effects burning fossil fuel has on climate change.

However, Covid-19 has brought about a significant drop in the carbon dioxide emission

from burning fossil fuels. The estimated fall in the global carbon dioxide emissions is 7%,

compared to the previous year (McSweeney & Tandon, 2020), while carbon dioxide emissions

from fossil fuels in the United States have fallen up to 12%. While researchers say that this drop

in emissions for the year may not slow global warming, they claim a "unique opportunity" to

secure emissions-cut by aligning economic recovery with tackling climate change in mind. As

evident in figure 6, the United States has seen a decrease in carbon dioxide produced in 2020.

The yearly increase from the different decades is more prominent as emission levels have nearly

tripled since 1959.

Agriculture and Landfills.
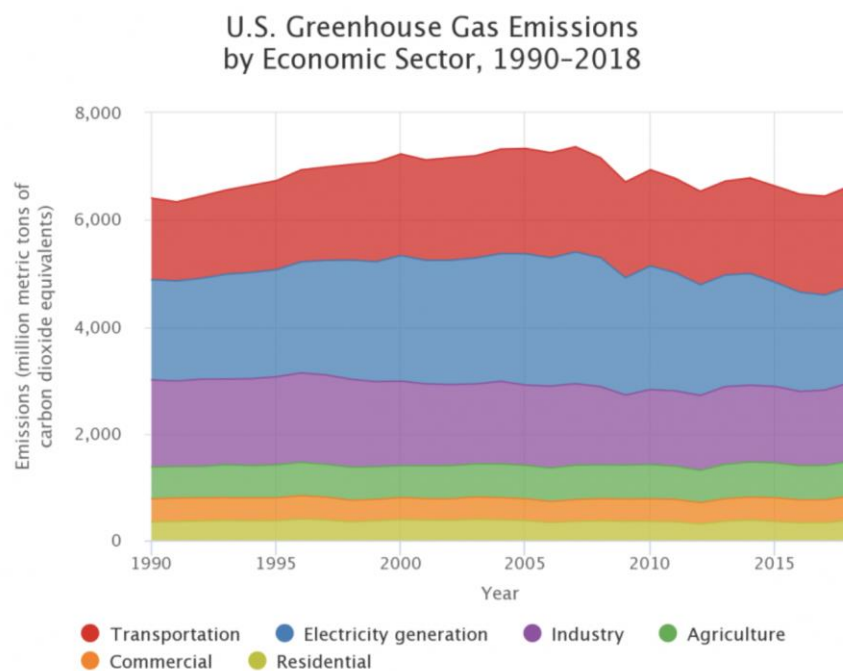
Figure 7: U.S Greenhouse Gas Emissions by Economic sector, 1990-2018 ("Environmental
Protection Agency," 2020)

The Agriculture and Landfills (Wastes) sector are both an independent controlled

variable. Food is a basic human need and the agriculture sector is there to make sure that it meets

the world's food needs. Unfortunately, it accounts for around 10% of the greenhouse gases in the

U.S measured from 1990-2018 (Figure 7). This is a controlled variable as it is a world necessity

and the covid-19 outbreak had no implications on the production of greenhouse gases from the

agriculture sector in 2020.
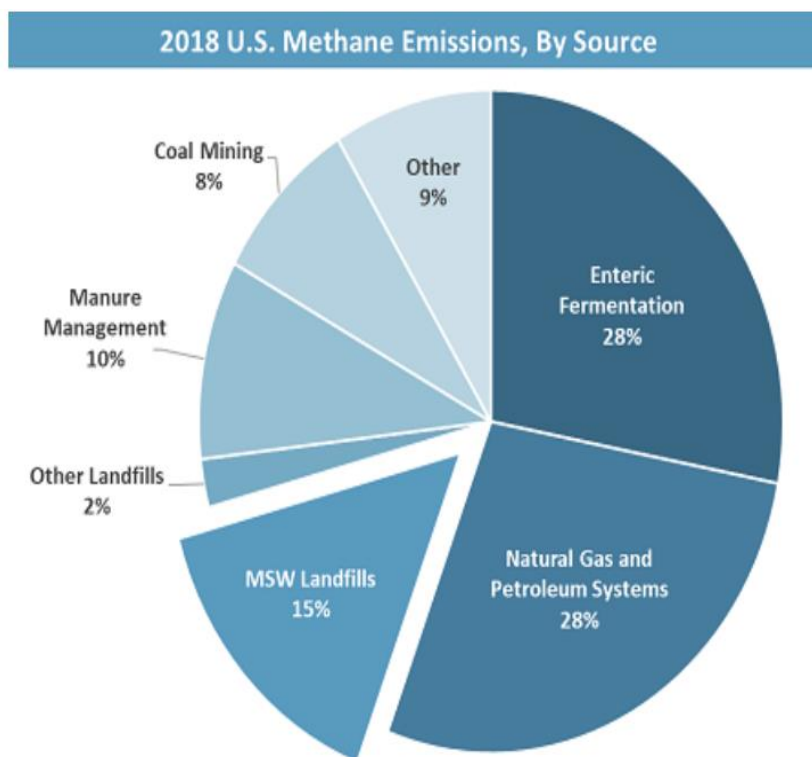
Figure 8: U.S Methane Emissions, 1990-2018 ("Environmental Protection Agency," 2020)

Landfills or Waste produced is a natural humanity outcome. From food waste to medical waste and other wastes, landfills are responsible for at least 15% of the total methane emissions in the U.S (Figure 8). The outbreak has actually caused a huge increase in medical waste around the world. However, this is a controlled variable as there is no implication of the outbreak in its production of greenhouse gases.

Hypotheses

Two Hypotheses have been developed based on this study's research question. The null hypothesis is that quarantine measures adopted during the pandemic do not impact greenhouse gas emissions in the U.S. The alternative hypothesis is that quarantine measures adopted during the pandemic do positively impact greenhouse gas emissions in the U.S.

H_0: Quarantine measures do not have any impact on greenhouse gas emissions in the U.S.

H_1: Quarantine measures have a positive impact on greenhouse gas emissions in the U.S.

Research Methodology and Analysis

Study Design

This research project's topic is the impact of the COVID-19 pandemic on climate change in the United States. This project aims to find out whether the lockdown measures implemented during the outbreak of pandemic have reduced greenhouse gas emissions significantly, which will slow down the rate of climate change. We will be collecting secondary data on greenhouse gas emissions from each of the 50 states, both before the outbreak of the pandemic and during the pandemic. The null hypothesis for this study is that the quarantine measures do not impact the greenhouse emissions in the U.S., while the alternate hypothesis is that quarantine measures positively impact greenhouse gas emissions in the U.S.

We will collect time-series data on each of the 50 states' greenhouse emissions before the pandemic and concurrent outbreak. Our data file will be collated in a Microsoft Excel spreadsheet, where each column represents a dependent variable and independent variables, and each row represents data from each state. We will then demonstrate a regression analysis, where we will be looking for relationships within the data and causal impact of independent variables on dependent variables.

Our data will be collected from a U.S. official environmental protection agency where greenhouse emissions are recorded yearly by state. Data on lockdown measures will also be collected from scholarly resources such as articles from official government bodies. Once collected and compiled, we will run a regression analysis that will show us the significance of

our independent variables on our dependent variables. The analysis will ultimately show which of our hypotheses can be used to conclude the study's research question.

Population and Sample

The population that we have selected is 50 different states from the U.S. The sample that we have chosen is the entire population as all of them had shown significant contribution to the total reduction in greenhouse gases during their respective lockdown periods. Furthermore, a sample size of above 30 would be a sufficiently large sample size so that the data presented is normally distributed. Therefore, our group has decided not to omit any of the 50 states from the population in our sample.

Variables and Measures

There are many variables discussed in this study. Firstly, our research paper's dependent variables are Greenhouse gases (GHG) emissions for 2019 and 2020. Figure 9 shows an increase in the GHG in the past years before the pandemic year. We have used secondary data from environmental websites such as the EPA to determine the total GHG for the United States' respective years. This measure helps to determine if there is a significant change in the GHG due to the pandemic. If there is a drop in greenhouse gases, we can infer that the pandemic positively impacts the environment.
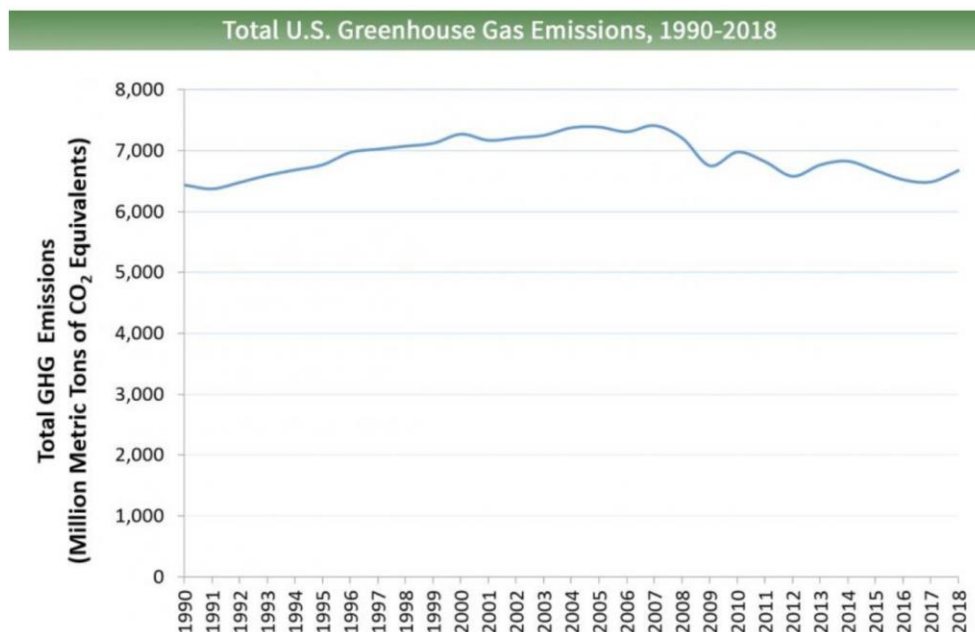
Figure 9: Total U.S Methane Emissions, 1990-2018 ("Environmental Protection Agency," 2020)

Secondly, this paper's independent variables are the degree of lockdown measures across the 50 states and the total emissions produced due to transportation. For this, we accumulated the strictness level of containment in each state. We compared it to see if the emissions produced by transportation in that particular state have been affected due to the strictness in a particular state. This step helps to breakdown the research as it proves that if the states have stricter lockdown measures, the emissions produced by transportation are lesser.

Lastly, this study's control variables are the closure of factories, power plants, companies, educational institutions, agriculture, and landfill wastes. Since our central aspect is emissions produced by transportation, we have kept all other factors contributing to greenhouse emissions as the control variables.

Data Collection Methods

Since the data we have used is a secondary type of data, we have retrieved it from many government websites. Our primary data sources will be scholarly articles and government

websites such as the U.S. Federal Data sites, Environmental Protection Agency, etc. The data

sources consist of greenhouse gas emission data from the different sectors for each U.S. state for

the control independent variables. Along with data from sectors, we were also able to gather data

on the level of strictness in lockdown measures for each state via a verified scholarly article. Our

focus area is before and after the pandemic impact on the GHG emissions in different sectors and

the 2020 lockdown measures. Thus, the data required will be from secondary data sources.

Data Analysis Methods

To better understand the variables, we will conduct a correlation coefficient between

them to identify any relationships at the beginning of the study. To further study the data, we will

be using the regression analysis as it will help in explaining the relationship between the

dependent variables and the independent variables. The regression equation is as follows:

$$\text{DEPVAR} = \beta_0 + \beta_1(\text{Lockdown Measures}) + \beta_2(\text{Transportation}) + \beta_3 \mathbf{X} +$$

$$\epsilon$$

DEPVAR refers to the range of greenhouse gases in the United States for the years 2019

and 2020. Additionally, *X* represents the control variables such as industries and power plants,

companies and educational institutions, burning of fossil fuels, and agriculture and landfills.

U.S TOTAL GREENHOUSE EMISSION	
2019	6,577 Metric Tons CO2
2020	5,160 Metric Tons CO2

Figure 10: Total Greenhouse Emissions

Lastly, these data analysis results can be interpreted by looking at the p-values produced

by the regression analysis. We will be using the beta and p-value to identify which independent

variables statistically significantly impact greenhouse gases. The p-values will determine

whether the relationships observed in the sample also exist in the larger population (Frost, 2017). Moreover, when a p-value is low, typically <0.05, which is the level of significance used in this analysis, the independent variables are statistically significant. The analysis will help answer the hypotheses that the study aims to discover by considering the variables' p-values and significance.

Conclusion

In conclusion, there have been no immediate and significant changes to the climate, even though greenhouse gas emissions have decreased noticeably in 2020 compared to 2019. However, as time goes by and the situation remains, there will be a positive impact on climate change. Additionally, including work from home measures regularly would be a generous contribution to the fight against climate change. Making work-from-home a permanent solution for the well-being of the environment is theoretically possible, but may face opposition, especially from the transportation sector. Moreover, due to the insufficient data for the year 2020, our hypothesis is still theoretical. Therefore, further observation needs to be done to see if the existing lockdown measures have a positive effect in the long run. The information gathered from this study can be used by policymakers to better understand the positive impacts of work from home measures. Policymakers can also support work from home measures being the new normal to continue the battle against climate change. A suggestion would be implementing a work from the home measures once every week. This would circumvent the problems, such as the disadvantages faced by the transportation as mentioned above.

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