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Thermometer of Discrimination: Analyzing the Nexus between Temperature and Hate Crimes

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ABSTRACT

Using daily variation in temperature and hate crime incidents across US counties, this paper estimates the impact of temperature on episodes of discriminatory violence. Results indicate the existence of significant contemporaneous effects of temperature on hate crimes. The intensity of such effects is higher on days with higher temperatures and lower on colder days. Our estimates also highlight a high degree of heterogeneity of these effects depending on the local socio-economic context. These effects are stronger in counties with a high share of unemployed, uneducated, and low-income population, as well as where racial fractionalization is large. Temperature effects do not depend on political orientation or the degree of political polarization of the population.

KEY WORDS: Climate change, Discrimination, Hate crime, Temperature, Weather.

JEL CODES: K38, Q54, J1

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1. Introduction

Adverse weather and climate variation can affect societies and their welfare in numerous ways (Carleton and Hsiang, 2016). Among such effects, there is mounting empirical evidence that temperature can induce behavioral problems, trigger aggression and interpersonal violence especially in areas with higher levels of social disadvantage (Mares, 2013).

Temperature influences violent behavior through both direct and indirect ways. Directly, extreme heat heightens physiological discomfort, potentially increasing irritability, and inclination to anger (Anderson et al., 2000; Miles-Novelo and Anderson, 2019). This can lower tolerance thresholds and possibly lead to discriminatory behavior, especially in contexts where prejudice already exists. Indirectly, high temperatures can have obvious social impacts that may contribute to the onset of violence. For instance, severe weather conditions can amplify resource competition and worsen economic conditions, which may exacerbate existing socio-economic disparities and increase tensions among diverse groups (Burke et al., 2015; Miguel et al., 2004). Under these scenarios, minorities may become the target of violence as dominant groups struggle to protect their interests. Lastly, temperature also affects the frequency of social interaction, with more/less people gathering in public spaces during warmer/colder weather, which can alter the opportunity for conflict to arise (Jacobs et al., 2007). In summary, temperature's direct impact on human behavior and its indirect socio-economic effects due to extreme weather can both contribute to increased violent behavior, disparities among socioeconomic groups, and provoke discriminatory violence.

While the link between temperature and violent behavior has been established, there is still limited empirical evidence on how temperature may exacerbate aggression toward marginalized groups. This paper contributes to the literature on temperature and violent behavior by studying the relationship between daily temperature variations and hate crime incidents across various U.S. counties. Hate crime is considered an extreme form of criminal discrimination. It involves criminal actions that are motivated by bias or prejudice against a particular group or an individual due to their perceived characteristics (e.g., gender and sexual orientation), appearance (race), or belief (religion). We reveal the temperature-violent-discrimination relationship by examining the heterogeneous temperature effect on hate crime incidents across different levels of socio-economic conditions of county population such as unemployment, low education, poverty, and racial fractionalization.

To identify the plausibly causal relationship between temperature and discriminatory violence, we exploit daily variation in temperatures and hate crimes within a county-year cell in the period 1996-2018. This allows us to remove potential (statistical) bias due to the inconsistent reporting of hate crimes both within and across counties over time, which could correlate with socio-economic factors also affecting discriminatory behavior. Our results provide evidence for temperature effects that are economically meaningful and statistically significant. Specifically, we find that the probability of hate crime incidence on a particularly warm day is nearly 10 percent higher than on a day with mild temperature. We also find that warm temperatures significantly increase the number of offenders and victims per incident. These effects are concentrated on hate crimes with racial bias, with some detectable evidence for crimes motivated against sexual orientation. We also find that colder temperatures diminish the probability of hate crime incidence. Finally, we do not find evidence that the effects of temperature vary with the political orientation or the political polarization of the population.

This paper makes three distinct contributions to the literature on temperature and discrimination. To our knowledge, we are the first to examine the effect of temperature on discriminatory violence. A few existing studies indicate that exposure to heat shocks increases discriminatory behavior toward outgroups (Choi et al., 2023; Van de Vliert, 2020), retaliation (Larrick et al., 2011), the incidence of harassment and discrimination in the workplace (Narayan, 2022), as well as of hate speech and aggression online (Stechemesser et al., 2022). Second, our results indicate that both low and high temperatures affect the incidence of hate crimes, although warmer temperatures matter the most. The shape of the estimated relationship, monotonically increasing, is in line with the existing temperature-crime literature (e.g., Hsiang et al, 2013; Ranson 2014). Finally, we explore the potential underlying circumstances that create a favorable environment for temperatures to trigger violent discriminatory behavior. Previous studies found that the effects of temperature on crime are particularly strong in areas with high poverty (Heilmann et al., 2021). Our results imply that the local socio-economic context is salient and that the effects are substantially heterogenous along several dimensions. Warmer days cause an increase in the occurrence of hate crime especially in counties that have a larger share of unemployed, uneducated, poor population, as well as more racially mixed population. In contrast, unusually colder days lead to a reduction in hate crime especially in counties with less unemployed, better educated, richer, or more racially mixed population.

2. Data

We draw data from two primary sources: the Uniform Crime Reporting (UCR) data from the US FBI, and the PRISM weather data. The two are discussed in detail below. Data on socio-economic variables come from IPUMS-CPS (Flood et al., 2022). Specifically, we include data on the share of high school dropouts and the share of population by gender, race, employment status, and poverty status.

The FBI UCR contains data on crimes collected by more than 18,000 agencies across the US. Agencies report voluntarily on a monthly basis on a number of different types of offenses. In this paper we focus only on hate crimes, which represent our measure of discrimination.

Because the number of reporting agencies is inconsistent from year to year, our analysis exploits day-to-day variation in hate crime incidents and weather within each county and year.[2] Moreover, previous literature shows that contemporaneous temperature fluctuation is an important trigger of aggressive behavior (e.g., Card and Dahl, 2011). To build the data used in our empirical analysis, we construct a daily time series for crime that is consistent within a county-year group of observations. We start by keeping only agencies that reported any hate crime at some point during our sample period, 1996-2018, for the contiguous US. Then, we drop counties with population of less than 1,000 people. Finally, we drop counties where no hate crime was reported on all days of one year.

For the remaining counties we calculate the total number of daily incidents of hate crime reported and the average number of victims and offenders involved per incident. Table A.1 provides their descriptive statistics. The total number of incidents are also calculated by bias type: race, gender, sexual orientation, and religion. On average, there are 2.1 incidents of hate crime in a county-year. Of these, about 70 percent are attributed to victim's race, 16 percent sexual orientation, and 13 percent religious motivation. The gender motivation is negligeable. The average number of victims per incident is 1.3 while there is just about one offender involved. To reduce the influence of potential outliers on the estimation, we record the daily

[2] To deal with the same issue Ranson (2014) analyze month-to-month variation in crime in a county-year cell.

number of cases to a maximum of 3. More than 99 percent of the data does not include more than 3 cases in a day.

We complement hate crime incidents with weather data obtained from PRISM. Specifically, we generated daily maximum temperature and precipitation for each county for which we have data on hate crime. After combining hate crime with weather data, we have a dataset that includes 2,111 counties with a total of 5,830,782 daily observations. Figure 1 show the spatial distribution of hate crimes across the available US counties.

3. Empirical Strategy

We exploit daily variation of temperature in a county-year cell to identify the temperature effect on hate crime. The daily distribution of temperatures is modeled nonparametrically using 9 bin variables: < -5 °C, -5 – 0 °C, 0 – 5 °C, 5 – 10 °C, 10 – 15 °C, 15 – 20 °C, 20 – 25 °C, 25 – 30 °C, and >30 °C. Each of the bins is defined as a dummy variable taking value equal to 1 when the daily maximum temperature is in the *b*-th bin, and 0 otherwise. Our regression equation is as follows:

$$y_{csdy} = \sum_{b \in B/[10-15]}^{B=9} \beta_b TMAX_{b,csdy} + \varphi X_{csdy} + \gamma_{cy} + \theta_{sm} + \delta_w + \eta_{csdy}, \quad (1)$$

where y_{csdy} denotes the outcome variable for county *c*, in state *s*, for the day *d* of the year *y*. $TMAX_{b,csdy}$ denotes *b*-th temperature bin. We choose the 10 – 15 °C bin as reference temperature so that the estimated effect is relative to that when the daily maximum temperature is in this range. We also control for additional weather conditions, X_{csdy}, such as a quadratic function of daily precipitation and relative humidity, which influence behavior correlated with aggressiveness, for example discomfort deriving from heat, or spending time outside.

The specification of regression (1) includes several sets of fixed effects to account for potential confounding factors which are correlated to temperatures and outcomes. County-by-year fixed effects, γ_{cy} implies that the effect of temperature on hate crime is identified off of the daily variation in weather and crime within each county-year cell. As described in the data section, this allows us to lessen the concern of differences in reporting of crime by county agencies over time. To control for state-specific seasonality in hate crime incidents that may be correlated with weather, we also include state-by-month fixed effects, θ_{sm}. Finally, following Mukherjee and Sanders (2021) day of the week fixed effects, δ_w, are included to control for common time-of-year effects that could affect both crime and weather such as holidays seasons that occur during colder times.

We quantify the causal effect of temperature on a series of outcomes. We start by investigating both the incidence of temperature on hate crime and the intensity of such effects by focusing on whether there was any hate crime on that day or the number of incidents of hate crime reported in the county on that day. Next, we move to investigate the intensive margin by switching to outcomes such as the number of victims and the number of offenders in a day. Finally, we examine the effects depending on whether the crime was motivated by bias against race, gender, sexual orientation, or religion. For this analysis the outcome variable is defined as a dummy variable denoting whether the crime committed was motivation by racial bias, or gender, orientation, or religious bias, respectively. These models are also estimated using a linear probability model. All regressions are weighted by county-year population and standard errors are clustered at the state level.

4. Results

The OLS results from estimating regression (1) are presented graphically: Figures 2 to 4.[3] Figure 2 shows the effect of temperature on the probability of a hate crime (top) and on the number of hate crimes reported daily (bottom). Both graphs report the estimated coefficients and the 95 percent confidence intervals for different temperature bins. The top graph shows that higher temperatures cause statistically significant increases in the probability of hate crime occurrence. Specifically, the probability of hate crime occurrence is between 5.9 to 8.8 percent higher in hotter days, compared to days that are 10-15 °C. The highest effect is estimated for the two higher temperature bins. Interestingly, colder temperature, below 0 °C, decrease the probability of hate crime occurrence. As an example, the probability that a hate crime would be committed in a warm day (15-20 °C) would be 1.1 percent higher than in a much colder day (in the -5-0 °C bin). This difference becomes much larger at the extremes of the temperature distribution: 2.2 percent. Results are qualitatively similar at the intensive margin. Higher temperatures cause an increase in the number of daily incidents of hate crime, relative to the reference temperature, with 7 to 12.6 percent more incidents.

The estimated regression on the number of victims and offenders in a day yield marked results as shown in Figure 3. With higher temperature there are both more victims and offenders, though the estimated effect is stronger for victims from warm to high temperature ranges while the effect at the highest temperature bin is higher for the number of offenders, with a 14 percent increase instead of an 11 percent for the number of victims at 30+ °C bin. This pattern is similar

[3] Point estimates are presented in Table A.3.

also for the decrease in hate crimes at the lowest temperatures, with a 13 percent decrease in the number of offenders (12 percent for victims). These results indicate that the number of people involved in these discrimination incidents is also sensitive to temperature.

Figure 4 and the estimated coefficients, Table A.4, show the effect on the probability of a hate crime incident depending on motivation or bias. The results show that temperature causes an effect on the probability of a hate crime mainly when the crime is racially motivated. Relative to the baseline temperature range, warmer temperatures lead to an 8.7 to 13 percent increase in hate crime involving racial bias. Very cold temperatures reduce the probability of such crimes in a similar fashion. Temperature starts to have positive effects on sexually motivated hate crimes, 8 to 12 percent increase, when temperatures surpass 25°C. Our results further indicate that temperature does not literally affect hate crimes that are motivated by gender or religion bias.

4.1 Robustness

We have used a linear model to estimate regression (1) when the outcome is either a binary variable, that is the probability of a hate crime, or the number of incidents. For the latter, given the nature of these data, a Poisson count model may be a more appropriate. Because of this, we re-estimated the regression for when the outcome variable is the number of incidents, the number of victims, and of offenders. The results that are presented in Figure A.1 are qualitative the same when using the linear model. However, the point estimates are massive relative to those obtained with OLS. This suggests that a linear model is more indicated to describe the causal relationship between temperature and the number of incidents of hate crime given the considerable large number of zeros in the data.

To examine the possibility that our results are driven by spurious patterns in the hate crime or weather data, we conduct a falsification test that involves re-estimating regression (1), where the temperature bin does not refer to the temperature of the day of the crime, but it is for the temperature 15 days from that day. As expected, with this test we find that future temperature has no effect on the probability of the occurrence of a hate crime. We present graphical evidence in Figure A.2.

There may be the concern that hate crimes are too infrequent, we aggregated the data at the county-month level and re-estimated regression (1). We do this after removing the week of the year fixed effect and where now bins denote the number of days temperature was in each specific range. Figure A.3 presents the estimated coefficients using a binary outcome variable: the occurrence of any hate crime incident. The results remain statistically but they are much smaller. Though, the point estimates are now interpreted as the effect of an extra day in each temperature bin relative to the omitted category.

Finally, we have also investigated whether temperature in the preceding days to the incident and not only contemporaneous temperature played a role. To do this we included a set of temperature bins representing the number of days in the six days leading to the reported hate crime, in which the temperature fell into the same temperature bin as in those specified in regression (1). Results suggest that, for the most part, we found that there are no substantial cumulative temperature effects.[4] For this reason, we decided to omit those variables from our empirical specification.

[4] Estimates for this part of the analysis are available upon request.

5. Investigating Underlying Conditions

Our results indicate that hate crimes are triggered by warm temperatures. What we need to recognize are the conditions that mediate the temperature-hate crime relationship. Here we investigate four possible indicators of social and economic distress that can be conducive to aggressive behavior. To examine the effect of these socio-economic conditions on the temperature-hate crime relationship, we modify Equation (1) by interacting each temperature bin by a dummy variable for the tercile of each of the socio-economic indicators as follows:

$$\begin{aligned} y_{ct} = & \sum_{b \in B/[10-15]}^{B=9} \beta_b^l TMAX_{b,ct} \times 1(\text{county } c \text{ in lowest tercile of } S_{year}) \\ & \sum_{b \in B/[10-15]}^{B=9} \beta_b^m TMAX_{b,ct} \times 1(\text{county } c \text{ in middle tercile of } S_{year}) \\ & \sum_{b \in B/[10-15]}^{B=9} \beta_b^h TMAX_{b,ct} \times 1(\text{county } c \text{ in highest tercile of } S_{year}) \\ & + \mu_1 P_{ct} + \mu_1 P_{ct}^2 + \varphi RH_{ct} + \gamma_{ct} + \theta_{sm} + \delta_w + \eta_{ct}, \end{aligned} \tag{2}$$

where *S* represents either the share of unemployed, the share of high school dropouts, the share of households below poverty line, and racial fractionalization of the county population. Racial fractionalization is calculated as $FRAC_{c,year} = 1 - \sum_j^J m_{j,c,year}^2$, where $m_{j,c,year}$ is the population share of the *j*-th racial group in county *c* in a given year. This index is a measure of the probability that two randomly drawn individuals in a county-year were not from the same racial group. This specification not only allows for nonlinear effects of temperature on hate crimes, but also varies annually by socio-economic level of the county.[5]

We estimate four separate regressions using the specification in (2) for each socio-economic indicator S. In each respective regression, the key parameters are β_b^l, β_b^m, and β_b^h, which represent the effects of temperature on hate crime in counties with low, medium, and high levels of unemployment, education, poverty, and racial fractionalization. The expectation is for the effects of temperature to be stronger, meaning causing a larger increase on hate crimes, in counties with poorer socio-economic conditions. As before, all regressions are weighted by county-year population and standard errors are clustered at the state level.

Figure 5 shows the results from estimating equation (2) for each of the indicators.[6] The top-left graph depicts estimates for when temperature bins are interacted with indicator for the unemployment tercile. For this, although warmer temperatures always cause an increase in the probability of occurrence of hate crimes, there are differences. The increase is larger in counties with higher unemployment. On the coolest days the decrease in probability is instead larger in counties with lower unemployment. The results for the interaction with high school dropouts, top-right graph, reveals considerable heterogeneity in temperature effects. In the counties with the highest population of dropouts, temperature effects at higher temperature are much larger. These effects are almost two times larger than in counties in the middle tercile for dropouts, with increases ranging between 0.9 to 1.3 percent. Higher temperatures have no effect in counties with low levels of high school dropouts, while cold temperatures there are considerable

[5] There is substantial heterogeneity in the outcome variable across terciles of these different indicators, Table A.5. Counties with bad socio-economic conditions show about twice the incidence of hate crimes than counties in the second tercile for the indicators, and about three times larger than counties in the best conditions. There is a remarkable difference between counties that are more racially homogenous and those that are very racially diverse, by almost one order of magnitude.

[6] The tables with the estimated coefficients are available upon request.

reductions in hate crime. On the contrary, counties with worse education show no reduction in hate crime at low temperatures.

Results are similar when focusing on poverty, bottom-left graph, although the difference in the magnitude of the effects is smaller. Also interesting are the results based on the racial heterogeneity of the county population, bottom-right graph. We can notice that only in more racially diverse counties do warmer temperatures have a statistically significant effect, with an increase between 6 and 10 percent. Counties with relatively homogenous there is no statistically nor economically significant effect. In days with the lowest temperatures, below 0 ℃, the effects can be quite different depending on the level of fractionalization of the county. In highly diverse counties, lower temperature causes a decrease in the probability of hate crimes and this effect has a larger magnitude than for high temperatures, 20 percent decrease. This occurs also in moderately diverse counties, although the effect is much smaller, almost 9 percent decrease. On the contrary, in more racially homogenous counties, low temperatures cause an increase in hate crimes. While the point estimate is small, the percentage change is quite large: between 19 and 22 percent increase.

As a last test for the heterogeneity of the results we study whether temperature effects on hate crimes differ depending on the political orientation of the population of a county. To do this we determine whether a county is leaning democrat or republican based on the results of presidential elections for the period 2000-2016.[7] We denote a county to be leaning democrat if for a presidential election the Democratic party received the majority of votes. The county is denoted to be leaning republican otherwise. We then estimate regression (2) where we replace the dummy for the tercile with an indicator for the political orientation of the county: democrat

[7] The data was obtained from the MIT Election Data and Science Lab (2018).

and republican. Results presented in Figure A.4, top graph, indicate that there are no significant differential effects based on the political orientation of the population of a county.

We repeat the analysis by focusing on the political polarization of the county. For this analysis we replace the party indicator with the terciles of the distribution of an index of polarization from Reynal-Querol (2002).[8] Results presented in Figure A.4, bottom, basically confirm our initial evidence, that is, temperature does not affect hate crimes differently depending on the degree of political polarization.

6. Conclusions

In this paper we investigate the effect of temperature on hate crime, a crime that is indicative of violence motivated by intolerance or discrimination. We do this by exploiting daily variation in a county-by-year cell which allows us to reduce the measurement error due to year-to-year inconsistent reporting of crime in the UCR data.

Our findings suggest a significant and contemporaneous impact of temperature on hate crimes. Specifically, the study reveals that both the incidence and intensity of hate crimes tend to be higher on warmer days and lower on colder days. Our results have clear policy implications. Improving socio-economic conditions alleviates the negative effects of warm temperatures, while increases the positive effects of cold temperature. Both lead to the reduction of the incidence of hate crimes. Economic policies aimed at reducing unemployment and poverty can bring clear benefits. Improving educational attainment also appears particularly fruitful, as

[8] The index of polarization corresponds to equation (1) in Reynal-Querol (2002) and is equal to: $IRC1 = 1 - \sum_{i=1}^{N} (0.5 - \pi_i)^2 \pi_i / 0.25$. In our analysis, this index is calculated for each county for each election year, and π_i corresponds to the share of voters for party *i*, where *i* = democrat, republican, other.

reducing the share of high school dropouts yields substantial reduction in the incidence of hate crime. The effects of temperature also vary considerably depending on the racial fractionalization of counties. Warmer (colder) days cause an increase (reduction) in the occurrence of hate crimes in counties that are racially mixed. Colder days in racially homogenous counties seem instead to increase hate crime. Temperature effects do not vary with the political orientation of the population. In light of the future increasing of temperature in the US, this analysis provides useful indications on how to target efforts in hate crime prevention and promoting tolerance.

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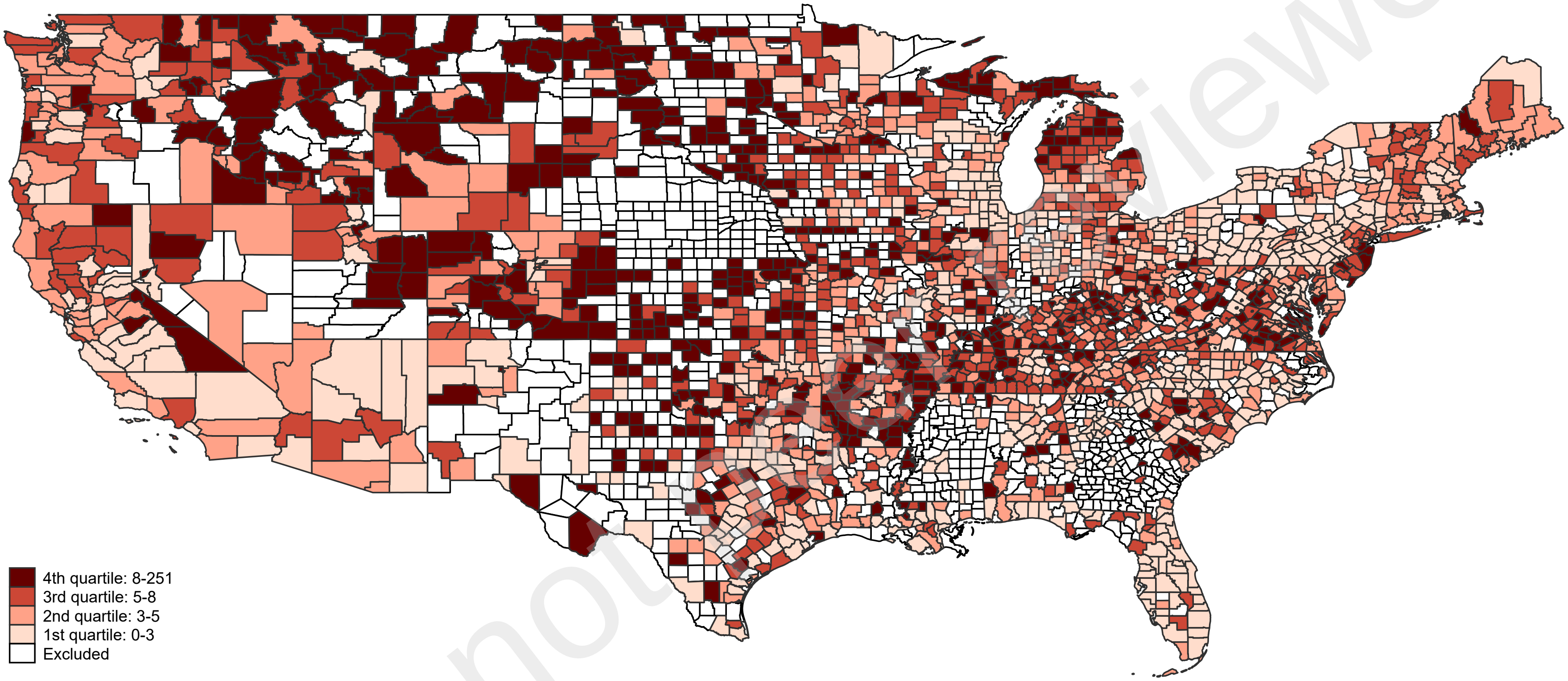
Figure 1. Geographic Distribution of Hate Crimes.



Note: Mean annual rate of hate crime incidents per 100,000 persons in 1996-2018 for 2111 counties

Figure 2. Effect of Temperature on Any Hate Crime (top) and Number of Hate Crime (Bottom)

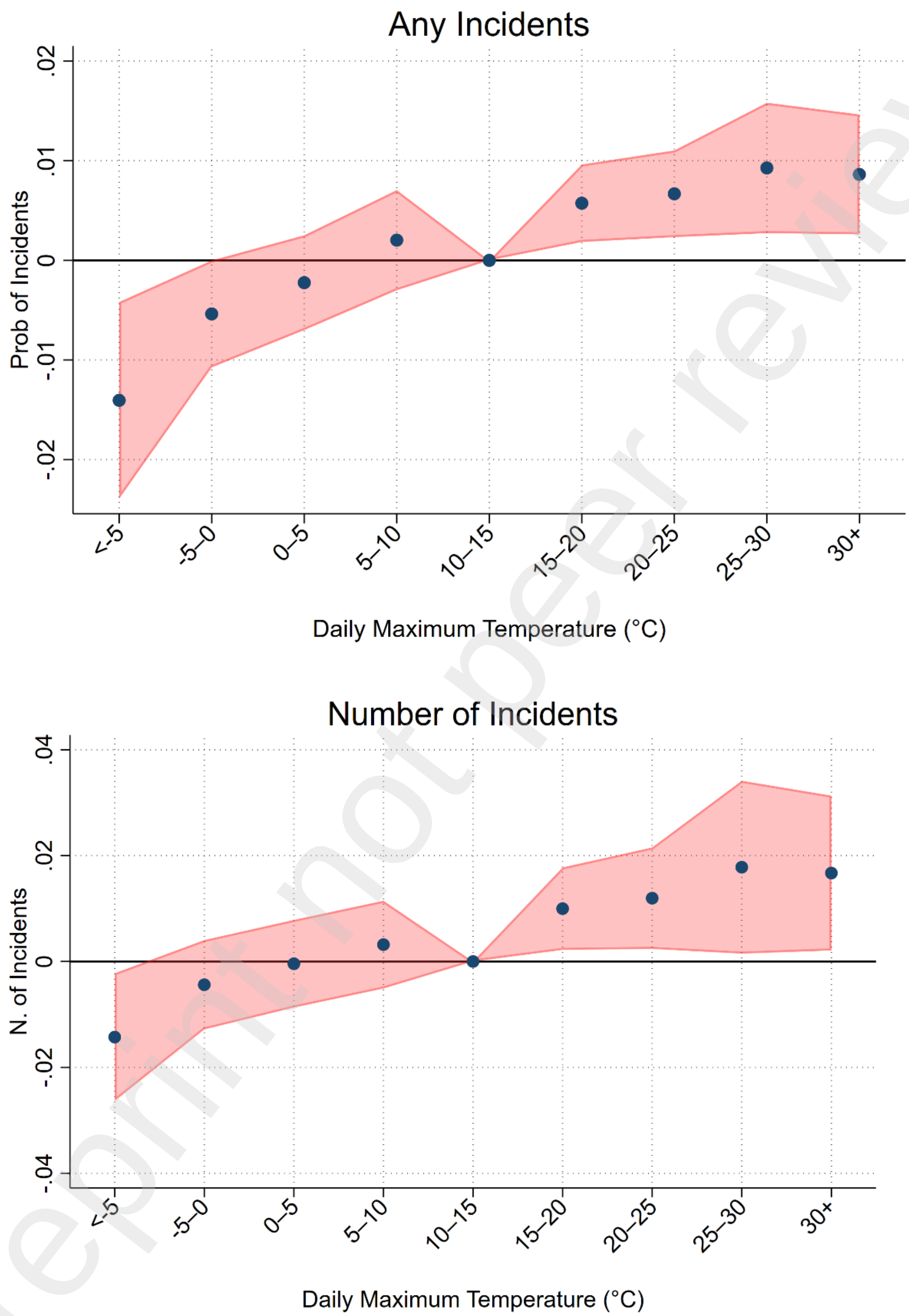


Figure 3. Effect of Temperature on the Number of Victims of Hate Crimes (Top) and the Number of Offenders (Bottom).

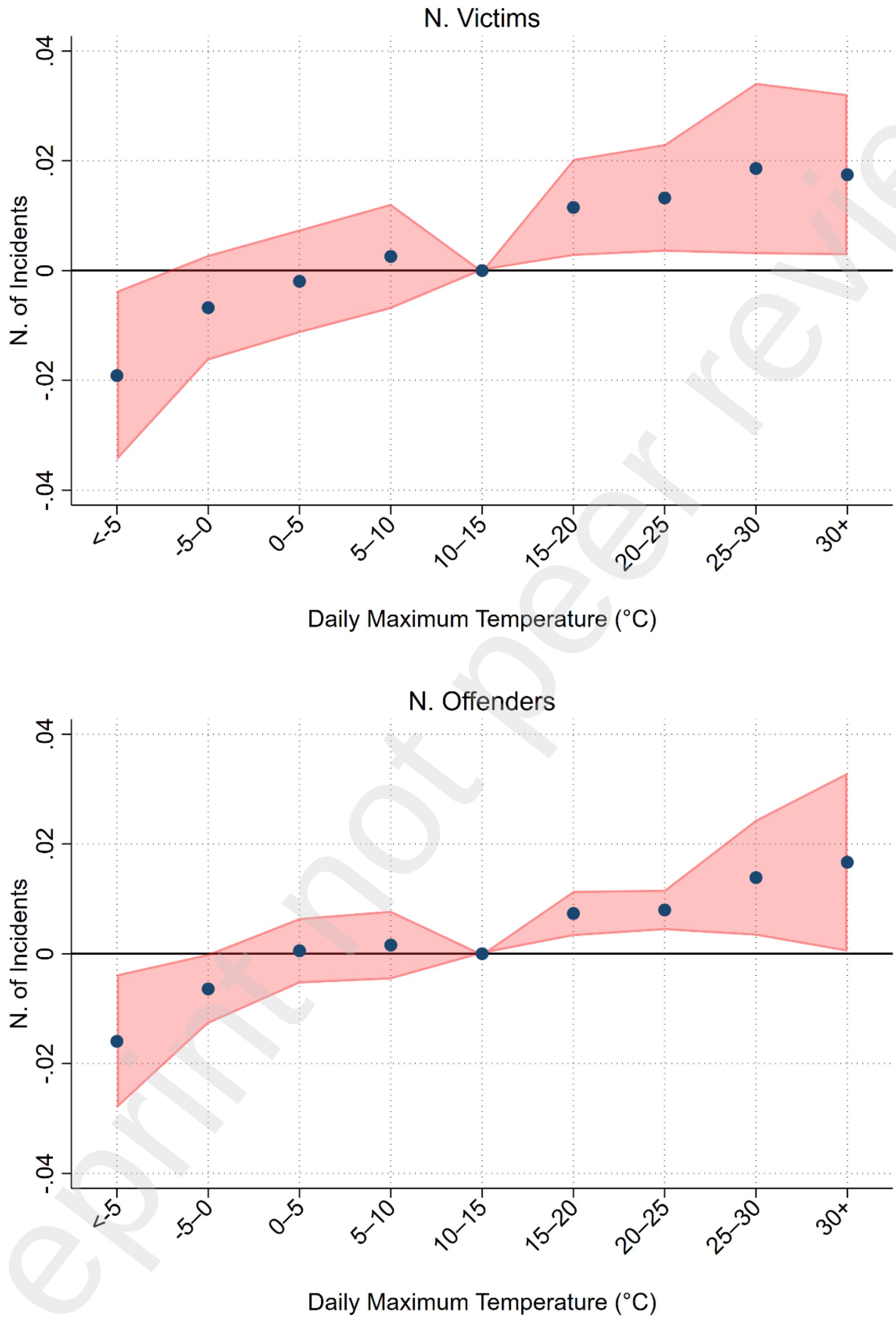


Figure 4. Effect of Temperature on Hate Crimes by Type of Bias.

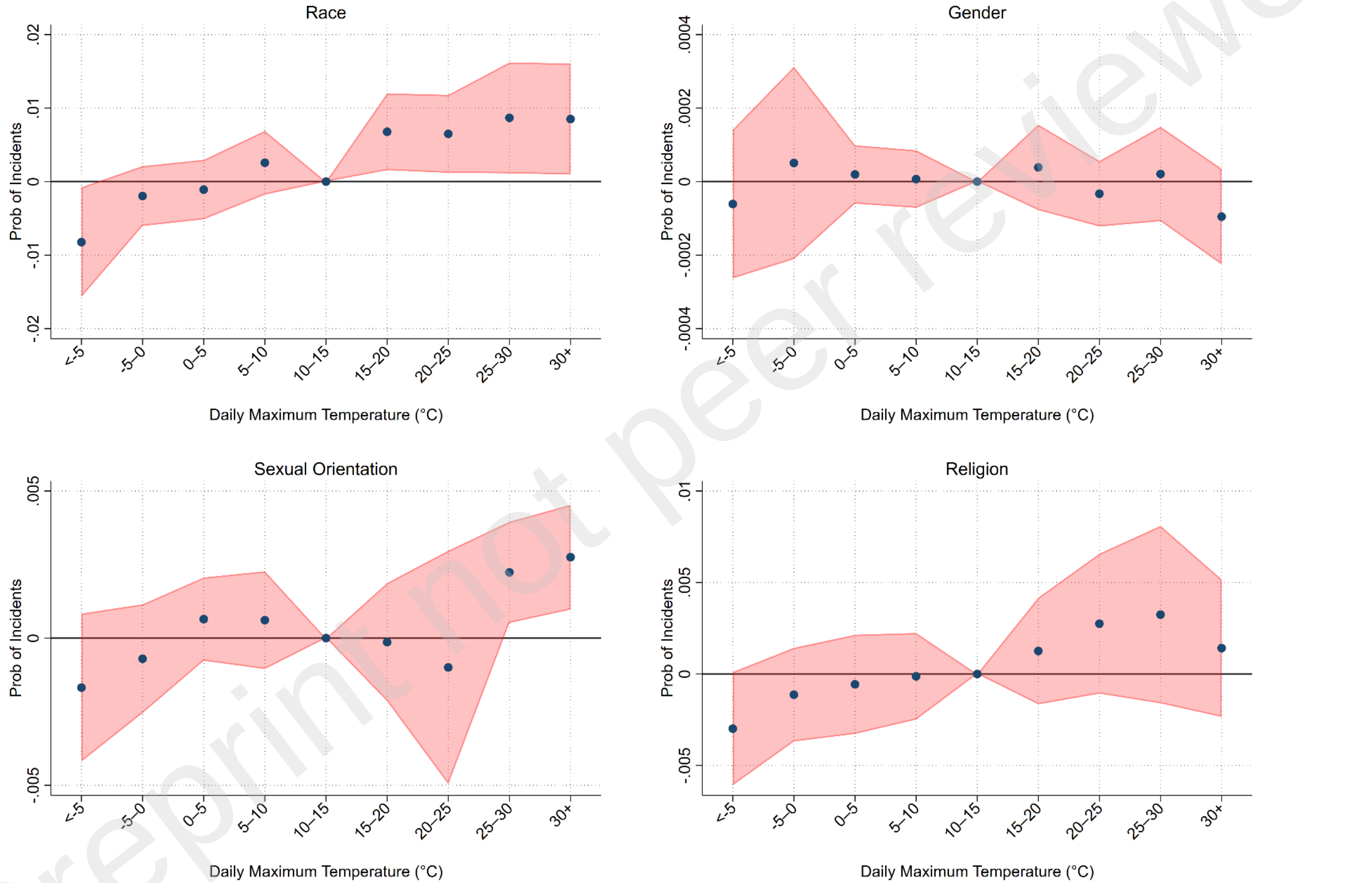


Figure 5. Effect of Temperature: Underlying conditions on the Probability of Hate Crimes.