Exploring the Relationship between American belief in Climate Change, NSF Funding and Political Leaning

DSS - Independent Research Project

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1 Introduction

Climate change is defined by the United Nations as the long-term shifts in temperatures and weather patterns due to human activity which have produced greenhouse gasses and may lead to irrevocable damage to our planet.[1] Climate.gov reports that 2021 was the sixth-warmest year on record based on National Oceanic and Atmospheric Administration's (NOAA) temperature data. The earth's temperature has risen by 0.08° Celsius per decade since 1880, and the rate of warming since 1981 is more than twice that at 0.18° C per decade. [2]. Moreover, in the last few years there has been an increased focus on climate change and its impact on the world. The United States of America has the second highest greenhouse emissions, after China [3]. An increasing number of Americans believe in climate change and there is increasing desire for legislation that leads to meeting benchmarks set in the Paris Climate Accord and ultimately slowing down climate change.[4]

Research on climate change topics like reducing greenhouse gas emissions, impact of global warming on biodiversity, improving renewable energy production and adoption are some of the important topics being studied to slow down climate change. This is necessary in order to prevent catastrophic consequences like frequent, high intensity natural disasters, habitat destruction, mass climate migration, and species extinction.[5] An important way to slow down climate change and meet goals in the Paris Climate Accord [6] is through strong public support for action and policy changes.

This project focuses on exploring the public opinion of Americans on climate change [7] in three ways. First, I investigated how research funding towards climate research on a state level is related to public opinion on it. I focused on research funding from the National

Science Foundation (NSF), one of the main organizations funding scientific research and education at higher education institutions in the United States. The NSF itself is funded by taxpayer money. Ideally, NSF funding should be awarded to research areas that the public prioritizes. Therefore, if NSF is increasing funding research related to climate change, it is reflective of the public priority and sentiment around the topic.

Second, on a county level, I investigated how the US public opinion on climate change is related to political leaning. A 2020 Political Voting Index (PVI) data at a county-level, similar to the Cook Political Report's PVI at the congressional district level is used and it tells us the partisan strength of a county. Pew Research's study on the 'Politics of Climate Change' [8] showed that Democrats were more likely to believe in climate scientists and their research than Republicans, but that overall, there was bipartisan support for policy changes to prevent damage from climate change, especially when it came to expanding solar and wind energy infrastructure.

Third, on a county level, I investigated how the US public opinion on climate change is related to monetary and human costs of climate-related damage. The idea behind this was that people's experience of the monetary and human costs of climate change influence their opinion on whether climate change is happening. The Spatial Hazard Events and Losses Databases for the United States (SHELDUS) data provides information on climate hazards/disasters costs in each county. Martinich et al. (2019) [9] has shown how continued trends of greenhouse gas emissions will cost the US hundreds of billions of dollars due to infrastructure damage resulting from climate change. Warren et al. (2021) [10] estimated the global aggregate climate change damage to be $48.7 Trillion from 2008-2200 for an approximated 1.5° Celsius increase in the earth's temperature.

Given these three focuses, my research questions were:

- On a national/state level, is there a positive correlation between national sentiment on climate change in the United States and NSF funding towards climate change related research?
- On a county level, is there a positive correlation between public opinion on climate change in the United States and political leaning?
- On a county level, is there a positive correlation between public opinion on climate change in the United States and the monetary and human costs of climate disasters?

These research questions were tested using linear and quantile regressions. American opinion on climate change on a state-level was positively correlated with increase in the log of NSF funding on climate change; and on a county-level, American opinion on climate change was positively correlated with PVI but not with the monetary and human costs of natural disasters. There was also a statistically significant difference in the quantile regression slopes for American opinion in 2014 vs PVI and American opinion in 2016, 2018, 2021 vs PVI.

2 Data

2.1 Data set 1: Yale Climate Impact data

The data for public climate change opinion comes from the Yale Climate Opinion Maps data.[7] The state- and county-level data was collected in all 50 states and DC, and all 3143 counties in the years 2014, 2016, 2018, and 2021. They surveyed people on a range of questions regarding their belief, risk perception and policy positions concerning climate change. The survey question pertinent to my research was 'Do you think that global warming is happening?'. The percentage of the population that said yes in every state and county in each of the 4 years was the response variable. There was no missing data in either the state- or county-level responses.

The years (2014, 2016, 2018, 2021) in this data were restricted based on data availability on the Yale Climate Opinion website [7]. As such, the data sets described in sections below (which serve as the predictor variables) are restricted to data from these years. The data for 2017, 2019 and 2020 was not available on the website or through email contact.

2.2 Data set 2: NSF Funding data

The data on the NSF funding came from the NSF Awards Search Tool [11] and was only available on the state-level. By utilizing the search tool, data on proposals containing the words 'climate change' in the title or abstract of a proposal for the years of interest (2014, 2016, 2018, 2021) was found. This contained information on what amount of funding those proposals received and which states the funding goes to (based on proposal authors location).

The NSF funding variable was the log of the total sum of funding a state received each year. The log transformation was done, because when plotted, the total funding data was highly skewed; the transformation allowed it to spread and conform better to a normal distribution. Figure 1 shows the average funding across 50 states.

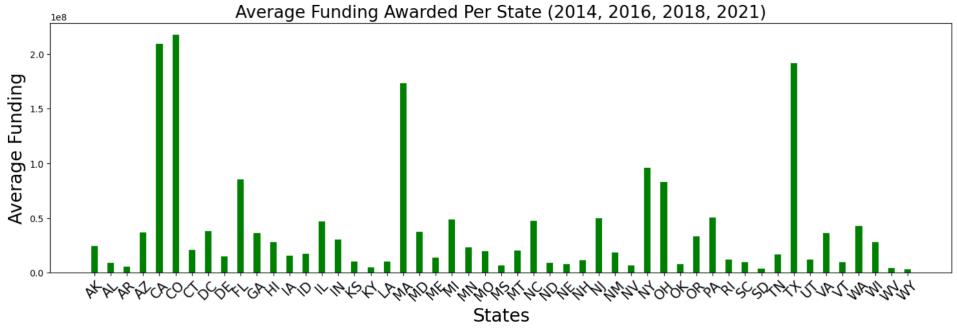

Figure 1: Average Funding Awarded Per State During 2014, 2016, 2018, 2021

2.3 Data set 3: PVI data

The Political Voter Index (PVI) data measured the partisan strength of each county in the US based on how each county voted in the 2020 Presidential Election results. The data used to calculate the PVI by county is available at: US County Level Election Results 2020 Github. This data was inspired by the Cook Political Report's PVI calculation available by congressional district [12]. This PVI data was missing for 357 counties and missing data was dropped for regressions.

The partisan strength of a county was measured by how many percent points the Democrat presidential candidate won by. For counties with PVI greater than 0, the Democrat candidate won, while for counties with PVI less than 0, the Republican candidate won. The larger the number, the more that county leaned towards that party.

2.4 Data set 4: SHELDUS data

The SHELDUS 20.0 version data was used and this data was released in February, 2022. This data was downloaded using the Arizona State University SHELDUS search tool for all counties in all states from 1960 till 2020, for all hazards and perils. Only data from the years of interest were used and data for 2021 was not available.

SHELDUS was a county-level hazard data set for the U.S. It covered data like event date, location, monetary losses per capita like property, crops, and human loss like injuries and fatalities for natural hazards such as thunderstorms, hurricanes, floods, wildfires etc. The loss data columns were used as predictor variables and were the average of each of the four losses for all hazards in each county for 2014, 2016 and 2018.

3 Methods

3.1 Linear Regression

First, a simple linear regression was conducted to look for a correlation between US public belief on climate change and NSF funding (only on state-level). As only 204 data points were available for this regression, an 80/20 train-test split was done.

Second, for the county-level data sets, five simple linear regressions were conducted at a county level for climate change belief vs each of the 4 averaged monetary and human loss variables (section 2.4), and political leaning (section 2.3).

The regressions were considered significant where p-value < 0.05 for the predictor. The linearity and residual normality assumptions were tested using the residuals vs fitted values

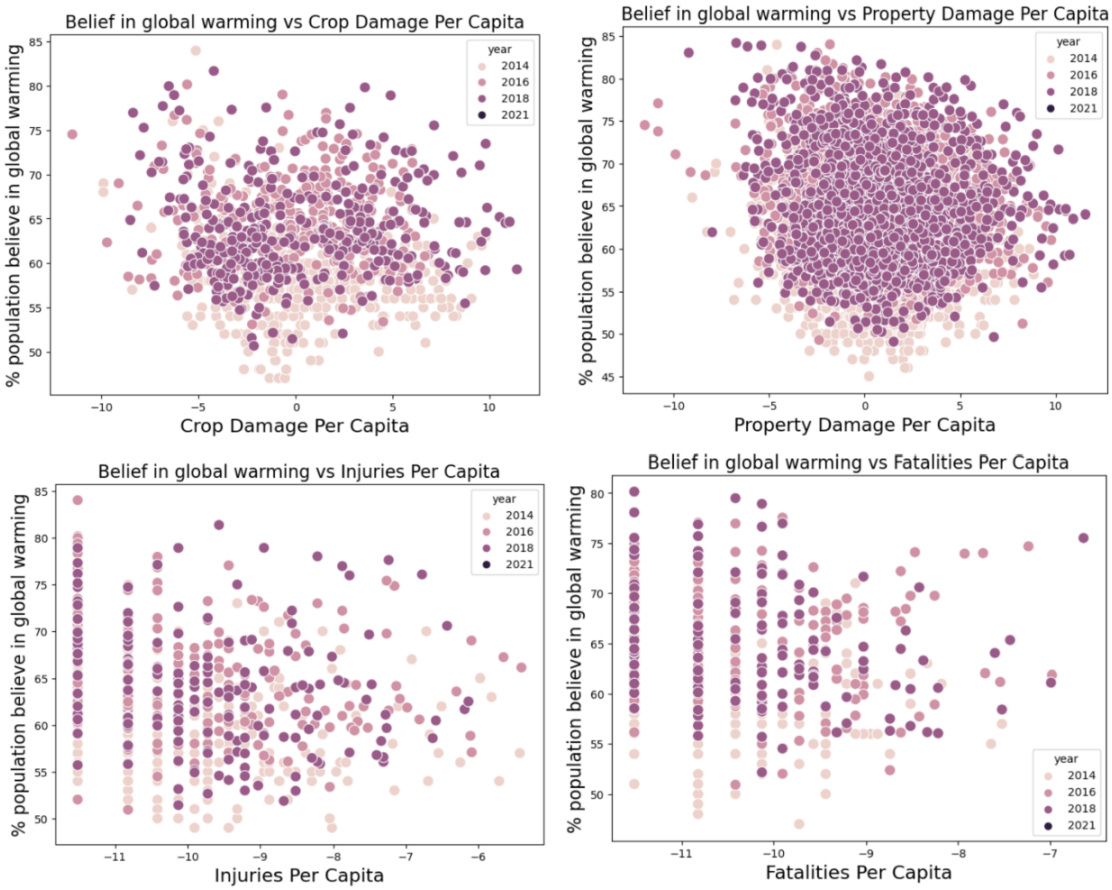

Figure 2: % population that believes in climate change (response variable) vs each of the 4 SHELDUS loss variables (Crop Damages Per Capita [top-left], Property Damages Per Capita [top-right], Injuries Per Capita [bottom-left], Fatalities per Capita [bottom-right])

plot and Shapiro-Wilk test [13], respectively. The residual vs fitted values plot was looked at to assess whether homoscedasticity or non linearity of residuals was an issue. For the Shapiro-Wilk test, if the p-value < 0.05, residuals were considered to be not normally distributed.

3.2 Quantile Regression

For the county-level regression for climate change belief vs political leaning (PVI), the residuals for the linear regression were not normal. Quantile regression was then conducted as it is an extension of linear regression that is used when the conditions of linear regression are not met [14]. This method, instead of estimating the mean of the response like in linear regression, estimated the median of the response when quantile (τ) was set to 0.5.

Quantile regressions were also conducted for belief vs PVI for each of the four years to see if correlation between years was significantly different. 5 fold cross validation was used to assess model performance for each of the regressions.

4 Results and Discussion

4.1 Linear Regression

The linear regression for the state-level data on American opinion on climate change vs NSF funding was statistically significant and did not violate the linearity and normality assumptions of linear regression. The R-squared value was 0.268 and test MSE was 21.7. The regression plot in figure 3 shows that as the log of NSF funding increased, there was an increase in Americans that believed in climate change. This meant that the research question on whether there was a positive correlation between American opinion on climate change and NSF funding was true: increase in NSF funding towards climate change related research can indicate increasing American belief towards climate change.

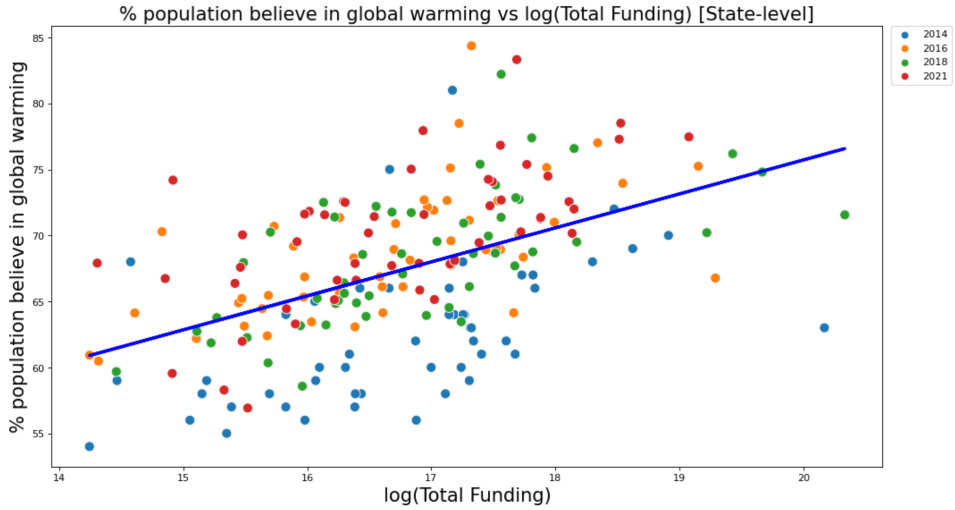

Figure 3: Linear Regression plot with % population that believes in climate change (response variable) and log of total NSF funding (predictor variable) on a state-level. (Data points are colored by the year data is from.)

Moving to the county-level data, the linear regressions with 4 loss variables in the SHELDUS data (section 2.4) were not significant. When the American belief data was plotted against each of the 4 loss variables (figure 2), it can be seen that the relationship is non linear, so the regression results are not surprising. Non-linear methods are better suited to understanding the relationship between beliefs on climate change and monetary and human costs of natural disaster events.

Moreover, the linear regression with PVI data (county-level) was significant but the residuals were not normal.

Quantile Regression by Year	Pseudo R-squared	Avg 5 fold CV MSE
2014	0.1936	14.639
2016	0.5331	6.706
2018	0.5450	7.135
2021	0.4863	10.952

Table 1: Quantile Regression statistics for population belief in climate change vs PVI (county-level) by year.

4.2 Quantile Regression

The quantile regression for American climate change belief vs PVI data (only county-level) was statistically significant, with a Pseudo R-squared value of 0.3486 and mean 5 fold cross-validation MSE of 16.96. Additionally, quantile regressions for opinions vs PVI for each of the 4 years was significant. The Pseudo R-squared value and mean 5 fold cross-validation MSE for 2014, 2016, 2018 and 2021 can be seen in table 1. Figure 4 shows that the regression line for 2014 was significantly different from the 2016, 2018 and 2021 years as the confidence interval around the regression line for 2014 did not overlap with the confidence intervals for the other regression lines.

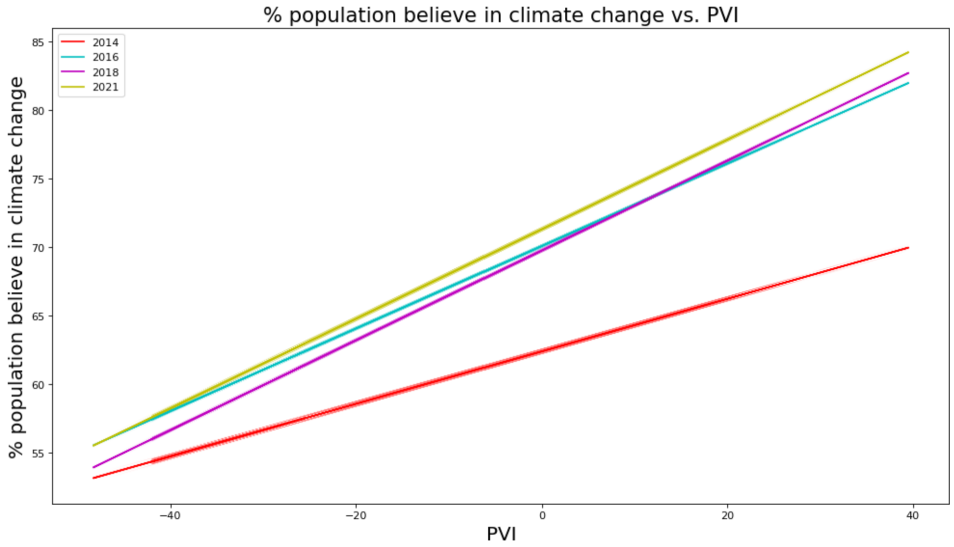

Figure 4: Quantile Regression plot with confidence intervals for % population that believes in climate change (response variable) and PVI (predictor variable) on a county-level for each of the 4 years individually. (Lines are colored by year)

This meant that as PVI increased, that is, as a county voted more strongly for the Democrat presidential candidate, the county residents believed more that climate change was happening. Figure 4 also showed that the relationship between the climate change belief and PVI became stronger from 2014 till 2021 as the 2014 regression line was less positive (coefficient value of 0.1916) vs the 2021 regression line which was more positive (coefficient value of

0.3270).

5 Conclusion

Positive correlations between American belief in climate change vs NSF funding (state-level) and between American belief in climate change vs PVI (county-level) were observed. Both of these indicated that increased NSF funding related to climate change research and increase in Democratic political leaning can lead to an increase in Americans who believe climate change is happening.

It would have been interesting to see if both NSF funding and political leaning (at county-levels) led to an increase in Americans believing in climate change. As NSF funding data was not available by county, it was not possible to evaluate this. Moreover, research funding awarded to a state does not necessarily indicate the climate change opinions of that area. Figure 1 showed that 4 states (CA, CO, MA, TX) received the most funding, because they have higher number of educational institutions than other states. Additionally, research funding used by institutions in one state can be used for research that benefits another state. For example, Massachusetts received one of the highest amounts of average NSF funding and has one of the highest number of educational institutions. But Massachusetts researchers may heavily focus research towards solar energy, the beneficiary of which would be states that have more available sunlight than Massachusetts, like Arizona and Kansas. Furthermore, the PVI data used was calculated using 2020 Presidential election results. Considering that the 2016 and 2020 US Presidential election results were different, perhaps the 2020 PVI data was not a good measure of political leaning in 2014 and 2016.

Moreover, American opinion on climate change data was only available for 2014, 2016, 2018 and 2021 from [7]. For completeness, the regressions should be run again with data from 2015, 2017, 2019 and 2020. It would also be useful to see if the regression slopes are statistically different between the earlier years and later years, indicating climate change support has increased with time. This can be seen currently with the quantile regressions in figure 4, where the slope for 2016, 2018 and 2021 is more positive and significantly different from the slope for 2014.

Finally, many factors can affect American public belief on climate change. Looking at education and income, in addition to NSF funding and political leaning, can be better ways of assessing these beliefs.

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