Social Media Campaigns, Lobbying and Legislation: Evidence from #climatechange/#globalwarming and Energy Lobby

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Abstract

To what extent do social media campaigns compete with fossil fuel industry's lobbying on climate change policy? In this article, I estimate the effect of social media campaigns and partisan identity on the effectiveness of lobbying by the fossil fuel industry on a congressperson's decision against climate change actions during the 113-115th Congresses. I find that a 1 percent increase in the activity of social media campaigns decreases the effectiveness of the fossil fuel lobbying on a Democrat's decision against climate change actions by 0.260%. The effectiveness of the fossil fuel lobbying is 13.3% greater on Republicans than on Democrats. The effectiveness of the fossil fuel lobbying on Republicans is likely to increase as social media campaigns become more popular. The effect of social media campaigns on the effectiveness of the fossil fuel lobbying on Democrats is quantified as \$0.82 million in terms of a stake of lobbying expenditure, which is very small relative to the size of fossil fuel lobbying against climate change actions, \$226.07 million. Average rates of returns to fossil fuel lobbying on a congressperson's decision against climate change actions are -87.67% on Democrats and 449.03% on Republicans.

Keywords: social media, campaigns, lobbying, legislation, policy, climate change, fossil fuel.
JEL Classification: D72, L31, Q40, Q54

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1 Introduction

Various forms of climate change policies including tax, subsidies, and cap-and-trades address negative externalities from greenhouse gas emissions. To facilitate climate change policies, climate activist groups have employed social media to carry on climate change campaigns. On the other hand, industry groups, particularly for fossil fuel industry, use lobbying as a vehicle to influence climate change policy in favor of their private return. Fossil fuel firms are inherently being a target of climate change regulations because of their enormous amount of greenhouse gas emissions.[1] Climate activist groups often blame a fossil fuel industry for lobbying against climate change actions. For example, Showstack (2019) reports that at the forum hosted by two climate activist groups—the League of Conservation Voters and the End Citizens United Action Fund—Senator Sheldon Whitehouse (Democrat-Rhode Island) said "The fossil fuel industry's dark money has polluted our politics as badly as its carbon emissions have polluted our atmosphere and oceans." Meng and Rode (2019) analyze the social cost of firms' lobbying effort to fail the Waxman–Markey bill that includes the establishment of a nationwide greenhouse gas cap-and-trade program as well as energy efficiency issues.[2] Their analysis suggests that the Waxman-Markery bill failed because of firms' lobbying, which incurred $60 billion (in 2018 dollars) of social cost. Although fossil fuel lobbying can play a positive role by informing politicians on climate change, this may result in the fossil industry's undue influence against climate change policy. This brings about the main question addressed in this study: To what extent do social media campaigns compete with fossil fuel lobbying on climate change policy?

Yu (2005) addresses to the following question—"how is it that environmental groups can have a strong impact on environmental policy but without much lobbying?"—by developing a theoretical model of political competition between the industrial group's lobbying and the environmental group's campaign. He finds that 1) lobbying the government and persuading the public are complementary under assumption that both groups are equally effective in doing so; and 2) if the environmental group's effectiveness is sufficiently greater than that of the industrial group's lobbying, lobbying and environmental campaign become substitutes, so that the environmental group can have a strong impact on environmental policy. Daubanes and Rochet (2019) develop a theoretical

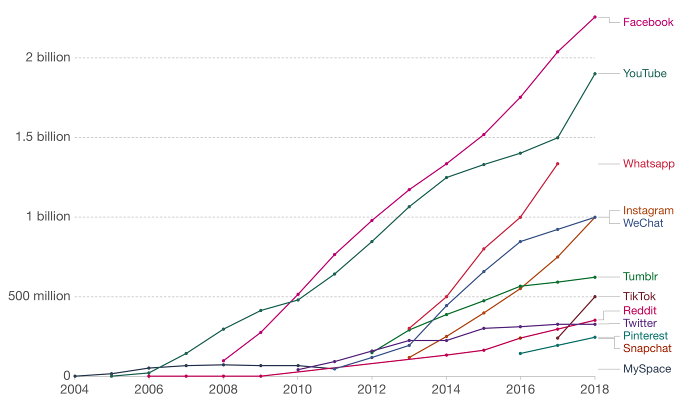
[1] Heede (2019) reports that a third of all carbon emissions from 1965 to 2017 around the globe were emitted from 20 companies that are all from a fossil fuel industry.

[2] The Waxman-Markery bill refers to the American Clean Energy and Security Act of 2009, which passed in the House but failed in the Senate.

model of activist non-governmental organizations (NGOs)' intervention on public regulations that are not socially beneficial under the the influence of industry's lobbying on regulations. They highlight that while public regulations are vulnerable to industry lobbying with the enormous stakes of industrial projects, the efficient NGOs' activism with the revolutionized communication technologies via the Internet can play a role in balancing industry's private interest with the goal of achieving socially optimal welfare.

Social media has become increasingly popular in the last two decades because of the advance in information technology. Figure 1 shows the increasing trend in the numbers of people using social media platforms such as Facebook, Twitter, YouTube, and Instagram from 2004 to 2018 across the planet. Nowadays, almost every influential public figure and organization including traditional mass-media companies and politicians use social media platforms to communicate with the public.

Figure 1: Number of people using social media platforms, from 2004 to 2018

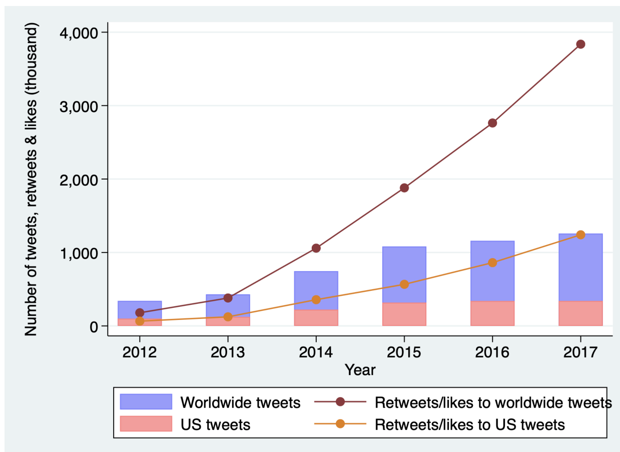


Sources: Our World in Data, Statista, and TNW

In social media, climate change has been one of the most controversial issues. While more than 95% of scientists agree that climate change is mainly caused by human activities, only slightly above 50% of the US public at county-level agree with anthropogenic climate change in 2016 (Howe et al. (2015), NASA (2019)). One of main reasons for this discrepancy between the scientific community and the public on climate change is that the main sources of scientific information for the public is not scientific research articles but simplified and biased news from social media, traditional news media, or words of mouth from neighbors. In addition, not all influential public figures agree with anthropogenic climate change. The 45th president of the United States, Donald Trump, is the most famous person who denies human-caused climate change.

Under this circumstance, various climate activist groups, ranging from ordinary people, NGOs, to international organizations, started climate change campaigns using social media to influence public awareness and policies on climate change. As a result, information about climate change and related issues has been extensively disseminated through social media campaigns. Figure 2 shows the number of tweets with #climatechange/#globalwarming from year 2012 to 2017 in the world and in the US.[3]

Figure 2: Trend in the number of tweets with #climatechange/#globalwarming and retweets/likes to those tweets

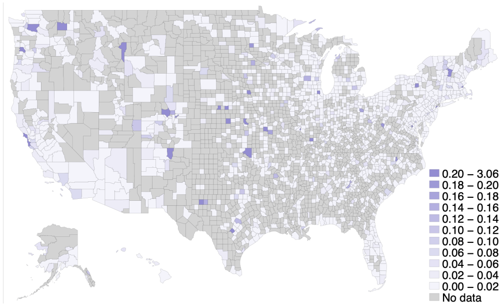


Twitter data with #climatechange/#globalwarming indicate that climate change campaigns in social media are most likely to be driven by active campaigners. While 753,853 Twitter users wrote 5,017,109 tweets with #climatechange/#globalwarming from 2012 to 2017 around the globe, only about 3.5% of these 753,853 Twitter users, approximately 26,385 users, wrote more than 3 million tweets with #climatechange/#globalwarming. Figure 3 shows the yearly US county maps for the per-capita number of tweets with #climatechange/#globalwarming, retweets and likes to such tweets. While the maps indicate the increasing trend for social media campaigns, their geographic variations are highly correlated with the US public's political ideology.

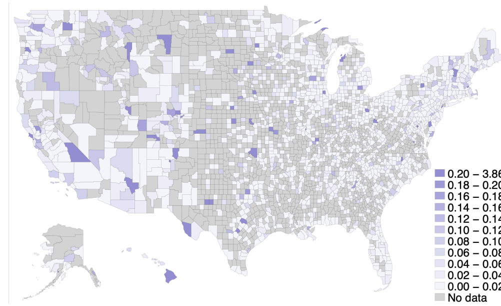
Climate activists can use social media to trigger a movement on climate change actions. For example, Greta Thunberg, a Swedish young climate activist, has been mobilizing global climate strikes using social media since 2018. Because political processes are required for an implementation of climate policy, climate change campaigns in social media often becomes political.

[3]Because social media users can easily track specific hashtags, campaigners using social media frequently use a hashtag # on keywords of their campaign contents to increase the visibility of the contents. In case of climate change, campaigners frequently put a hashtag on climate change or global warming.

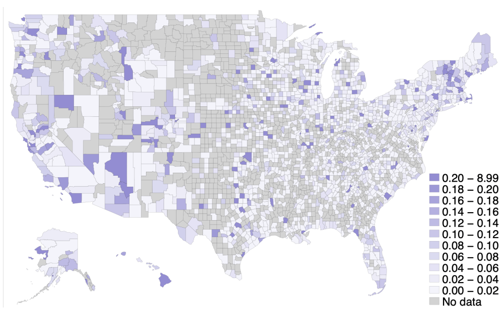
Figure 3: Per-capita number of tweets, retweets and likes with #climatechange/#globalwarming (multiplied by 100)



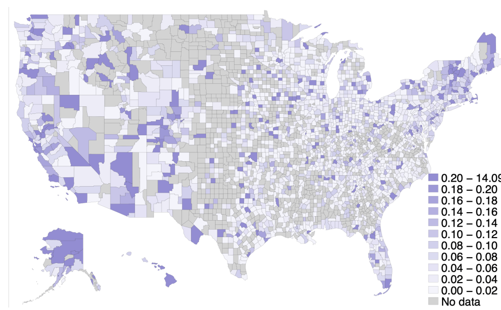
(a) 2012



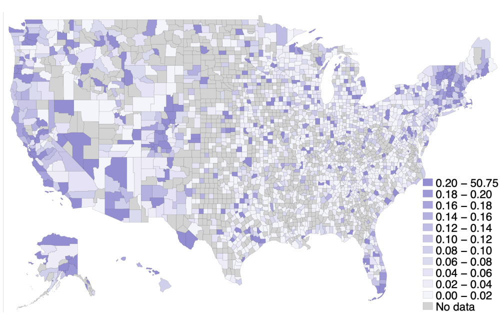
(b) 2013



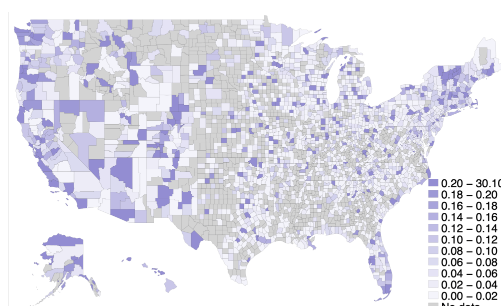
(c) 2014



(d) 2015



(e) 2016



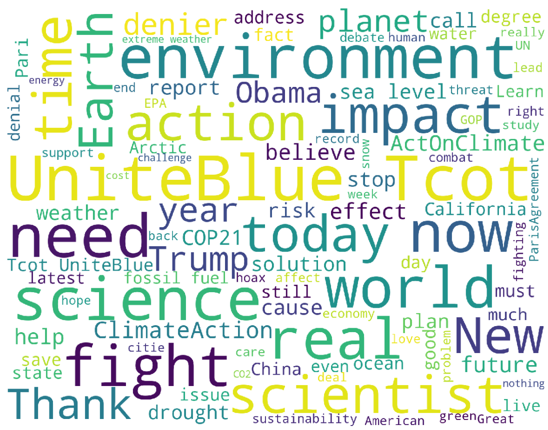
(f) 2017

Figure 4 shows word clouds for US users' tweets with #climatechange/#globalwarming during the years from 2012 to 2017.[4] Each word cloud contains the top 100 words that are most frequently

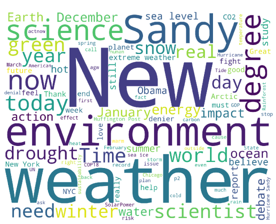
[4]Word clouds sort out words by their frequencies of usage and differentiate them with the size of words. Table 7 in Appendix B lists out the most frequently used words in tweets with #climatechange or #globalwrming during the years from 2012 to 2017.

used in the US users' tweets.

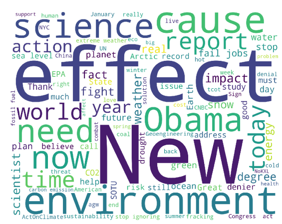
Figure 4: Word clouds from US tweets with #climatechange/#globalwarming



(a) 2012-2017



(b) 2012



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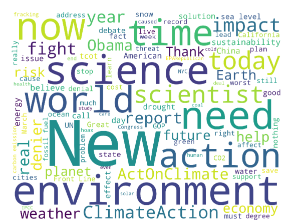
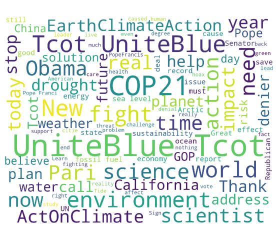
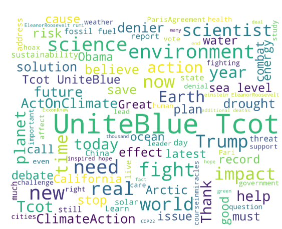


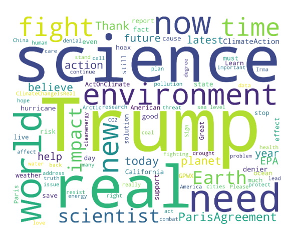
(d) 2014



(e) 2015



(f) 2016



(g) 2017

The two most frequently used words in the tweets other than "climate change" and "global warming" are the two political words—"UniteBlue," the Democrat supporters' slogan, and "Tcot," an abbreviation for Top Conservatives on Twitter. The 44th and 45th US presidents, Obama and Trump also appeared as one of the most frequently used word in years 2012-2014 and year 2017 respectively. Words “p2,” a short for “Progressive 2.0,’ and “NoKXL,” a campaign slogan to oppose the Keystone XL pipeline, also appeared in 2012.[5] Furthermore, text analysis indicates that at least 20% of US tweets with #climatechange/#globalwarming contain political words. All of these appearances of political words in climate change campaigns imply that climate change campaigns in social media massively engage in political debates between the Democratic and the Republican party supporters. Shi et al. (2020) provide word-level network and temporal analysis on worldwide tweets with #climatechange/#globalwarming. They describe that the worldwide trend in tweets with #climatechange/#globalwarming became less political, which is different from the trend in the US tweets. Bail et al. (2018) report the importance of social media as a source of political news and information. By conducting a field experiment on Twitter, they find that exposure to opposing political views can increase political polarization. Because the sample data used in this paper reveal that climate activists’ social media campaigns have been likely to be highly political, it is questionable whether climate change campaigns using social media have been competitive against fossil fuel industry’s lobbying on climate change policy.

During the 113th to 115th Congresses, many bills related to climate change actions were introduced. Most bills, however, were not progressed into the roll-call voting stage at the House of the Congress. Furthermore, some bills sponsored by the Republicans are unfavorable to the action on climate change. Those bills include sections that set back or withdraw regulations on greenhouse gases. For instance, the bill “H.CON.RES.119-115th”, a resolution type of bill, expresses “the sense of Congress that a carbon tax would be detrimental to the United States economy,” which is contrary to what most professional economists agree on. The bill, “H.R.1582-113th” prohibits the government administrator from conducting any cost-benefit analysis with the social cost of carbon relating to an energy-related rule estimated to cost more than $1 billion unless and until a federal law is enacted. The bill, “H.R.3354-115th” prohibits specified funds from being used for the Green Climate Fund.[6] Such bills are summarized in the following Table 1 and in Appendix C.

Table 1 also provides renewable energy and fossil fuel industries’ lobbying expenditures as well as total expenditure for all lobbying issues for each bill in Table 1 (Hereafter, I call bills in Table

[5]Democrats and republicans had a battle over the Keystone XL pipeline more than seven years since 2011. Trump administration ratified the construction of the pipeline.

[6]The Green Climate Fund is established by the UNFCCC to assist developing countries in climate change adaptation and mitigation projects to fight climate change.

1 anti-climate change bills).[7] The amount of lobbying expenditures are enormous—ranging from $10.41 million dollars to $435.80 million dollars. While the renewable energy industry has always ranked low in terms of lobbying expense, the fossil fuel industry has been ranked relatively high or top for almost every bill. Similarly, Brulle (2018) analyzes lobbying spending on climate change legislation in US from 2000 to 2017. He describes that (1) from year 2000 to 2016, over $2 billion was spent on lobbying climate change legislation; (2) fossil fuel industry spent $370.44 million (17.7% to total lobbying expenditure) on climate change legislation, while the renewable energy industry spent $78.68 million (3.8% of total lobbying expenditure).

Table 1: Bills that include sections, which are unfavorable to the action on climate change

Bill Number	Congress	Year	Title	Status	Total Expenditure on Lobbying Issues by Renewable Energy Industry	Total Expenditure on Lobbying Issues by Fossil Fuel Industry	Total Expenditure on All Lobbying Issues
H.R.2609	113	2013	Energy and Water Development and Related Agencies Appropriations Act, 2014	Passed House	$1.41M	$18.34M	$237.56M
H.R.1582	113	2013	Energy Consumers Relief Act of 2013	Passed House	·	$48.86M	$219.88M
H.R.4660	113	2014	Commerce, Justice, Science, and Related Agencies Appropriations Act, 2015	Passed House	·	$11.55M	$326.21M
H.R.4923	113	2014	Energy and Water Development and Related Agencies Appropriations Act, 2015	Passed House	$0.35M	$39.43M	$278.16M
H.R.2	113	2014	American Energy Solutions for Lower Costs and More American Jobs Act	Passed House	·	$22.00M	$109.63M
H.R.2685	114	2015	Department of Defense Appropriations Act, 2016	Passed House	$0.17M	$20.65M	$280.30M
H.R.2822	114	2015	Department of the Interior, Environment, and Related Agencies Appropriations Act, 2016	Introduced	$2.41M	$25.28M	$316.98M
H.R.5293	114	2016	Department of Defense Appropriations Act, 2017	Passed House	$0.12M	$6.1M	$290.69M
H.R.5538	114	2016	Department of the Interior, Environment, and Related Agencies Appropriations Act, 2017	Passed House	$1.60M	$18.01M	$252.50M
H.R.3354	115	2017	Interior and Environment, Agriculture and Rural Development, Commerce, Justice, Science, Financial Services and General Government, Homeland Security, Labor, Health and Human Services, Education, State and Foreign Operations, Transportation, Housing and Urban Development, Defense, Military Construction and Veterans Affairs, Legislative Branch, and Energy and Water Development Appropriations Act, 2018	Passed House	$3.94M	$7.62M	$435.80M
H.CON.RES.119	115	2018	Expressing the sense of Congress that a carbon tax would be detrimental to the United States economy	Agreed to in House	·	$8.25M	$10.41M

Using data for the 110th Congress, Kang (2015) estimates the structural model of lobbying and policy in the energy sector. She finds that although the effect of lobbying expenditures by the energy industry on the probability of policy enactment is very small, the average return to the

[7]In Table 1, fossil fuel industry includes a group of firms involving oil & gas production, oilfield service, equipment & exploration, petroleum refining & marketing, gasoline service stations, fuel oil dealers and coal mining.

energy industry's lobbying expenditure is very large because the value of policy is enormous to the energy sector. Note that all the anti-climate change bills except for the bill, H.CON.RES.119, in the 115th Congress, address not only climate change issues but also various other issues. Kang (2015) discusses problems of using bills as a unit of analysis for estimating the effect of lobbying on a policy. The main problem is that climate activists and energy lobbying groups target a policy related to climate change or energy issues, rather than one entire bill. If we estimate the effect of lobbying expenditure or climate change campaigns on a congressperson's roll-call voting to anti-climate change bills, we can never guarantee the estimated coefficients to be unbiased unless we control all main determinants of congresspersons' voting on anti-climate change bills that address multiple heterogeneous issues.

In this article, I focus on the effect of social media campaigns and partisan identity on the effectiveness of lobbying by the fossil fuel industry on a congressperson's decision against climate change actions during the 113-115th Houses of the Congress. The effectiveness of the fossil fuel lobbying is measured by the congressperson's responsiveness to fossil fuel lobbying when making decisions on anti-climate change bills. That is to say, the greater the congressperson's responsiveness to fossil fuel industry's lobbying against climate change actions, the more favorable to the fossil fuel industry anti-climate change bills are. I find that a 1% increase in the activities of social media campaigns decreases the effectiveness of the fossil fuel lobbying on Democrats by 0.266%. Second, the fossil fuel industry's lobbying against climate change actions is 13.0% more effective on Republicans than on Democrats. Third, the effectiveness of the fossil fuel lobbying on Republicans is likely to grow as social media campaigns become more popular. This implies that (1) most Republicans are likely to be at least ignorant to influences by climate activist groups' social media campaigns; (2) Republicans are potentially susceptible to influences by anti-climate change information providers such as FOX news that frequently downplays the consequence of climate change; and (3) Republicans' climate change preferences become more against climate change actions if they are exposed to climate activists groups' social media campaigns that support Democrats or oppose Republicans. Fourth, partisan identity plays much more significant role in a congressperson's preference on climate change issues than social media campaigns. This is partly because social media campaigns are not effective in persuading Republicans. This also explains the big effect of partisan identity and the small effect of social media campaigns on congresspersons' responsiveness to fossil fuel lobbying. Lastly, average rates of returns to fossil fuel lobbying expenditure on a congressperson's decisions against climate change actions are inferred from the estimated climate change preferences. The average rates of returns to fossil fuel lobbying expenditure is -87.67% on Democrats and 449.03% on Republicans. This implies that on average, the effectiveness of the fossil fuel lobbying on Democrats decreases by 87.67% as the proportion of fossil fuel lobbying expenditure on an anti-climate change bill increases. Similarly, the effectiveness of the fossil fuel lobbying on Republicans increases by 449.03% as the proportion of fossil fuel lobbying expenditure on an anti-climate change bill increases.

This study contributes to the literature of competition for political influences by providing an empirical evidence on to what extent activist groups' social media campaigns compete with industry groups' lobbying efforts on public policy. Firstly, while the importance of social media campaigns on legislation have been widely discussed, there has been a lack of research on estimating the effects of social media campaigns on public policy. I employ worldwide-US Twitter activities with #climatechange/#globalwarming as a proxy for climate change campaigns using social media to test a hypothesis that climate change campaigns using social media affect climate change legislation. Secondly, I find that congresspersons, particularly for Republicans, are likely to be susceptible to fossil fuel industry's lobbying against climate change actions. This is an addition to the literature of lobbying influences on public policy and an empirical evidence for what climate activist groups blame fossil fuel industry for their lobbying activities. Lastly, I provide an implication for social media campaigns to better compete with lobbying for political influences. Climate activist groups' social media campaigns may better targeting Republican audiences with less political voices. This helps avoid adverse effects of exposure to opposing political views on political polarization, while increasing Republican supporters' awareness on climate change issues.

2 Background and Data

I construct a dataset on climate change campaigns using Twitter, energy lobbying, and climate change legislation for this study that covers years from 2012 to 2017 and the 113-115th Houses of the Congress. I use worldwide-US Twitter climate change activities—tweets with #cliamtechange or #globalwarming, retweets and likes to such tweets—as a proxy for climate change campaigns in social media.

Tweets that have either "#climatechange", #globalwarming," or both hashtags are collected using web-page scrapping programmings.[8] Related information about tweets such as Twitter users

[8] An amount of tweets is limited by 500,000 per month if using Twitter Premium API only. An automated web

who retweeted or liked the tweets, and bio profiles including locations of those Twitter users are also collected from tweets' web pages.

Sentiments scores of tweet messages are obtained by using TextBlob, a Python library for natural language processing tasks. Sentiment in social media campaigns may play an important role in persuading people's opinion (Gorodnichenko et al., 2018) because most economic agents are not only rational but also emotional. Sentiment score from -1 to -0.05 is classified as negative sentiment; -0.05 to 0.05 is neutral sentiment; and 0.05 to 1 is positive sentiment. Loureiro and Alló (2020) assess the relationship between sentiments of climate change-related tweets and climate change and related energy issues during the first six months of 2019 in the United Kingdom and Spain. They find that renewable energy is associated with positive sentiment, and coal with negative. They argue that sentiment information reveals the public's perception on climate change, and is useful in climate change communication.

The worldwide Twitter corpus with #climatechange/#globalwarming includes 5,017,108 tweet messages posted from the beginning of 2012 to the end of 2017 across the planet. Twitter users' locations are identified at US city/town-level or county-level from users' profile text, because not many Twitter users allow geographic coordinates to be included in their tweet information.[9] If users' profiles do not specify US city/town-level or county-level location, I discard those users' information from the sample. Sisco et al. (2017) find that the estimation of the weather effects on Twitter activities is robust to location inaccuracies from textual identification by performing Monte Carlo simulations using geo-coded tweets taking into account the loss of information due to missing location in profile. In this study, the location matches with where user lives and is identified at city, county and congressional district level, so that it can be allowed to be coarser than the weather-tweet relationship study in Sisco et al. (2017).

The total number of US users in the sample data is 310,717, approximately 1% of the US population. The US Twitter corpus #climatechange/#globalwarming, written by US users includes 1,444,766 tweet messages posted between January 2012 and December 2017. It is assumed that Twitter users stay in the same location during the sample period, which is a caveat of the Twitter sample data. However, it is possible to check the robustness of social media campaigns to location inaccuracies by the similar fashion in Sisco et al. (2017).

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scraping on Twitter's Advanced Search Results makes it possible to collect public information in historical tweets.

[9] Identifying the true locations where tweets are written is inherently limited to somewhat crude geographic precision (Graham et al., 2014).

Data for federal bills related to climate change, renewable energy and energy efficiency are collected from the GovTrack.us, the Library of Congress and the Clerk of the US House of Representatives by using Python web-page scrapping programming and ProPublica API. I identify bills against climate change actions if a bill prohibits the federal government agencies or other US authorities from implementing regulations on greenhouse gas emissions or using funds for international climate change agreements (see Appendix C for more details).

Firm-level data for lobbying are collected from the Center for Responsive Politics. Lobbying data specify a client, an amount for lobbying expense for each lobbying issue, lobbying category, firm's industry, targeted bills, targeted government agencies, and year of lobbying conducted. I assume that when an anti-climate change bill is targeted by one lobbying issue from a firm in a fossil fuel industry, all anti-climate actions in the anti-climate change bill are lobbied by the respective lobbying entity. Classification of supporting or opposing a bill is straightforward, based on types of energy industry and contents of anti-climate change policies in a bill.

Data for state-level and metropolitan city-level Google Trends of terms "climate change" and "global warming" are collected using Google Trend API. Google Trends provides a time trend of an intensity of internet searches for terms, so that it can be used as a proxy for the public salience of climate change. Herrnstadt and Muehlegger (2014) study how search patterns of climate change vary with locally extreme weather events. Several recent studies (Burchardi et al. (2018), Loureiro and Alló (2020), Vu (2020)) employ Google Trends data as a proxy for a measure of information demand. Google Trends is calculated as follows:

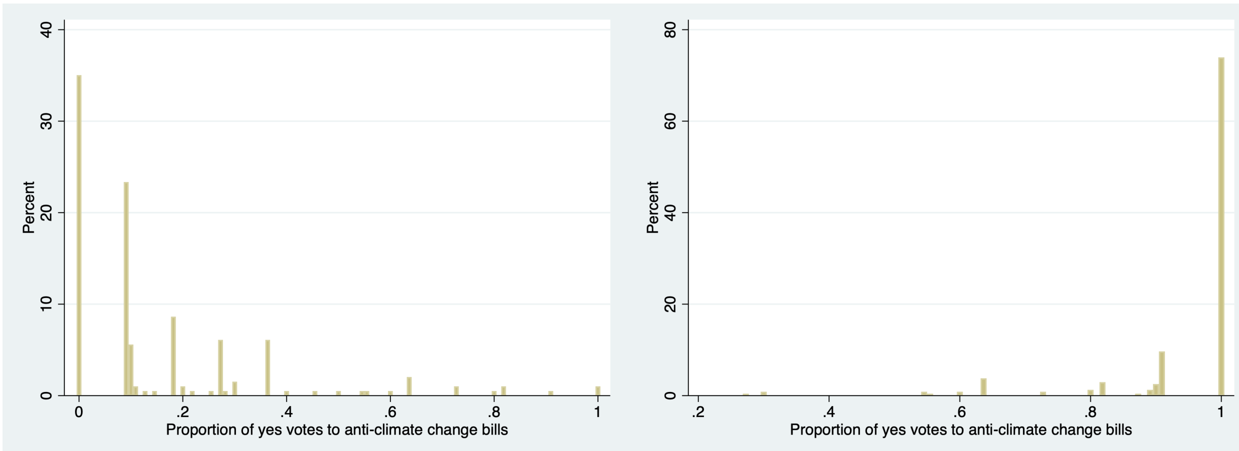
$$G\,(\,i, xy\,) \;=\; \left\lfloor 100 \times \frac{share(i, xy)}{\max_{\delta}\,\{share(i, \delta y)\}} \mathbb{1}\,[\,\#(i, xy) \geq T\,] \right\rceil ,$$

where $\lfloor \cdot \rceil$ is the integer round function, $share(i, xy) > 0$ is the share of search query i in region x in time y, $\max_{\delta}\{share(i, \delta y)\}$ is the maximum share of search query i across all regions in time y, $\mathbb{1}\,[\,\#(i, xy) \geq T\,]$ is an indicator function that is one if the number of searches for query i in region x in time y is greater than the number T, which is the (unreported) search volume threshold.

Survey data for climate change belief are obtained from Howe et al. (2015), which are published every two years from 2014. Data for monthly maximum temperature as well as precipitation for each county in the U.S. are collected from the file transfer protocol (FTP) server at the National Oceanic and Atmospheric Administration (NOAA). Data for socio-economic controls such as age, gender, education, races and income are collected from US Bureau of Census.

2.1 Roll-call votes on the bills

Figure 5: Proportion of yes votes to anti-climate change bills



(a) Democrat (b) Republican

Figure 5 shows histograms of the Democrats and the Republicans' roll-call votes to the anti-climate change bills. Democrats are generally against anti-climate change bills, and republicans are generally in favor of anti-climate change bills. About 35% of the Democrats voted no to all the anti-climate change bills, while over 70% of the Republicans voted yes to all the anti-climate change bills.

Figure 6: Trend in proportion of yes votes to anti-climate change bills

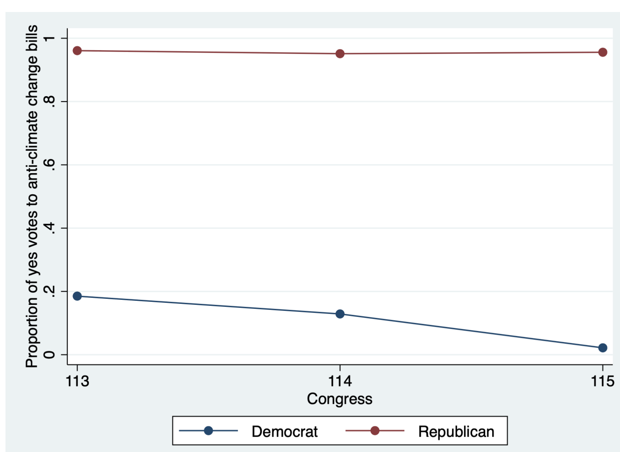


Figure 6 shows a time trend in proportion of yes votes to all anti-climate change bills. Democrats' proportion of yes votes decreases to nearly zero over the Congresses, while republicans' proportion of yes votes is stable at nearly 1. Although anti-climate change bills address not just climate change and energy issues but also heterogeneous multiple issues, there could be a cause for the pattern in Figure 6 related to social media campaigns and energy lobbying. Appendix A describes that while 275 lobbying categories lobbied at least one anti-climate change bill, only two groups of lobbying categories—fossil fuel industry and environmental groups—lobbied all anti-climate change bills.

3 Conceptual framework

The conceptual framework for the empirical model in Section 4 is mainly inspired by Papke (1995) and Daubanes and Rochet (2019). Assume that congressperson d never votes yes to any anti-climate change bill if and only if he or she is sufficiently concerned about the consequence of climate change, which is represented in their functions of climate change preference, $M(\,\cdot\,; Campaign_{dy-1}, GOP_d, \cdots)$. Variable $Campaign_{dy-1}$ is the per-capita number of social media campaigns in year $y-1$. Variable GOP_d is a partisan identity dummy that is 1 if congressperson d is Republican and 0 if Democrat. In the spirit of Hiriart and Martimort (2012) and Daubanes and Rochet (2019), assume that lobbying activities influence a congressperson's preference. Given variable $LobbyFossilFuel_b$—fossil fuel industry lobbying expenditure for the level of anti-climate policy in bill b—and variable $LobbyRest_b$—the rest of industries' lobbying expenditure for other heterogeneous issues in bill b—, congressperson d maximizes utility by choosing levels of response to variables $LobbyFossilFuel_b$ and $LobbyRest_b$, denoted by f_{db} and z_{db} respectively.

$$\max_{f_{db}, z_{db}} U_{db} = U_e(x_{db}) + U_a(z_{db}; LobbyRest_b)$$

$$\begin{aligned} \text{subject to} \quad & x_{db} = M(f_{db}; LobbyFossilFuel_b, Campaign_{dy-1}, GOP_d, \cdots), \\ & f_{db} + z_{db} \leq 1 \\ & f_{db} \in [0,1], \, z_{db} \in [0,1]. \end{aligned}$$

where $U_e(\cdot)$ and $U_a(\cdot)$ are weakly concave utilities of responses to fossil fuel lobbying and the rest of industries' lobbying respectively. The sum of $LobbyFossilFuel_b$ and $LobbyRest_b$ is the total lobbying expenditure for bill b, $LobbyTotal_b$:

$$LobbyTotal_b = LobbyFossilFuel_b + LobbyRest_b.$$

Congressperson d chooses $f^*_{db} > 0$ if and only if congressperson d votes yes to anti-climate change bill b.[10] Congressperson d receives climate change or energy-related information from fossil fuel lobbying industry, social media campaigns, his or her political party as well as several other channels. Benefit of fossil fuel industry and social cost of climate change or energy-related policy in case bill b becomes law is processed through the climate change preference function $M(f_{db}; \cdots)$. Given processed information via the function $M(f_{db}; \cdots)$, congressperson d revises how much against climate change actions in bill b. Accordingly, the level of response to fossil fuel lobbying, f_{db}, reflects a quality of anti-climate change policy in bill b, and is heavily influenced by the climate change preference $M(f_{db}; \cdots)$. The larger the congressperson's responsiveness to fossil fuel lobbying f^*_{db} is, the more the congressperson d is friendly to the fossil fuel industry's requests that are against climate change actions, thereby the greater effectiveness of the fossil fuel lobbying against climate change actions.

Replacing z_{db} using the constraint with binding responses to lobbying, congressperson d maximizes utility by choosing the level of response to fossil fuel lobbying f_{db}:

$$\max_{f_{db} \in [0,1]} U_{db} = U_e(M(f_{db}; \cdots)) + U_a(1 - f_{db}; LobbyRest_b)$$

Congressperson d chooses $f^*_{db} > 0$ if at $f_{db} = 0$

$$\frac{\partial M}{\partial f_{db}} \cdot \frac{\partial U_e}{\partial x_{db}} > \frac{\partial U_a}{\partial z_{db}}, \tag{1}$$

Equation (1) says that the congressperson d votes yes to bill b if the derivative of climate change preference function with respect to the response to fossil fuel lobbying, $\frac{\partial M}{\partial f_{db}}(f_{db}, \cdots)$, is greater than the marginal rate of substitution between a response to fossil fuel lobbying and a response to lobbying by the rest of industries.

For a simple analysis, impose a logarithm, a quadratic, and an exponential functional forms on the utilities and the climate change preference in the following way.

$$\begin{aligned} U_e(\cdot) &= \log(\cdot), \\ U_a(\cdot) &= LobbyRest_b \times z_{db} - \frac{LobbyTotal_b}{2} \times z^2_{db}, \\ M(f_{db}, \cdots) &= exp(LobbyFossilFuel_b \times m(\cdots) \times f_{db}). \end{aligned}$$

[10] Unless $z_{db} = 1 - f_{db}$, the choice of $z_{db} \in [0, 1)$ is not precisely corresponding to a congressperson's voting, because we do not know whether the lobbing by the rest of industries support, oppose, or is neutral to bill b.

The quadratic term in the utility $U_a(\cdot)$ reflects the casual fact that the marginal utility U_a depends on the level of z_{db} in the following stylized fashion:

$$\frac{\partial U_a}{\partial z_{db}} \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0 \quad \text{if} \quad z_{db} \begin{Bmatrix} < \\ = \\ > \end{Bmatrix} \frac{LobbyRest_b}{LobbyTotal_b}.$$

Then, congressperson d solves the following utility maximization problem:

$$\begin{aligned} \max_{f_{db}\in[0,1]} U_{db} &= LobbyFossilFuel_b \times m(GOP_d, Campaigns_{dy-1}, \cdots) \times f_{db} \\ &+ LobbyRest_b \times (1 - f_{db}) - \frac{LobbyTotal_b}{2} \times (1 - f_{db})^2, \end{aligned}$$

The optimal solution for the response to fossil fuel lobbing, f_{db}, is

$$f_{db} \approx \frac{LobbyFossilFuel_b}{LobbyTotal_b} \times \left[1 + m(GOP_d, Campaigns_{dy-1}, \cdots)\right] \in [0,1]. \tag{2}$$

Solution equation (2) implies that sufficiently low (high) value of the climate change preference function $m(\cdots)$ leads to $f^*_{db} = 0$ ($f^*_{db} = 1$). Considering the fossil fuel lobbying expenditure normalized by the total lobbying expenditure as an input for the fossil fuel industry's lobbying outcome, the congressperson's climate change preference $m(GOP_d, Campaigns_{dy-1}, \cdots)$ determines the rate of returns to fossil fuel lobbying on a congressperson's decision against climate change actions. Assuming linearity and statistical properties in the congressperson's climate change preference, $m(\cdots)$, equations (1) and (2) as well as the function of a congressperson's climate change preference can be estimated by the empirical model in Section 4.

4 Models

I apply the correlated random-effects (CRE) fractional response (FR) heteroskedastic probit model for estimating the effect of social media campaigns and partisan identity on congresspersons' responsiveness to energy lobbying to anti-climate change bills.

The FR model is the most appropriate for estimating the mean level of a congressperson's responsiveness to fossil fuel lobbying. With the CRE framework, the FR model can consistently estimate the expected value of proportion that is bounded by 0 and 1 (Wooldridge (1996), Papke and Wooldridge (2008), Wooldridge (2011), Wooldridge (2019)). Standard linear models are not appropriate because the predicted values from standard linear models of fractional data can go beyond 1 or below 0. We might consider applying the standard binary response model by transforming fractional data into binary data, as the value of total lobbying expenditure is observed by econometrician. However, unless rounding up the value of lobbying expenditures, the number of observations for the transformed data for estimating standard binary response models blows up to billions, which is not practical to estimate. In addition, fossil fuel industry's lobbying expenditure and total lobbying expenditure do not have the same characteristics in terms of the goal of lobbying.

The CRE model, developed by Mundlak (1978) and Chamberlain (1980), allows for correlation between unobserved effects and explanatory variables. The CRE model is more reliable than traditional RE, fixed-effects (FEs), bias-corrected FEs, pooled logit/probit, or linear models of a fractional dependent variable. Firstly, FEs estimator in non-linear model suffers from an incidental parameter problem, as the variables of unobserved effects are treated as parameters to be estimated. Secondly, although bias-corrected FEs model, developed by (Fernández-Val and Weidner, 2016), deals with an incidental parameter problem, it requires weak time-serial dependence in the data generating process. The correlated REs probit allows for any time-serial (in)dependence (Wooldridge (2010) and Wooldridge (2019)). Time dimension in equation (3) is bill, so congresspersons' roll-cal votes on anti-climate change bills over the years are not necessarily weakly-dependent. Thirdly, traditional random-effects model is undesirable because of the independence and the distributional assumption on the error term. Fourthly, linear models of a fractional dependent variable generate predicted fractions that are often greater than one or less than zero. Lastly, pooled estimators are generally less efficient than panel estimators and likely to be biased.

Finally, I allow for residual variances to differ across group variable GOP_d. Figures 5 and 6 suggest that Democrats may have a larger-variance stochastic component to their decision-making on a response to fossil fuel lobbying than Republicans.

The estimating equation is as follows:

$$
\begin{aligned}
& E\left[\, Vote_{dsbyc} \times \frac{LobbyFossilFuel_b}{LobbyTotal_b} \,\middle|\, \cdot \,\right] \\
&= \mathbf{\Phi}\,\big(\, \alpha_1\, GOP_d \,+\, \beta_1\, Campaign_{dy-1} \,+\, \beta_2\, GOP_d \times Campaign_{dy-1} \\
&\qquad +\, \eta_1\, StateAdjacency_{dsb} \,+\, \eta_2\, GoogleTrend_{dy-1} \,+\, \eta_3\, Belief_{dc} \\
&\qquad +\, \lambda_1\, Positive_{dy-1} \,+\, \lambda_2\, Negative_{dy-1} \\
&\qquad +\, \sum_{\ell \in \left\{\{.6,.7\},\{.7,.8\},\{.8,.9\},\{.9,1.0\}\right\}} \mu_1^{\ell}\, Temperature_{dy-1}^{\ell} \,+\, \sum_{\ell \in \left\{\{.6,.7\},\{.7,.8\},\{.8,.9\},\{.9,1.0\}\right\}} \mu_2^{\ell}\, Precipitation_{dy-1}^{\ell} \\
&\qquad +\, \theta\, \mathbf{X}_{dy-1} \,+\, \omega_b \,+\, \psi_d \,+\, \kappa_{by} \,+\, \chi_c \,\big)\,. \qquad (3)
\end{aligned}
$$

Subscripts d, s, b, y and c represent congressional district, state, anti-climate change bill, year and congress. Variable $Vote$ is a a congressperson's roll-call vote—1 if yes and 0 if no. Variable $LobbyFossilFuel_b$ is a fossil fuel industry's lobbying expenditure for anti-climate change bill b. Variable $LobbyTotal_b$ is total lobbying expenditures for bill b. The left-hand side of equation (3) is the expected value of a congressperson's responsiveness to energy lobbying expenditure conditioning on all variables in the right-hand side of equation (3). Value $E\left[\, Vote_{dsbyc} \times \frac{LobbyFossilFuel_b}{LobbyTotal_b} \,\middle|\, \cdot \,\right]$ measures how much congressperson d is responsive to fossil fuel industry's lobbying against climate change actions in bill b or how much fossil fuel industry's lobbying is effective on a congressperson's decision against climate change actions in bill b.

The right-hand side of equation (3) is the cumulative probability function of the standard normal distribution. Variable GOP_d is a a congressperson's political party—1 if Republican and 0 if Democrat. Variable $Campaign_{dy-1}$ is the per-capita number of the sum of the numbers of tweets, retweets and likes multiplied by one hundred. Variable $StateAdjacency_{dsb}$ is a logarithm of the sum of other congresspersons' yes roll-call votes in the same state. Variable $GoogleTrend_{dy-1}$ is a logarithm of average value of Google Trend for terms between "climate change" and "global warming'.' Variable $Belief_{dc}$ is a percentage level of pubic opinion on climate change from Yale Climate Change Communication (Howe et al., 2015). Variables $Positive_{dy-1}$ and $Negative_{dy-1}$ are the proportion of tweets with positive and negative sentiments respectively. Variable $Temperatue_{dy01}^{\ell}$ ($Precipitation_{dy-1}^{\ell}$) is the number of months in a bin ℓ in which monthly average of daily maximum temperatures (precipitations) is either 60-70%, 70-80%, 80-90% or 90-100% level in last 40 years of the same month. Weather variables are controlled, because climate-economy literature says short-run weather variations influence people's belief about climate change. Herrnstadt and Muehlegger (2014) find that abnormal weather is further associated with pro-environmental voting behavior of U.S. congress members whose home states experience abnormal weather. Gagliarducci et al. (2019) find that politicians from districts that have experienced a hurricane recently are more likely to support legislation of green bills after the disaster.

A vector of variables $\boldsymbol{X}_{dy-1}$ contains average levels of socio-economic characteristics—age, gender, races, years of education and household income—of people in congressional district d as well as a congressperson's age and gender. Variable ψ_d is unobserved effect of congressional district. Following the tradition of the CRE model, I assume that the congressperson's unobserved characteristics is correlated with the average of explanatory variables in equation (3), $\overline{\boldsymbol{W}}_{dsbyc}$:

$$E[\psi_d \mid \cdot] = \overline{\boldsymbol{W}}_{dsbyc} \, \Xi + \epsilon_d, \tag{4}$$

where Ξ is a vector of coefficients and ϵ_d is an error term. The CRE assumption (4) is not strong, because the congressperson d is representative for people in congressional district d. Variable ω_b is a trend in the proportion of fossil fuel lobbying expenditure for bill b. Variable κ_{by} is unobserved effect of bill b in year y that bill b was voted. Variable χ_c is unobserved effect of congress c.

5 Results

Table 2 presents estimated coefficients from the CRE-FR model in Section 4 in column (1), the FR model without the CRE framework in column (2), fixed-effects linear model in column (3), random-effects linear model in column (4) and pooled OLS model in column (5). Table 2 shows that the CRE-FR model has a quite different result from the other models. Nonetheless, the CRE-FR estimates are the most reliable, as $\Xi \neq \boldsymbol{0}$ and some predicted values from all the linear models go beyond the unit line.

Table 2: Estimations of equation (3)

	(1)	(2)	(3)	(4)	(5)
	CRE-FR	FR	Linear, FE	Linear, RE	Linear, Pooled
GOP_d	1.745***	1.052***	0.0830***	0.125***	0.125***
	(0.158)	(0.0977)	(0.0195)	(0.00529)	(0.00594)
$Campaign_{dy-1}$	-2.381***	-4.506***	-0.0306	-0.0297**	-0.0297
	(0.803)	(1.145)	(0.0227)	(0.0140)	(0.0210)
$GOP_d \times Campaign_{dy-1}$	2.385***	4.602***	0.0386*	0.0355**	0.0355
	(0.804)	(1.144)	(0.0228)	(0.0142)	(0.0223)
$StateAdjacency_{dsb}$	0.0603**	0.0542***	0.0478***	0.00469***	0.00469**
	(0.0276)	(0.0132)	(0.00766)	(0.00141)	(0.00212)
$GoogleTrend_{dy-1}$	0.00136	0.0933**	0.0255	0.00680	0.00680
	(0.0158)	(0.0410)	(0.0227)	(0.00427)	(0.00630)
$Belief_{dc}$	0.117	-1.180***	0.944***	-0.0314	-0.0314
	(0.180)	(0.235)	(0.120)	(0.0250)	(0.0311)
$Negative_{dy-1}$	0.000392	0.000231	0.0000603	0.000162	0.000162
	(0.000577)	(0.00162)	(0.000442)	(0.000304)	(0.000304)
$Positive_{dy-1}$	0.000806	0.00160	0.00000232	0.0000620	0.0000620
	(0.000627)	(0.00174)	(0.000377)	(0.000259)	(0.000256)
$Temperature^{.9,1.0}_{dy-1}$	0.0523	0.218**	0.0989***	0.0573***	0.0573***
	(0.0331)	(0.110)	(0.0191)	(0.0171)	(0.0168)
$Temperature^{.8,.9}_{dy-1}$	-0.00571	-0.0700	0.00901	-0.00338	-0.00338
	(0.0189)	(0.112)	(0.0178)	(0.0157)	(0.0159)
$Temperature^{.7,.8}_{dy-1}$	-0.00332	0.247**	0.0933***	0.0577**	0.0577**
	(0.0261)	(0.126)	(0.0302)	(0.0253)	(0.0267)
$Temperature^{.6,.7}_{dy-1}$	0.0126	0.106	0.0664***	0.0325	0.0325
	(0.0291)	(0.117)	(0.0241)	(0.0216)	(0.0224)
$Precipitation^{.9,1.0}_{dy-1}$	0.0141	0.229**	0.0475*	0.0554**	0.0554**
	(0.0232)	(0.109)	(0.0264)	(0.0238)	(0.0233)
$Precipitation^{.8,.9}_{dy-1}$	-0.0203	-0.0776	0.0139	0.0102	0.0102
	(0.0284)	(0.142)	(0.0303)	(0.0255)	(0.0245)
$Precipitation^{.7,.8}_{dy-1}$	0.0263	0.0636	0.0833**	0.0503	0.0503
	(0.0459)	(0.201)	(0.0388)	(0.0341)	(0.0330)
$Precipitation^{.6,.7}_{dy-1}$	-0.0669	-0.362**	-0.0384	-0.0644**	-0.0644**
	(0.0448)	(0.162)	(0.0290)	(0.0260)	(0.0270)
ω_b	1.136***	3.412***	0.673***	0.566***	0.566***
	(0.325)	(0.0451)	(0.0309)	(0.0246)	(0.0215)
Ξ	$\neq \mathbf{0}$				
Observations	4,599	4,599	4,599	4,599	4,599
Pseudo R^2	0.269	0.341			
R^2_{within}			0.589	0.551	
$R^2_{between}$			0.103	0.915	
$R^2_{overall}$			0.266	0.614	0.614

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.1 Endogenous Partisan Identity

Variable GOP_d can be potentially endogenous, because there could be a long-lasting mutual relationship between fossil fuel industry and congresspersons that are interested in changing climate change policies. The literature on lobbying does not strongly support the dynamic effects of firms' lobbying on public policy. Rather, firms that want to lobby legislators would like to hire lobbyists that have cultivated relationships with politicians and legislators (Blanes i Vidal et al. (2012)). Still, this potential endogeneity concern should be addressed.

A variable for mean-level years of education in congressional district d, $Educ_{dy-1}$ is selected to instrument a variable GOP_d. Variable $Educ_{dy-1}$ is robust ton an omitted variable bias in equation (3) as an education level is controlled by a variable for the percentage of people who hold a bachelor's degree in a vector of variables X_{dsbyc} in equation (3). In the first-stage, a variable GOP_d is regressed on a variable $Educ_{dy-1}$ and all explanatory variables in equation (3). Table 12 inf Appendix D shows the first-stage estimation result. The first-stage result indicates that variable $Educ_{dy-1}$ is sufficiently correlated with variable GOP_d. In the second stage, a variable of first-stage residuals is added to the right-hand side of equation (3) as an additional regressor (Terza et al. (2008), Wooldridge (2010), Wooldridge (2011)).

Table 3 shows estimation results with an instrumentation of variable GOP_d. An estimated coefficient for the variable of first-stage residuals, $1stStageResidual_{dsbyc}$, is statistically significant, implying that the hypothesis—variable GOP_d is exogenous—is rejected and the instrumentation is plausible, although the estimates in columns (1)-(2) in Tables 2 and 3 are not significantly different from each other.

Table 3: Estimation of equation (3) with the first-stage residuals

	(1)	(2)	(3)	(4)	(5)
	CRE-FR	FR	Linear, FE	Linear, RE	Linear, Pooled
GOP_d	1.797***	1.375***	0.0830***	0.125***	0.125***
	(0.132)	(0.103)	(0.0195)	(0.00529)	(0.00594)
$Campaign_{dy-1}$	-2.392***	-4.341***	-0.0306	-0.0297**	-0.0297
	(0.801)	(1.119)	(0.0227)	(0.0140)	(0.0210)
$GOP_d \times Campaign_{dy-1}$	2.390***	4.411***	0.0386*	0.0355**	0.0355
	(0.801)	(1.118)	(0.0228)	(0.0142)	(0.0223)
$StateAdjacency_{dsb}$	0.0564**	0.0230	0.0478***	0.00469***	0.00469**
	(0.0260)	(0.0141)	(0.00766)	(0.00141)	(0.00212)
$GoogleTrend_{dy-1}$	0.00355	0.0879**	0.0255	0.00680	0.00680
	(0.0165)	(0.0391)	(0.0227)	(0.00427)	(0.00630)
$Belief_{dc}$	0.318	-0.156	0.944***	-0.0314	-0.0314
	(0.247)	(0.277)	(0.120)	(0.0250)	(0.0311)
$Negative_{dy-1}$	0.000272	-0.000678	0.0000603	0.000162	0.000162
	(0.000554)	(0.00156)	(0.000442)	(0.000304)	(0.000304)
$Positive_{dy-1}$	0.000803	0.00151	0.00000232	0.0000620	0.0000620
	(0.000625)	(0.00168)	(0.000377)	(0.000259)	(0.000256)
$Temperature^{.9,1.0}_{dy-1}$	0.0484	0.225**	0.0989***	0.0573***	0.0573***
	(0.0321)	(0.110)	(0.0191)	(0.0171)	(0.0168)
$Temperature^{.8,.9}_{dy-1}$	-0.00831	-0.0816	0.00901	-0.00338	-0.00338
	(0.0199)	(0.113)	(0.0178)	(0.0157)	(0.0159)
$Temperature^{.7,.8}_{dy-1}$	-0.00708	0.244*	0.0933***	0.0577**	0.0577**
	(0.0270)	(0.126)	(0.0302)	(0.0253)	(0.0267)
$Temperature^{.6,.7}_{dy-1}$	-0.00163	0.0329	0.0664***	0.0325	0.0325
	(0.0293)	(0.120)	(0.0241)	(0.0216)	(0.0224)
$Precipitation^{.9,1.0}_{dy-1}$	0.0191	0.254**	0.0475*	0.0554**	0.0554**
	(0.0244)	(0.111)	(0.0264)	(0.0238)	(0.0233)
$Precipitation^{.8,.9}_{dy-1}$	-0.0297	-0.109	0.0139	0.0102	0.0102
	(0.0313)	(0.142)	(0.0303)	(0.0255)	(0.0245)
$Precipitation^{.7,.8}_{dy-1}$	0.0330	0.101	0.0833**	0.0503	0.0503
	(0.0488)	(0.203)	(0.0388)	(0.0341)	(0.0330)
$Precipitation^{.6,.7}_{dy-1}$	-0.0732	-0.392**	-0.0384	-0.0644**	-0.0644**
	(0.0473)	(0.163)	(0.0290)	(0.0260)	(0.0270)
ω_b	1.165***	3.414***	0.673***	0.566***	0.566***
	(0.330)	(0.0451)	(0.0309)	(0.0246)	(0.0215)
$1stStageResidual_{dsbyc}$	-0.0713*	-0.385***			
	(0.0426)	(0.117)			
Ξ	$\neq \mathbf{0}$				
Observations	4,599	4,599	4,599	4,599	4,599
Pseudo R^2	0.269	0.342			
R^2_{within}			0.589	0.551	
$R^2_{between}$			0.103	0.915	
$R^2_{overall}$			0.266	0.614	0.614

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2 Marginal Effects of Social Media Campaigns and Energy Lobbying

Table 4 presents average marginal effects (AMEs) and marginal effects at a representative value (MERs) of partisan identity and social media campaigns on the effectiveness of the fossil fuel lobbying on a congressperson's decision against climate change actions. The first row of columns (1) indicates that the fossil fuel industry's lobbying is 13.3% more effective on Republicans than on Democrats. This AME estimate of GOP_d is similar to the coefficient from the linear RE IV estimate in column (4) in Table 3. The second row of columns(1) in Table (4) indicates that one percent increase in the per-capita level of social media campaigns in year $y-1$ decreases the effectiveness of the fossil fuel lobbying by 0.122%. The third row of columns (2) indicate that one percent increase in the per-capita level of social media campaigns in year $y-1$ decreases the effectiveness of the fossil fuel lobbying on Democrats by -0.260%. The forth row of columns (2) indicate that the effect of social media campaigns in year $y-1$ is not statistically significant on the effectiveness of the fossil fuel lobbying on Republicans.

Table 4: Marginal effects on the expected value of a congressperson's responsiveness to fossil fuel lobbying

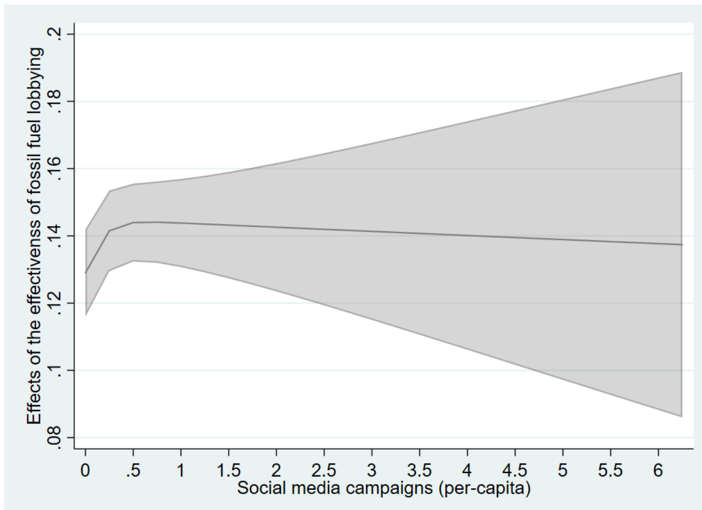
	Fossil Fuel	
	(1)	(2)
	AMEs	MERs
GOP_d	0.133***	
	(0.00634)	
$Campaign_{dy-1}$	-0.00122***	
	(0.000331)	
——Democrat		-0.00260***
		(0.000716)
——Republican		-0.0000793
		(0.000277)

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 7 depicts the effect of Republican identity on the effectiveness of the fossil fuel lobbying against climate change actions conditioning on the per-capita level of social media campaigns. The effects of Republican identity are all statistically significant at all levels of social media campaigns in Figure 7. The effectiveness of the fossil fuel lobbying on Republicans is likely to increase with the per-capita level of social media campaigns at a decreasing rate in a range from 0 to .9 of social media campaigns, in which 99% of congressional districts in the sample data belong to. This implies that social media campaigns function differently with each partisan identity. In a range from 0 to

.9, the effectiveness of the fossil fuel lobbying on Republicans slightly decreases, implying that the effectiveness of the fossil fuel lobbying on a Republican that is representative for a district with the top 1 percent level of social media campaigns (e.g. New York City and San Francisco) is more uncertain than on a Republican with less levels of social media campaigns.

Figure 7: Marginal effects of the partisan identity on responsiveness to fossil fuel lobbying conditioning on social media campaigns



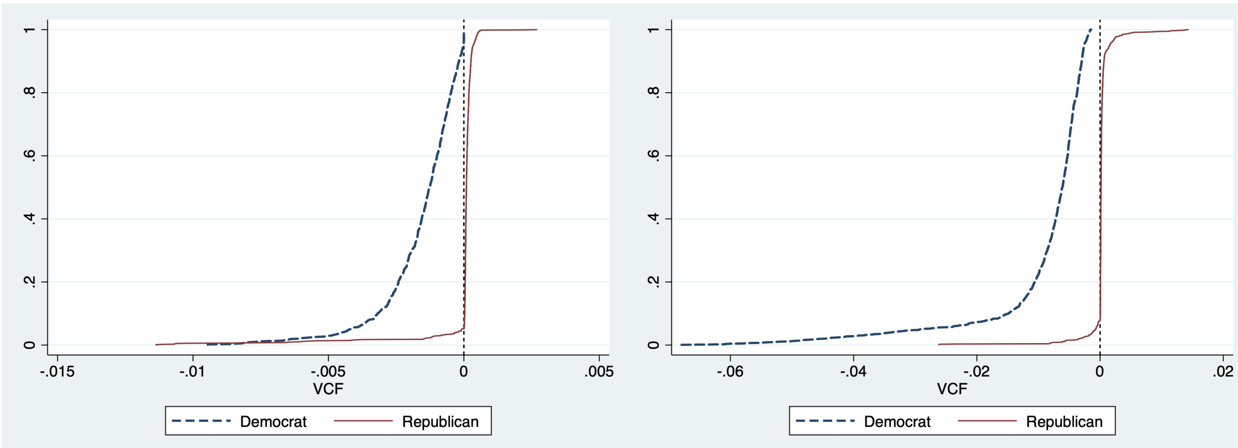
5.3 Value of Social Media Campaigns on Energy Lobbying

I begin by a counterfactual exercise on how the effectiveness of the fossil fuel industry's lobbying on a congressperson's decision against climate change actions would be if there were no social media campaigns. For this analysis, let VCF_{dsbyc} be the expected value of social media campaigns on the effectiveness of the fossil fuel lobbying if there were no social media campaigns.

$$\begin{aligned} VCF_{dsbyc} &= E\left[Vote_{dsbyc} \times \frac{LobbyFossilFuel_b}{LobbyTotal_b} \middle| \cdot \right] \\ &\quad - E\left[Vote_{dsbyc} \times \frac{LobbyFossilFuel_b}{LobbyTotal_b} \middle| Campaign_{dy-1} = 0, \cdot \right] \end{aligned} \tag{5}$$

Figure 8 depicts empirical cumulative distribution functions (CDFs) of values VCF_{dsbyc} conditioning on a congressperson's partisan identity and levels of social media campaigns. Blue dashed-lines in Figure 8 correspond to Democrats. Red solid-lines in Figure 8 correspond to Republicans. Right panel in Figure 8 shows the same monotonic relationship between value VCF_{dsbyc} and partisan identity, with a larger absolute value of VCF_{dsbyc}. Estimated values of VCF_{dsbyc} for Democrats are all negative, while estimated values of VCF_{dsbyc} for Republicans are mostly near zero and some VCF_{dsbyc} for Republicans are positive. This implies that most Republicans are ignorant to influences by climate activist groups' social media campaigns. This also can be interpreted that some Republicans are potentially susceptible to influences by misinformation of climate change, and that some Republicans are against climate change actions just because climate activists express supports for Democrats in their social media campaigns.

Figure 8: Empirical cumulative distributions of VCF_{dsbyc} conditioning on partisan identity



(a) Social media campaigns (percentile < 50%)　(b) Social media campaigns (percentile $\geq$ 50%)

Table 5 shows the back-of-the-envelope calculation of VCF_{dsbyc} on fossil fuel lobbying for each anti-climate change bill. In the back-of-the-envelope calculation, I assume the scenario in which fossil fuel industry spent all of its lobbying expenditure only on congresspersons that voted yes. The estimated value of social media campaigns on the effectiveness of the fossil fuel lobbying on Democrats is $822,111 in terms of a stake of total lobbying expenditures for anti-climate change bills, which is statistically significant. However, this value is economically insignificant compared to the fossil fuel industry's lobbying expenditure, which is $226.07 million. The estimated value of social media campaigns on the effectiveness of the fossil fuel lobbying on Republicans is neither statistically nor economically significant.

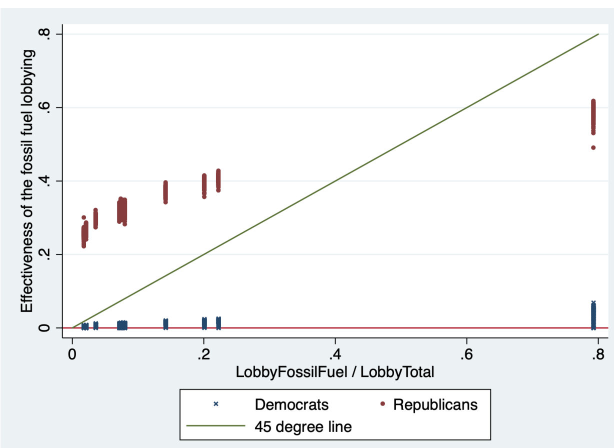
This counterfactual analysis implies that it is challenging for climate activists to persuade Republicans, or those who have strong preferences against climate change actions, while it is relatively less challenging for climate activists to persuade Democrats, or those who have less strong preference against climate change actions. However, the value of social media campaigns is only a small fraction of fossil fuel industry's total lobbying expenditure. The reason total value of VCF_{dsbyc} is so small is that social media campaigns are not effective in persuading Republicans, or those who have strong preference against climate change actions.

Table 5: Estimated value of social media campaigns on fossil fuel lobbying conditioning on partisan identity

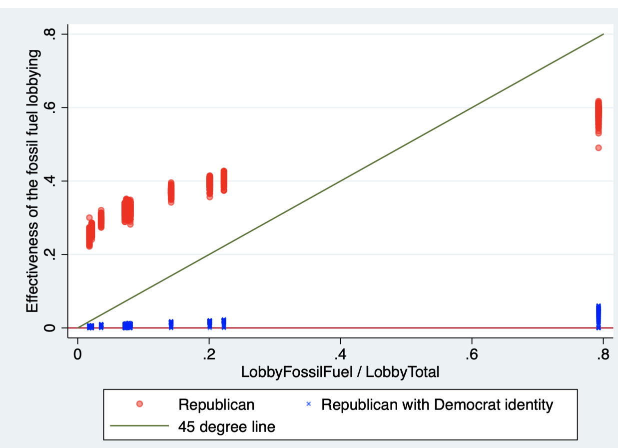
Congress	Bill	Lobbying expenditure ($M)		VCF | DEM ($)			VCF | GOP ($)		
		Total	Fossil fuel	Estimates	Confidence intervals (95%)		Estimates	Confidence intervals (95%)	
113	HR2609	238.00	18.30	-8,725.77	-15,601.34	-1,850.21	25,233.89	-125,135.10	175,602.90
	HR1582	220.00	48.90	-9,820.60	-18,746.09	-895.10	40,797.13	-149,842.00	231,436.30
	HR4660	326.00	11.50	-258,471.30	-416,581.50	-100,361.00	28,516.40	-143,093.00	200,125.80
	HR4923	278.00	39.40	-113,136.00	-198,887.60	-27,384.38	45,451.43	-157,590.90	248,493.70
	HR2	110.00	22.00	-9,251.36	-17,004.09	-1,498.63	14,019.95	-78,462.91	106,502.80
114	HR2685	280.00	20.70	-192,119.60	-309,064.00	-75,175.23	-12,366.69	-251,916.10	227,182.70
	HR2822	317.00	25.30	-4,975.91	-8,409.74	-1,542.08	-33,660.25	-318,764.00	251,443.50
	HR5293	291.00	6.10	-201,848.30	-314,379.50	-89,317.02	-5,902.23	-229,455.70	217,651.30
	HR5538	252.00	18.00	-12,829.77	-21,934.88	-3,724.66	-22,518.48	-301,283.30	256,246.30
115	HR3354	436.00	7.62	-7,906.87	-13,054.78	-2,758.96	49,551.16	-292,819.20	391,921.50
	HCONRES119	10.40	8.25	-3,026.27	-6,165.08	112.53	1,785.34	-6,753.15	10,323.84
Total		$2,758.40M	$226.07M	-$0.82M	-$1.34M	-$0.30M	$0.13M	-$2.06M	$2.32M

5.4 Climate Change Preferences and Average Rate of Returns to Fossil Fuel Lobbying

Figure 9: Effectiveness of the fossil fuel lobbying against climate change actions



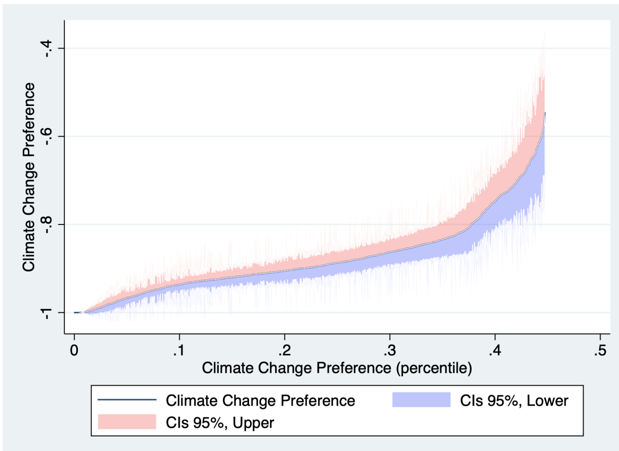
(a) Effectiveness of the fossil fuel lobbying on Democrats and Republicans



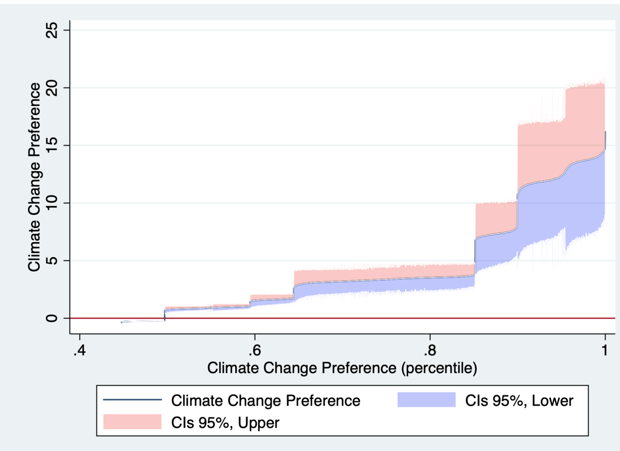
(b) Effectiveness of the fossil fuel lobbying on Republicans

Left panel of Figure 9 shows the estimated effectiveness of the fossil fuel lobbying on congresspersons' decisions against climate change actions. The horizontal axis represents the proportion of the fossil fuel industry's lobbying expenditure. Red dots in right panel of Figure 9 are the estimated effectiveness of the fossil fuel lobbying on Republicans, just as in the left panel. Blue x-dots in the right panel of Figure 9 are the estimated effectiveness of the fossil fuel lobbying on Republicans if Republicans had a Democrat identity in their climate change preference functions.

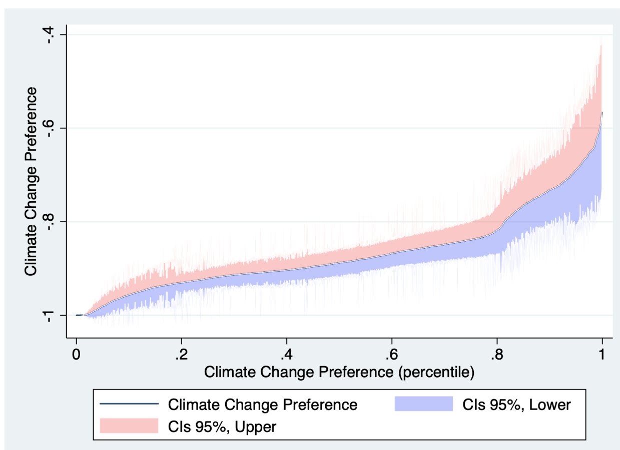
Figure 10: Climate change preferences



(a) Democrat's climate change preference



(b) Republican's climate change preference



(c) Republican's climate change preference if they had Democrat identity on climate change issues

Figure 10 depicts the estimated value of Democrat's and Republican's climate change preference functions, as in equation (2). Left top panel in Figure 10 shows that all of the values of Democrats' climate change preference function are below zero, so that the fossil fuel lobbying on Democrats are not effective. On the other hand, the right top panel in Figure 10 shows that more than 90% of the values of Republicans' climate change preference function are above zero, so that the fossil fuel lobbying on Republicans are effective. The bottom panel in Figure 10 shows that most of the values of Republicans' climate change preference function are below zero if Republicans had a Democrat identity in their climate change preference functions.

Table 6: Average rate of returns to fossil fuel lobbying inferred from climate change preference

Congress	Bill	Lobbying expenditure ($M)		Average rate of returns to fossil fuel lobbying					
				Democrats			Republicans		
		Total	Fossil fuel	Estimates	Confidence intervals (95%)		Estimates	Confidence intervals (95%)	
113	HR2609	238.00	18.30	-86.65%	-90.57%	-82.73%	326.25%	209.50%	443.00%
	HR1582	220.00	48.90	-92.06%	-94.78%	-89.33%	83.37%	59.81%	106.94%
	HR4660	326.00	11.50	-77.73%	-84.58%	-70.87%	732.72%	451.99%	1013.45%
	HR4923	278.00	39.40	-90.53%	-93.32%	-87.75%	161.94%	113.72%	210.17%
	HR2	110.00	22.00	-92.21%	-94.74%	-89.69%	97.36%	68.45%	126.28%
114	HR2685	280.00	20.70	-88.46%	-91.88%	-85.04%	349.96%	232.33%	467.59%
	HR2822	317.00	25.30	-89.91%	-93.01%	-86.82%	310.49%	196.71%	424.27%
	HR5293	291.00	6.10	-79.94%	-89.27%	-70.62%	1181.31%	649.12%	1713.50%
	HR5538	252.00	18.00	-91.01%	-94.17%	-87.86%	352.96%	224.10%	481.83%
115	HR3354	436.00	7.62	-79.95%	-91.47%	-68.42%	1365.50%	692.76%	2038.25%
	HCONRES119	10.40	8.25	-95.55%	-98.93%	-92.17%	-25.67%	-32.14%	-19.19%
Total		$2,758.40M	$226.07M	-87.67%	-92.41%	-82.92%	449.03%	261.01%	637.05%

Average rate of returns to fossil fuel lobbying on a congressperson's decision against climate change actions can be inferred from the estimated function of a congressperson's climate change preference.[11] Table 6 shows average rates of returns to fossil fuel lobbying on a congressperson's decision against climate change actions for each bill b. During the 113-115th Congresses, an average rate of returns to fossil fuel lobbying on Democrats is -87.62%, while that on Republicans is 449.73%. That is, the effectiveness of the fossil fuel lobbying on Democrats decreases by 87.62% as the proportion of fossil fuel lobbying expenditure on an anti-climate change bill increases. Similarly, the effectiveness of the fossil fuel lobbying on Republicans increases by 449.03% as the proportion of fossil fuel lobbying expenditure on an anti-climate change bill increases. This counterfactual implies that a partisan identity is the most accountable factor for a congressperson's preference on climate change issues, which in turn determines the effectiveness of the fossil fuel lobbying.

6 Discussion

Both social media campaigns and lobbying have the common goal of influencing the politician's decision on public policies in favor of their private or public interests. To what extent do social

[11] The level of average rates of returns to fossil fuel lobbying here does not directly imply the level of the fossil fuel industry's profit from lobbying congresspersons, because energy- or climate-related policies in the anti-climate change bills are heterogeneous in terms of benefits to the fossil fuel industry when the anti-climate change bills are enacted. Rather, the average rate of returns to fossil fuel lobbying measures how much a congressperson is in favor of the fossil fuel industry's lobbying in terms of a percentage of the fossil fuel industry's lobbying expenditure.

media campaigns compete with fossil fuel lobbying on climate change legislation? Social media campaigns decreases the effectiveness of lobbying by the fossil fuel industry on a Democrat's decision against climate change actions, but are likely to increase that on a Republican's decision against climate change actions. Nonetheless, such effects of social media campaigns are economically very small relative to the amount of fossil fuel industry's lobbying expenditure. The fossil fuel industry's lobbying efforts to persuade congresspersons, particularly for Republicans, to implement anti-climate change policies have much larger impacts on congresspersons' decisions on climate change legislation than social media campaigns.

The results imply that politicians' partisan identity plays a significant role in a competition between social media campaigns and lobbying. a congressperson's partisan ideology is the most accountable determinant for the level of relative effectiveness between social media campaigns and lobbying efforts. For Democrats, social media campaigns and fossil fuel lobbying are likely to be substitutes. This is because the effectiveness of the fossil fuel lobbying on Democrats decreases with social media campaigns, which would create incentive for the fossil fuel industry to decrease its lobbying effort on Democrats as social media campaigns become more popular. For Republicans, social media campaigns and fossil fuel lobbying are likely to be complements. This is because the effectiveness of the fossil fuel lobbying on Republicans increases with social media campaigns, which would create incentive for the fossil fuel industry to increase its lobbying effort on Republicans as social media campaigns become more popular. In addition, average rate of returns to fossil fuel lobbying on Democrats' decision against climate change actions are negative, while it is positive on Republicans' ones. This would be related with the pattern that the fossil fuel industry contributes 5-7 times more to Republicans' election campaigns than Democrats' election campaigns during the years 2012-2018 (Center for Responsive Politics, 2020).[12]

Why is the effect of social media campaigns on the effectiveness of the fossil fuel lobbying so small? On social media platforms, people is free to choose with whom they communicate. Various dimensions of preferences such as areas of interests and political ideology influence people's choice of news sources from social media. On top of that, people tend to interact with those who have similar interests, which is a phenomenon called homophily and has been reported in a variety of social network studies (Golub and Jackson (2010), Golub and Jackson (2012), Halberstam and Knight (2016), Golub and Sadler (2016), Wikipedia (2019)). People are also susceptible to influ-

[12]For years from 2012 to 2018, oil & gas industry contributes \$116.16 million to Republicans' election campaigns, and \$19.03 million to Democrats' ones (Center for Responsive Politics, 2020).

ences by information they repetitively receive, a phenomenon called a persuasion bias. Homophily in conjunction with persuasion bias in social media plays a central role in forming public opinion over socially controversial issues such as climate change and related policies, although they are neither controversial nor contentious in a scientific community. Using Twitter data, Halberstam and Knight (2016) and Gorodnichenko et al. (2018) find strong evidence of political homophily in social media—liberals are more likely to interact with other liberals and conservatives more likely to interact with other conservatives. Gorodnichenko et al. (2018) also conduct a sentiment analysis showing that sentiments in tweets reinforce persuasion bias. DeMarzo et al. (2003) show that persuasion bias implies that 1) a group's opinion depends not only on an accuracy of one's opinion but also on how well-connected one is to the group in the social network, and that 2) individuals' opinions on a vast range of unrelated issues (e.g. military spending to environmental regulation) can be represented by one position on a one-dimensional finite line (e.g. conservative or liberal). Fryer Jr. et al. (2018) develop a model in which economic agents receive signals about the state of the world, and signals are open to the agents' interpretation, leading to confirmation bias—the tendency to recall or interpret information in a way that confirms one's prior opinion—and a polarized view of the same information. They find this theoretical prediction by conducting an online experiment in which the experiment subjects interpret research summaries about climate change.

Inherently, social media campaigns are likely to be under the influence of homophily and persuasion bias, thereby creating an echo chamber found from several studies (DellaVigna and Kaplan (2007), Martin and Yurukoglu (2017), Allcott and Gentzkow (2017), Bail et al. (2018), Gorodnichenko et al. (2018), Allcott et al. (2020)). Republicans tend to interact with Republican supporters that are ignorant of or opposed to climate change actions such as carbon taxes, while Democrats tend to interact with Democrat supporters that support climate change actions. As a result, Republicans are likely not to pay sufficient attention to climate change campaigns or possibly to be persuaded by anti-climate change campaigns in social media, while it is the opposite to Democrats.

In addition, one's political attitude rarely changes by reading just one campaign. Bail et al. (2018) find that Republican supporters become substantially more conservative after reading politically liberal contents, and Democrat supporters become slightly more liberal after reading politically conservative contents. To overcome political polarization in social media, climate activists may better consider targeting conservative audiences with less political contents. Rather, giving an example of Republicans who support bipartisan approaches to climate change policy may help increase public awareness of climate change among Republican supporters.

Misinformation and framed news about climate change in social media may be one of the reasons social media campaigns have the opposite effects on the effectiveness of the fossil fuel lobbying on Democrats' and Republicans' decisions against climate change actions. Such concerns about wide-spreading misinformation or fake news in social media have been reported by several papers (Allcott and Gentzkow (2017), Allcott et al. (2019)). For example, one of the most popular conservative news outlets, FOX news, often ignores the consequence of climate change and focuses only on the cost side of climate policy such as a burden of carbon taxes, damages in fossil fuel energy sectors and reduction in red meat consumption. This type of news combined with political ideology may strongly influence Republicans, thereby supporting policies against climate change actions. Recently, one of the most popular social media platforms, YouTube, puts the Wikipedia's climate change page on any climate change-related YouTube videos. On the other hand, Twitter has introduced a policy that if tweet messages include potentially harmful information, misinformation or fake news, Twitter blocks such tweets, and instead notify that the tweet messages conflicts with the experts' opinions. This type of information policy on social media may help prevent social media users from being misinformed about climate change and related issues, thereby make social media campaigns more effective.

7 Conclusion

This paper studies a competition between social media campaigns and fossil fuel industry's lobbying on a congressperson's decision on climate change policy using a standard utility model and a reduced-form estimation. For this analysis, I consider bills that include policies against climate change actions during the 113-115 Congresses. I find that although climate activist groups' social media campaigns become increasingly popular, the effects of social media campaigns on the effectiveness of lobbying by the fossil fuel industry on a congressperson's decision against climate change actions is very small relative to the amount of fossil fuel lobbying expenditure. Particularly, fossil fuel industry's lobbying against climate change actions is significantly effective on Republicans. I also find that the effectiveness of the fossil fuel lobbying against climate change actions on Republicans is likely to increase as social media campaigns become more popular. This implies that some Republicans are likely to be susceptible to influences by misinformation on climate change in social media. It can also implies that some Republicans become more against climate change actions if they are exposed to climate activists groups' political messages—supporting Democrats or opposing Republicans—in their social media campaigns. From counterfactual analysis, I also find that social media campaigns are more effective in persuading Democrats than Republicans, and that Republicans are mostly ignorant to climate activists' social media campaigns.

This paper provides an implication for activists' social media campaigns to better compete with lobbying for politicians' decisions on climate change policy. Word analysis on social media campaigns and the estimation results imply that while climate activists' social media campaigns have competed with fossil fuel lobbying for climate change policy, their highly political campaigns using social media have not been competitive against fossil fuel lobbying for influencing politicians' decisions on climate change actions. In order to better compete with fossil fuel lobbying, climate activists' may better adopt communication strategies that target conservative audiences without string their political ideology.

I leave a number of questions that can be investigated from the future research. First, I do not consider estimating the welfare consequences of social media campaigns and fossil fuel lobbying. Although the effect of social media campaigns on the effectiveness of the fossil fuel lobbying and the rate of returns to fossil fuel industry's lobbying can be linked with the social welfare generated by social media campaigns and fossil fuel industry's net profit from lobbying, I did not specify social benefits and costs or fossil fuel industry's benefits and costs under the scenarios in which anti-climate policies become enacted and do not become enacted. Second, while I consider a congressperson's response to social media campaigns and fossil fuel lobbying, I do not estimate models of climate activists' and fossil fuel industry's decisions. Finally, the unit of analysis on this paper is not explicitly a policy level, but a a congressperson's conceptual response to fossil fuel lobbying against climate change actions. I hope that more evidence on a competition between social media campaigns and lobbying for political influences come out in the future.

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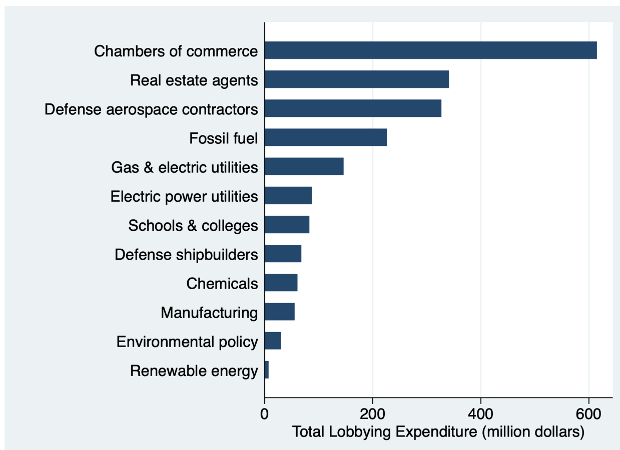
Appendix

A Lobbying Categories

Figure 11 shows the top 10 categories, environmental policy and renewable energy industry's ' total lobbying expenditures for all anti-climate change bills. In terms of total lobbying expenditure, fossil fuel industry is ranked at top 4, while renewable energy industry is ranked at 49 out of 275 categories that lobbied at least one anti-climate change bill.

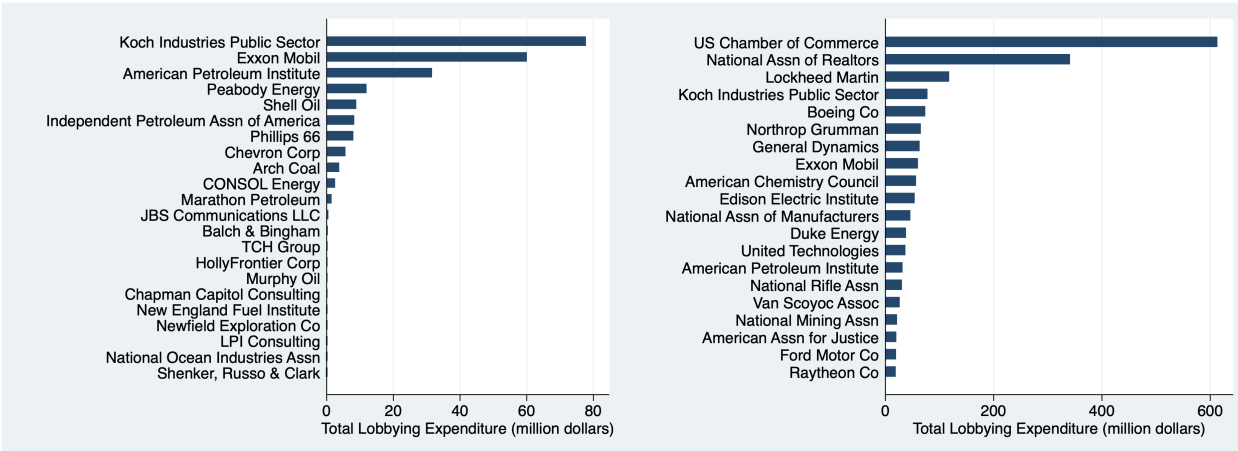
Figure 11: Top 10 lobbying categories plus environmental policy and renewable energy



Out of 275 lobbying categories, only the two categories—fossil fuel industry and environmental policy—lobbied all the anti-climate change bills. These two groups' position on climate change policies tend to be opposite: fossil fuel industry's lobbying support policies that are unfavorable to climate change actions, while the environmental policy group generally opposes such policies. This implies that in each bill there are climate change or energy-related policies that are related with public or private interest of fossil fuel industry and environmental groups.[13]

[13] For example, two environmental preservation organizations such as Sierra Club and League of Conservation Voters are categorized as environmental policy group for lobbying the anti-climate change bills.

Figure 12: Lobbying expenditure by firms



(a) Fossil fuel industry

(b) All industries

Left panel in Figure 12 shows total lobbying expenditure for the anti-climate change bills by fossil fuel firms or related association. Koch Brothers spent the largest amount \$77.64 million on lobbying the anti-climate change bills.[14] Right panel in Figure 12 shows total lobbying expenditure for the bills in Table 1 by all firms. In terms of total lobbying expenditure for the bills in Table 1, Koch Brothers Public Sector is ranked at 4th, followed by US Chamber of Commerce, National Assn of Realtors and Lockheed Martin.

[14]The American Petroleum Institute is the US trade association for oil and natural gas industry, representing over 600 oil & natural gas firms including Koch Brothers, Exxon Mobil, BP, and Chevron.

B Descriptive Statistics

Table 7: Most frequently used words in social media campaigns with #climate-change/#globalwarming during 2012-2017

Rank	Words	Score	Rank	Words	Score
1	uniteblue tcot	1.0000	16	thank	0.5526
2	environment	0.9326	17	trump	0.5478
3	need	0.9083	18	year	0.5462
4	science	0.9000	19	planet	0.5269
5	now	0.8406	20	denier	0.4826
6	world	0.8301	21	obama	0.4668
7	fight	0.8294	22	climateaction	0.4574
8	real	0.8183	23	actonclimate	0.4570
9	time	0.7435	24	effect	0.4544
10	impact	0.6980	25	believe	0.4500
11	scientist	0.6791	26	future	0.4462
12	action	0.6569	27	help	0.4195
13	today	0.6437	28	cause	0.4072
14	new	0.6360	29	stop	0.4024
15	earth	0.5678	30	cop21	0.3882

Table 8: Summary Statistics for Main Variables

Variable	Panel	Mean	Sd	Min	Max	Observations
# (Tweets + Retweets + Likes)	Overall	643	1830	0	45850	# Obs. = 5,034
	Between		1490	0	23967	n = 435
	Within		1092	-18714	22526	T = 11.57
——Weak Negative	Overall	8501	23329	0	554119	# Obs. = 4,993
	Between		19324	0	296523	n = 435
	Within		13375	-217163	266097	T = 11.48
——Strong Negative	Overall	1065	2899	0	71080	# Obs. = 4,993
	Between		2336	0	36670	n = 435
	Within		1750	-26090	35475	T = 11.48
——Weak Positive	Overall	18909	54184	0	1385987	# Obs. = 4,993
	Between		43960	0	713688	n = 435
	Within		32353	-557917	691209	T = 11.48
——Strong Positive	Overall	2475	7154	0	171311	# Obs. = 4,993
	Between		5710	0	90482	n = 435
	Within		4386	-68020	83304	T = 11.48
——Neutral	Overall	33360	96673	0	2402507	# Obs. = 4,993
	Between		77982	0	1259357	n = 435
	Within		58284	-1002166	1176509	T = 11.48
# 100×(Tweets + Retweets + Likes) / # Population	Overall	0.0881	0.2490	0.0000	6.2881	# Obs. = 5,034
	Between		0.2035	0.0000	3.2875	n = 435
	Within		0.1476	-2.5540	3.0887	T = 11.57
——Weak Negative	Overall	0.0117	0.0317	0.0000	0.7599	# Obs. = 4,993
	Between		0.0264	0.0000	0.4068	n = 435
	Within		0.0180	-0.2960	0.3648	T = 11.48
——Strong Negative	Overall	0.0015	0.0039	0.0000	0.0975	# Obs. = 4,993
	Between		0.3192	0.0000	5.0306	n = 435
	Within		0.2368	-3.5525	4.8639	T = 11.48
——Weak Positive	Overall	0.0259	0.0738	0.0000	1.9001	# Obs. = 4,993
	Between		0.0601	0.0000	0.9790	n = 435
	Within		0.0438	-0.7615	0.9477	T = 11.48
——Strong Positive	Overall	0.0034	0.0097	0.0000	0.2349	# Obs. = 4,993
	Between		0.0078	0.0000	0.1241	n = 435
	Within		0.0059	-0.0927	0.1142	T = 11.48
——Neutral	Overall	0.0457	0.1314	0.0000	3.2949	# Obs. = 4,993
	Between		0.1064	0.0000	1.7272	n = 435
	Within		0.0787	-1.3682	1.6134	T = 11.48
Proportion of Weak Positive Tweets	Overall	0.2946	0.0629	0.0000	1.0000	# Obs. = 4,993
	Between		0.0338	0.1162	0.7164	n = 435
	Within		0.0529	-0.1023	0.9007	T = 11.48
Proportion of Strong Positive Tweets	Overall	0.0384	0.0221	0.0000	0.2222	# Obs. = 4,993
	Between		0.0105	0.0129	0.1014	n = 435
	Within		0.0194	-0.0425	0.1716	T = 11.48
Proportion of Weak Negative Tweets	Overall	0.1386	0.0464	0.0000	0.5713	# Obs. = 4,993
	Between		0.0226	0.0485	0.2378	n = 435
	Within		0.0405	-0.0312	0.4720	T = 11.48
Proportion of Strong Negative Tweets	Overall	0.0184	0.0144	0.0000	0.2313	# Obs. = 4,993
	Between		0.0064	0.0026	0.0494	n = 435
	Within		0.0130	-0.0275	0.2064	T = 11.48
Proportion of Neutral Tweets	Overall	0.5100	0.0653	0.0000	0.9629	# Obs. = 4,993
	Between		0.0330	0.1957	0.6765	n = 435
	Within		0.0563	0.0785	0.8587	T = 11.48

Table 9: Summary Statistics for Lobby and Legislation

Variable	Panel	Mean	Sd	Min	Max	Observations
Proportion of Vote Yes	Overall	0.5856	0.4927	0.0000	1.0000	# Obs. = 5,034
	Between		0.4301	0.0000	1.0000	n = 435
	Within		0.2419	-0.3310	1.5023	T = 11.57
Proportion of the Republican	Overall	0.5518	0.4974	0.0000	1.0000	# Obs. = 5,034
	Between		0.4841	0.0000	1.0000	n = 435
	Within		0.1169	-0.3648	1.3018	T = 11.57
(# Energy Lobby Issues)/(# Total Lobby Issues)	Overall	6.6547	9.8548	0.0000	30.5263	# Obs. = 5,034
	Between		0.7049	1.3208	9.3109	n = 435
	Within		9.8341	-2.6562	32.4082	T = 11.57
# Energy Lobby Issues	Overall	27	25	0	72	# Obs. = 5,034
	Between		2	9	36	n = 435
	Within		25	-10	77	T = 11.57
# Total Lobby Issues	Overall	1095	656	26	2019	# Obs. = 5,034
	Between		44	906	1320	n = 435
	Within		655	-200	2208	T = 11.57
# other Congresspersons' Yes Votes in a State	Overall	9.3634	7.4854	0	30	# Obs. = 4,948
	Between		7.0658	0.0000	26.2500	n = 428
	Within		2.4345	-0.8366	23.1134	T = 11.56
Log of (# other Congresspersons' Yes Votes in a State)	Overall	2.0487	0.8209	0	3.4340	# Obs. = 4,948
	Between		0.7899	0.0000	3.3018	n = 428
	Within		0.2274	1.0809	3.3410	T = 11.56
Google Trend	Overall	18.2277	12.5777	-18.3843	93.1086	# Obs. = 5022
	Between		11.4452	-3.9361	79.4418	n = 435
	Within		5.1765	-5.7253	72.6470	T = 11.54
Log of Google Trend	Overall	3.5717	0.3398	0	4.7229	# Obs. = 5022
	Between		0.3096	2.4912	4.5853	n = 435
	Within		0.1394	1.0805	4.7662	T = 11.54
Belief	Overall	52.5618	6.6432	38.0000	74.8300	# Obs. = 5,034
	Between		5.8093	41.3496	69.2585	n = 435
	Within		3.2517	45.6351	60.6012	T = 11.57
Log of Belief	Overall	3.9541	0.1248	3.6376	4.3152	# Obs. = 5,034
	Between		0.1089	3.7193	4.2364	n = 435
	Within		0.0616	3.8235	4.1014	T = 11.57

Table 10: Summary Statistics for Maximum Temperatures and Precipitations

Variable	Panel	Mean	Sd	Min	Max	Observations
$\textit{Temperature}^{.9,1.0}$	Overall	0.1674	0.1385	0.0000	0.7474	N = 5,022
	Between		0.0435	0.0684	0.3383	n = 435
	Within		0.1315	-0.1466	0.5764	T = 11.54
$\textit{Temperature}^{.8,.9}$	Overall	0.1544	0.1142	0.0000	0.5833	N = 5,022
	Between		0.0493	0.0417	0.3155	n = 435
	Within		0.1032	-0.1107	0.5029	T = 11.54
$\textit{Temperature}^{.7,.8}$	Overall	0.0886	0.0655	0.0000	0.5000	N = 5,022
	Between		0.0292	0.0071	0.1970	n = 435
	Within		0.0586	-0.0835	0.4011	T = 11.54
$\textit{Temperature}^{.6,.7}$	Overall	0.1300	0.0803	0.0000	0.4167	N = 5,022
	Between		0.0346	0.0333	0.2363	n = 435
	Within		0.0726	-0.1023	0.3869	T = 11.54
$\textit{Temperature}^{.5,.6}$	Overall	0.1021	0.0713	0.0000	0.4167	N = 5,022
	Between		0.0253	0.0218	0.1890	n = 435
	Within		0.0668	-0.0805	0.3868	T = 11.54
$\textit{Precipitation}^{.9,1.0}$	Overall	0.0935	0.0780	0.0000	0.4499	N = 5,022
	Between		0.0346	0.0208	0.1746	n = 435
	Within		0.0699	-0.0704	0.3921	T = 11.54
$\textit{Precipitation}^{.8,.9}$	Overall	0.1209	0.0697	0.0000	0.4167	N = 5,022
	Between		0.0316	0.0304	0.2250	n = 435
	Within		0.0622	-0.0666	0.4090	T = 11.54
$\textit{Precipitation}^{.7,.8}$	Overall	0.0744	0.0559	0.0000	0.4167	N = 5,022
	Between		0.0247	0.0124	0.1655	n = 435
	Within		0.0502	-0.0889	0.3382	T = 11.54
$\textit{Precipitation}^{.6,.7}$	Overall	0.1257	0.0701	0.0000	0.4167	N = 5,022
	Between		0.0286	0.0248	0.2262	n = 435
	Within		0.0641	-0.0566	0.4090	T = 11.54
$\textit{Precipitation}^{.5,.6}$	Overall	0.1024	0.0637	0.0000	0.4159	N = 5,022
	Between		0.0260	0.0278	0.1926	n = 435
	Within		0.0582	-0.0661	0.3588	T = 11.54

Table 11: Summary Statistics for Socio-Economic Characteristics

Variable	Panel	Mean	Sd	Min	Max	Observations
Proportion of Female Congresspersons	Overall	0.1881	0.3908	0	1	# Obs. = 5,034
	Between		0.3729	0	1	# Obs. = 435
	Within		0.1224	-0.7210	1.1048	# Bills = 11.57
Average Age of Congresspersons	Overall	58.1007	10.7412	30	91	# Obs. = 5,034
	Between		9.9499	32.9167	86.0000	# Obs. = 435
	Within		4.1513	31.6007	90.5007	# Bills = 11.57
Proportion of People Holding Bachelor's Degree	Overall	0.6486	0.0944	0.3216	0.9032	# Obs. = 5,034
	Between		0.0935	0.3319	0.8971	# Obs. = 435
	Within		0.0120	0.5466	0.7520	# Bills = 11.57
Household Income, Mean	Overall	74,526	20,043	31,638	165,342	# Obs. = 5,034
	Between		19,833	37,089	152,502	# Obs. = 435
	Within		2,640	39,477	92,116	# Bills = 11.57
Proportion of Ages 25–54	Overall	0.4047	0.0293	0.2839	0.5445	# Obs. = 5,034
	Between		0.0288	0.3032	0.5409	# Obs. = 435
	Within		0.0055	0.3623	0.4361	# Bills = 11.57
Proportion of Female	Overall	0.5079	0.0094	0.4637	0.5514	# Obs. = 5,034
	Between		0.0093	0.4682	0.5460	# Obs. = 435
	Within		0.0011	0.5019	0.5145	# Bills = 11.57
Proportion of Hispanic	Overall	0.1725	0.1815	0.0077	0.8793	# Obs. = 5,034
	Between		0.1815	0.0092	0.8761	# Obs. = 435
	Within		0.0059	0.1176	0.2541	# Bills = 11.57
Proportion of African American	Overall	0.1226	0.1413	0.0037	0.6654	# Obs. = 5,034
	Between		0.1424	0.0040	0.6566	# Obs. = 435
	Within		0.0080	0.0341	0.2412	# Bills = 11.57
Proportion of Asian	Overall	0.0508	0.0666	0.0030	0.6046	# Obs. = 5,034
	Between		0.0681	0.0034	0.5964	# Obs. = 435
	Within		0.0029	0.0326	0.0795	# Bills = 11.57
Proportion of Native American	Overall	0.0068	0.0197	0.0003	0.2349	# Obs. = 5,034
	Between		0.0193	0.0004	0.2324	# Obs. = 435
	Within		0.0022	-0.0379	0.0647	# Bills = 11.57
Proportion of Hawaiian	Overall	0.0037	0.0085	0.0002	0.1508	# Obs. = 5,034
	Between		0.0087	0.0004	0.1450	# Obs. = 435
	Within		0.0005	-0.0013	0.0096	# Bills = 11.57
Proportion of White	Overall	0.6436	0.2313	0.0226	0.9703	# Obs. = 5,034
	Between		0.2319	0.0239	0.9688	# Obs. = 435
	Within		0.0116	0.4313	0.7296	# Bills = 11.57

C Summary of Congress Bills

- H.R.2609-113th
  - (Sec. 531) Prohibits the use of funds made available in this Act to: ... (3) implement, administer, or enforce lifecycle greenhouse gas emissions restrictions on federal agency procurement of certain alternative or synthetic fuels.

- H.R.1582-113th
  - Prohibits the Administrator from using the social cost of carbon in any cost-benefit analysis relating to an energy-related rule estimated to cost more than $1 billion unless and until a federal law is enacted authorizing such use.
- H.R.4660-113th
  - Prohibits the use of funds made available by this Act for: ... designing, implementing, administering, or carrying out the U.S. Global Climate Research Program National Climate Assessment, the Intergovernmental Panel on Climate Change's Fifth Assessment Report, the United Nation's Agenda 21 sustainable development plan, or the May 2013 Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order No. 12866
  - Prohibits ... negotiating or entering into a trade agreement that establishes a limit on greenhouse gas emissions, except with respect to the administration of a tax or tariff.
- H.R.4923-113th
  - (Sec. 531) Prohibits funds made available by this Act from being used to design, implement, administer or carry out several programs, reports, and technical updates related to global climate change and the social cost of carbon.
  - (Sec. 532) Prohibits funds made available by this Act from being used for DOE's Climate Model Development and Validation program.
- H.R.2-113th
  - Prohibits the Administrator, in issuing any rule establishing performance standards for greenhouse gas emissions from new sources in such subcategory, from setting a standard based on the best system of emission reduction unless the standard has been achieved on average for at least one continuous 12-month period (excluding planned outages) by each of at least 3 units within such subcategory that meets the unit requirements specified by this Act for the coal category.

  - (Sec. 205) Prohibits the Administrator from using the social cost of carbon in any cost-benefit analysis relating to an energy-related rule estimated to cost more than $1 billion unless and until a federal law is enacted authorizing such use.
  - (Sec. 213) Precludes from taking effect, unless a federal law is enacted specifying an effective date, any EPA rule or guideline that: (1) establishes any performance standard for greenhouse gas emissions from a modified or reconstructed source that is a fossil fuel-fired electric utility generating unit, or (2) applies to greenhouse gas emissions from such an existing source.
  - (Sec. 214) Nullifies specified proposed rules (or similar successor proposed or final rules) for Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units that are issued before enactment of this Act, including proposed rules targeting specified: (1) Carbon Pollution Emission Guidelines for Existing Stationary Sources; and (2) Carbon Pollution Standards for Modified and Reconstructed Stationary Sources. Includes any successor proposed or final rules applicable to any existing, modified, or reconstructed source that is a fossil fuel-fired electric utility generating unit.
  - Prohibits the lead agency from using the social cost of carbon in the any environmental review or environmental decision making process.

- H.R.2685-114th

  - (Sec. 8128) Prohibits funds provided by this bill from being used to enforce section 526 of the Energy Independence and Security Act of 2007, which restricts the procurement of certain alternative or synthetic fuels unless the lifecycle greenhouse gas emissions associated with the fuel is less than or equal to emissions from the equivalent conventional fuel produced from conventional petroleum sources.

- H.R.2822-114th

  - (Sec. 428) Prohibits EPA from using funds provided by this bill to develop, issue, implement, or enforce any greenhouse gas New Source Performance Standards on any new or existing source that is an electric utility generating unit.

  - (Sec. 437) Prohibits funds from being used to incorporate the social cost of carbon into any rulemaking or guidance document until a new Interagency Working Group makes specified revisions to the estimates.

- H.R.5293 -114th

  - (Sec. 8130) Prohibits funds provided by this bill from being used to enforce section 526 of the Energy Independence and Security Act of 2007, which restricts the procurement of certain alternative or synthetic fuels unless the lifecycle greenhouse gas emissions associated with the fuel is less than or equal to emissions from the equivalent conventional fuel produced from conventional petroleum sources.
  - (Sec. 10013) Prohibits funds provided by this bill from being used to implement Department of Defense Directive 4715.21 on Climate Change Adaptation and Resilience, which establishes policy and assigns responsibilities to provide DOD with the resources necessary to assess and manage risks associated with the impacts of climate change.

- H.R.5538-114th

  - (Sec. 431) Prohibits EPA from using funds provided by this bill to develop, issue, implement, or enforce any greenhouse gas New Source Performance Standards on any new or existing source that is an electric utility generating unit.
  - (Sec. 436) Prohibits funds from being used to incorporate the social cost of carbon into any rulemaking or guidance document until a new Interagency Working Group makes specified revisions to the estimates.
  - (Sec. 455) Prohibits the EPA from using funds provided by this bill for specified regulations, as proposed to be revised under the proposed rule entitled "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles-Phase 2," with respect to glider kits and glider vehicles.
  - (Sec. 467) Prohibits funds provided by this bill from being used for the proposed EPA rule entitled "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles-Phase 2," with respect to trailers.

- H.R.3354 -115th

- Prohibits specified funds provided by this division from being used for: ... (2) the Green Climate Fund.
- (Sec. 463) Prohibits funds provided by this division from being used to prepare, propose, or promulgate any regulation that relies on analysis contained in several technical support documents related to the social cost of carbon.
- (Sec. 518) Prohibits funds provided by this division from being used to prepare, propose, or promulgate any regulation or guidance that references or relies on the analysis contained in specified technical support documents and guidance related to the social cost of carbon and greenhouse gas emissions.

• H.CON.RES.119-115th

- Expresses the sense of Congress that a carbon tax would be detrimental to American families and businesses and is not in the best interest of the United States.

D First-stage regression

Table 12: First-stage regression of GOP_d on $Educ_{dy-1}$ and all other explanatory variables

	(1) GOP_d
$Educ_{dy-1}$	-1.980***
	(0.273)
$Campaign_{dy-1}$	0.410***
	(0.117)
$StateAdjacency_{dsb}$	0.499***
	(0.0415)
$Google_{dy-1}$	-0.111
	(0.115)
$Belief_{dc}$	-20.35***
	(0.682)
$Negative_{dy-1}$	0.0230***
	(0.00765)
$Positive_{dy-1}$	0.00380
	(0.00542)
$Temperature^{.9,1.0}_{dy-1}$	0.0338
	(0.334)
$Temperature^{.8,.9}_{dy-1}$	0.111
	(0.322)
$Temperature^{.7,.8}_{dy-1}$	0.735
	(0.472)
$Temperature^{.6,.7}_{dy-1}$	1.216***
	(0.399)
$Precipitation^{.9,1.0}_{dy-1}$	-0.642
	(0.484)
$Precipitation^{.8,.9}_{dy-1}$	0.208
	(0.448)
$Precipitation^{.7,.8}_{dy-1}$	-0.294
	(0.589)
$Precipitation^{.6,.7}_{dy-1}$	-0.243
	(0.452)
$LobbyPropOilGasMining_{db}$	0.171
	(0.180)
Observations	4,599
Pseudo R^2	0.652

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

E Areas of Lobbying Issues

Table 13: Areas of Lobbying Issues

Code	Description	Code	Description
ACC	Accounting	HOM	Homeland Security
ADV	Advertising	HOU	Housing
AER	Aerospace	IMM	Immigration
AGR	Agriculture	IND	Indian/Native American Affairs
ALC	Alcohol & Drug Abuse	INS	Insurance
ANI	Animals	LBR	Labor Issues/Antitrust/Workplace
APP	Apparel/Clothing Industry/Textiles	INT	Intelligence and Surveillance
ART	Arts/Entertainment	LAW	Law Enforcement/Crime/Criminal Justice
AUT	Automotive Industry	MAN	Manufacturing
AVI	Aviation/Aircraft/Airlines	MAR	Marine/Maritime/Boating/Fisheries
BAN	Banking	MED	Medical/Disease Research/Clinical Labs
BNK	Bankruptcy	MIA	Media (Information/Publishing)
BEV	Beverage Industry	MMM	Medicare/Medicaid
BUD	Budget/Appropriations	MON	Minting/Money/Gold Standard
CAW	Clean Air & Water (Quality)	NAT	Natural Resources
CDT	Commodities (Big Ticket)	PHA	Pharmacy
CHM	Chemicals/Chemical Industry	POS	Postal
CIV	Civil Rights/Civil Liberties	RRR	Railroads
COM	Communications/Broadcasting/Radio/TV	RES	Real Estate/Land Use/Conservation
CPI	Computer Industry	REL	Religion
CSP	Consumer Issues/Safety/Protection	RET	Retirement
CON	Constitution	ROD	Roads/Highway
CPT	Copyright/Patent/Trademark	SCI	Science/Technology
DEF	Defense	SMB	Small Business
DOC	District of Columbia	SPO	Sports/Athletics
DIS	Disaster Planning/Emergencies	TAR	Miscellaneous Tariff Bills
ECN	Economics/Economic Development	TAX	Taxation/Internal Revenue Code
EDU	Education	TEC	Telecommunications
ENG	Energy/Nuclear	TOB	Tobacco
ENV	Environmental/Superfund	TOR	Torts
FAM	Family Issues/Abortion/Adoption	TRD	Trade (Domestic & Foreign)
FIR	Firearms/Guns/Ammunition	TRA	Transportation
FIN	Financial Institutions/Investments/Securities	TOU	Travel/Tourism
FOO	Food Industry (Safety, Labeling, etc.)	TRU	Trucking/Shipping
FOR	Foreign Relations	URB	Urban Development/Municipalities