Hurricanes, Natural Disasters, and Climate Salience

EC 590 Research Proposal

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Introduction

Climate change is the central issue of our time. The Paris Climate Accords set a target limit between 1.5° C and 2° C to prevent insecure food and drinking water supplies, loss of biodiversity, and large scale events such as increased hurricanes or fires (IPCC, 2014b, 2018). There is an overwhelming scientific consensus climate change is anthropogenic, yet pollution continues unabated, and the temperatures rise. Markets seem to have a hard time incorporating these expectations in production decisions.

Achieving the Paris climate target requires people adapting their production and consumption decisions to internalize the pollution externality of various commodities. If pollution is an externality as it is normally treated in basic economic models, people have no reason to adapt their decisions, and pollution will continue unabated. A competing theory says that people are over producing and consuming commodities because they underweight the probability of climate related events such as hurricanes (Bordalo et al 2012). In the latter case, people's decisions should change if the salience of such an event increases. One way this could happen is by living through a hurricane or fire.

The two theoretical frameworks for why people pollute have drastically different policy implications. If pollution is caused by an externality, it needs to be corrected with a

mechanism through which the pollution is internalized. This can be either a tax or subsidy (Holterman 1976). If however pollution is caused by incorrect decision weights, the policy implications are unclear. We should observe polluting behavior changing in the aftermath of a climate event. This however, is not an actionable policy; we cannot ethically force decision makers into hurricanes. Pollution correction becomes a much harder problem if salience is its main driver.

This proposal has two main aims. First, I will add to the body of literature reviewed below which finds that climate events such as hurricanes change people's salience of climate change. Previous studies have found that people search more for climate related terms, and Senators and shareholders vote for more pro-climate proposals (Herrnstadt and Muehlegger 2023)(Fich and Xu 2023) after a hurricane. My focus will be on how people's strategic behavior in hiding polluting activity changes. This is like the "first stage" of an instrumental variables study. We really care about if pollution actually decreases in response to changing salience, so the second contribution will be running the "second stage" of the study. I will test if a change in salience decreases pollution directly. I will do this by testing if cities/counties which are not hit by a climate event, but are similar to areas that are decrease their pollution in a "climate sympathy" action.

Literature Review

Salience

As it is a central premise of the proposal, I will briefly review the theory of salience following Bordalo et al 2012. Consider an agent with value function:

$$V(L_i) = \Sigma_{s \in S} \pi_s v(x_s^i) \tag{1}$$

Where L_i are lotteries the agent chooses between which here are consumption decisions. S are states of the world, and each sub state s occurs with an unchanging, known probability π_s. x_s^i are payoffs in each state.

The intuition here is that the agent is choosing between lotteries which here represent the state of the world where they produce/consume many commodities (where thus the risk of climate events is increased), and the state of the world where they produce/consume few (where the risk is small). Simply, the agent is choosing to produce/consume a lot and be at risk for hurricanes, or consume little and so be safe from them. In the standard model presented above, the probability of being in a hurricane is known in each state, so the agent can make the optimal decision to choose which state to be in.

Under the salience model, π_s is no longer unchanging and known. The probabilities are distorted in two steps. First, the agent ranks the states in S by salience, this then determines the probability π_s^i. The salience function σ determines the salience ranking. Bordalo et al show that events with the smallest probability are subject to the greatest distortion, and in contrast to Tversky and Kahneman 1979, these low probability events can be either over or under weighted.

Under the salience model, the agent under weights the probability of hurricanes in the high production/consumption state of the world, so when choosing between high and low consumption, they are more likely to choose the former. Because they under weight the risk, this is no longer the optimal decision, and we can have over production/consumption. If a hurricane can decrease the salience distortion, we would then return to the no salience world, and the agent would once again make the optimal decision.[1]

Climate Salience Affect Actions

There are several papers describing changes in behavior following a climate event which use similar methodology to mine. I describe several of them here. The first paper I can find

[1]Mapping this model to my situation here is still a work in progress. For now this is just for intuition.

which that tries to measure changing climate salience is from Herrnstadt and Muehlegger in 2013. They used google search patterns as a proxy for salience, and find that searches for terms like "climate change" and "global warming" trend up following extreme shifts in weather patterns. Using this as an instrument, they then show that congress members vote for more pro-environmental issues after their home state was hit by an extreme weather fluctuation.

There are several gaps in this that my paper will help to address. It is an observational study. They control for fixed effects to try and isolate the effect of the climate changing on search results, but obviously this is not realistic. My paper will as described later use diff-in-diffs methodology to isolate the causal effect. While changing voting patterns is certainly interesting, my paper aims to measure the direct effect of pollution decreasing following a climate event. There are several other papers that attempt to do the same.

One such paper is Ji and Cobourn (2021) who study the long run impact of weather fluctuations on output. Unlike the majority of papers studying climate salience (including this proposal) they avoid looking at only contemporaneous effects of weather fluctuations by seeing if fluctuation in the weather affect agricultural output in the future. Output decisions are modeled as a function of the expectations of natural endowments which are themselves functions of past realizations of agricultural output. A climate shock can change realizations which affect future production decisions. The paper's main finding is that farmers don't form these expectations perfectly rationally. Instead, they adopt various heuristics which can cause over reactions to small weather fluctuations. This suggests that the effects I observe in response to hurricanes may be large, and the decrease in pollution may be significant.

Another such paper by Fich and Xu (2023) finds that institutional shareholders support more environmental friendly proposals after experiencing a hurricane. This effect holds even when the firm was not affected by the hurricane, and the shareholder has no history of voting for such proposals before. The authors use a diff-in-diffs with funds who's location was hit by a hurricane as the treatment group, and similar funds that weren't hit as a control. The

shareholders in each of the groups voted the same proposals such as "adopt quantitative greenhouse gas emission goals". This paper is similar to my design. I also propose using a diff-in-diff design to detect the changing salience and outcomes. My paper is differentiated here because again I aim to measure the direct effect on pollution rather than indirect outcomes such as voting which may or may not lead to changes in pollution.

Strategic Air Monitoring

When using air pollution as an outcome variable, it is important to measure it correctly. Zho (2021) shows that this is not as easy as it sounds. Air quality, measured as the particulate matter concentration in the atmosphere is monitored under the Clean Air Act using ground based monitoring stations. Due to budget limitations, many monitors are only run one one-in-six day schedules. Because there are penalties for failing to meet emissions goals, this creates an incentive to strategically reduce air pollution on monitored days to fool regulators. Zho shows that there is a 7% drop on monitored days.

As I will discuss below, this affects the data I will use for the project, and also provides an opportunity to find another way to test the changing salience in response to a hurricane.

There exists a gap in the literature to measure a direct effect of the changing of climate salience. Previous papers have focused on proxy variables which are like the "first stage" of a two stage regression. They have shown that climate events can affect people's actions, but are missing the "second stage" where we see how those actions translate into a possible reduction in pollution.

Data

I currently have three data sources for this project. To measure the effect of hurricanes on pollution output, we need data on both where hurricanes strike, and a way to measure air pollution. We also need to correct for the strategic monitoring effect described by Zho.

The first two data sources described below deal with the effect, and the third lets me track hurricane strikes.

MODIS

MODIS stands for Moderate Resolution Imaging Spectroradiometer. It is one of the key instruments on board NASA's Terra and Aqua satellites. The instrument measures aerosol concentration in the atmosphere by measuring the scattering of sunlight. The satellites orbit in such a way that they view the entirety of the Earth's surface every one to two days.

This is the "space truth" of air pollution. I will use this as the main measure of pollution. The other use for this data will be to detect the pollution gap that Zho detected. I will explain in further detail in the methodology section.

AQS

AQS is the air quality monitoring system by the EPA. This is the "ground truth". This data comes from the thousands of local ground based air quality monitors mandated by the EPA. The aerosol measure is slightly different that the one reported by MODIS, but following Zho (2021), I will treat them as comparable.

I won't use this data set for the main test because of the strategic reporting issue. This data will be used to test if salience changes in the "first stage".

National and Central Pacific Hurricane Center

This data set provided by NOAA provides detailed information on every hurricane to make landfall on the US gulf and east coasts as well as the Mexican east coast. Along with latitude and longitude data, it also contains air pressure and wind speed measurements at 15 minute intervals throughout the landfall. The pressure and wind speed data allows the treatment to not just be binary (does a hurricane hit or not), but continuous. I can test how the intensity

of treatment affects the outcome, rather than just the binary event.

Methodology

I have two different specifications for this research proposal. This first is the "first stage" of testing if hurricanes affect climate salience in which I will test if people's strategic hiding of air pollution changing following a climate event. The second is the "second stage" where I will test if the hypothetical change in salience follows through to an actual decrease in pollution. Both tests will use a diff-in-diffs specification. My source of exogenous variation is hurricane strikes. For cities situated in hurricane prone areas, which city is hit is plausibly random, so we can use a hurricane strike as the event for the diff-in-diffs specification.

One difficulty in both of these test is that I cannot directly test if areas directly hit by a hurricane, fire, or other climate event change their behavior following the event because the climate event directly has a direct effect on pollution. A hurricane for example will likely damage polluting infrastructure if it has enough power to cause a change in salience. This is not an interesting effect for my purposes; I want to investigate the indirect, potentially longer lasting effect from change in beliefs. Therefore the treatment group will be similar areas not directly hit by the hurricane such as towns in the same state with similar susceptibility to hurricanes. For example, Mobile, Alabama and Tallahassee, Florida both have populations around 200,000 and similar risk of hurricanes hitting from the Gulf of Mexico. It is plausible that a hurricane hitting Mobile would be big news in Tallahassee and cause people to reevaluate their climate beliefs. The control group would be similar cities with no risk of hurricane such as Huntsville, Alabama which has a similar population but is inland enough to not be at risk of hurricane strike.

The other possibility is to use wind speed and pressure to test if the intensity of a hurricane affects salience. In this case I could use directly hit cities as the treated group, but limit the sample to areas where the intensity was low enough to plausibly avoid the

direct affects on pollution from the hurricane. Given the high fidelity of my data sources, I have the opportunity to test for urban/rural heterogeneity in any specification. I will use the same methodology for each of the two following specifications.

"First Stage"

The first part of this proposal tests if people's strategic hiding of pollution changes after they experience a climate event. Zho (2021) showed that because air quality monitors are only turned on once every six days, there are large incentives for government officials to decrease pollution levels only on the monitored day to look better, and avoid any repercussions from high levels of pollution. I propose to test if this behavior changes after a similar area has been hit by a hurricane.

I view this test as a continuation of the research presented above where an indirect but important effect of the change in salience is identified. If I identify a decrease in strategic hiding of air pollution, this is an important step in reducing emissions. Accurate data allows researchers and government agencies to correctly assess the climate situation and adapt policies to fit the situation instead of hunting ghosts of misreported data.

"Second Stage"

The second part of the proposal tests if pollution actually changes in response to the change in beliefs found in the literature and my proposed first stage. Here, I will test if cities similar to one hit by a hurricane experience a "climate sympathy" effect. I propose that if a city is hit by a hurricane, similar cities may realise their true risk of climate events is higher than previously thought, and the salience distortion will diminish. In this case, they may decrease output and pollution in response. I view this as the more important of the two tests as it aims to identify a direct effect of reduced air pollution levels.

A limitation to this test is that my prior is this effect will be fairly small. I also have a small sample size given the limited number of plausibly similar areas on the US gulf and

East coasts, so the effect my not be detectable with this methodology. A synthetic control specification may help with this problem.

Conclusion

This proposal contributes to the literature in two ways. First, it adds to the body of evidence that experiencing a climate event can change climate salience and promote pro-climate actions using a novel outcome measuring a change in strategic hiding of pollution data. Second, it expands the literature to directly measure the change in pollution following a change in salience from experiencing a climate event.

The policy implications of any paper in this strand of literature are murky. The government cannot mandate anyone directly or indirectly experience a hurricane, so there is no clear way to make use of these effects. Knowledge of this effect may even be a net negative for climate policy as it could lull policy makers into a false sense of security that over-pollution will correct itself as more people's salience is corrected from increasing hurricane frequencies. Never-the-less, I think the results would be important. Knowledge of different channels through which over-pollution is corrected allows for a clearer picture of the climate, and how we can keep the world livable.

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