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Climate change beliefs, environmental policies support and the fossil fuels industry

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Abstract

This thesis aims to provide a contribution to the analysis of how relevant the presence of the fossil fuels industry is in shaping the attitudes toward climate change and environmental policies. This presence is studied in the form of coal plants at county-level and in the aftermath of the Deepwater Horizon oil spill of 2010 in Louisiana, a state that largely relies on oil and gas extractive activities. Using a repeated cross-section analysis in the first approach and a Synthetic Control Method (SCM) in the second one I confirm and further explore the results of the previous literature: the more relevant the fossil fuels industry to the local economy the lower the share of people that believe that climate change is happening and that supports environmental policies. And the effect is larger and robust in rural areas. However, some green policies seem to be more acceptable than others among coal plant-communities. The closure of a local coal-fired generator does not seem to influence these same variables. While Louisiana has experienced an exponential growth in solar energy consumption after 2010 I find no causal relationship with the oil spill and many other states actually share the same path. These results are consistent with the theory that the presence of the fossil fuel industry is a determinant of climate change beliefs and of support for environmental policies.

Keywords: Environmental Policies, Climate Change Beliefs, Deepwater Horizon Oil Spill, Coal Plants
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1 Introduction

The goal of this thesis is to provide an intuition on how environmental policies and global warming issues are perceived in communities where the fossil fuel industry is a relevant source of employment and a guarantee of economic development. The beliefs about climate change, the support for green policies and the energy production from renewable sources will be studied in their evolution after certain events. In particular, counties where a coal plant is present will be analysed to see how locals' attitudes are affected by the closure of the plant and Louisiana as a state will be studied in the aftermath of the Deepwater Horizon oil spill. The presence of a coal plant in this setting is meant to represent the presence of the fossil fuels industry. As far as Louisiana is concerned, about 5% of its GDP comes from oil and gas extractive activities (BEA), while the average measure for the US is about 1%. The underlying idea is to understand how the support to certain environmental policies is shaped by the presence of the fossil fuel industry and whether experiencing a natural disaster can help raising awareness about the necessity of green policies in areas where the fossil fuel industry is a major economic actor. The investigation provides a reply to questions like "Do people who are affected by disasters caused by human activity change their behaviours as a consequence of their exposure and decide to reduce their reliance on energy production from fossil fuels despite the economic relevance of these on the local economy?" or "How does the presence of a coal plant shape locals' views about climate change and green policies? Is there any difference in rural and small communities where that coal plant might be a relevant source of employment? Does the closure of these coal plants determine a shift in attitudes and supports? If yes, in what direction?". The answer to these question is not straightforward. For example, on the one hand, the presence of a coal plant might pose a serious threat to the health of the people living close to it. On the other hand, people might give more importance to the economic benefits that the presence of the coal plant guarantees than to the health risks that are a consequence of it. Any result that is able to produce a solution to these questions is worth investigating in order to provide policymakers with an intuition on what to expect as a result of these events in terms of support for green policies and beliefs about global warming. And given that most of the environmental policies that are necessary to slow down global warming will affect the use of fossil fuels, understanding how their presence influences beliefs about climate change and support to green policies is a topic of primary relevance.

The analysis will be carried out using a repeated cross-section with year-FE specification to estimate the impact of the presence of coal plants on the share of people that believe that global warming is happening and that support three green policies which are all aimed at reducing CO_2 emissions. However, what distinguishes these policies are the different methods that are promoted: one policy would require at least 20% of the electricity to be produced from renewable sources, the second policy would promote a general reduction of CO_2 emissions without specifying the source and the last policy proposes reducing CO_2 emissions from coal plants specifically. Given these differences in the tools being proposed, I can have a clear understanding of how the presence of

coal plants shape these outcome variables. Of course, a comparison between the policy for the general reduction of CO_2 and for the reduction of the same pollutant from coal plants is of particular interest when dealing with coal plant-counties. The expectation that the last policy is the one that receives the least support is indeed supported by the data. Because I have had the possibility to access data on coal plant presence for different years, I also look at how the closure of the local plant affected the variation in these same variables between two different periods. I find no significant effect of the closure in driving environmental policy support in any direction, and the result is robust to different IV specifications. The case of Louisiana, a state that heavily depends on its fossil fuels resources, is studied using the Synthetic Control Method approach. The resulting synthetic Louisiana is formed by other southern US states, which provides reliability to the results of the approach. However, I am not able to find any significant increase in solar energy consumption after the Deepwater Oil spill, where I used this outcome variable as a good proxy for environmental attitudes. Both of the results seem to point to conclusions to which the previous literature had already come: fossil fuels industries are major actors in significantly shaping the attitudes of the locals about climate change. In particular, the case of Louisiana is very significant: the previous literature on the same topic had established that the exposure to disastrous events significantly increase people's worries about the consequences of climate change. While this is true in the case of the Deepwater Horizon oil spill too for the other states in the Gulf of Mexico (see Walters et al. (2014), Hamilton et al. (2012)) , this is not observed in the case of Louisiana and the authors point to its economic dependency on fossil fuels activities as a possible explanation.
While building and confirming some of the findings from the previous literature, this thesis is making a contribution to the topic of "economy-vs-environment" (Olson-Hazboun et al. (2018)) by focusing on coal plants in the first part, which are destined to be among the first targets of the green policies, and by focusing on solar energy consumption in Louisiana. In this second case, instead of focusing on beliefs and opinions, I am looking at solar energy consumption which is a more solid variable as it really shows when environmental concerns are turned into actions.

The rest of the thesis is structured as follows: section 2 provides evidence of the the importance that environmental issues in current political agenda, section 3 presents an overview of the previous findings on the topic of environmental policies, the relationship between natural disaster and climate change beliefs with a particular attention to the case of Deepwater Horizon oil spill and on the influence of coal plants and fossil fuels industry on climate change beliefs; section 3 presents data and results from the analysis on coal plants; section 5 presents data and results from the analysis of Louisiana after the oil spill; section 6 concludes and provides some comments.

2 The relevance of environmental policies

The importance of carrying out an energy transition from the current model that heavily depends on fossil fuels and on which our economy is currently based to one where energy is produced without the emission of pollutants or to a carbon neutral one is something that some politicians, some policymakers and most of the scientists recognize and prioritize nowadays. However, despite the fact that this issue has been discussed for more than two decades by now, no plan has been able to achieve a significant reduction or even a mild mitigation to the increasing global temperature process yet. The problems related to the global warming phenomenon have become clearer these years as the number of wildfires is increasing every summer (for instance, have a look at episodes form Australia and California), as hurricanes become more frequent and more violent, as the rising sea levels threaten the existence of coastal communities and most projections predict that a large majority of the global population will run out of water because of more frequent droughts in the next decades which will in turn produce terrible consequences in terms of conflicts and social instability. Those that will suffer the most from these episodes are some of the poorest communities in the world. So, the consequences of global warming are not just environmental or economic, they involve social inequality as well and might actually produce a large increase in social disparity. Recent researches also point out that if we will not be able to manage an energy transition and a reduction in global warming we will probably have to learn how to deal with more and more frequent pandemics as the one we are currently experiencing as I am writing (see, for example, what the International Monetary Fund wrote about it[1]).

Several international meetings (starting with the first United Nations Climate Change conference in Berlin in 1995 to the one that should have been held in Glasgow in 2020) have set targets to be met in a not so distant future in order to prevent the temperature trajectory from reaching the tipping point and in an attempt to keep the global temperature increase within 1.5°C / 2°C. Despite all these global concerns and commitments we still find ourself lacking a serious plan to actually achieve those goals. And it is undeniable that as we plan new policies we are running out of time. Furthermore, political elections in recent time have given power to presidents that decided to take their country out of the international agreements: Donald Trump's Administration has decided to withdraw the country from the Paris Agreement "because of the unfair economic burden imposed on American workers, businesses, and taxpayers by U.S. pledges made under the Agreement"[2]. And rumour were circulating that Jair Bolsonaro might have done the same for Brazil. Of course, the withdrawal of some the largest CO_2 emitters really undermines the chances that the current trend of raising global temperature can be reversed or halted.

Meanwhile, on the other side of the Atlantic Ocean, the European Elections held in

[1] https://www.imf.org/external/pubs/ft/fandd/2020/09/investing-in-a-green-recovery-volz.htm

[2] https://www.state.gov/on-the-u-s-withdrawal-from-the-paris-agreement/, Press Statement by Michael R. Pompeo, Secretary of State, on November 4th 2019

2019 produced the best political result ever for The Greens (Parliamentary Group of The Greens, the European political group of Green parties from all over the EU) and the elected president of the new European Commission, Ursula von der Leyen, while not being a member of the Greens herself, has committed her legislative activity toward achieving carbon neutrality by 2050 for the EU as an aggregate and is currently working on fulfilling her promises: "I am pleased to tell you that the Commission has just adopted our proposal for the first ever European Climate Law. This proposal sets in stone our objective to be climate neutral in 2050."[3]. While it is still remains to be proven whether these targets will be met and these commitments fulfilled, it is clear that there is something moving, at least within the European borders: the European Commission has passed into law a european Green Deal to help private citizens and businesses from all its member countries become carbon neutral by 2050. These policies include investments to turn the European economy into a circular one, investments in rail transportations to reduce CO_2 emissions from the air travel sector, incentives to farms to reduce their coal footprints and a substantial reduction of fossil fuels use, among others[4].

While all of this is being done on an international level, many individual states are not wasting their time and are independently introducing measures and policies to reduce their dependency on fossil fuels. The three largest economies in the European Union are all committing themselves to reducing the use of coal: the French government has pledged to get rid of all France's coal-fired electricity plants by 2022[5]; ENEL, the largest energy provider in Italy has just presented its plan to completely close all its coal-fired electricity plants in Spain and to cut more than 50% of its electricity production from coal in Italy[6]; German Chancellor Angela Merkel presented her government's plan to close down all German coal plants by 2038 at the price of around $44 billions [7]. The recent presidential elections in the USA resulted in the victory of a candidate that called upon unity and action to curb down climate change and his project calls again on the importance to understand how people will react to the measures being introduced and to the policies being promoted. He has promised to remove carbon from the power sector by 2035 and to invest almost $2tn over the four years of his presidential term on projects that would promote solar and wind energy production [8]. All of this proves the relevance that environmental policies have been acquiring during recent time among politicians and require investigating how much support we can expect from the

[3] https://ec.europa.eu/commission/presscorner/detail/en/statement_20_381, Press remarks by President von der Leyen on the occasion of the adoption of the European Climate Law

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu_en

[5] https://in.reuters.com/article/us-france-electricity-coal/french-government-sticks-to-targets-for-closing-coal-power-plants-idINKCN1RF19N

[6] https://www.spglobal.com/platts/en/market-insights/latest-news/coal/110620-enel-to-unveil-coal-closure-plan-nov-24

[7] https://www.reuters.com/article/us-germany-politics-climate-change-idUSKCN1VQ1U9

[8] https://www.ft.com/content/f6a2ee7f-3ae9-465f-8497-784cd36e51c0

communities that will be affected the most. Notably, these are the communities that rely on fossil fuels activities the most.
The point I am trying to make by describing the events above is that while policymakers struggle to find new policies that are effective in cutting down our dependency on fossil fuels, the social and economic impacts that these same policies might have on people are often ignored or vastly underestimated. In most of the cases people find it either too hard or too expensive to adapt to new measures, they feel they are the only ones carrying the burden and they manifest concerns about their future. What is sometimes needed are alternatives so that the transition from our current fossil fuel economy to a carbon neutral one can be as painless as possible. The events outlined above make it necessary to gain an understanding of what are the consequences of some of the measures that are introduced at every administrative level. And as we can expect more and more natural disasters to happen in the next decades because of rising global temperatures, it might be relevant to understand what effect these events have on the affected communities' attitudes toward green policies. Is it possible that after having gone through them people will understand how dangerous is it for their health and their environment to keep on relying on fossil fuels? Focusing on recent events, will locals change their view about the intensive use of fossil fuels and increase support for green policies in the Mauritius archipelago after the oil spill that occurred in July? Will natural disasters caused by human activity help convincing people to shift toward energy production from renewable sources? How does an active presence of the fossil fuel industry affect this? While climate change deniers could still point out that they do not see any correlation between global warming and the increased frequency and magnitude of extreme natural events, it is impossible to deny human fault behind some of the events that can still hold negative impacts on the environment and on the economy. This is the case in the event of an oil spill, when shores are inundated by oil or other chemical materials. This is also the case when disasters takes place in electricity generation plants, such as nuclear plants, another common human activity, and the local communities suffer from spillover of toxic materials. While dreadful, these events can still hold a lesson for those involved and open their eyes to the necessity of the transition toward clean energy.

3 Literature Review

3.1 Environmental Policies

The large predominance of environmental policies in political agendas in recent years have contributed to the high number of papers being dedicated to investigations about the effectiveness of these same policies (Shrimali et al. (2015), Burns and Kang (2012), McCright et al. (2016), Cook et al. (2019), Grant et al. (2014), Bevan (2020). Some researchers have also investigated how green policies shape people's attitudes toward climate change and the focus on this outcome variable is an approach closer to the one I am presenting here: Beattie et al. (2019) explores the effects that the presence of rooftop solar panels might produce on people living in the nearby area. The study exploits the large incentives that the Australian government provided its citizens with in order to promote the adoption of rooftop solar panels and the large growth in solar production that these same incentives generated. Besides simply providing financial incentives for solar solutions, the different policies introduced by local authorities in Australia affected the way people thought about the global warming issue. The explanation the authors provide to this effect is that citizens might interpret the green solutions adopted by their peers as a signal of how committed they are to the cause and this results in an increased awareness in the neighbourhood. On average, an additional 1000 solar panels in the local area increases the share of the locals that believe that climate change is mostly caused by humans by about 7 percentage points. However, the authors find other spillovers that might negatively affect the results of this sort of policies. In fact, people living in areas with more solar panels report, on average, being less worried about the consequences of global warming. A possible explanation to this mitigation effect is that people may feel reassured about the fact that something is being done to contrast climate change. Comin and Rode (2013) exploits the German EGG law (Renewable Energy Sources Act), a feed-in tariff policy for electricity produced from PV systems, to estimate the effect that the incentives had both on renewable energy production and on people's attitude toward global warming issues. The feed-in policy contributed to a ten-fold increase in PV installations in Germany between 1999 and 2003 but what is most relevant is the effect that this had on locals' support for the Green Party, which may represent a good proxy for concerns about climate changes issues. In fact, the authors are able to show that the large PV system adoption caused by the new policy is responsible for a 25 percent increase in the share of valid votes for the Green Party in federal elections between 1998 and 2009. Another channel that policies might sometimes exploit is the peer interaction channel: Bollinger and Gillingham (2012) show that social interaction in California is a relevant determinant in explaining new PV installation. In fact, the authors estimate that an additional installation is able to increase the probability of another installation in the same zip code by 0.78 percentage points. And the dimension of the installation is relevant too, with larger PV systems being more likely to induce additional PV adoptions. This implies that social interactions too could be a driving force in raising awareness about environmental issues and could potentially be exploited by policymakers. Niles et al. (2013) analyses policy response among farmers in California to find that the way global warming is percieved among them is strictly related to exposure to past environmental policies and that the quality of these is a relevant determinant of reactions to future policies.

3.2 Natural Disasters and Climate Change attitudes

The hypothesis that natural disasters and extreme weather events can influence people's attitudes toward global warming has been the topic of many researches that have focused on different kinds of events and on different outcome variables (see for example Baccini and Leemann (2020), Dixon et al. (2019), Whitmarsh (2008), Konisky et al. (2016), Dai et al. (2015), Sisco et al. (2017), Zanocco et al. (2018), Goebel et al. (2015)) All of these papers have been able to prove that exposition to extreme weather events such as wildfires, heatwaves, tornados or excessive flooding significantly increases support for environmental policies and worries about the consequences of global warming. The effect is even larger, some of these studies find, when the event generates financial losses for the communities involved and, on average, the larger the damage the larger the increase in environmental support. However, a different story is the one coming from the Deepwater Horizon oil spill. Comparing data from two different surveys conducted in 2008 and 2010, Lilley and Firestone (2013) analyses how locals' attitudes changed between these two years, before the oil spill and after it. While a drop in support for offshore drilling is observed (the share of people supporting it goes from 66% to 59%) the result is not statistically significant. A significant, but small, effect with respect to this measure is observed only among residents in some coastal counties. Moreover, no effect is observed on support to offshore wind plants. The share of people that supports this form of energy production was already higher than that supporting offshore drilling in 2008 and remains higher in 2010 but no significant increase is observed after the oil spill. Using data obtained through 2,000 interviews run in late summer 2010 Hamilton et al. (2012) investigate environmental views from coastal communities of southern US states to estimate the effect of the oil spill. The results of the the study gives credit to the hypothesis that because some communities in Louisiana depends on the oil and gas industry they might show different reactions to the environmental issues compared to communities from other states. In fact, despite reporting that the oil spill really impacted their lives and despite being more affected by the event because of the proximity, respondents from Louisiana were significantly less likely to support renewable energy production, a moratorium on further offshore drilling activities or a conservation policy to safeguard natural resources, even though all of these might help prevent new oil spills. The data coming from the surveys administered in Walters et al. (2014) tells a different story about the impact of the same oil spill on environmental concern among people in Mississippi. About 86% of the people interviewed reported some level of environmental worry related to the oil spill and 81% were worried about the possible environmental effects of a similar event in the future. A small correlation is observed between volunteer environmental activity and the experience with the disaster. In general, a vast majority of the people reported a negative impact of the oil spill on their life mainly through job loss or geographical displacement. The idea that some communities, while being seriously hit by the oil spill in terms of exposure to pollutants and of depleted environmental resources, did not show any reaction against further drilling or any increased opposition to the fossil fuel industry finds further evidence in Bishop

(2014), using data from Louisiana: there is no evidence of positive attitudes toward offshore drilling in 2008, 2 years before the oil spill, even in those counties that heavily rely on this industry. However, after the event and while debates about environmental concerns and the necessity of a moratorium were capturing media attention, these same counties showed a marked increase in pro-drilling support. The interesting suggestion of the author is that the interest in preserving one's dependency on a certain industry might remain quiet and silent in normal times to arise only when the existence of that industry is threatened. Moreover, residence in a county afflicted by the oil spill does not show any correlation with opposition to oil drilling industry, providing further support to the idea that the economic advantages that this industry brings to the community are more relevant than the environmental and health risks its presence might pose.
I am adding findings to the these papers by focusing on changes in actions rather than on attitudes for the affected communities using data on energy production from renewable sources. To a certain extent, this is similar to Barrage et al. (2020), which investigate the correlation between investments by BP, the owner of the oil rig, and the margins and volumes that the company made in the affected areas. In fact, what the authors study are the actions rather than the sentiments. The intuition behind it is that affected communities might have decided to punish the company for the disaster by boycotting its gas stations and by purchasing gasoline from other companies. This is indeed an example of how people's attitude changed after the event but the investigation does not proceed in the same direction as the one I am presenting here: purchasing gasoline from other companies still does not reduce the carbon footprint because it simply reallocates profits among different suppliers to punish that which is held responsible for the disaster. On average, BP saw its profits declining by 2.9 percent per gallon and its volume by 4.2 percent in the first month after the spill. However, this result is not universal. The company had embarked in a campaign called "Beyond Petroleum" in 2000-2008 in an attempt to build a reputation for green being a green company. The authors show that the campaign seriously reduced consumers' response in areas where people were exposed to the advertising the most.

3.3 Presence of fossil fuels activities

The presence of coal mines, coal plants or any other activity that is related to electricity production through fossil fuels is another factor that might influence people's support of environmental policies or their beliefs about global warming. Olson-Hazboun (2018) investigate the feelings toward green policies among the communities of Emery County, UT and Uintah County, UT, two counties that have a long history and a large reliance on fossil fuels-related activities (the first has both a coal mine and a coal-fired plant while the second one only have a coal-fired plant). The results from the survey that the authors conducted suggest that renewable energy is generally perceived not only as a threat to the existing local economy but also as a threat to the identity of the local communities, which have a long history of fossil fuels activities. Additionally, the respondents felt they were not fairly treated by local, state and federal administrations because these provide the incentives and the funds for the energy transition, favouring renewable sources over fossil fuels. A large sentiment of being unfairly punished was recorded among the locals. Olson-Hazboun et al. (2018) use survey data from 2008 to 2015 to study the support for environmental policies in counties that rely on oil ad natural gas extractive activities, therefore contributing to what the authors call “the economy-versus-environment debate”. While they recognize that individual factors such as education and political ideology still constitute good predictors of environmental attitudes, the support for green policies also depends on how relevant the fossil fuel industry is for the local economy. And they are able to confirm that the communities where extractive activities are a relevant source of employment show lower support for renewable energy policies.

Given the high emission potential of coal combustion it is not surprising that many of the current green policies implemented around the world involve, to different extents, the closure of coal mines and coal-fired plants. For this reason, the issue has recently been the topic of many researches that focused on economic, employment, environmental or health consequences of the closures (Collier and Venables (2014), Burke et al. (2019), Barker et al. (2016), Spencer et al. (2018)). From an economic prospective, the main concerns of these studies has been to understand the impacts in terms of GDP and employment. While focused on a different aspect from the one I am focusing on here, these studies might hold an explanation for the results that I observe. Burke et al. (2019) provide a full analysis of the effects of the closure of coal plants on local unemployment in Australia between 2012 and 2017. The authors acknowledge that this kind of policy does not probably affect unemployment in large urban areas where employment opportunities are more and where the job market is probably more dynamic, but the transition might cause some unemployment issues in areas where the local economies traditionally rely on coal activities such as coal mining or coal-fired electricity production. Using monthly data from the Australian Bureau of Statistics and controlling for regional fixed effects and state-specific dummies the paper addresses to question of whether we can observe a rapid increase of unemployment in rural areas after the decision of closing down the local coal plant. Other factors being constant, the authors show that the unemployment rate increased by about 0.7 percentage points in these areas. And this increase is still evident, in some cases, even after 6 months from the closure. The reason for a such a large effect is mainly due to the effect that in most cases the closure of a coal plant does not simply and exclusively affects people working there, but it probably expands to other businesses at different positions in the electricity supply chain. The worries about how to bring along a fair energy transitions in terms of jobs being lost because of coal mines and coal plants being closed is the topic discussed by Spencer et al. (2018) where the analysis focuses on the US to point out that while coal mining activities only provided 66,000 jobs in 2016 compared to a total employment of around 153 million, these coal related jobs where specifically located in some areas that would suffer a lot from green policies that imply closures without a real plan on how to reallocate the people left unemployed. And as the article points out, the same heterogeneous distribution of coal mining jobs could be observed in the UK during the closures in 1980s which lead to large social unrest events. The authors conclude that coal activities being deeply integrated in some local economies a poorly managed energy transitions might generate large unemployment shocks.

4 Coal plants' presence and environmental attitudes

The large amount of pollutants that each coal-fired plant emits in producing electricity has convinced many policymakers and politicians to make the closure of coal plants part of their climate agenda. The questions I am addressing here with this analysis concern the relation between the presence of coal plants and locals' attitudes and support toward green energy policies. In particular, I am investigating how the presence of coal plants shape the ideas and the opinions about climate change and the acceptance of green measures aimed at reducing global warming. The idea behind this is to see whether people in small counties where the coal plant is a major employer and where many jobs are guaranteed by the presence of the plant even besides those provided by the energy production process (the entire coal supply chain and other activities that might rely on the presence of the coal plant) show, on average and after having controlled for other factors that might explain climate change denial, a lower level of belief that climate change is caused by human activities and a lower acceptance of policies that might harm the presence or seriously reduce the activity of the plant. Of course, this measure would not only capture the support, or the opposition, by the employees, but has the potential to capture any sentiment that is expressed, for example, by a family member that is worried that a relative might lose the job after the plant is shut down. Or it might even capture the lower support of those that do not work at the coal plant but whose jobs depend on its presence.

As of 2015 around 72% of all mining and extraction firms operated in the fossil fuel industry and employed around 544,000 employees. Of the 1.6 million Electric Power Generation and Fuels employees, fossil fuel technologies account for about 63% of employment. Fossil fuel production, processing and related activities support the majority of jobs in this sector (52%), at just over 832,000 workers, while fossil fuel-based electric power generation employs around 136,000 individuals (US Energy and Employment Report (USEER), US Department of Energy[1]). While these employees represent a small percentage of the whole US 2015 employment count of around 149.5 million of people[2], the geographical distribution of coal plants implies that some local economies might rely on their presence as a source of large employment. In fact, as Figure 1 below makes it evident, coal-fired plants are mostly located in the Mid-West area of the country. This heterogeneous distribution explains why some economies

[1]https://www.energy.gov/downloads/us-energy-and-employment-report

[2]https://www.bls.gov/opub/mlr/2016/article/unemployment-rate-nears-prerecession-level-by-end-of-2015.htm

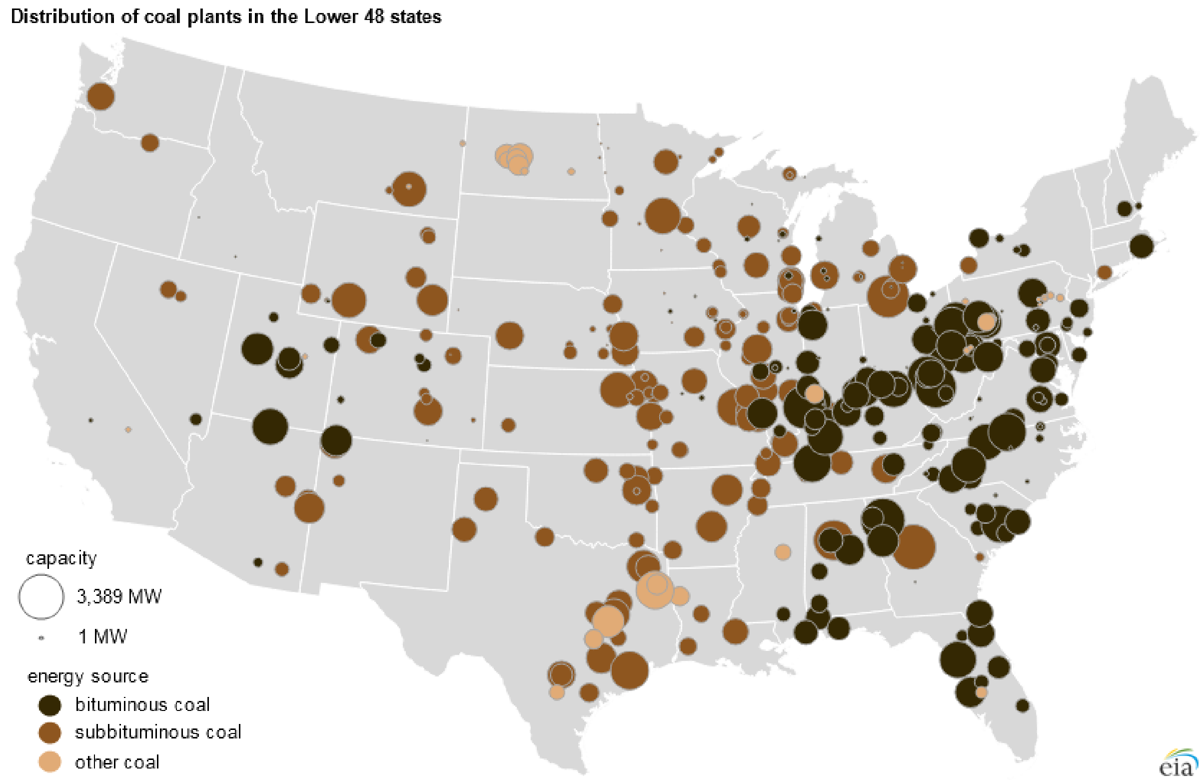


Figure 1: Distribution of coal plants in the Lower 48 States by type of coal that is employed. Source: "Most coal plants in the United States were built before 1990", EIA

might suffer more than others should these plants be closed. A further suggestion of how relevant some coal plants might be to the local economy can be given by the population data of the county they are located in: Form-860 by the Energy Information Administration contains data on each regulated generator in the USA including its geographical position. Using this information for the year 2014, which is the first year in the dataset I am using, one would come up with the following results: the average county with the presence of a regulated electricity coal-fired generator had a population of around 105,000, with a median of 43,000 and around 43% of these counties classify as "rural" according to the definition provided by the US Economic Research Service at the United States Department of Agriculture[3]. Bearing in mind that not only employees but also their relatives might oppose coal plants regulations, this might give an idea of what sentiment to expect in these small counties.

4.1 Data

The dependent variables that I am using for this analysis come from Ballew et al. (2019) and are the products of the joint efforts of the Yale Program on Climate Change

[3]https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/

Communication and George Mason Center for Climate Change Communication. The data represent an attempt to provide a county-level description of risk-perception, policy support and belief about global warming. County-level estimates for the USA are only available for years 2014, 2016, 2018 and 2020. However, given the lack of data for the control variables for the last year, I am only using data from 2014, 2016 and 2018. Of course, the availability of data for more than a year gives me the opportunity to study how climate change sentiments changed after certain events or after new policies have been promoted. State-level estimates are available for a longer time period but I believe that an entire state represents too a large unit to be able to observe variations across time and in different areas. For each sentence in the survey that is used in order to collect the data multiple possible options were given to the respondent but in most of the cases these possible replies only included agreement, disagreement or an option not to reply or "do not know". However, in some cases, more possibilities were given but the answers were then grouped into three groups that resemble the reply structure of the other sentences. The survey questions I focus on are: "What do you think: Do you think that global warming is happening? "How much do you support or oppose the following policy? Regulate carbon dioxide as a pollutant", "How much do you support or oppose the following policy? Set strict CO2 limits to existing coal-fire plants", "How much do you support or oppose the following policy? Require utilities to produce 20% electricity from renewable sources". For the last three questions I am focusing on people were given the following options: "Strongly support", "Somewhat support", "Somewhat oppose" and "Strongly oppose".The first two options were grouped into a single reply of "Support" while the last two into "Oppose". The summary statistics in Table 1 below reports the share of the population that supports a certain policy and the share of the population that believes that global warming is happening. The data are grouped by year.

As far as the control variables are concerned, these are the measures that I am using to predict support climate change measures and beliefs about global warming:

GPD: County-level Current-dollar Gross Domestic Product in thousands of dollars from the Bureau of Economic Analysis (BEA).

CP: this is a dummy variable that equals 1 if the county has a regulated coal-fired electricity generator in a given year. The data are obtained from the Form EIA-860 which collects generator-level information about existing, planned and retired generators. I am classifying a generator as a carbon-fired one if its primary energy source is coal, irrespective of what kind of coal that is. However, note that each generator might employ different energy sources but in most cases if the primary one is coal the second one is a different type of coal.

Education: county-level data on education are provided by the Economic Research Service of the United States Department of Agriculture. Unfortunately, 2014-2018 data are only available as a 5 years average. On one side, this does not give me any variation through time; on the other side, I do not expect educational attainment to vary so much in such a short period at a county-level. The variable is expressed as the share of adults with a bachelor's degree or higher.

Rural: this dummy variable captures the US Department of Agriculture's classification of a county in terms of population size and in terms of proximity to a metropolitan area. In fact, classifying a county only through its population size might not be ideal if that county is part of a larger metropolitan area. The classification by USDA takes into consideration both of the relevant aspects: population size of the county and proximity to a metropolitan area.

CM: this is a dummy variable that equals 1 for year t if there is at least one active coal mine in the county. The presence of a coal mine could in fact influence the attitudes toward global warming and given the possibility of a correlation between the presence of a coal plant and that of a coal mine I am including this dummy to avoid OVB concerns. The information about the presence of a coal plant is provided by the Annual Coal Report by the Energy Information Administration (EIA).

West, NE, MW, South: this dummies provide a geographical control for the different counties in accordance with the classification by the Census Bureau.

Table 1: Dependent variables summary statistics by year

	RPS	**Limits CO_2**	**Limits plant**	**Happening**
2014				
Mean	57.514	71.97549	59.41375	59.10216
SD	4.307316	3.823515	7.013974	4.909568
Min	45	59	32	45
Max	77	88	85	84
Count	3142	3142	3142	3142
2016				
Mean	60.81922	70.3937	62.32591	64.18682
SD	4.4358	4.134556	7.220903	5.457991
Min	48	56	34	48
Max	75	83	83	84
Count	3142	3142	3142	3142
2018				
Mean	58.17155	73.22374	62.662	63.48727
SD	4.393584	3.48845	6.969599	5.866741
Min	48	64	36	49
Max	74	85	85	84
Count	3142	3142	3142	3142

Note: data are obtained from Ballew et al. (2019).

4.2 Methodology and results

The way I am estimating the effect of the presence of a coal plant on the climate change attitude is through the following repeated cross-section specification:

$$\begin{aligned} Y_i = \beta_0 + \beta_1\phi_i + \beta_2 GDP_{i,t} + \beta_3 Education_i + \beta_4 CM_{i,t} + \beta_5 West_i + \\ + \beta_6 NE_i + \beta_7 MW_i + \beta_8 Rural_i + \beta_9 CP_{i,t} + \beta_{10} rural\_CP_{i,t} + \epsilon_i \end{aligned} \quad (1)$$

Where Y_i represents one of the outcome variables I presented in Table 1, β_9 and β_{10} are the parameters I am interested in and $rural\_CP$ represents the interaction dummy between $Rural$ and CP. ϕ_i represents year fixed effect. A specification including an interaction dummy variable between the rural dummy variable and the dummy for the presence of a coal plant, as the one that is included in the equation above, is necessary in order to better address the idea that the share of the population believing in climate change and supporting climate change mitigation proposals might be lower in counties where a coal plant is present but might potentially be even lower if that county is a rural one. The idea is that the coal plant itself, but also all the accessory activities such as coal transportation or any form of electric distribution infrastructure whose existence is linked to that of the plant, might provide a large number of jobs in the local area. And this assumption is even more relevant in rural counties because the population is smaller and the relative impact of the plant on the local economy is larger. This implies that the effect that I will observe is not only driven by the sentiment among coal plant's employees, but also by their relatives, friends or whoever else whose current employment depends on the presence of the coal plant. Controlling for many other factors, I think this approach might provide some insights into understanding how beliefs are shaped in accordance to who or what is paying most of the salaries in the county.

Whenever an approach such as the one presented in (1) is used some words of concern are necessary because of the many possible biases that may affect the result of the study. I do not believe there should be any worry about reverse causality: it is not reasonable to assume that coal plants were purposely built in counties where concerns about global warming and support for green policies were lower. In fact, of the 709 regulated coal-fired electricity generator that were still active in 2014, the first year I am considering, 362 were built before 1970 (around 51%) and 538 (about 75.8%) before 1980 while climate change policies only appeared in political agenda and began being discussed in the mid-80's (Moser (2010)) and in 1981 Hansen et al. (1981) still concluded that "more observations and theoretical work are needed to permit firm identification of the CO_2 warming and reliable prediction of larger climate effects further in the future". And James Hanses has been able to present the issue of global warming to a vast audience only in his audience before the US Congress in 1988 [4]. Another reasonable concern when it comes to a regression as the one in (1) is the presence of

[4]https://www.nytimes.com/1988/06/24/us/global-warming-has-begun-expert-tells-senate.html

an Omitted Variable Bias (OVB): if there is any correlation between the error and one of the regressors then one of the assumptions that guarantees an unbiased estimation is violated. However, it is sometimes possible to get an idea about the direction of the OVB and understand whether the unbiased estimator would actually have a larger or smaller effect than the estimated one. For example, suppose that true model is given by $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + u$ and that I only have data on x_1. This would give me the following estimation: $\tilde{y} = \tilde{\beta_0} + \tilde{\beta_1} x_1$. If I could regress x_2 on x_1 I could obtain: $\tilde{x_2} = \tilde{\delta_0} + \tilde{\delta_1} x_1$. It can then be shown that $\tilde{\beta_1} = \hat{\beta_1} + \hat{\beta_2} \delta_1$. By taking expectations, $\mathbb{E}[\tilde{\beta_1}] = \mathbb{E}[\hat{\beta_1}] + \mathbb{E}[\hat{\beta_2}]\tilde{\delta_1}$, we end up with an expression, $\mathbb{E}[\tilde{\beta_1}] = \beta_1 + \beta_2 \tilde{\delta_1}$, that allows us to understand what might be the sign of the bias and speculate on what the regressor would have looked like if the relevant factor had not been omitted. For example, with the regression (1) above that I am estimating, it is plausible to assume that pollutants emissions might be an omitted variable. And of course, the level of pollutants emissions is positively correlated to the presence of a coal plant. This implies that the factor $\tilde{\delta_1}$ is positive. It is also reasonable to assume that the level of pollutants is directly correlated to support for green measures and belief that climate change is happening, which would imply that β_2 is positive too . In this case, if the regressor on the variable CP happens to be negative, the OVB formula implies that, actually, the real value of the regressor should still be negative, but larger in magnitude. In fact, because it is reasonable to assume that both $\tilde{\delta_1}$ and β_2 are positive, they would be added to the estimated effect of the presence of a coal plant. This means that the estimate that I am observing on CP is probably larger in absolute value. However, it is still possible that people are not aware of the presence of pollutants or they do not really pay attention to them as long as they do not have visible effects on their health. In that case, I would expect the value of β_2 to be 0. The only case in which the OVB bias increases the magnitude of the observed effect of CP, if the effect of the presence of coal plant is negative, is the case in which the level of emissions and the belief about climate change or the support for green policies are negatively correlated. In that specific case the actual negative effect of the presence of the coal plant would be smaller in magnitude than the one I observe. However, I do not believe that, no matter how much denial a local community might be, it would show a negative correlation between the high level of pollutants and the support for mitigation policies. And unfortunately, county-level data on emissions are not available, but I hope that the reasoning proposed above makes sense.
One more source of concern might be the absence of any control that is able to capture the political sentiment of a county: a measure such as the party affiliation of the local administration or results in local or state elections might give an idea of where the people in one county stand in the political spectrum. While there might be a correlation between the presence of a coal plant and the support for the Republican Party, assuming, as it seems legitimate, that members of this party are less willing to accept the evidence of global warming, these controls might risk representing a bad control. In fact, I believe people who do not share the scientific concern about climate change will end up voting for the party that better suits their belief. That is, people have their own opinions and vote for the party that better represents these opinions. What I am

saying is that support for a certain party is likely to be the result of certain positions on climate change rather than being the cause of them. On the other hand, I could not rule out the possibility that the process works in the opposite way, with people choosing a party over ideological positions and then adopting the party's view on global warming. Because the direction of causality is not clear I am not including any form of political sentiment. With these caveats in mind I proceed with a repeated cross-section regression to estimate the effect of the presence of a coal plant on locals' belief about climate change. Particular interest might be given to the attitudes toward the proposal that is aimed at reducing CO_2 emissions from coal plants, and the fact that another policy precisely address a similar goal but without making an explicit reference to coal plant might provide a meaningful opportunity to see how the position changes with or without mentioning coal plants.

Table 2 below reports the results from running the specification in (1). Over concerns of the possibility that the errors within each county might be correlated I am reporting the county-level clustered standard errors in square brackets. The results really confirm one of the possible direction I mentioned in the Introduction in which the presence of a coal plant might affect beliefs about climate change and supports for environmental policies. In fact, the presence of a coal plant reduces, on average and keeping everything else fixed, the share of the people that believe that climate change is happening by 1.091 percentage points (p.p.) and the result is statistically significant no matter what errors I refer to. I am not able to find any significant opposition to the Renewable Portfolio Standard policy (RPS) that would require 20% of the electricity to be produced from renewable sources. The support for the policy that would require reducing CO_2 emissions no matter what the source finds lower support in coal-plant counties only if the assumption of homoskedasticity holds, which is actually something I would turn down. Using county-level clustered standard errors, I find no significant reduction for this policy in coal plant-counties. As one could have foreseen, the largest reduction in policy support is observed for that policy which promotes the reduction of CO_2 specifically from coal-fired plants: the reduction in support is statistically significant and equals -2.954 percentage points (p.p.). Of course, given that the targets are coal-fired plants it perfectly makes sense that this is the policy that receives the least support if coal plant-counties.
If the assumption that fossil fuels-related activities really shape locals' environmental attitudes holds, the effect should be even larger in rural areas, where the population is smaller and the relative importance of the coal plants and all the correlated activities on the labor market and on the economy in general is larger. And this is indeed the story that the results in Table 2 tells: no matter what is the outcome variable one focuses on, the rurality of the county contributes to a further reduction. And this further reduction in support is again larger for the policy that would require limiting CO_2 emissions from coal-fired plants: the rurality of the coal plant further reduces the share of people supporting that policy by 5.542 percentage points and the result is statistically significant no matter what errors I use.

Table 2: Estimates of climate change attitudes

	(1) Happening	(2) RPS_support	(3) CO2_limits	(4) CO2_Plant
2016.Year	5.025	3.271	-1.612	2.797
	(0.1085)	(0.08863)	(0.07870)	(0.1448)
	[0.06029]	[0.06356]	[0.05328]	[0.1061]
2018.Year	4.281	0.595	1.196	3.063
	(0.1085)	(0.08867)	(0.07874)	(0.1448)
	[0.06764]	[0.07048]	[0.05364]	[0.1079]
GDP	3.04e-08	2.22e-08	1.69e-08	3.58e-08
	(1.807e-09)	(1.477e-09)	(1.311e-09)	(2.412e-09)
	[7.626e-09]	[5.555e-09]	[4.588e-09]	[8.083e-09]
Education	0.226	0.175	0.0996	0.218
	(0.005601)	(0.004576)	(0.004063)	(0.007474)
	[0.01062]	[0.007693]	[0.006625]	[0.01218]
CM	-3.016	-2.108	-1.296	-4.319
	(0.2051)	(0.1676)	(0.1488)	(0.2737)
	[0.2824]	[0.2131]	[0.2153]	[0.4874]
West	3.102	1.164	0.688	3.202
	(0.1395)	(0.1140)	(0.1012)	(0.1861)
	[0.2541]	[0.2052]	[0.1779]	[0.3149]
NE	3.142	3.548	5.225	6.837
	(0.1892)	(0.1545)	(0.1372)	(0.2524)
	[0.2769]	[0.2138]	[0.1599]	[0.3165]
MW	-0.00768	0.667	0.847	1.930
	(0.1033)	(0.08443)	(0.07497)	(0.1379)
	[0.1528]	[0.1152]	[0.1110]	[0.2002]
Rural	-0.0923	-0.818	-1.015	-0.298
	(0.1071)	(0.08753)	(0.07772)	(0.1430)
	[0.1689]	[0.1301]	[0.1181]	[0.2068]
CP	-1.091	-0.256	-0.474	-2.954
	(0.2435)	(0.1989)	(0.1766)	(0.3249)
	[0.3825]	[0.2907]	[0.2787]	[0.6450]
rural_CP	-2.198	-1.334	-1.560	-5.542
	(0.3581)	(0.2926)	(0.2598)	(0.4779)
	[0.6239]	[0.4726]	[0.4702]	[1.1241]
N	9426	9426	9426	9426

Standard errors in parentheses. County-level clustered erros in square brackets

The rurality of a coal-plant county implies an additional reduction of the share of the people that climate change is happening of 2.198 percentage points, a result that is statistically significant no matter what errors I refer to. Additional support reductions in rural counties are observed for the support to RPS policies and for the support to general CO_2 limitations. One interesting aspect of the findings outlined in Table 2 which is true both in general and for rural counties is that there seem to be different levels of support for different policies. That is to say, even though the three proposed policies all aim at reducing the emissions of pollutants, the support levels that they find in coal-plant counties are different. The fact that the largest reduction of support is observed for the reduction of plants' emissions is not surprising and the fact that this is even larger in rural counties, even when I control for the educational attainment, provides evidence of how an increased relative importance of the fossil fuel industry has a larger effect on environmental attitudes. Concerns about the effects on the local economy are larger when the county is smaller and relies more on the presence of the coal plant. As far as the other two policies are concerned, the Renwable Portfolio Standard policy seems to be more supported than the general reduction of CO_2 no matter what the source. This could be explained by the fact that, despite not making specific reference to coal plants, this second policy is very likely to involve coal-related activities, so even coal plants. Because the RPS policy does not state anything about reducing emissions, some people might still believe that this will have small or no impact on their local economy.

4.3 Coal plant closures

The possibility to access observations from different years both on the presence of a coal plant in each county and on the beliefs about global warming and support to environmental policies provide the excellent settings for a study on how the closure of a coal plant in a county affects the attitudes of the locals toward climate change. It is indeed possible that this event might generate two opposite results. In one case, after the closure, the locals might deny global warming even more if they believe that global warming policies determined their loss of job. On the other, they might decide to accept the scientific evidence about climate change and become more supportive of green policies. The Form-860 EIA (Energy Information Administration) that I have used to locate regulated electricity generators in the USA also provides data on generators' closures. So, by referring to the form of 2016 I am able to see how many regulated coal-fired electricity generators were closed between 2014 and 2016. Another possibility would be to use the same form from 2014 because the Administration reports the planned year of retirement, if a retirement plan has been approved, for each generator [5]. Out of the 707 regulated coal-fired electricity generators that are listed in the Form-

[5] However, I had some concerns that more generators have been closed than planned because of misreporting or other reasons, so I am using the actual number of closures form the Form-860 EIA from 2016. And the same EIA confirms that the data about the planned retirement year were not trustworthy: https://www.eia.gov/todayinenergy/detail.php?id=15031

860 EIA from 2014, 127 were closed in the period 2014-2016 (around 18%), while only 46 were closed during the period 2016-2018. My idea is to capture the shift in the sentiment as closely as possible to the period after the closure and given that the Yale Program on Climate Change Communication only has observations for every two year and the fact that more coal-fired generators were closed during the 2014-2016 period than during the 2016-2018 period, I am focusing on data from the former. In order to do this I generated a new independent dummy variable, *Closed_2016*, that equals 1 for a county if that county experienced the closure of one or more coal-fired generators in its local electricity plant. The idea to exploit closures of coal plants to explain variations in economic variables has recently found large application because of the various programs governments around the world are implementing to cut down CO_2 emissions. However, in most of the cases, these analysis only focus on the impact of the closures on economic variables such as unemployment at a local level and GPD at the same level. For example, Burke et al. (2019) study the effect of coal plant closures in Australia to find out that, after controlling for several other closures and a list of economic factors, they led to an increase in local unemployment of around 0.7%. Focusing on a macroeconomic model rather than elaborating on data, Barker et al. (2016) find that if the coal plant closures are supported by simultaneous additional policies such as energy efficiency measures more jobs can be created than lost and the GPD would increase.
The dependent variables I will focus on are the 2014-2016 variations of the variables presented above in Table 1 measured in percentage points (p.p.). The summary table below, Table 3, provides the summary statistics for the dependent variables and gives an idea of how much variation is observed in the 2014-2016 period.

Table 3: Summary statistics for 2014-2016 variations

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
ΔCO2_Plant	4.81	5.816	-12	34	247
ΔRPS_support	4.057	3.074	-7	17	247
ΔCO2_limits	-1.194	2.766	-14	10	247
ΔHappening	5.794	3.138	-6	17	247

The specification I am running is the following cross-sectional OLS regression:

$$\Delta Y_i = \beta_0 + \beta_1 NE + \beta_2 West + \beta_3 MW + \beta_4 Rural + \\ + \beta_5 Education + \beta_6 Closed\_2016 + \beta_7 Closed\_2016 * Rural + \epsilon \tag{2}$$

Where ΔY_i is one of the dependent variables whose summary statistics I am showing in table 3. The factors I am most interested in are the ones given by β_6 and β_7 from equation (2). These estimations will return an insight on how people changed their opinions and beliefs about climate change after the closure of the local coal plant. The counterfactuals I am using are the other counties that had a coal plant in 2014 and did not experience any coal-fired electricity closure during the 2014-2016 period. This explains why the number of observations drops to 247 and is not 3142, which is the number of counties in the US. Out of the 247 counties that had coal-fired electricity generator in 2014, 57 counties (about 23%) experienced a coal-fired generator closure. It is true that the variables *Education* and *Rural* do not change across time in my dataset, but they might still provide good controls for the prediction of the shifts in the attitudes. I would not expect a large variation for the former in only two years and for the latter, unless large demographic changes occurred, it is really difficult to find a rural county in 2014 and that is not classified like that in 2016.

One of the major concerns when running a specification such as the one presented in equation (2) is about reverse causality: it might in fact be the case that coal plants were closed in those counties where locals showed more support for such a policy. Or, in another way, the closure of a coal plant might be the result rather than the cause of beliefs in climate change and support for green policies. However, this possibility can be ruled out by looking at the data: the average share of the population in 2014 that believed that climate change is happening in the counties that did not experience a closure was about 43% and the same belief is 44% in the counties where at least one coal-fired generator was closed. Moreover, of all the counties that experienced a closure, Humphreys, TN, is the one where most coal-fired generators were closed, 6, and the share of people that believed that climate change is happening was 38% in 2014. Four counties had 5 coal-fired generators closed between 2014 and 2016 and the share of people that believed that climate change is happening was 44% in 2014, as in the counties that did not have any generators closed. Furthermore, EIA analysis suggests that coal plant closures are more related to high operating costs[6], the average age of the generators and their dimension[7], increased competition from other sources[8] and flat electricity demand[9]. The concern about the presence of estimation problems linked to reverse causality is not probably relevant in this specification.

Table 4 above shows the results from running the OLS cross-sectional regression specified in 4. This shows that that the closure of coal plants did not really affect the attitudes toward climate change during the 2014-2016 period. It is true that for two of the policies, RPS support and general limitations to CO_2 emissions (columns 1 and 2), the effect in rural communities seems to be reduced, but no regressor here is statistically significant, no matter what error one decides to use. None of coefficients on closure of a coal plant and on the interaction between that dummy and the dummy for the rurality of the county show any statistical significance. However, the main concern with the robustness of the results above is actually given by the presence of endogeneity problems. The endogeneity problem is given by the fact that the closure of some coal plants, the event I am focusing on here, might be correlated with some other event or with some economic variables other than the ones I am controlling for

[6]https://www.eia.gov/todayinenergy/detail.php?id=42155
[7]https://www.eia.gov/todayinenergy/detail.php?id=37814
[8]https://www.eia.gov/todayinenergy/detail.php?id=44976
[9]https://www.eia.gov/todayinenergy/detail.php?id=40212

Table 4: OLS estimates of global warming attitudes change

	(1)	(2)	(3)	(4)
	ΔRPS_support	ΔCO2_limits	ΔCO2_Plant	ΔHappening
NE	-2.294	-1.167	-4.579	-0.328
	(2.2153)	(1.9616)	(3.9122)	(2.1802)
	[0.6463]	[0.8709]	[1.5322]	[0.7536]
MW	-1.176	-0.982	-4.352	0.0961
	(0.4287)	(0.3796)	(0.7571)	(0.4220)
	[0.4254]	[0.3664]	[0.7617]	[0.4085]
West	-1.323	-2.165	-5.981	-2.492
	(0.6358)	(0.5630)	(1.1229)	(0.6258)
	[0.7105]	[0.6652]	[1.0579]	[0.6894]
Education	0.00877	0.0428	0.0391	0.0525
	(0.02404)	(0.02129)	(0.04245)	(0.02366)
	[0.02350]	[0.02028]	[0.03899]	[0.02273]
Rural	-0.150	0.0877	-0.441	-0.416
	(0.5008)	(0.4435)	(0.8844)	(0.4929)
	[0.5131]	[0.4558]	[0.9445]	[0.5068]
Closed_2016	0.738	0.156	0.0721	-0.131
	(0.5926)	(0.5248)	(1.0466)	(0.5833)
	[0.5414]	[0.4513]	[0.8863]	[0.5313]
Closed_Rural	-0.826	-0.324	0.334	0.319
	(0.9514)	(0.8424)	(1.6801)	(0.9363)
	[0.8496]	[0.7288]	[1.4670]	[0.8083]
N	247	247	247	247
R^2	0.049	0.079	0.171	0.116

Standard errors in parentheses. Heteroskedastic robust erros in square brackets and that these missed controls might be correlated with the change in climate change beliefs observed between 2014 and 2016. Such a problem could for example be caused by some environmental policy that is introduced at the local level and that determined the closure of the local coal plant. If the introduction of such a policy is correlated with the attitudes toward global warming the concern about endogeneity actually becomes a problem. Because I cannot rule out the possibility that the estimated effects are affected by this problem, in order to solve it I am using an IV approach. I need to make sure that the instrument that I am using satisfies both of the assumptions that are necessary in order to guarantee that I am dealing with a valid instrument: (1) Relevance: this is a testable hypothesis and it implies that there must be some correlation between the instrument that I am using and the variable that is being instrumented and (2) Validity (or Exclusion): requires that the instrument is not a direct determinant of the dependent variable, it is not correlated with any other control and the only way in which it can affect the dependent variable is through the variable that is being instrumented (Angrist and Pischke (2008) and Wooldridge (2016)). Unfortunately, this second assumption is not directly testable and requires justification from theory, knowledge of the process or any other relevant information that might be relevant in order to assess its validity. The instrumental variable that I am using in this approach is the average price that a plant paid for the coal it used in its generators. This information is collected by the Energy Information Administration in its Form EIA-923 and is presented for every month. The survey returns every supply contract that the plant has signed, for each month, the mine from which the coal comes, the type of coal and the price that is paid. The price reported represents all the costs incurred in the purchase and delivery of the fuel to the plant in cents per million BTU. The fact that the prices are expressed in cents per million BTU has the advantage of making different types of coal perfectly comparable, irrespective of their heat content. And, in fact, different types of coal have different prices, with subbituminous coal being cheaper than bituminous one. Of the 127 coal-fired generators that were closed in the 2014-2016 period 88 (about 69%) used bituminous coal as their first energy source while 39 used subbituminous coal. However, because coal-fired generators are not closed overnight but the decision is taken some years before the actual closure, the Form EIA-923 version I am using is the one from 2010. I am showing in the Appendix tables A3, A4, A5 and A6 that the IV relevance assumption holds using data from 2011, 2012, 2013 and 2014 too and that the results are robust to using fuel costs from different years. Out of the 22545 coal supply contracts that were in place in 2010, 14567 supplied bituminous coal while 7077 supplied subbituminous coal. The other 901 contracts provided coal-fired generators with either lignite coal or waste coal. However, none of the generators that were closed in the 2014-216 period used these types of coal. First of all, I want to rule out the possibility that the vast majority of closures of coal-fired generators are linked to bituminous coal because of environmental concerns. In fact, if these generators were closed because they used a type of coal that is more pollutant than others I might run into a problem of reverse causality: the generators to be closed are those that use the most polluting type of coal and this happens because of concerns about global warming.

However, for each million of British Thermal Units (BTU) bituminous coal emits 205.7 pounds of CO_2, while subbituminous coal emits 214.3 pounds (EIA[10]). So, the idea that the bituminous-fired generators were closed because they were more polluting does not hold. A quick look at the data reveals that the average price paid per million BTU when using bituminous coal is 300.65$ and 170.4$ for the subbituminous type. The large difference in prices that is observed between these two types can be explained by the fact that out of the 14567 bituminous coal contracts, 5745 were signed with coal companies that extracted that coal from underground mines, while the number of underground mines supplying subbituminous coal is 32. I believe it is reasonable to assume that underground extraction is, on average, more expensive than surface extraction. The idea that fuel price or any other operating cost might indeed predict the closure of a coal plant is an idea that has been recently supported by an Energy Information Administration's analysis on coal plant closures in 2018[11]. That analysis focuses on all coal plants in the US irrespective of the sector they operate in, while I am only focusing on operators in the electric utility sector, but it still provides evidence that the IV used makes sense and that using data from other years should hold the same results. The results shown in table 5 below confirm that while I might be tempted to conclude that there has been a large shift in climate change attitudes, given that some of the estimates are as large as 5 percentage points (p.p.), I have to rule out the possibility that local closures have had any impact on the beliefs because all the regressors are not statistically significant. The first stage regression, which I show in the first column of the table, confirms that the relevance assumption is a valid assumption: higher fuel costs increase the likelihood of a plant closure and the result is statistically significant. The values of the regressors and both the standard errors and the county-level clustered errors are different between the OLS and IV approach. However, the IV estimation confirms the results that are found in the OLS approach: local coal plant's closure does not seem to have had any effect on the change in attitudes and beliefs toward global warming between 2014 and 2016. One could have expected such a result considering that IV errors are, on average, larger than the one obtained in an OLS approach. I can rule out the possibility that I am not able to find any effect because my variable for the closure is "raw" in the sense that I am assigning the same value, 1, to closures that might have actually involved more generators and might then have been larger: in Appendix tables A7 and A8 I am using a *n_closures* variable to control for the number of coal-fired generators that were closed in each county. Note that the result is not affected: I still cannot find any evidence that the closure of a coal-fired electricity generators has had any impact on the difference that we observe in policy support and global warming beliefs that are observed in the 2014-2016 period.

Over concerns that the exclusion assumption might not hold, I am showing that the results are robust even to a different IV. These concerns mainly come from the fact that the presence or the closure of a coal mine in a county might affect the change in

[10]https://www.eia.gov/tools/faqs/faq.php?id=73&t=11
[11]https://www.eia.gov/todayinenergy/detail.php?id=42155

Table 5: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.249	-0.423	-1.151	-3.485	-0.540
	[0.07389]	[0.8928]	[0.9704]	[1.7599]	[1.0163]
	(0.3050)	(2.2202)	(2.8308)	(4.3933)	(2.2057)
MW	0.173	0.102	-1.612	-4.891	-1.227
	[0.06853]	[0.4985]	[0.6458]	[1.0042]	[0.4903]
	(0.06750)	(0.4774)	(0.6087)	(0.9447)	(0.4743)
West	0.0331	-2.555	-1.020	-5.687	-2.053
	[0.08661]	[0.7170]	[0.8432]	[1.1612]	[0.7149]
	(0.09620)	(0.6502)	(0.8291)	(1.2867)	(0.6460)
Education	-0.000249	0.0540	0.00764	0.0436	0.0421
	[0.003266]	[0.02274]	[0.03070]	[0.04383]	[0.02264]
	(0.003357)	(0.02374)	(0.03027)	(0.04698)	(0.02359)
Rural	-0.0138	-0.313	-0.100	0.00224	0.161
	[0.06319]	[0.4834]	[0.6299]	[0.9926]	[0.4819]
	(0.06436)	(0.4639)	(0.5915)	(0.9180)	(0.4609)
FuelCost	0.000910				
	[0.0003764]				
	(0.0003543)				
Closed_2016		-0.274	5.873	6.152	3.038
		[2.9863]	[3.8162]	[5.8947]	[3.0465]
		(2.7540)	(3.5115)	(5.4497)	(2.7361)
N	245	245	245	245	245
F	9.527				

Standard errors in parentheses. Heteroskedastic robust erros in square brackets beliefs about global warming. And the presence or not of a coal mine in a county is for sure related to the fuel price that a plant in that same county pays. This implies that there is at least one other control the instrument is correlated with. For this reason, I am providing in the Appendix two more table,Table A1 and Table A2 where a different instrument is used: the average building year of the generators in each coal plant.

5 Deepwater Horizon oil spill

In order to assess the effects of the Deepwater Horizon oil spill of 2010 on renewable energ consumption in Louisiana I will exclude some states from the donor pool. This represents a common practice in the Synthetic Control Method (SCM) literature: it is necessary to make sure that the units that are in the donor pool are not affected by the same event. The fact that I am focusing on a disaster such as an oil spill provides a natural experiment setting to the study. In fact, it is reasonable to assume that the event could not be foreseen by the population (had that been the case I would have had to move the treatment period to the year where people started to change their behaviours in accordance to their expectations) and only some states were affected by it. For this reason I am not considering the states in the Gulf of Mexico but Louisiana: Alabama, Florida, Mississippi and Texas will not be considered as potential donors. Alaska and Hawaii are left out of the donor pool too. I am no considering these two states because the lack of territorial continuity. They are two peculiar states and neither of them would constitute a good donor to describe Louisiana. Moreover, Alaska has very limited possibility to invest in renewable energy production, especially solar energy. So, the donor pool is made of the contiguous lower states minus Alabama, Florida, Mississippi and Texas. However, I am using observations from these last states too when I run placebo experiments to test the significance of the results. The decision to focus on Louisiana only makes sense considering that it was the most affected state. Moreover, previous literature has established a positive effect of disasters on climate change attitudes even in the case of the Deepwater Horizon oil spill (Walters et al. (2014)). However, given the high relevance of the fossil fuels industry in the economy of Louisiana, one might wonder whether the employment and the economic development that it guarantees are more important than environment safeguard. Given the media coverage of the event it might not be completely safe to assume that the population of other states has not been affected by the event: access to images, news and videos through social media and news media migth have had an impact on the decision to invest in renewable energy in other states too. However, it is very likely that the direction of the influence of the disaster is similar to the one that might be expected in Louisiana: by being exposed to the consequences of this men-made disaster people will be more willing to invest in renewable energy. If that is the case, this will be reflected in the synthetic Louisiana I am using to estimate the result. This will imply that the effect that I get as the difference between the real Louisiana and the synthetic one is a conservative estimate and should represent the lower bound of the actual effect of the disaster on renewable energy consumption. The hypothesis that geographically distant disasters might have some effects on the local policy in some different regions is not so difficult to consider: Goebel et al. (2015) provides evidence of the effects of the Fukushima nuclear disaster on the attitudes of the German population toward nuclear energy production and of the increased local support for the Green party in Switzerland and the UK too. All of this is a consequence of the possibility to access news and images of disasters from all around the world. Because the donor pool is formed by other US states which are culturally and geographically closer to each other than Japan to European countries, I cannot completely rule out this possibility. But, again, this would only mean that the actual effect on Louisiana's consumption of energy from renewable source is larger than what observed.

In the case of Louisiana, the same Energy Information Administration (EIA) points out to poor energy potential from wind (see figure A1 and A2 in the Appendix). Neither for hydro nor for geothermal does Louisiana show high level of potential exploitation[9]. Given these limitations I have decided to focus on solar energy consumption. The reason is that even well before the oil spill in the Gulf of Mexico the technology for solar production was already available and other states were already investing in it (see Jones and Bouamane (2012)). Moreover, given the position of Louisiana in the South of the country, the state has a fairly high potential for photovoltaic installations and this kind of energy production is not as limited as the one related to energy production from wind. Furthermore, photovoltaic installation requires expenses that are way more affordable to the single consumer than the investments required by wind farms; this implies that consumers might decide to move to green energy production by installing photovoltaic cells even if the State Government has not implemented any energy policy in that direction. The fact that PV installations are more independent than other renewable energy sources that would require large investments from corporations or local administrations provide a valid proxy for attitudes toward environmental issues.

5.1 Data

The dependent variable I will focus on is total solar consumption in the period 1980 -2017 as a share of total energy consumption. This period provides 30 pre-treatment observations and 8 post-treatment observations. The importance of having a large number of pre-treatment observations is a topic of fundamental relevance in the case of SCM: relying on a short period might not provide enough data for an optimal pre-treatment fit (Abadie (2019)). However, considering the outcome variable I am using, the solar energy market is not very relevant in the 80': during this period the only state that really began investing resources in this sector was California and it took some years before other states would follow in its footsteps. Jones and Bouamane (2012) claim that both wind and solar productions are higly vulnerable to changes in oil and natural gas prices and because of the low price of both of these energy alternatives in

[9]https://www.eia.gov/state/analysis.php?sid=LA

the second half of the 80's and due to the policy shifts in the same period these two technologies suffered from an abrupt stop during their development phase. They only gained new popularity after 2000 when the federal government enhanced new projects for solar energy production and in the face of evidence of climate change. The way I decided to measure solar energy consumption is by expressing it as a percentage of total energy consumption. By doing so, I am able to account for eventual moments of high energy consumption that might drive higher solar energy consumption; the decision to focus on consumption rather than on production comes from the presence of the interstate energy market and it might be the case that the energy produced by one state is actually transferred to a different state. So, I decided to focus on solar energy consumption to better track people's attitude toward environmental issues.
The independent variables I use in order to explain the percentage of energy consumption from solar power are the following:

Republican: it is a dummy variable that only takes two possible values, 1 or 0, where the former indicates that for a given year the State had a republican governor and the latter indicates that the State governor was either a democratic or independent. I use this variable in order to control for the different attitudes local governments might have toward renewable energy.

RPS: this is another dummy variable that only takes the value of 1 or 0. The former value is assigned to a State from the moment it implements a Renewable Portfolio Standard on (there are no cases of states that introduce such a policy and then withdrew it after a while). Different states have expressed the goals of their RPS programme in different ways but the idea is always to set a goal of renewable energy production for a certain year. Investor-owned utilities, municipalities and cooperatives are the main targets of these programmes and they must obtain Renewable Energy Credits (RECs) by sending out green energy to the grid. These RECs are then used to verify that each unit is reaching its objectives. Today, more than half of the states and the District of Columbia have implemented such programmes, which are often introduced together with some forms of loans and tax credits to further incentivize the adoption of green solutions. In labelling the programmes, I am only considering those states that have adopted mandatory ones rather than the voluntary form (the latter will be considered as if they have introduced no policy at all). While each state might decide to focus on some specific source, solar production represents a constant across all states.

Income: this variable represents per capita disposable income obtained from the Bureau of Economic Analysis (BEA).

Oil Price: the variable is the average price of all petroleum products (among others, hydrocarbon gas liquids, kerosene, motor gasoline and petroleum coke) for all sectors (transportation, industrial, electric power and commercial). It is meant to provide a good approximation of the average market price for oil. The data are provided by the Energy Information Administration (EIA).

Coal Price: again, this represents the average price of all coal products across all sectors and I use it to control for the patterns in coal market price. The data are provided by the Energy Information Administration (EIA).

Natural Gas Price: the average price of natural gas across all sectors. The data are provided by the Energy Information Administration (EIA).

Solar Consumption(2005), Solar Consumption(2009): these variables represent solar energy consumption from two years that are close to the treatment period. Using lagged values of the dependent variable is a common apporach in SCM literature. On the other hand, using too many lagged values and giving them too much relevance might risk to obscure the effects of the other independent variables. See Abadie et al. (2010) or Andersson (2019) for evidence of such an approach. Data are provided by the Energy Information Administration (EIA).

Solar Potential: this variable ranks each state according to its solar potential on a scale from 1-7 where the value of 7 is assigned to the states that have the highest solar potential. The data to construct this classification are provided by the National Renewable Energy Laboratory and are summarized in Figure A1 in the Appendix.

Table 1: Solar Energy Consumption Predictor Means before Oil Spill (2010)

Variables	Louisiana	Synth.Louisiana	Donor Pool
Republican	0.5	0.52	0.47
RPS	0	0	0.15
Income	18423.17	17978.62	21134.65
Oil Price	8.26	9.77	10.18
Coal Price	1.7	1.77	1.61
Natural Gas Price	3.75	5.72	5.96
Solar Consumption(2005)	0.0017	0.0018	0.023
Solar Consumption(2009)	0.002	0.003	0.011
Solar Potential	5	4.696	3.43

Table 1 above is used to give an idea of how synthetic Louisiana compares to real Louisiana and to the average values of the units in the donor pool in the pre-treatment period, between 1980 and 2009. Synthetic Louisiana is constructed as the weighted average of units from the donor pool using the values of the predictor variables to make it as similar to real Louisiana as possible. See the last section in the Appendix for a detailed explanation of how the SCM works. The states and their respective weights are displayed in Table 2 below. The synthetic Louisiana constructed using the states from the donor pool provides a better benchmark than the one constructed as the simple average of the entire donor pool for each variable: in no case the donor pool average value is closer to the one from real Louisiana. This is one of the main reason why using a SCM approach is a reasonable choice in this context. In particular, synthetic

Louisiana perfectly matches the treated unit with respect to the RPS dummy variable and does a good job with the lagged values of the dependent variables, with the dummy for Republican administration and with the variable for solar potential. Some words about the values we observe for real Louisiana are necessary here: the state is among the poorest in the US and given its relevant role as a producer of both oil and gas it seems reasonable to expect that prices for these two commodities are on average lower here than in the rest of the country. This is to say that for some variables the observations from Louisiana might be extreme. This is in a way similar to what Abadie et al. (2015) states about trying to match the inflation rate for West Germany: because the treated unit has the lowest value observed for that variable it is very hard to perfectly match that same value using a combination of the units from the donor pool, but the result achieved is much better than the one obtained using a simple average of the observations from the donor pool.
Table 2 below reports the different weights that are attached to each unit from the donor pool.

Table 2: State Weights in Synthetic Louisiana

State	Weight	State	Weight	State	Weight
Arizona	0	Arkansas	0	California	0
Colorado	0	Connecticut	0	Delaware	0
DC	0	Georgia	0.089	Idaho	0
Illnois	0	Indiana	0	Iowa	0
Kansas	0	Kentucky	0.138	Maine	0
Maryland	0	Massachusetts	0	Michigan	0
Minnesota	0	Missouri	0	Montana	0
Nebraska	0	Nevada	0	New Hampshire	0
New Jersey	0	New Mexico	0	New York	0
North Carolina	0	North Dakota	0	Ohio	0
Oklahoma	0.023	Oregon	0	Pennsylvania	0
Rhode Island	0	South Carolina	0.749	South Dakota	0
Tennessee	0	Utah	0	Vermont	0
Virginia	0	Washington	0	West Virginia	0
Wisconsin	0	Wyoming	0		

How to explain these weights? First of all, it is clear that all the units from the donor pool that are used to construct the synthetic Louisiana are southern states. This represents a large advantage for the study because using states that have a similar history and that are geographically close to Louisiana (rembmber that Texas and Mississippi, two bordering states, are left out of the donor pool) provides confidence in the quality of the pre-treatment period fit. Even if there are some control variables I might be missing, using states from the same area of the country could help control for these missing variables. The state that receives the largest weight is South Carolina and the other are, in descending order, Kentucky, Georgia and Oklahoma.

5.2 Results and placebo tests

In the following graph in Figure 1 I present the main result of the SCM. First of all, the pre-treatment fit is very good; for most of the periods it is almost impossible to distinguish synthetic Louisiana (the dashed line) from the real one (the solid one). The fact that synthetic Louisiana is able to match real Louisiana in the pre-treatment period is one of the most important aspect to consider when it comes to assessing the validity of the whole method (see Abadie (2019) and Botosaru and Ferman (2019) for a further discussion). There are of course some differences: synthetic Louisiana is slightly above the real one for some periods and slightly below for others but the overall quality of the fit is good.

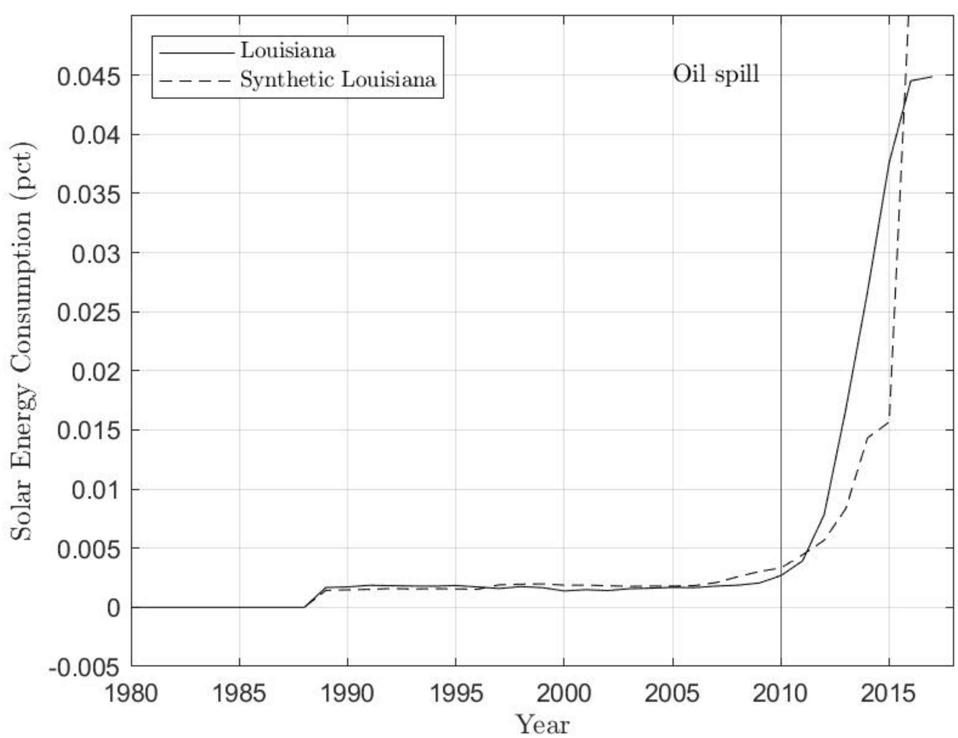


Figure 1: Path plot of Solar Energy Consumption during 1980-2017: Louisiana and Synthetic Louisiana.

The path of solar energy consumption for Louisiana in the pre-treatment phase is common to many other state. We observe a value of zero for some periods before a timid increase in 1988. The low price of fossil fuels is a major explanation for this pattern: there was no incentive to invest in alternative energy technologies if the mainstream ones were very cheap in a period when climate change concerns were not as relevant as they are today. The idea that the consumption of solar energy was 0 because no technology was available can be rejected as California was already investing in it as of 1984. However, as new policies are introduced in other states (such as the RPS) and as climate change concerns rise throughout the country, Louisiana too begins investing in solar energy and after 2010 an exponential growth can be observed. While the exponential growth is something experienced by synthetic Louisiana too, this is something that only begins after some periods and for the period 2010-2015 real Louisiana's share of solar energy consumption is much higher than the one observed in the synthetic state. In particular, for the period where the difference is at its peak, which is 2015, the value for Louisiana is about 0.023 percentage points (p.p.) higher than that of synthetic Louisiana. After all, while it is already possible to observe a higher solar consumption in the first post-treatment period, 2011, it is not surprising to see that the peak is reached 5 years after the event: it might take a while for citizens and local authorities to fund investments in solar energy and to really start benefiting from those. The excellent pre-treatment fit and the good fit for pre-treatment covariates really give confidence in this result. In order to provide a better visualization of the the results, I show here another graph, Figure 2, where I plot the difference between the two line to better understand the path of post-oil spill solar energy consumption in Louisiana.

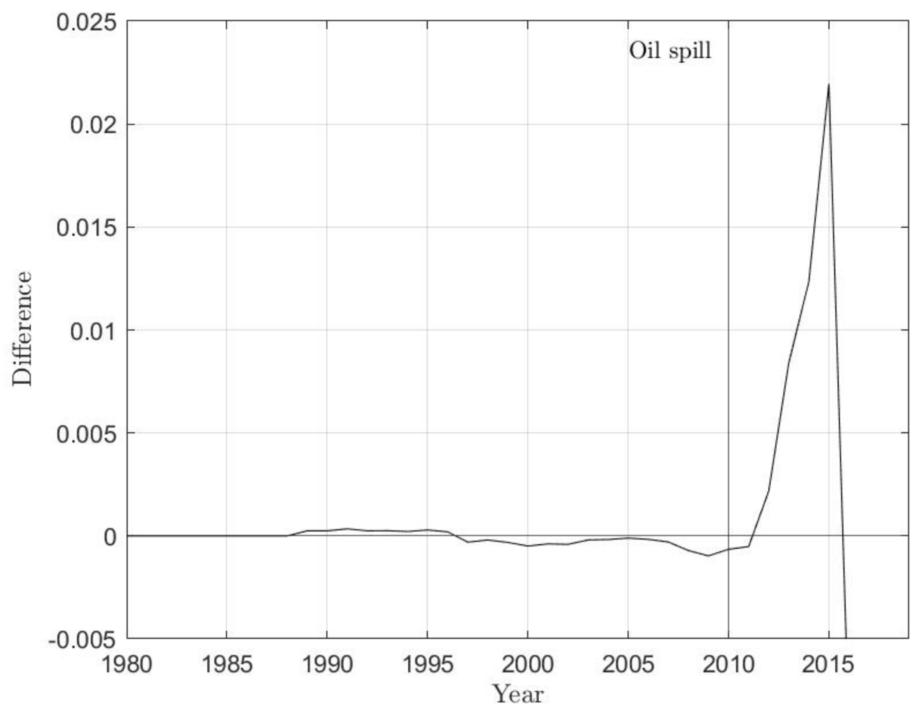
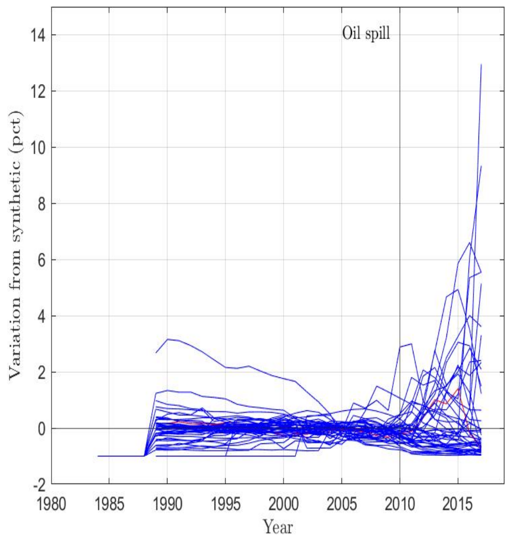


Figure 2: Path of the difference between Louisiana and synthetic Louisiana during 1980-2017.

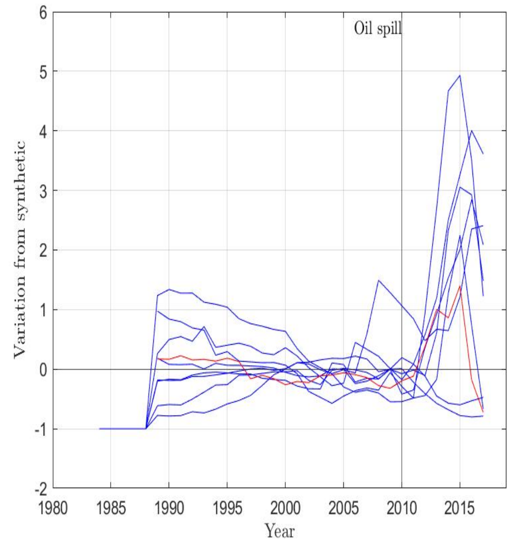
The graph above in Figure 2 provides further confidence in the results that were highlited before. It is clear that the difference between the two line is very close to

zero, slightly above it or slightly under it for some periods, for all the pre-treatment observations. At the peak, the difference between the treated unit and the synthetic one is around 0.023 percentage points. One other relevant thing to notice is that after an interval of high growth in solar energy consumption, the trend for real Louisiana slightly moves back to the level of synthetic Louisiana and then under it. This behaviour might be related to lower fossil fuels prices, which is a covariate that I control for, or to disappearing positive attitude toward renewable energy. It might well be the case that people were more concerned about climate change and environmental pollution right after the event but these concerns faded away after a while.
In order to provide additional confidence to the results outlined above, SCM literature would usually recommend running a series of placebo tests. These placebo tests are meant to study the sensitivity of the results to variations "in time" and "in space". Since the first appearances of SCM (Abadie et al. (2010) and Abadie and Gardeazabal (2003)) to the most recent ones (Andersson (2019)) the idea of what placebo tests to run has changed but the intuition behind them has remained a constant: "in time" placebo tests require shifting the treatment period backward in time, under the hypothesis that event was actually produced in a different period (of course, this could be done only to a limited extent because moving the placebo tratment too early in time would not provide enough pre-treatment observations); "in space' placebo tests would usually require lifting the restrictions that were initially imposed (add those units that were excluded because affected by the same event to the donor pool), applying the same method to all the units in the donor pool (this test is meant to understand how likely it is that one would have observed the same result if had taken a unit had been randomly drawn) and a "take-one-out" placebo test, where the units in the donor pool that recieved a weight are taken out one by one.

In the left graph of figure 3 I present the results obtained from applying the same SCM specification to all the units in the donor pool. The red line represents the result for Louisiana and is measured as a percent deviation from the synthetic counterpart. As of 2015 Louisiana does not actually show any particularly large effect compared to the other states. On the one side, 6 states out of the 44 in the donor pool does represents a large percentage, and it would imply that if I had randomly drawn a unit from the donor pool I would have had a 6/44 odds, or about 13.64 % chances, of finding a result at least as large as that observed for Louisiana, which is relatively high in the SCM literature. On the other hand, however, the second graph, the one on the right, tells a different story. I focus here on the units from the donor pool for which I observe unusually positive large values in 2015. While I really observe a much larger effect than the one I found for Louisiana, the performance of the pre-treatment period cast some doubt about how reliable most of these results might be. Given that the quality of the results is related to the quality of the pre-treatment period (Abadie (2019), Abadie et al. (2015), Abadie and Gardeazabal (2003)) it is clear that I cannot make any significant conclusion about the effect of the oil spill on solar energy consumption in the other states. Moreover, for some of them, the difference is negative for some periods after 2010 and only becomes positive after a while, providing additional evidence against the



(a) The path of solar energy consumption (percentage deviation from synthetic) for Louisiana donor pool unitsl



(b) The path of solar energy consumption (percentage deviation from the synthetic) for Louisiana and top performersr in 2015

Figure 3: Two graphs to study the relative effect of Deepwater Horizon oil spill on Louisiana and the other states in the donor pool

idea that what happened in 2010 could have affected their post-treatment values for the dependent variable. A different approach might have been to focus only on those states whose pre-treatment fit pattern is similar to that of Louisiana, but the conclusions would not probably change because these units would have a lower value as of 2015.

The LHS graph in Figure 4 shows the main result again but this time the states that were excluded because affected by the same event, namely Texas, Mississippi, Florida and Alabama, are allowed to be part of the donor pool. This implies that the donor pool is now formed by all the 48 contiguous states except for Louisiana, which is the treated unit. This change affects the result: the new weight matrix is now differently composed: Mississippi and Texas, mainly because of regional proximity, show similar values for some variables and are now assigned a large weight (the two states combined account for about 81% of this synthetic Louisiana). This of course has an impact on the magnitude of the result but its direction is still unchanged: from period 2010 onward real Louisiana still experiences an exponential growth and has a remarkably higher solar energy consumption compared to synthetic Louisiana. I again observe the same path after 2015: synthetic Louisiana recovers and takes over real Louisiana in 2016. Again, the magnitude of the result is changed: in 2015 the treatment unit is about 0.025 percentage points (p.p.) higher than its synthetic counterpart.. The graph on the RHS reports the difference between Louisiana and synthetic Louisiana. With respect to what observed before the pre-treatment is now even better. The effect is then shown after the 2010 oil spill: there is a spike in the difference and the maximum is reached, again, 5 years after the event, in 2015. As mentioned before, from then on the difference is abruptly reduced and eventually becomes negative.

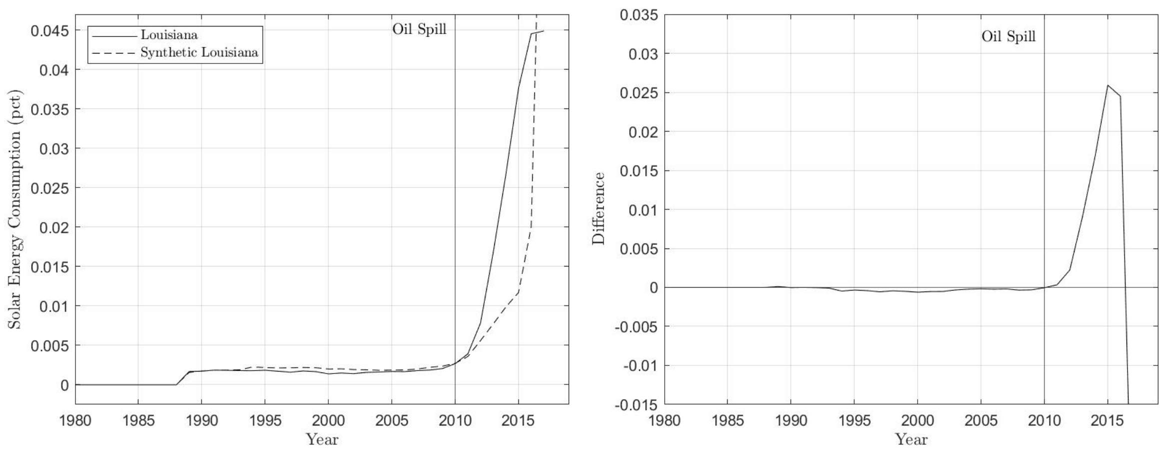


Figure 4: The SCM is run again but this time all the restrictions are lifted: the donor pool is now made of all the lower US states but Louisiana

The last "in space" placebo test that I am running is the "take-one-out" test; I am imposing the restrictions again on the units that form the donor pool and I am running the SCM again taking out, one by one, the donor units that received a weight. By doing so my aim is to prove that the results are not sensible to what units are gathered in the donor pool . In practice, this implies taking Georgia out of the donor pool and running the SCM again and then doing the same for all the other units in the donor pool that were assigned a positive weight (Oklahoma, Kentucky and South Carolina).

Figure 5 reproposes the main result of the SCM approach but in order to evaluate the sensibility of the finding to the composition of the synthetic unit I have run a placebo test where I take out, one by one, those units that received a positive weight. Of course, the black line for observed Louisiana does not change but given that the composition of synthetic Louisiana is what is really affected here, I observe some variations in the values of the synthetic unit. First thing to notice is that taking out the components of the synthetic unit one-by-one alters the result in two directions: first of all the quality of the pre-treatment fit is slightly compromised especially for few periods right before the treatment; second of all, while the direction of the results is left unchanged, its magnitude is really reduced in every case. These results might cast some doubts about the robustness of the findings. The fact that the quality of the pre-treatment is somehow threatened by this placebo test casts new doubts about the significance of the result that is observed. It is true that the direction of the effect is left unchanged as of 2015 but the lower quality of the pre-treatment fit cannot be ignored.

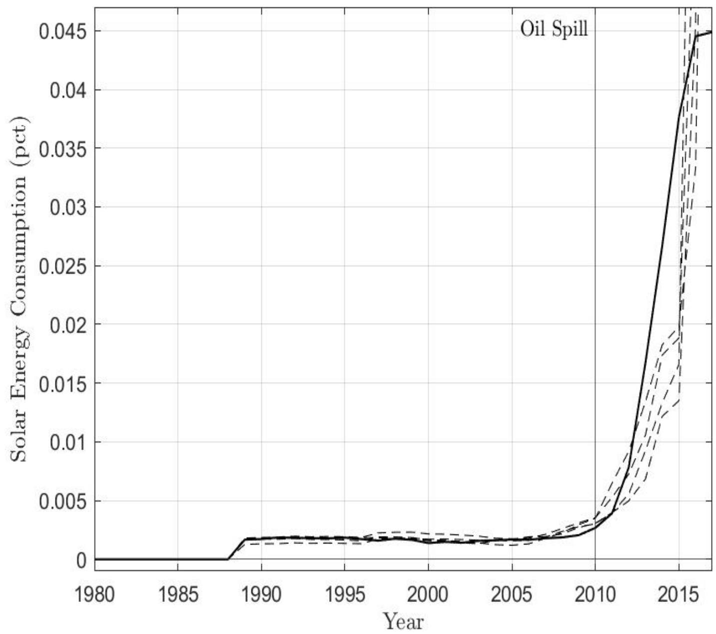


Figure 5: Placebo test run by taking out the units from the donor pool with a positive weight, one by one, during 1980-2017.

The last placebo test I am running in order to assess the significance of the result is the "in-time" placebo test which consists in moving the treatment period backward before the actual one.

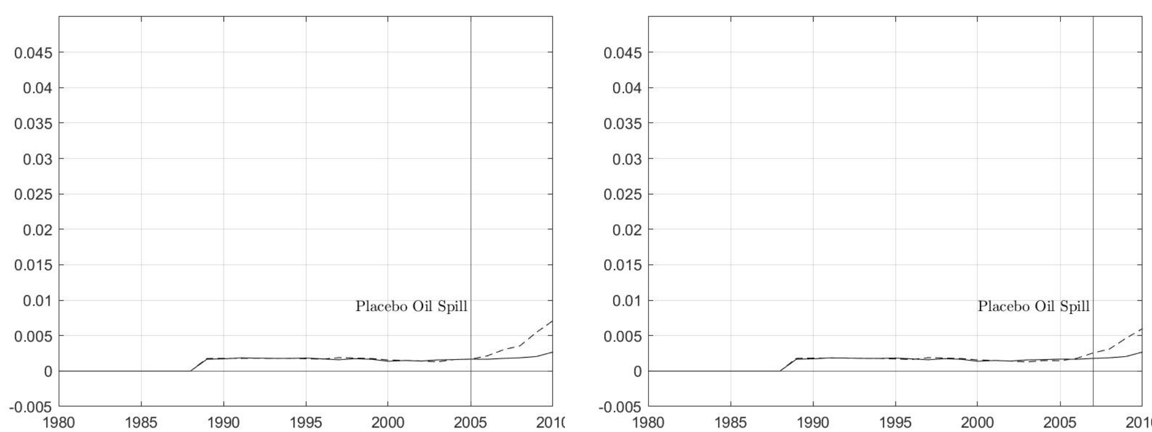


Figure 6: Results from the "in-time" placebo test for years 2005 and 2007

The results in figure 6 above represent the last step of the placebo tests that are

commonly used in the literature of SCM in order to assess the significance of the results. I have moved the treatment period before the actual one. The conclusion from the main specification in Figure should be robust no matter no matter what is the year to which I move the treatment period. However, it is already clear from the the two graphs in Figure 6 above that moving the treatment period to three years and five years before the actual event, to year 2005 and to 2007 already confirms the doubt about the significance and the robustness of the finding. I am keeping the size of the two graphs in Figure 6 unchanged with respect to Figure 1 so that it is as possible to compare the two figures. Of course, I am only focusing to the period 1980-2010 in Figure 6 because I only care about the pre-treatment fit and not about the whole result. Is clear that the quality of the pre-treatment fit is negatively affected by these changes.
The results from different placebo tests show that the result that is observed in the main specification of the study,while large, is not statistically significant. While the data really show that there is an exponential growth in solar energy consumption in Louisiana starting in 2010, there seems to be no causality effect between the oil spill and the increase in solar energy consumption.

6 Discussion and Conclusion

Using county-level data and state-level data this thesis has tried to understand how relevant the presence of the fossil fuels industry is in shaping locals' attitudes toward global warming. The two form of presence of the fossil fuels industry on which I focused are coal-fired electricity plants and oil and natural gas extractive activities. I used the data from the EIA form-860 to track the presence of regulated coal-fired electricity generator in each county in the US between 2014 and 2018 and data from the SEDS program from EIA for the period 1980-2017 to study the case of Louisiana after the Deepwater Horizon oil spill in 2010. Louisiana ranks among the first positions the USA in terms of how much of its GDP is generated from oil and gas extractive activities and in terms of the employment that these same activities provide: as of 2010, the year of the oil spill, 6.9% of the US GDP from oil and gas extraction came from Louisiana (BEA) and in the same year 4.4% (BEA) of the US employees in the same field were in Louisiana, while the state only accounted for 1.5% of the US population. As far as the presence of coal-fired plants is concerned, I cannot rule out that even people that don't work there but who live in the same county might profit from their presence. This is true for any auxiliary activity such as coal transportation and energy transmission, but it is potentially applicable to any other commercial enterprise in the same zone.

The idea I started with, that the presence of fossil fuels-related activities might reduce people's support for environmental policies and beliefs that climate change is really happening has found evidence in the results of this analysis. In fact, in the counties where a coal-fired electric generator is present, everything else constant, the share of people that believe that climate change is happening is 1.091 percentage points (p.p).

lower, the result is statistically significant no matter if I use the standard errors or the county-level clustered ones and significantly larger in rural coal plant counties. What is really interesting about the presence of coal-fired electricity generators is that they shape the preferences for environmental policies in different ways: some policies are more supported than others. For example, a general reduction of CO_2 emissions, no matter what the source, is less supported than Renewable Porfolio Standard (RPS) policies. And the result is robust even when I allow for it to be different in rural counties, where the presence of the coal plant might be more relevant to the local economy. However, if the policy specifies that the CO_2 emissions reduction should be restricted to coal plants (the sentence in the survey goes "Set strict CO_2 limits on existing coal-fired power plants") the counties where one of these is present show, on average and keeping everything else fixed, -2.954 percentage points (p.p.) of people supporting that policy and again, the result is even larger in rural coal plant-counties. The policy that finds a level of support as close as possible to that of other counties, where the reduction is the smallest, is the RPS policy. The sentiments toward global warming captured in the survey might reveal not just the opposition of coal plant's workers but potentially of their family members and of anyone else in the county that believes the plant's presence is important for the local economy. I cannot rule out the possibility that in some counties, especially where the plant is really old and where also a coal mine is present, community identity is another factor influencing the opposition to environmental polices: in counties that have a long history of reliance on fossil fuels-related activities and where these provided employment for many different generations, the feeling that these activities constitute the defining characteristics of the community may potentially be very strong (see for example Olson-Hazboun (2018)). A policy aimed at promoting energy production from renewable sources finds lower support in coal plants counties: the share of people that support a policy that would require at least 20% of the total energy to be produced from renewable sources is, on average and keeping everything else fixed, 0.256 p.p. lower but not statistically significant. A significant reduction in support is only observed in rural coal plant-counties. The observed lower support for such a policy coal plant-counties can be explained by the fact that it promotes different ways of producing electricity other than the coal plants. However, this risk of generating many competitors in the utility sector where these coal plants operate (remember that I am only focusing on electricity generators) is not perceived to be as dangerous as a policy that would promote a general reduction in CO_2 emissions. Respondents might be aware that, despite not making a precise reference to coal plants, this last policy might still affect any point in the energy supply chain that goes from coal extraction to the use of coal for electricity generation. Moreover, the RPS policy could be perceived as simply offering an alternative to the coal-fired plant. Maybe some of the respondents believe that replacing coal with renewable sources in the same county would not have any negative impact on the economy and on the labour market. It would just imply that the jobs lost due to restricted activities in the coal plant are compensated by the new possibilities offered by the renewable energy plant. Under this prospective, this hypothesis would contribute to explaining why an RPS policy does not find a support reduction as high as the one observed for the other two policies, both of which would require the closure or the reduction of the activities of the coal plant. Offering an alternative to the communities that would suffer the most from the negative effects of green policies on the local economy could potentially be a tool to make these policies more acceptable. The results really suggest that different policies produce different levels of support in coal plant communities, even though they all have the same goal of reducing pollutants emissions. As far as the closure of one or more coal-fired electricity generator is concerned, no statistically significant effect is found and the result is robust to different IV approaches and to a specification that considers the number of generators that were closed, as one might have expected a larger effect in the counties that experienced more closures.

A different approach to studying how the dependency on the fossil fuels industry can influence attitudes and beliefs toward climate change is the one where I studied solar energy consumption in Louisiana after the Deepwater Horizon oil spill. This variable represents a good proxy of attitudes toward environmental issues given how easier it is to produce energy from solar sources for citizens compared to other forms of renewable energy. The previous literature on the subject of the relationship between exposition to extreme events and views on climate change has established that, on average, the exposure to such events increase the share of people that believe that climate change is happening and the worry that a similar event might happen in the future (Baccini and Leemann (2020), Dixon et al. (2019), Whitmarsh (2008), Konisky et al. (2016), Dai et al. (2015), Sisco et al. (2017), Zanocco et al. (2018)) even when the exposure is only through media and the variation is observed in communities really far from the zones affected by the event (Goebel et al. (2015)). And the same result is observed in the communities of Mississippi that suffered the consequences of the same oil spill I am studying (Walters et al. (2014)). The placebo studies that I implemented to test the robustness of the results from the Synthetic Control Method suggest that there is no real causality of the oil spill on energy consumption from solar sources. And this result is consistent with the findings of many other papers that, using different approaches, investigated the same question in the same state. What I have done differently compared to these papers is focusing on solar energy consumption rather than just on sentiments and beliefs. This also came as the result of the necessity to focus on a time series as long as possible and finding one for the attitudes toward climate change is hard. The findings in Lilley and Firestone (2013) perfectly explain what I found here: no significant change in opposition to offshore drilling and no significant change in support to wind energy production were paralleled by no significant effect of the oil spill on solar energy consumption. And Hamilton et al. (2012) provide further support to the idea that the relevant presence of the fossil fuel industry in Louisiana is responsible, at least in part, for the lack of reaction that is observed. This theory is even more consistent when looking at the results of Walters et al. (2014) from Mississippi, a state where the oil and gas extraction industry accounts for about 1% of the GDP (BEA), where the concerns about the environment were increased by the same event. So, despite the general view on the topic that extreme events really affect people's views on environmental topics and despite the evidence from Mississippi, another state that was affected by the same event, the large relevance of the fossil fuels industry in Louisiana meant no real change in environmental issues. The particular case of Louisiana and the oil spill had already been studied by other papers which came to similar conclusions about the presence of the fossil fuels industry and I provided here further evidence in that direction.

The presence of fossil fuels-related activities seriously undermine the possibility of carrying out a painless transition toward a greener economic model. The presence of coal plants in some counties and the relevance of oil and gas extractive activities on Louisiana's economy represent two examples of the serious obstacles to the introduction of environmental policies and to the adoption of scientific views about global warming. While the data from coal plant counties suggest that some policies might be more acceptable than others, the oil spill in the Gulf of Mexico revealed how difficult it is to drive a change in people's environmental attitudes even after they experienced a disaster as large as that of the Deepwater Horizon oil spill. This is something policymakers should think about when planning policies to cut down use of fossil fuels.

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Appendix

Alternative IV approach: building year

Table A1: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.393	-0.162	-2.153	-4.425	-0.883
	[0.08285]	[0.7380]	[0.7090]	[1.5186]	[0.8799]
	(0.2801)	(2.1703)	(2.1993)	(3.8717)	(1.9853)
MW	0.0368	0.00886	-1.205	-4.435	-1.096
	[0.05520]	[0.4125]	[0.4286]	[0.7809]	[0.3774]
	(0.05408)	(0.4260)	(0.4317)	(0.7600)	(0.3897)
West	-0.0624	-2.447	-1.233	-5.941	-2.047
	[0.07035]	[0.6775]	[0.6925]	[1.0383]	[0.6499]
	(0.07971)	(0.6223)	(0.6306)	(1.1101)	(0.5693)
Education	-0.00171	0.0525	0.00966	0.0391	0.0436
	[0.002874]	[0.02236]	[0.02334]	[0.03829]	[0.02044]
	(0.003032)	(0.02345)	(0.02376)	(0.04183)	(0.02145)
Rural	0.0201	-0.306	-0.301	-0.330	0.0821
	[0.05598]	[0.4417]	[0.4475]	[0.8232]	[0.3999]
	(0.05805)	(0.4469)	(0.4528)	(0.7972)	(0.4088)
BuiltYear	-0.0147				
	[0.002027]				
	(0.002046)				
Closed_2016		0.881	1.049	1.028	1.454
		[1.0580]	[1.0694]	[1.9147]	[0.9044]
		(1.0808)	(1.0952)	(1.9280)	(0.9886)
N	247	247	247	247	247
F	11.75				

Standard errors in parentheses. County-level clustered erros in square brackets

The new instrument performs really well under the Validity assumption and the results really make sense: the coefficient is negative, implying that the older the average generator in the coal plant, the more likely it is that the coal plant will close one of its generators. And the result is highly statistically significant. But the fact that the average generator was built in 1970 helps making the restriction assumption more credible.

Fuel Cost 2011

Table A2: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.221	-0.422	-1.182	-3.694	-0.641
	[0.07572]	[0.8373]	[0.8796]	[1.6364]	[0.9560]
	(0.3028)	(2.2015)	(2.7779)	(4.2275)	(2.1245)
MW	0.182	0.102	-1.599	-4.800	-1.183
	[0.06795]	[0.4733]	[0.6062]	[0.9295]	[0.4520]
	(0.06613)	(0.4607)	(0.5813)	(0.8847)	(0.4446)
West	0.0535	-2.555	-1.030	-5.753	-2.085
	[0.08675]	[0.7125]	[0.8310]	[1.1255]	[0.6981]
	(0.09613)	(0.6437)	(0.8123)	(1.2362)	(0.6212)
Education	-0.000232	0.0540	0.00762	0.0435	0.0420
	[0.003275]	[0.02274]	[0.03037]	[0.04239]	[0.02197]
	(0.003339)	(0.02374)	(0.02996)	(0.04559)	(0.02291)
Rural	-0.00945	-0.312	-0.107	-0.0457	0.138
	[0.06291]	[0.4751]	[0.6118]	[0.9480]	[0.4586]
	(0.06394)	(0.4592)	(0.5794)	(0.8818)	(0.4432)
FuelCost2011	0.00108				
	[0.0003802]				
	(0.0003547)				
Closed_2016		-0.268	5.716	5.097	2.529
		[2.4753]	[3.0803]	[4.7656]	[2.4056]
		(2.3408)	(2.9536)	(4.4950)	(2.2589)
N	245	245	245	245	245
F	6.679				

Standard errors in parentheses. County-level clustered erros in square brackets

Fuel Cost 2012

Table A3: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.252	-0.448	-0.989	-3.438	-0.638
	[0.07419]	[0.8913]	[0.9995]	[1.7236]	[1.0003]
	(0.3051)	(2.2218)	(2.9916)	(4.4253)	(2.1439)
MW	0.181	0.114	-1.683	-4.912	-1.185
	[0.07183]	[0.4832]	[0.6571]	[0.9868]	[0.4619]
	(0.06921)	(0.4776)	(0.6430)	(0.9512)	(0.4608)
West	0.0482	-2.563	-0.969	-5.671	-2.084
	[0.08940]	[0.7237]	[0.8782]	[1.1681]	[0.7065]
	(0.09860)	(0.6507)	(0.8761)	(1.2961)	(0.6279)
Education	-0.000640	0.0540	0.00777	0.0437	0.0420
	[0.003320]	[0.02277]	[0.03243]	[0.04418]	[0.02198]
	(0.003362)	(0.02376)	(0.03200)	(0.04733)	(0.02293)
Rural	-0.0127	-0.318	-0.0631	0.0132	0.139
	[0.06365]	[0.4756]	[0.6573]	[0.9835]	[0.4632]
	(0.06444)	(0.4643)	(0.6251)	(0.9247)	(0.4480)
FuelCost2012	0.000991				
	[0.0004142]				
	(0.0003848)				
Closed_2016		-0.402	6.688	6.394	2.544
		[2.8500]	[3.7767]	[5.4682]	[2.7733]
		(2.7499)	(3.7027)	(5.4774)	(2.6536)
N	245	245	245	245	245
F	9.988				

Standard errors in parentheses. County-level clustered erros in square brackets

Fuel Cost 2013

Table A4: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.298	-0.486	-1.331	-3.655	-0.860
	[0.08259]	[0.9152]	[0.9168]	[1.7309]	[1.0020]
	(0.3071)	(2.2286)	(2.6711)	(4.2905)	(2.0440)
MW	0.168	0.130	-1.534	-4.817	-1.088
	[0.06938]	[0.4878]	[0.5980]	[0.9744]	[0.4480]
	(0.06686)	(0.4808)	(0.5763)	(0.9257)	(0.4410)
West	0.0357	-2.575	-1.078	-5.741	-2.155
	[0.08640]	[0.7306]	[0.8004]	[1.1356]	[0.6913]
	(0.09692)	(0.6529)	(0.7825)	(1.2568)	(0.5988)
Education	-0.000249	0.0540	0.00749	0.0435	0.0418
	[0.003319]	[0.02283]	[0.02888]	[0.04261]	[0.02087]
	(0.003359)	(0.02381)	(0.02854)	(0.04584)	(0.02184)
Rural	-0.0109	-0.327	-0.141	-0.0368	0.0880
	[0.06383]	[0.4785]	[0.5951]	[0.9633]	[0.4426]
	(0.06467)	(0.4658)	(0.5583)	(0.8968)	(0.4272)
FuelCost2013	0.00101				
	[0.0004317]				
	(0.0003993)				
Closed_2016		-0.593	4.963	5.294	1.423
		[2.9748]	[3.3752]	[5.4568]	[2.7031]
		(2.8102)	(3.3682)	(5.4102)	(2.5775)
N	245	245	245	245	245
F	9.971				

Standard errors in parentheses. County-level clustered erros in square brackets

Fuel Cost 2014

Table A5: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.294	-0.836	-1.114	-3.762	-1.069
	[0.08640]	[1.0651]	[1.1164]	[1.9059]	[1.0892]
	(0.3098)	(2.3826)	(2.9207)	(4.3054)	(2.0356)
MW	0.147	0.283	-1.628	-4.770	-0.997
	[0.06808]	[0.5686]	[0.6989]	[1.0718]	[0.4870]
	(0.06618)	(0.5408)	(0.6630)	(0.9773)	(0.4621)
West	0.00309	-2.687	-1.009	-5.775	-2.221
	[0.08413]	[0.7751]	[0.8504]	[1.1317]	[0.7108]
	(0.09504)	(0.7002)	(0.8583)	(1.2653)	(0.5982)
Education	0.0000341	0.0537	0.00767	0.0434	0.0416
	[0.003347]	[0.02414]	[0.03102]	[0.04190]	[0.02034]
	(0.003376)	(0.02501)	(0.03066)	(0.04520)	(0.02137)
Rural	-0.0222	-0.407	-0.0916	-0.0614	0.0400
	[0.06381]	[0.5069]	[0.6603]	[0.9833]	[0.4387]
	(0.06457)	(0.4998)	(0.6126)	(0.9031)	(0.4270)
FuelCost2014	0.000866				
	[0.0004537]				
	(0.0004334)				
Closed_2016		-2.360	6.060	4.752	0.368
		[3.8656]	[4.5741]	[6.9785]	[3.3257]
		(3.7057)	(4.5426)	(6.6963)	(3.1661)
N	245	245	245	245	245
F	10.54				

Standard errors in parentheses. County-level clustered erros in square brackets

Number of closures

Table A6: OLS estimate of global warming attitudes change

	(1) ΔRPS_support	(2) ΔCO2_limits	(3) ΔCO2_Plant	(4) ΔHappening
NE	-2.264	-1.132	-4.584	-0.309
	(2.2100)	(1.9564)	(3.9028)	(2.1751)
	[0.6825]	[0.8862]	[1.4994]	[0.7268]
MW	-1.133	-0.977	-4.354	0.0803
	(0.4252)	(0.3764)	(0.7508)	(0.4184)
	[0.4184]	[0.3610]	[0.7529]	[0.4054]
West	-1.240	-2.125	-5.983	-2.492
	(0.6338)	(0.5611)	(1.1193)	(0.6238)
	[0.7062]	[0.6614]	[1.0564]	[0.6923]
Education	0.0104	0.0435	0.0392	0.0525
	(0.02399)	(0.02124)	(0.04237)	(0.02361)
	[0.02362]	[0.02037]	[0.03908]	[0.02278]
Rural	-0.302	0.0327	-0.356	-0.334
	(0.4557)	(0.4034)	(0.8048)	(0.4485)
	[0.4523]	[0.3962]	[0.8358]	[0.4469]
n_closures	0.217	0.0788	0.0971	0.0568
	(0.1731)	(0.1532)	(0.3057)	(0.1703)
	[0.1448]	[0.1326]	[0.2977]	[0.1748]
N	247	247	247	247
R^2	0.049	0.079	0.171	0.116

Standard errors in parentheses. County-level clustered erros in square brackets

Table A7: IV estimates of climate change attitudes shifts

	(1) Closed_2016 (FS)	(2) ΔHappening	(3) ΔRPS_support	(4) ΔCO2_Plant	(5) ΔCO2_limit
NE	-0.574	-0.411	-1.419	-3.766	-0.679
	[0.2051]	[0.8194]	[0.7869]	[1.5563]	[0.9097]
	(0.8168)	(2.1944)	(2.7082)	(4.2890)	(2.1351)
MW	0.334	0.0875	-1.291	-4.554	-1.061
	[0.1908]	[0.4208]	[0.5420]	[0.8576]	[0.4126]
	(0.1808)	(0.4234)	(0.5225)	(0.8275)	(0.4120)
West	-0.0305	-2.567	-0.763	-5.417	-1.920
	[0.1830]	[0.7524]	[0.8282]	[1.1815]	[0.7361]
	(0.2577)	(0.6929)	(0.8552)	(1.3544)	(0.6742)
Education	-0.00521	0.0536	0.0170	0.0534	0.0469
	[0.007795]	[0.02335]	[0.03087]	[0.04485]	[0.02325]
	(0.008991)	(0.02424)	(0.02992)	(0.04738)	(0.02359)
Rural	-0.133	-0.322	0.0950	0.207	0.262
	[0.1615]	[0.5330]	[0.6539]	[1.0583]	[0.5108]
	(0.1724)	(0.4969)	(0.6132)	(0.9711)	(0.4835)
FuelCost	0.00258				
	[0.0009603]				
	(0.0009489)				
n_closures		-0.0966	2.074	2.172	1.073
		[1.0558]	[1.3026]	[2.0462]	[1.0454]
		(0.9732)	(1.2011)	(1.9022)	(0.9469)
N	245	245	245	245	245
F	8.326				

Standard errors in parentheses. County-level clustered erros in square brackets

Wind and solar potential maps

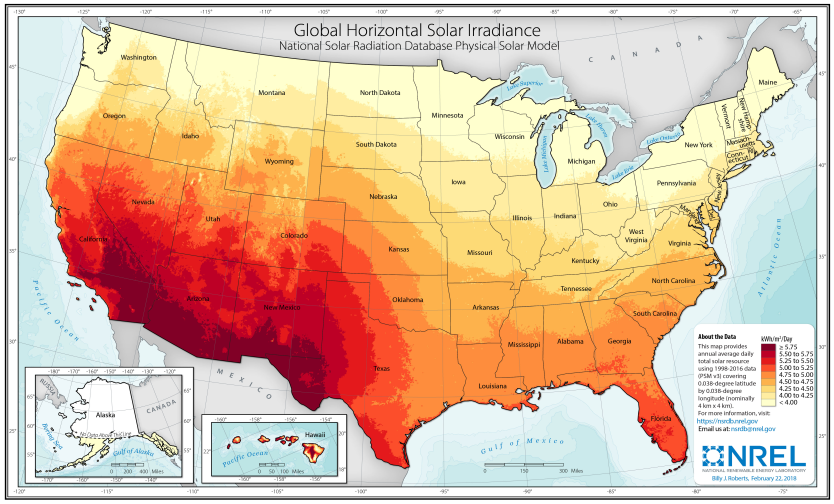

Figure A1: The map provides the annual average daily Kilowatthours per squared meter that could be produced using photovoltaic cells. Source: Sengupta et al. (2018)

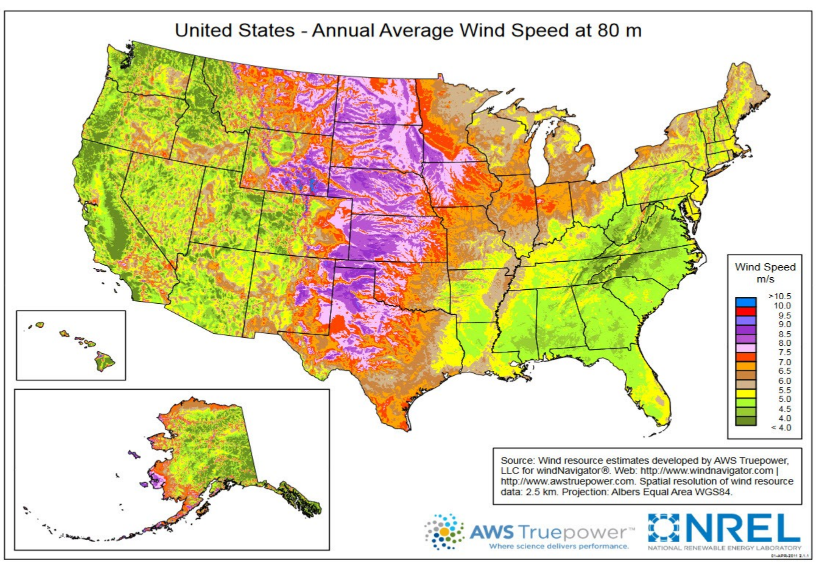

Figure A2: U.S. Average Annual Wind Speed at 80 meters: The map shows the predicted mean annual wind speeds at an 80-m height. Areas with annual average wind speeds around 6.5 meters per second and greater at an 80-m height are generally considered to have a wind resource suitable for wind development. Source : https://windexchange.energy.gov/maps-data/319

Synthetic Control Method: the Theory

The method that I will apply in order to understand the way renewable energy consumption was affected by the Deepwater Horizon Oil Spill of 2010 is the Synthetic Control Method (SCM) as first developed by Abadie and Gardeazabal (2003) and that has found wide application in several different fields in recent years (see Cavallo et al. (2013), Abadie et al. (2015), Coffman and Noy (2012), Barone and Mocetti (2014), Abadie et al. (2010), Born et al. (2019), Andersson (2019)). The main advantage of the method is that it makes possible to obtain estimates of the effects of events that only involve one unit and for which we are not able to find any suitable unit of comparison. In most of the cases these affected units are represented by aggregated entities such as states, macroregions, provincies, regions and so on. The underlying idea is to construct a "synthetic" unit that resembles the affected one for all the pre-treatment observations. The longer the pre-treatment period and the closer the syntjetic pre-treatment observations to the ones from the treated unit the more reliable the results that will be obtained. In cases where the pre-treatment fit is not satisfying or the number of pre-treatment observations is not large enough, the researcher is strongly advised against using the Synthetic Control Method (see Abadie et al. (2015) on the limitations of the approach and on recommendations for empirical practice). On the other hand, the researcher might sometimes need to use a long series of post-treatment periods too if she believes that the effect of the treatment is only observed after several periods. In practice, the units that consitute the donor pool, those that are used to construct the synthetic unit that resembles the treated one, should be as similar as possible to the trated unit: in many cases the elements of the donor pool belong to the same international economic organization as the treated unit, or they are states from the same continents as the treated unit or regions from the same state. However, should there be any chance that one or more units in donor pool are either affected by the same event or by any idiosyncratic shock that might influence the value of the dependent variable, these units should be left out of the donor pool and not considered when constructing the synthetic counterpart. In the following application I will present the treated unit is the US state of Louisiana and the donor pool is composed of all the other US states. However, because, given their proximity to the Gulf of Mexico, some other states might have been influenced by the oil spill, I am leaving out Texas, Mississippi, Florida and Alabama.

I am now providing here an intuition of how the method works: suppose we can observe $J+1$ units and that the first unit among these is the one affected by the event (any single unit in the group can be the treated one, the assumption does not compromise the generality of this analysis). This implies that the other J units are left unaffected by the treatment and can then be used for comparison. Assume that no single unit among these J can provide a valid counterpart for this analysis. The approach used in the SCM is then to use these units from $J = 2$ to $J + 1$ to compose the "donor pool". Furthermore, assume that the sample is a strongly balanced panel: all variables,

the dependent one and the independent as well, are observed for all units, those in the donor pool and the treated one, at each time period $t = 1, ..., T$. It is necessary to assume that we have the treatment period among this set of time periods; that is, we need to be able to devide the whole set of time periods into a "pre-treatment" group and a "post-treatment" group, where we denote the treatment period as T_0. The unit of interst, the treatment unit, is exposed to the event along the periods $T_0 + 1, ..., T$ and the event has no effect on the observations for the pre-treatment periods (the time periods $1, 2, ..., T_0$). Note here that it might sometimes be necessary to distringuish the actual treatment period from the official one. This is often the case when the SCM is used to study policies and reforms: if a new policy is announced before being actually introduced, this might affect the expectations of the people and they might decide to change their behaviors accordingly. If there is any doubt that this is indeed the case, it is better to place the treatment period not to the moment when the policy comes into existance but to the moment when it was first announced and people first changed their expecations for the future. However, this is a concern that I do not need to think about: in the event of natural disasters it is reasonable to assume that no one could see it happen in advance and so the treatment period is placed exactly at the time period when the event happens. Given that none of the elements in the donor pool is individually able to provide a valid counterpart to the treated unit we will have to construct a synthetic control, which is simply defined as a weighted average of the elements that consitute the donor pool. This is to say, take the vector of weights $W = (w_2, w_3, ..., w_{J+1})'$, whose dimension is $(J \times 1)$, with $0 \leq w_j \leq 1$ for $j = 2, 3, ..., J$ and where $\sum_{j=2}^{J+1} w_j = 1$.
The idea here is to choose the elements in the W vector so that the resulting synthetic control matches the treated unit in the pre-treatment periods. Let X_0 be a $(k \times 1)$ vector that contains the pre-treatment values of the independent variables that are used to predict the dependent variables for the treated unit. Similarly, let X_1 be a $(k \times J)$ matrix containing the pre-treatment values for the same independent variables that are used in X_0 but for the J elements in the donor pool. Actually, it is not uncommon, in order to provide to increase the quality of the pre-treatment fit, to include lagged values of the dependent variable in X_0 and X_1 for the treated unit and the donors respectively. The problem that follows now is a minimization problem: we need to find the optimal values for the W vector, W^*, that minimizes the difference $X_0 - X_1 W$. In a very easy way, we procede as follows: for $m = 1, 2, ..., k$, let X_{0m}, be the value of the m-th variable for the trated unit and the X_{1m} be a $(1 \times J)$ vector containing the values of the same m-th variable for each unit in the donor pool. Then, the vector W^* we look for is the one that minimizes :

$$\sum_{m=1}^{k} v_m (X_{0m} - X_{1m} W)^2 \tag{3}$$

Where v_m is another weight vector that reflects the relative importance that is assigned to the m-th variable when the difference between trated unit and synthetic controls is

measured. Actually, the approach proposed in equation (1) is the one used in Abadie et al. (2010) and in Abadie and Gardeazabal (2003), but a more general approach would be to choose any norm $\| \cdot \|$ and use that to minimize the distance between the synthetic unit and the treatment unit. For example, a very common approach is to use $\|X_0 - X_1 W\| = \sqrt{(X_0 - X_1 W)'(X_0 - X_1 W)}$.
Let Y_0 be a $((T_0 + 1) \times 1)$ vector that stores the post-treatment values of the dependent variable for the treated unit. Similarly, let Y_1 be a $((T_0 + 1) \times J)$ matrix where the j-th column contains the values for the dependent variable for unit $j + 1$. The final result we are looking for is given by the difference between the value of the dependent variable for the treated unit and for the synthetic one for a given year. If the pre-treatment fit is sufficiently good we can use the synthetic unit, which has not been affected by the event, as a doppleganger for the treated unit and obtain an estimate of the impact of the event in every period after the treatment period by simply computing, $\forall t \geq T_0$:

$$Y_{0t} - \sum_{j=2}^{J+1} w_j^* Y_j t \tag{4}$$