Disorganized Political Violence: A Demonstration Case of Temperature and Insurgency

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How likely is an act of battlefield violence to result from organizational strategy or a combatant's personal motives? To measure the relative contribution of each, our research design leverages the predictable effect of ambient temperature on human aggression and the variation in organizational control required for launching insurgent attacks during the Afghanistan and Iraq wars. We test whether temperature and violence are linked for attacks that can be initiated by individual combatants, but not for those requiring organizational coordination. To distinguish alternative explanations about the effect of temperature on the behavior of attack targets, we test situations in which these are fixed or stationary. We find that the more discretion combatants have over the initiation of violence, the more battlefield outcomes are shaped by their individual, embodied motivations and that this autonomy robustly influences conflict intensity. To confirm the embodied motivation mechanism, we show that ambient temperature affected the willingness of military-age Iraqi men to endorse violence against international forces. The results caution against attributing strategic moti-

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vations to observed acts of violence, especially when individual combatants have autonomy over the initiation and intensity of attacks. They also encourage future attention to the interaction of strategic- and individual-level motivations in conflict settings.

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From the Kremlin to South African trade unions, the strategic calculations of political organizations sometimes require that their members engage in violent action. To ensure that the type, target, and frequency of violence further their strategic objectives, these organizations employ a command structure to train combatants and govern their battlefield behavior (Hoover Green 2018).

Viewing combatants as agents who produce optimal levels of violence that further an organization's strategic goals has deepened our understanding of the dynamics of war (Salehyan et al. 2014). The evident effort by political organizations to harness combatant violence toward their strategic objectives makes this a reasonable assumption (Grossman 2014). States task their officer corps with the "management of violence" to ensure that the type, target, and frequency of violence is optimized for strategic ends (Huntington 1957: p. 13). Non-state groups similarly manage their production of violence (Shapiro 2013). Even if some combatants deviate on the margins, political organizations generally direct their actions to fulfill their strategic interests. Idiosyncratic individual behaviors disappear into the error term, and violence "attributed to an organization" is usually interpreted as "ordered (at some level of command) and strategic" (Gutiérrez-Sanín and Wood 2017: p. 24). The payoff for understanding international relations by treating states as rational, unitary actors has long been evident and has also paid dividends in the burgeoning field of sub-state conflict.

Some explanations of organized political violence rely more on this assumption than others. Rational choice models of political violence assume that individual idiosyncrasies or the passing emotional states of critical decision makers are peripheral to the outcome. But when describing knife-edge equilibria, theories of strategic interaction are especially sensitive to individual outlier behavior that is out of step with institutional strategy. Proponents recognize that acts "in non-iterative situations by individual decision makers (such as in crisis situations)" are not well explained with rational choice models (Tsebelis 1990: p. 38). But individuals need not occupy a high office for their internal motivations to influence conflict outcomes. If particular intrinsic motivations systematically shape the judgments and behaviors of enough conflict participants, they will affect organized violence for as long as combatants are able and willing to fight each other.

The assumption that violent organizations can generally solve, or at least manage, the principal-agent problem has always been understood as a bet (Powell 2017). Even in the abstract economic world of widget production, a well- and long-understood risk is that the conflict between "intrinsic motivation and extrinsic incentives" does not inherently resolve in favor of the latter in determining a worker's actions (Kreps 1997). The generation of violence is fundamentally different from the production of widgets since it requires managing not only the material incentives of front-line workers, but also the "fear of killing and fear of dying represent psychological hurdles not easily overcome" (Hoover Green 2018: p. 28).

In the field of social psychology, most accumulated findings undermine the prudence of assuming that human behavior aligns neatly with the organizational incentive structures seeking to shape that behavior. The tension between the two has become the subject of an emerging "behavioral IR" discussion, which seeks to integrate "new behavioral findings at the individual level [with] collective decision making" (Hafner-Burton et al. 2017: p. 19). This discussion contributes to a growing body of work within political science that strives to establish how and to what degree individual-level motivations influence violent political processes between organizations, including states (Mercer 2005b; Hall and Ross 2015; Little and Zeitzoff 2017; Davis and McDermott 2021).

The assumption that individuals enact organizational preferences has long been a necessity arising from the empirical limitations of exploring individual-level motivations. According to McDoom (2012: p. 129-30), "scholars lack microlevel data [...] forcing them to make inferences from highly aggregated phenomena." However, recent conflicts have generated more and better data, some of which fills the scholarly need for disaggregated data. The public release of fine-grained conflict data recorded during the recent Afghanistan and Iraq wars has been particularly influential in shaping our understanding of insurgent warfare (Balcells and Stanton 2021: p. 63).

The literature's emphasis on imputing strategic organizational motivations also stems from the difficulty of uncovering "with an acceptable level of accuracy the individual motives behind violent acts" (Greenstein and Polsby 1975: p. 75). In "summarizing an observed pattern rather than an intention," the literature drifts from observed action to assumed intent (Gutiérrez-Sanín and Wood 2017: p. 24). This has been a serious obstacle to inferences concerning the interaction of organizations and individuals in observational studies of conflict.

We propose that the reliable effect of ambient temperature on human levels of aggression can be used to distinguish patterns of violence motivated by organizational strategy from acts more influenced by individual combatants. This article presents evidence that in recent U.S.-led counterinsurgent conflicts, ambient temperature affected how and when individual insurgents initiated attacks and that individual-level aggression was one mechanism driving the relationship, measured through the endorsement of violence by combat-aged males. Our research design relies on one feature of these wars: Insurgents produced a variety of violent acts with varying levels of organizational control, which makes it possible to distinguish the relative contributions of strategic and embodied motivations in the production of overall violence.

In this context, high temperatures lead to an increase in the kinds of violence over which individuals have ample discretion, but not over the types of violence that require more organizational control. The statistical tests reveal that ambient temperature positively affected the production of the least organizationally constrained violence during conflict and the likelihood that surveyed Iraqi males would express support for violence against multinational forces. The effect of temperature on violence is positive but diminishes at particularly high temperatures. The relationship between temperature and both of the above outcomes share very similar estimated functional forms. Finally, the magnitude of estimated effects is substantial. The results are robust to a variety of alternative specifications and tests, and they are replicated in country-wide analyses for both Afghanistan and Iraq.

Taken together, these test results demonstrate that the effects of temperature on individual combatants are both identifiable and trigger meaningful changes in key wartime outcomes. This builds toward an understanding of the conditions under which embodied motivations will be non-negligible. The more autonomous individual combatants are, the more embodied motivations will influence the contours of combat.

These findings are based on internal U.S. Department of Defense records of Iraq and Afghanistan insurgent violence against local government, American, and other international forces. First, we use the complete Afghanistan War dataset of insurgent violence released by Shaver and Wright (2016) to assess insurgent fatalities. Second, although abridged versions have previously been available, the Iraq War dataset covering the entire war period had remained classified and is included with the replication file for this article. Our third main data source is a monthly survey conducted by an Iraqi firm, which we used to measure endorsement of violence throughout the conflict. Some 175,000 Baghdad residents responded to the survey, which was previously processed by Klor et al. (2016).

1.1 Embodied motives for violence

Balcells and Stanton (2021) locate explanations for violence "at five different levels of analysis: international, domestic, subnational, organizational, and individual" (Balcells and Stanton 2021: p. 45). What differentiates the fifth of these levels of analysis is that individuals are biologically embodied, activating a range of possible physiological, cognitive, and psychological motivations for violent behavior that are not activated at the other four levels.

Much current sub-state conflict research treats individual combatants and civilians as strategic actors, presuming that their actions reflect the pursuit of calculated political and military strategies–and that individual-level motivation is successfully minimized to conform to organizational demands. For instance, Bueno de Mesquita (2013) conceptualizes an insurgent's choice of target as a rational response to the organization's environment and requirements. The findings of numerous empirical studies are consistent with these assumptions (Berman et al. 2011). Kalyvas and Balcells have established strategic and political motivations for violence against non-combatants in civil war settings (Kalyvas 1999; Kalyvas et al. 2006; Balcells 2011). Explaining the choice to relegate psychological variables to the error term, Kalyvas argues that political and non-political violence are separate phenomena, partly because individuals "involved in the production of political violence appear to lack the kind of 'extreme' personality features that tend to correlate with expressive violence" (Kalyvas et al. 2006: p. 25).

Paying specific attention to emotion in the study of violent political conflict, embodied individual-level effects have been invoked to explain errors and deviations from ostensibly *correct* or *rational* actions. Mercer (2005a) proposes instead that *all* human acts arise from a combination of emotional and cognitive sources. McDermott (2004) argues that affective and strategic determinates are not zero-sum, but are psychologically and neurologically "intimately intertwined and interconnected processes" (p. 693). Some political scientists have undertaken empirical research that accounts for psychological biases, with a focus on the implication for the long-standing assumption of rationality among scholars (Sasley 2010; Ross 2013).

Another integrative approach acknowledges the combination of both embodied motivations and strategy to produce the general preference structures within which human agents seek to maximize their rewards. For instance, Posen (1993) and Kalyvas (2003) argue that emotion-based grievances can motivate strategic behavior, such as when individuals join groups for emotional reasons and then use violence to pursue the group's strategic goals.

Embodied motivations are diverse in their sources and effects. Renshon and Lerner (2012) distinguish between integral and incidental emotional drivers. Unlike integral emotions, the latter are "normatively unrelated to the decision at hand [but] affect decision-making in critical and often unappreciated ways" (Renshon and Lerner 2012: p. 1). Incidental emotions non-consciously influence an individual's behavior and are beyond the "control" of rational calculation (Lerner et al. 2015).[1] Emotions that are integral to an experience are especially difficult to isolate from non-emotional motivations. However, incidental emotions exogenously provoke behavior, making them empirically distinguishable from other determinates of behavior that include organizational constraints and integral emotions.

Embodied, aggressive motivations for violence can be perfectly aligned with an organization's institutional strategy. For instance, self-sacrificing heroism is an emotional motivation for violence that has strategic institutional value. What happens when the two are misaligned? When equipped with the means and opportunity to commit a violent act, what is the relative influence of the organizational strategy and embodied motivation on the individual combatant? An analysis of a variable that reliably influences the propensity for violence among individual combatants without affecting their organization's strategy or tactics can provide us with an answer. That variable is ambient temperature.

1.2 Ambient temperature and embodied aggression

Ambient temperature reliably influences the willingness of humans to behave aggressively and violently. Decades of observational and laboratory evidence demonstrate a reliable, statistically significant, and substantively large causal effect. In laboratory settings, warm temperatures produce increases in verbally reported hostile attitudes, impaired cognitive

[1] Evidence for this phenomenon is robust (Schwarz and Clore 1983; Gallagher and Clore 1985; Bodenhausen 1993; Lerner and Keltner 2000, 2001; Han et al. 2007).

performance, and the experience of negative emotional states (Anderson et al. 1995; Pilcher et al. 2002).[2] The effect of temperature on behavior is immediate (Anderson 2001; Ranson 2012). Vrij et al. (1994a) found that police officers discharged more bullets in a shooting simulator at elevated temperature ranges, Nathan DeWall and Bushman (2009) found that individual subjects had aggressive thoughts and Gockel et al. (2014a) concluded that subjects were more likely to judge a murderer's motive as an emotional impulse.[3]

Crime records confirm the human tendency to behave more violently at higher temperatures, leaving "little doubt or controversy about the existence of a heat-violence relation in real-world data" (Anderson et al. 2000: p. 67). Psychologists, criminologists, sociologists, and other scholars have investigated this phenomenon.[4] Anderson et al. (1997) found that temperature is positively correlated with "serious and deadly assault even after time series, linear year, poverty, and population age effects were statistically controlled." The effect is anything but minor, with one study finding that "ambient temperature explained 10% of variance in the violent crime rate in Finland" (Tiihonen et al. 2017). Property crime, which is unrelated to ephemeral changes in embodied aggressive tendencies, shows no such covariation with temperature. Ranging from hedonic states measured by sentiment analysis of social media to suicide rates, general well-being has also been shown to be a partial function of temperature (Baylis 2015; Noelke et al. 2016; Thompson et al. 2018). Climate change

[2]Non-human organisms also react violently to heat. In the marine environment, for example, coral reef fish and sea turtles are more aggressive at higher temperatures (Biro et al. 2009).

[3]Multiple studies show that making affected individuals aware of the stimulation source eliminates the effect. For example, Schwarz and Clore (1983) found that subjects reported lower levels of happiness on rainy days. Those who were either directly reminded that weather can affect mood or indirectly primed by being asked about their local weather did not report lower life satisfaction. These reminders are uncommon, leaving human behavior sensitive to emotional stimuli. Research regarding the effects of temperature on aggression has produced similar findings. For instance, Palamarek and Rule (1979) found that experiment subjects who were more aggressive when hot became gentler once they became aware of the temperature.

[4]Key contributions to this expansive literature include: Dodge and Lentzner (1980); Kenrick and MacFarlane (1986); Reifman et al. (1991); Vrij et al. (1994b); Anderson (2001); Rotton and Cohn (2001); Nathan DeWall and Bushman (2009); Gamble and Hess (2012); Gockel et al. (2014b); Cohen and Krueger (2016); Bruederle et al. (2017); Tiihonen et al. (2017); Younan et al. (2018).

predictions have re-invigorated the study of the relationship between temperature, social aggression, and violence (Price and Elu 2017; Van de Vliert and Daan 2017; Rinderu et al. 2018).

Despite extensive multidisciplinary research, the precise mechanism through which temperature shapes the propensity to engage in violence is not yet known (Koubi 2019: p. 346). It is likely that a combination of emotional, cognitive, and physiological factors combine inside the human body in response to ambient temperature, creating a direct and immediate effect (Miles-Novelo and Anderson 2019: p. 2). Given the current state of knowledge, it is most accurate to refer to the "effects" of temperature on violence.

The temperature ranges most predictive of aggression and violence depend on measurement strategies and context. Many studies have located the effect at warmer temperatures. Gamble and Hess (2012) identifies the association with peak violence at a daily mean of 80°F. Others have reported increased violence at more moderate temperatures. Cohn and Rotton (1997) adopted a three-hour temperature interval that mapped rates of assault to the approximate actual temperature at which they occurred and estimated that assaults were most likely to occur around 75°F. Uncertainty also persists over the function of the relationship. Gamble and Hess (2012) concluded that "daily mean ambient temperature is related in a curvilinear fashion to daily rates of violent crime" while others have found a linear rise in violence.[5]

In addition to the multiple mechanisms at work, the variation in temperature ranges most associated with aggression and violence is likely the result of differences in how closely the temperature is linked to the violent act in time and space, how temperature scores are aggregated, whether they are measured at their mean or maximum, and which temperature treatments were chosen in laboratory settings. Despite this uncertainty regarding the mech-

[5]The main arguments concerning the functional form are found in Anderson and Anderson (1984), Cohn and Rotton (1997), Rotton and Cohn (2000a), Rotton and Cohn (2001), and Anderson et al. (2000).

anism's nature, we can be sufficiently confident in the pervasive and reliable relationship between temperature and violence to isolate individual-level motivations for violence from organizational determinants. We rely on the short-term relationship between temperature and individual-level violence for our testing strategy. Temperature and violence also interact in other important ways. For example, temperature can shape the conscious behavior of combatants in a myriad of forms, ranging from equipment failure to combatant death in extremes of cold or heat. These short-term effects are separate from the long-term, compounding effects of the relationship between temperature and organized violence, including through climate change (Miles-Novelo and Anderson 2019: p. 2). We address these long-term effects further in the discussion section.

2 Identifying individual-level violence with temperature

Research from several human behavior disciplines provides overwhelming evidence that violence intensity is exogenously influenced by ambient temperature. The effects of temperature on violence are pervasive, predictable, and non-trivial in magnitude. This makes ambient temperature a purely incidental individual-level motivation for violence distinguishable from strategic behavior in observational conflict data. Among individual-level causes of violence, temperature offers methodological and empirical advantages. First, combatants are invariably exposed to fluctuating temperatures because wars are fought outdoors–even if electric cooling and communication technologies place some combatants in different temperatures. Second, reverse causality in statistical testing is impossible. Third, temperature has been precisely recorded in many conflicts. Fourth, temperature varies significantly over time.

The section to follow generates testable propositions for leveraging temperature effects to demonstrate individual deviation from organizational violence strategies. This is done by differentiating between attack types whose initiation is under the control of individual combatants, usually those using small arms, and those that are organizationally coordinated, such as car bombs. Temperature should influence the former, but not the latter. As a result, our research design isolates an incidental effect exerted exogenously on individual combatant bodies. As an effect independent of organizational constraints, ambient temperature shows the conditions under which individual-level motivations contribute to conflict outcomes jointly with the strategic calculations of the organization in which combatants are embedded.

To be useful in distinguishing individual- from organizational-level influences, the magnitude of temperature effects on the production of violence should be modest. First, an abundance of drivers and inhibitors of violence act on organizations and individuals. Second, the relationship's general curvilinearity means that temperature is just as implicated in the production of violence as it is in its inhibition. Third, and most important in our project to separate organizational from individual effects, is that the effects depend on being undetectable by either organizations or individuals, which keeps them below the threshold of conscious management.[6]

Fine-grained, voluminous, and geo-referenced data on combatant behavior and civilian attitudes generated throughout the US-led counterinsurgent wars in Afghanistan and Iraq makes it possible to measure the effect created by a reliable source of individual-level motivation. We exploit several characteristics central to how insurgents fought, together with variation in specific characteristics from these conflicts across distinct contexts and with different units of analysis. This limits the possibility that any single unobserved variable influenced the results.

If embodied motivations shape conflict, we should find evidence consistent with hypotheses regarding these two dependent variables: attack frequency and civilian support for vio-

[6]The effect of temperature could theoretically be measured and incorporated into tactical planning. That may be conceivable for future bio-sensing AI-enabled combat systems, which were not fielded by combatants in this study.

lence.

Attack frequency. We verify the presence of a relationship between ambient temperature and insurgent violence consistent with individual-level motivations in two ways: First, we test for a relationship between temperature and attack types. Only attack types over which individual insurgent combatants had discretion are expected to vary with temperature. The second set relates to the timing of the attack. We test alternative explanations because attack frequency outcomes might correlate with temperature for reasons unrelated to individual combatant motivations.

Civilian support for violence. If individual, embodied aggression is a mechanism that connects the temperature-violence relationship, expressions of hostility should vary with ambient temperature in patterns similar to combatant behavior. We assess this proposition through the endorsement of violence in civilian surveys and temperature. This second set of tests allows us to evaluate whether a temperature-aggression relationship manifests attitudinally in a conflict setting by measuring ambient temperature and attitudes toward violence among combat-age males in Baghdad during the recent Iraq War. An advantage of using survey responses is that the strategic choice considerations that we would expect to influence an insurgent's judgment of an attack's costs and benefits do not affect public opinion poll answers. Survey respondents were not asked to consider the costs of fighting, the risk of death, or the tactics of U.S. forces, leaving only the factor of how temperature affected the civilian endorsement of violence.

2.1 Attack frequency

Detailed information collected by U.S. forces during the recent Afghanistan and Iraq wars provides an opportunity to test hypotheses. Covariation in daily insurgent violence and temperature levels are evaluated to determine whether insurgents launched more attacks on hotter or cooler days, allowing us to estimate the functional form of the relationship.

The events recorded in the databases reflect the actions of insurgencies in a highly asymmetric contest with counterinsurgent forces. This makes it a hard case for demonstrating the limits of organizational control over combatants because counterinsurgents with airpower, heavily armored vehicles, and precise artillery should force insurgent organizations to act with caution and battlefield discipline.[7]

2.1.1 Organizational constraints

Insurgents should not be influenced by temperature in those operations directed by senior combatants with predetermined targets and dates. Attack types that leave decisions–such as when and how intensely to engage enemy targets–to individual fighters should vary with temperature. Whether attacks over which individual combatants exercise significant discretion vary with temperature while those subject to organizational constraints do not is identified by exploiting variation in daily temperature and insurgent attacks that employ specific weapons. These weapons can be divided into two general classes:

The first weapon class consists of highly mobile weaponry, which is subject to the fewest organizational constraints. Insurgents enjoy significant discretion in discharging these weapons since they are designed to be fired by a single individual. This class includes small arms such as pistols and automatic rifles. These can be rapidly and repeatedly directed against both stationary and mobile targets.[8]

The second class consists of organizationally constrained weapons. Unlike mobile weaponry, many of these are single-use and reserved for highly planned operations in which the attack's location and timing are determined in advance by senior combatants. They include vehicle-borne improvised explosive devices, suicide vests, and other weapons whose use was more

[7]Embodied motivations should also act on counterinsurgent combatants.

[8]While these weapons can be used during highly coordinated offensive measures, such as planned ambushes, their use was not restricted to such organizational engagements during the conflicts in question.

strictly governed by the insurgent organizations. While an individual combatant ultimately exercises responsibility for the detonation, this discretion is likely to exist within narrow temporal and geographic bounds proscribed by operational planning.[9]

If temperature influences insurgent violence by affecting only individual combatants, the frequency with which organizationally constrained attack types are used should not vary with temperature.

Hypothesis 1 *The frequency of organizationally unconstrained attacks has a positive relationship with temperature.*

2.1.2 Attack frequency by timing

Skeptics of the embodied temperature-aggression mechanism have advanced the "routine activity theory" as an alternative explanation to the widely observed temperature-violence correlation (Cruz et al. 2020). This theory emphasizes the influence of temperature on many aspects of social behavior, including the likelihood of interpersonal contact (Rotton and Cohn 2000b).

If this alternative to our embodied explanation is correct, violence is merely a function of increased interactions between potential perpetrators and their targets. Applied to the insurgency setting, evidence for this competing explanation should be observed in insurgent attack patterns on moving targets. Troops adhering to a population-centric counterinsurgency doctrine seek contact with civilians. If civilians are more likely to gather in public places during particular temperature ranges, counterinsurgents leave their bases and become more vulnerable to attack. In the Iraq and Afghanistan cases, the employment of

[9] The simultaneous bombings at the headquarters of the United Nations, the Jordanian embassy, and the Iraqi parliament were all perpetrated with such weapons (Roberts 2003; bbc 2003, 2007). This class includes strategic attacks such as assassinations, even if the weapon used was mobile.

IEDs against counterinsurgent forces can therefore be used to test whether temperature was correlated with roadside attacks on moving targets.

Hypothesis 2 *Attack frequency against moving targets has a positive relationship with temperature.*

Confirmation of this competing hypothesis reveals only the presence of a target movement effect. Evidence in its favor does not invalidate the embodied aggression effect we are aiming to identify. However, we can isolate the effect of individual-level aggression by restricting the test only to nighttime attacks in and around Baghdad. These are unlikely to correlate with temperature for three reasons:

First, a nighttime curfew was in effect for the city during the entire study period. Civilians found in violation risk their lives (Mansoor 2008). Because civilian movement is constrained, nighttime counterinsurgent patrols are unlikely to have varied with civilian movement. Second, supply convoys travel at night. This accounts for much of the counterinsurgent's nighttime activities, and they did not vary their activities with temperature. The opposite was the case: The military directed convoys to "create irregular patterns" (ALSA 2014: p. 52).

Following the target movement explanation, nighttime attacks would not vary with temperature because patrol movement was effectively held constant–or intentionally randomized. If individual-level motivations contributed to patterns of attack, we should observe variation in the use of the least organizationally constrained weapons in response to temperature variation. Confirming evidence of this hypothesis strongly supports our embodied aggression theory.

Hypothesis 3 *At night, only the frequency of organizationally unconstrained attacks has a positive relationship with temperature.*

2.2 Support for violence

Individuals with the potential to produce violence should express levels of aggression that vary with their exposure to ambient temperature. Borrowing from the psychological research, this hypothesis should hold as long as combatants were unaware of the temperature's effect on their emotional state.[10]

Hypothesis 4 *Endorsement of violence has a positive relationship with temperature.*

3 Data sources

We introduce our primary datasets here, beginning with the source for our measurements of insurgent violence, followed by the survey data to assess hostile attitudes, and concluding with temperature and other meteorological variables. Descriptive statistics appear in Appendix A.1.

3.1 Attack frequency and insurgent fatalities

Three sources provided insurgent violence data. Throughout the Afghanistan and Iraq wars, international forces and their local partners maintained records of "significant activities" (SIGACTs). These included attacks experienced or observed by international and/or local governmental forces. Our statistical tests used two distinct Iraq War SIGACTs datasets and one comprehensive SIGACTs dataset covering the Afghanistan War.

The three datasets share many characteristics. All of them identify the location of each attack within several meters, expressed in military grid reference system (MGRS) coordinates. They also contain the date and general category of attack, including "direct fire,"

[10] See footnote 3.

"indirect fire," and "improvised explosive device". The datasets differ in other key respects. For the Iraq War, a limited set of SIGACTs data covering the period from February 2004 to February 2009 was originally obtained and released by Berman et al. (2011) (Release I). This release included details of the specific weapon types used in attacks.[11]

In 2014, the U.S. Department of Defense released all Iraq War SIGACTs (Release II). This second release covered December 2003 to the end of December 2011, when American forces completed their withdrawal from Iraq. This was the first public release of this collection containing 253,286 observations. These data lack specific attack-type descriptions. However, they include several variables absent from the first dataset, including the actual time of insurgent attacks.

Shaver and Wright (2016) obtained and prepared the Afghanistan data. As with the Iraq SIGACTs (Release II), these data include information related only to the general category of attack. As with Release II, they include detailed time stamps for each attack.

Insurgent violence was widespread in Baghdad, Basra, and the fourteen Afghanistan districts during the day-level study period. The two Iraqi cities experienced a combined total of 55,851 major insurgent attacks, including 21,862 direct fire and 21,767 IED attacks. The fourteen most violent Afghan districts experienced 44,172 direct fire and 11,927 IED attacks. Of the 44,284 combat-age male survey respondents who responded to all relevant questions in our analysis, nearly 60% expressed support for violence against international forces.

[11]For instance, an attack using a rocket-propelled grenade was directly identified and also assigned to the more general classification of "direct fire". Attacks using rifles and other small arms also qualified as direct fire.

Figure 1: Insurgent attacks plotted on IIACSS' survey blocks in Baghdad City. Source: Shaver (2016).

3.2 Iraqi civilian attitudes

The Independent Institute for Administration and Civil Society Studies (IIACSS), an Iraqi firm under U.S. military contract, surveyed civilian attitudes throughout the conflict. This initiative solicited responses from approximately 175,000 Baghdad residents across the city's ten neighborhoods (*mahalas*). In turn, these were divided into the 467 blocks that are depicted in Figure 1 alongside incidents of insurgent violence. The firm collected information on respondents' views and demographics, including attitudes toward violence directed against international forces. Klor et al. (2016) first introduced these data.

3.3 Meteorological variables

The U.S. Government National Climatic Data Center provides day-level time series datasets. These include ambient temperature and various meteorological covariates such as visibility, wind speed, precipitation, dewpoint, and cloud cover collected by weather stations. We matched station data to the cities and districts in the study.[12]

4 Empirical testing

We conduct two general sets of statistical tests relating ambient temperature to the frequency of insurgent violence and hostility of civilian attitudes.

4.1 Temperature and attack frequency

4.1.1 Temperature response

To assess the relationship between temperature and the intensity of insurgent violence, we take two broad approaches. These will be described before detailing the specific statistical tests we carry out. We first test the following set of models, in which the temperature response function $f(T_{i,t})$ represents a series of regression specifications consisting of linear and higher order polynomial terms.[13]

$$Y_{t,i} = f(T_{i,t}) + \sum_{j=1}^{m^*}(\alpha_j Y_{t-j,i} + \boldsymbol{\beta_j'}\boldsymbol{D}) + \boldsymbol{\varrho}'\boldsymbol{V} + \upsilon_v + \nu_i + e_{t,i}$$

For each set of model specifications in $f(T_{i,t})$, we calculate mean predicted values from the

[12]As we discuss later, we also used hour-level time series datasets to construct an alternative measure of daily temperature (median) as a robustness check on our results, as well as to explore whether the patterns we uncovered at the day-level manifested hourly. Meteorological covariates available at the hourly level vary slightly, as indicated later.

[13]We limit the expressions to no more than a third (cubic) term to avoid possible over-fitting.

full set of predicted values ($\hat{Y}_i$) to identify the temperature value at which political violence was most likely to occur. All models measure the temperature at the daily maximum, although results are consistent if we instead evaluate the median[14] or the mean.[15]

To account for the possible influence of previous temperature levels or previous levels of insurgent violence by type on our outcome measures, we augment the model with vectors $\sum_{j=1}^{m^*}(\alpha_j Y_{t-j,i} + \boldsymbol{\beta_j'} \boldsymbol{D})$, following standard time series measures.[16] The value m^* controls for measures over the preceding week, with lags for each of the seven previous days. Both time (υ_v)[17] and unit fixed effects (ν_i) further supplement the models. Finally, $\boldsymbol{V}$ is a matrix of time and unit varying contemporaneous controls. As discussed below, these vary across models but always include vectors of meteorological controls.

4.1.2 Temperature deviation from seasonal expectation

Our second approach measures daily temperature deviations from their expected seasonal value ($\Delta T_{i,t}$). Given possible diminishing or decreasing returns to outcome measures at high temperatures, we interact this term with a high-temperature (γ) threshold indicator variable to allow deviations to assume positive or negative values, conditional upon where they fell on the observed temperature spectrum: $\mathcal{D} = 1[T_{i,t} > \gamma]$.

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[14]If proximate temperatures are the relevant treatment, then overall exposure to particular temperatures may be a more direct measure of the relationship than the daily maximum or mean. Analyzing the distribution of hourly temperatures across average daytime temperatures using hourly temperature data from Baghdad, Basra, and Mosul, we find that the distributions were often skewed: The frequency of hours at a given temperature was not necessarily most likely to occur on days with that average temperature Consequently, we use hourly temperature data for Baghdad and Basra to calculate *median* daily temperatures. Retesting the models with this alternative measure yields results consistent with those using maxima and means

[15]We report primary results using mean temperatures in the appendix.

[16]$\boldsymbol{D}$ is given in matrix notation because this set of controls includes not only lagged values of the outcome variable (e.g. direct fire attacks) but lagged values of other types of violence (e.g. indirect fire and IED attacks).

[17]All models include week fixed effects. We replicate all models using month fixed effects as well.

$$Y_{t,i} = \beta \Delta T_{i,t} + \xi\, \mathcal{D} * \Delta T_{i,t} + \zeta\, \mathcal{D} + \sum_{j=1}^{m^*} (\alpha_j Y_{t-j,i} + \boldsymbol{\beta_j'} \boldsymbol{D}) + \boldsymbol{\varrho}' \boldsymbol{V} + \upsilon_v + \nu_i + e_{t,i}$$

We use local polynomial regression to estimate and remove the general trend for all unit time series. We then calculate $\Delta T_{i,t}$ by taking the difference in the expected value of temperature (the polynomial fit)[18] minus the observed value ($T_{i,t}$). Appendix Figure 7 provides examples of this approach. Given that γ must be supplied to the model, we generate results allowing γ to vary over a range of daily maximum temperature values (Γ = [75°F, 105°F]).[19]

By studying random temperature deviations from seasonal expectations, this latter approach allows us to identify the day-to-day impact of temperature changes on insurgent violence. Given that naturally occurring short-term temperature variation is exogenous and largely unpredictable, our estimates capture the effect of plausibly randomized treatment exposure.[20] A second benefit is that we can identify more precisely the range of temperatures across which effects on violence and aggression manifested as γ increased.

4.1.3 Model specifics

Across both the temperature response and deviation models, we analyze distinct violent outcomes. We compare the association between temperature and both the least and the

[18] That is, the expected temperature based on estimated individual time series seasonality.

[19] As described below, we find that decreasing returns to temperature, in the models for which they were identified, start somewhere beyond $\approx 90°F$. Given previous temperature effect findings, this range of Γ is informed both by previous work and the results of our research.

[20] Insurgents could conceivably adjust their operations to weather forecasts. However, this was unlikely during the conflicts in Afghanistan and Iraq for several reasons, including electricity shortages and lack of internet penetration (World Bank 2021a,b), as well as modest mean (absolute value) day-to-day changes of around 3°F that had no apparent tactical implications. Furthermore, the study focused on violence over which individual foot soldiers had the most discretion, furthest from centralized directives.

most organizationally constrained attacks. If temperature affects insurgent violence by influencing combatants' aggressive impulses, there should be little to no effect of temperature on organizationally constrained attacks. Furthermore, to rule out the possibility that a temperature-violence relationship is driven by the activities of government forces,[21] we also study the relationship between temperature and roadside bomb (improvised explosive device, IED) attacks. In both Afghanistan and Iraq, IEDs were used for the nearly exclusive purpose of targeting vehicles. As a result, they offer a strong test of whether attack patterns varied with temperature as a function of military movement. We replicate this analysis using more general attack data from the Afghanistan War.

As an additional check, we associate temperature with direct fire and roadside bomb attacks during Baghdad's nighttime curfew. Civilian travel during this period was effectively fixed and military movement was more likely to be randomized than during the day. This ensures that target movement does not influence the study results.

We carry out all tests using ordinary least squares regression and calculated heteroscedasticity-consistent standard errors.[22][23] Because $Y_{t,i}$ is a count variable, we also test the relationship using quasi-Poisson regression. We use results from these tests to calculate the magnitude of estimated effects. For the temperature response models, we calculate mean expected counts of insurgent violence for the range of annual average temperatures observed in the study data, holding covariates at their observed values.[24] We generate uncertainty estimates at

[21]For instance, forces conducting population-centric counterinsurgent activities might be expected to travel outside of bases during times at which civilians are more likely to be in public, and this may be influenced by temperature.

[22]Given the small number of geographic units in our samples, we do not cluster since the number would fall short of the minimum (≈30) indicated by Cameron et al. (2008).

[23]We set the outcome equal to $ln(Y_{t,i}+1)$ given non-normality of residuals when outcome $Y_{t,i}$ was directly included (MaCurdy and Pencavel 1986). Instead, the results are robust to the use of an inverse hyperbolic sine transformation for the outcome variables ($ln(Y_{i,t}+\sqrt{Y_{i,t}^2+1})$). Tables available from the authors upon request.

[24]To ensure that rarely observed temperature values do not skew the findings, we generate results with

the 95% significance level with quasi-Bayesian Monte Carlo simulations. For the temperature deviation models, we calculate the difference between the expected count of violent attacks given a one standard deviation temperature deviation increase ($\Delta T_{i,t} \approx 4°$) and the expected count in the absence of a temperature deviation ($\Delta T_{i,t} = 0°$). For comparability purposes, we then calculate the percentage change that quantity represented relative to mean level violence, which we denote as ρ.

Our core results are generated using a daily city panel dataset for Iraq and a daily province dataset for Afghanistan. The Iraq panel is constructed from two independent time series for the Iraqi cities of Baghdad and Basra.[25] The cities were selected due to the availability of the greatest number of relevant controls. Together, they capture approximately 42% of recorded insurgent attacks during Operation Iraqi Freedom. The Afghanistan panel is constructed from data for the country's fourteen most violent districts, which jointly account for approximately 43% of violence documented by the U.S. Department of Defense during Operation Enduring Freedom.[26] Our entire set of controls are described in Appendix A.3.

For the nighttime curfew test, we assess whether the hypothesized temperature-direct fire relationship manifested during the curfew period in Baghdad when civilian movements that might otherwise have affected insurgent targeting were effectively held constant. For this purpose, we use the time stamps available in Release II of the SIGACTs dataset to create a

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and without these most extreme values (the top and bottom 1.25 percentiles).

[25] For each city, we construct the most extended time series possible given data availability. For Baghdad, the time series covers January 2005 to February 2009. For Basra, this period runs from February 2004 to February 2008. Both series cover the most intense period of fighting in the war.

[26] Limited weather station information narrowed the Afghanistan day-level analysis to: Panjwayi, Zhari, Maywand, and Kandahar in Kandahar Province; Nad Ali, Nahri Sarraj, Sangin, Musa Qala, Naw Zad, Garmser, and Kajaki in Helmand Province; Dara-I-Pech in Kunar Province; Saydabad in Wardak Province, and Barmal in Paktika Province. The dates for each district vary but they collectively cover all days between 2005 and 2014. Owing to the lack of specific attack coding in the Afghanistan SIGACT, the Iraq tests cannot be exactly duplicated. Instead, the general category of "direct fire" subsumes small arms attacks to evaluate the effect of temperature on individual combatants. The IED category tests the alternative explanation that a temperature-violence relationship arose from target movement. The same controls are in place, with the exception of the electricity supply that is described below.

nightly time series of our variables and replicated the tests described above.[27]

4.2 Temperature and aggressive civilian attitudes

The final tests associate temperature and the expressed aggression of Iraqi males surveyed throughout the war. If changes in perpetrator aggression drive changes in the effects of temperature on violence, a corresponding relationship between ambient temperature and this variable should also be observed. IIACSS survey data provide an opportunity to test whether respondents were more likely to support violent attacks on American forces at elevated ambient temperatures.

Following the same testing strategy described earlier, we generate temperature response and deviation results with the survey respondent as our unit of analysis. Seeking to assess the effect of temperature on aggressive ideation in individuals most representative of combatants, we subset the survey data to male respondents of fighting age. The outcome measure Y_i is a binary indicator reflecting whether each respondent i affirmatively answered the question "Do you support attacks against: Multi-National Forces?"[28] Because the outcome is dichotomous, we generate estimates with linear probability models and logistic regression.

We include a vector of individual respondent controls, including reported income (weighted by household size), education level, age, number of hours worked per week, and household size. Differences in electricity demand and supply were likely to have been greatest at

[27]Incidents between 11:00 pm and 5:00 am are subset. Although curfew hours varied during the conflict, this range was consistently covered according to various press reports. Release II broadly categorizes violence, making a division into constrained and unconstrained violence impossible. Instead, we compare IED with direct fire attacks since the latter were primarily conducted using small arms. Because the nighttime time series is constructed from hour-level weather station data, these meteorological controls differed slightly from those described above. Specifically, we control for wind speed, visibility, and dew point at the hour level. Given missing precipitation data (rare in Baghdad), we controlled for cloud cover. See: ftp://ftp.ncdc.noaa.gov/pub/data/noaa/ish-abbreviated.txt

[28]Although direct questions on sensitive topics can elicit biased responses, Appendix A.4 explains why this is not a concern in this case.

higher temperatures. Given unmet electricity demands during such periods, anger with the international occupying forces may have driven a relationship between temperature and attitudes toward the use of violence against these forces. We therefore control directly for perceptions of electricity supply.[29] Neighborhood fixed effects control for time-invariant characteristics specific to each neighborhood. Similarly, by absorbing across-time variation, month-of-response indicators reduce potential bias by deriving estimates of interest based on within-month data variation.[30]

Estimates of magnitude are similarly calculated for this analysis. To determine temperature response functions, we generate the predicted probabilities of support for violence across the range of temperatures observed in the study period.[31] For temperature deviations, ρ represents the difference between the predicted probability of support given a one standard deviation temperature deviation increase in temperature and the predicted probability of support in the absence of a temperature deviation. This quantity is divided by mean support for violence.

A second test verifies the results. Survey respondents were interviewed in their homes. For most respondents, the absence of electricity throughout the Iraq War ensured that daily measures of ambient temperature closely approximated actual temperature levels to which individuals were exposed during interviews. However, wealthier citizens were more likely to have access to private generators and fuel to power fans or air-conditioners. If including wealthy respondents in the original sample attenuates the results because they were not

[29] In particular, we include responses to the question "How do you feel the conditions of the following have changed in the past 3 months?: Availability of electricity".

[30] We also perform more stringent tests in which we included survey block fixed effects in place of neighborhood fixed effects. The results are consistent, as we report later. For these tests, we only generate results with month fixed effects. This is because although surveys were carried out across multiple days within weeks, within-week temperature variation was minimal. When survey days were grouped by week, a σ change in temperature was less than 1°F.

[31] Quasi-Bayesian Monte Carlo simulations again generate uncertainty estimates.

subject to the ambient temperature treatment, we expect intensified results after excluding those who reported the highest income levels.

4.3 Attack frequency results

Across these distinct conflicts with somewhat varying climates, the estimates show the strong positive effect of increased daily maximum temperatures on insurgent production of organizationally unconstrained violence. Consistent with existing research and Hypothesis 1, both response and deviation results provide evidence of diminishing and possibly decreasing returns of violence to temperature at the highest levels. Confirming Hypothesis 3, this relationship holds at night. These results indicate that temperature works through the embodied motivations of individual combatants. Contrary to the expectations of Hypothesis 2, this relationship does not hold for roadside attacks. This result shows that the violence-temperature link is not explained by changes in the movement of targets.

Figure 2 illustrates the estimated relationship between temperature level and attack frequency. The plot on the left displays the overall relationship in the two conflicts, which shows the expected relationship between ambient temperature and attacks types whose initiation was organizationally unconstrained. The panels on the right disaggregate attacks into different types for each conflict, as derived from count model results. The results collectively indicate that across these distinct conflicts with somewhat varying climates, political violence involving significant individual discretion showed significant positive returns to ambient temperature. The effect existed at most temperatures, with potentially diminishing or decreasing returns at high levels. In contrast, the results show no clear relationship between temperature and the detonation of weapons typically directed against military targets, suggesting that neither organizationally constrained violence nor target movement was responsible for the observed temperature-violence relationship.

Figures 3 and 4 display temperature deviation results for Iraq and Afghanistan, respec-

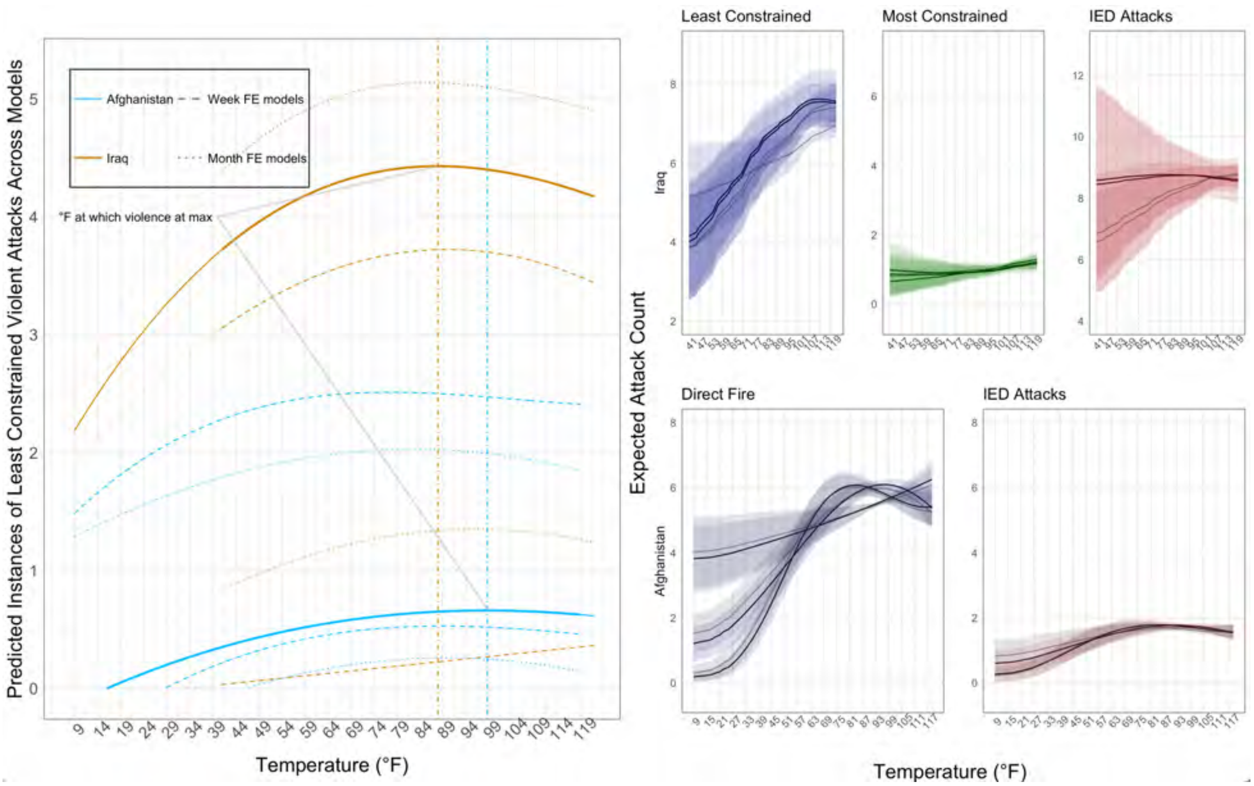

Figure 2: The left figure plots predicted instances of violent attacks from statistically significant model specifications in $f(T_{i,t})$. Predicted model values are given by dashed lines when they include week-administrative unit fixed effects and dotted lines for month-administrative unit fixed effects. Solid lines indicate country average values across models. The dashed vertical line for each country provides the estimated daily maximum ambient temperature at which political violence was most likely to occur. The range of temperatures across which predictions are plotted represent all temperatures observed across both countries. Bold line segments represent the set of temperatures observed solely within that country's sample. The figures on the right display the estimated attack counts by attack type. 95% uncertainty estimates are generated using quasi-Bayesian Monte Carlo simulation.

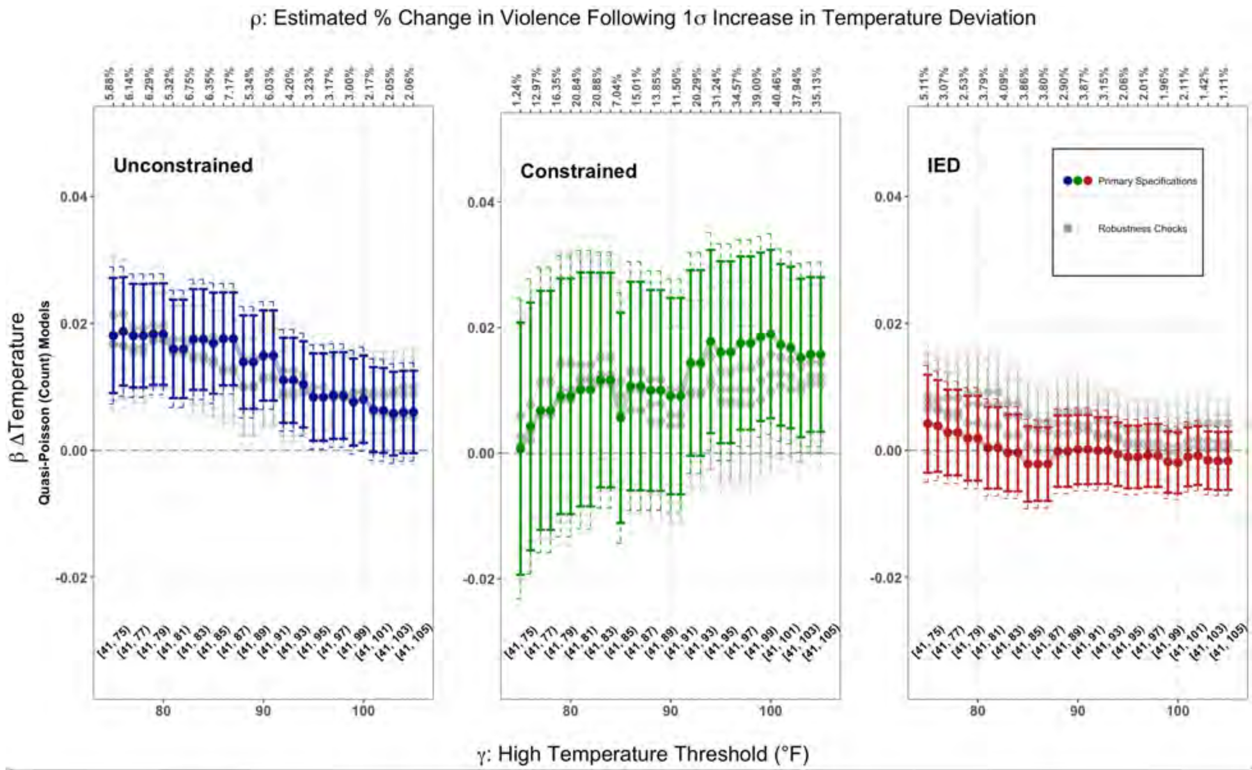

Figure 3: Estimated daily changes in insurgent violence by type in Baghdad and Basra following random temperature fluctuations ($\Delta T_{i,t}$) in degrees Fahrenheit. Changes in the least constrained violence, most constrained violence, and IED attacks are plotted respectively in blue, green, and red. Estimated changes in violence following a one standard deviation increase in temperature deviation (≈4.02 °F), expressed as a percentage of the mean for each respective violence type, are displayed on the upper x-axes. 90% and 95% confidence intervals are shown respectively in solid and dashed lines. Point estimates and confidence intervals in gray denote alternative specifications carried out as robustness checks. OLS results appear in Appendix A.12.

tively. The left plots in both figures illustrate the expected relationship between temperature and attack types under individual combatant control. Figure 3's middle plot shows the absence of such a relationship for attacks that are centrally controlled by the insurgent command structure. The right plot indicates that the relationship also does not hold for roadside bombs, which Hypothesis 2 would expect. The results shown on the right in Figure 4 confirm this.

The results demonstrate that the effect of ambient temperature on insurgent violence is

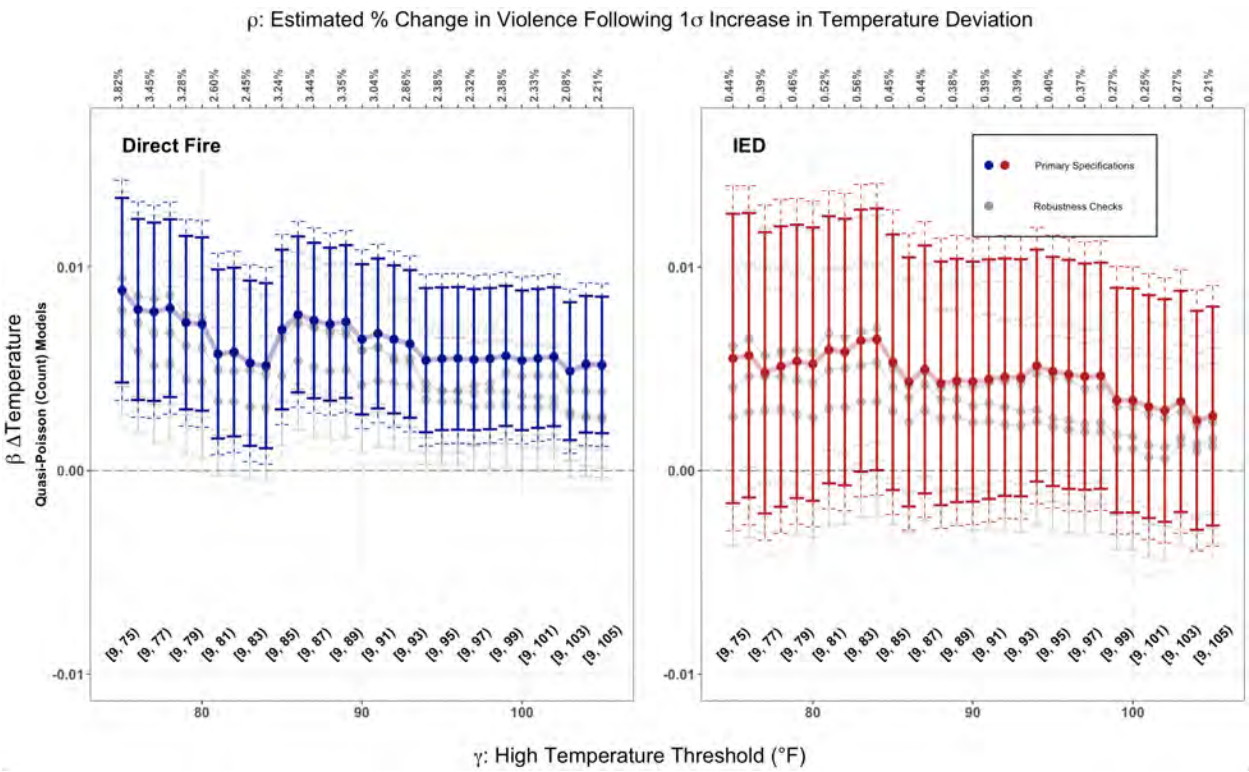

Figure 4: Replication of Figure 3 for Afghanistan. Model results are based on data from the fourteen most violent districts, aggregated to the province. ρ is calculated given a one standard deviation increase in temperature deviation of ≈4.64 °F. OLS-based results appear in Appendix A.12.

substantively significant. In levels, the results indicate significant increases in the number of least constrained attacks as temperatures moved from the coolest levels into and above 90°F (nearly double in Iraq and more than double in Afghanistan). This is shown in the right side set of figures depicting expected attacks counts involving least constrained attacks in Iraq and direct fire in Afghanistan across different count model specifications.[32]

Temperature deviation results show similarly substantial changes. At its maximum, ρ (the estimated percentage increase in least constrained violence following a σ increase in $\Delta T_{i,t}$, relative to mean violence, which appears along the upper x-axis of Figures 3 and 4) respectively exceeds 7% and 3% for the Iraq and Afghanistan results.[33] As the left side plots of Figures 3 and 4 labelled "Unconstrained" and "Direct Fire" show, positive and statistically significant increases in violence are associated with positive temperature deviations. This is especially true when the temperature threshold indicator is set to values below 100 °F. Increases in the threshold temperature level can be observed moving from left to right across the bottom x-axis. In fact, we observe that the strongest returns to violence tend to take place when deviations occur across relatively low starting temperatures.

Nighttime results conducted as an analysis of violence patterns when civilian movements were kept fixed by the imposition of a curfew are consistent: Direct fire attacks are estimated to increase substantially with nighttime temperature while roadside bomb attacks do not share a statistically significant association (see Appendix Figure 8). These results confirm Hypothesis 3 and are only expected if violence initiated by individual combatants is responsive to ambient temperature.

The differences in temperature response and deviation results highlight a key feature of

[32]The results on the left side of the figure illustrate predicted instances of violent attacks from statistically significant model specifications in $f(T_{i,t})$ using OLS regression.

[33]In re-estimated models that dropped the lowest and highest temperatures, the magnitudes of the temperature response results and the temperature deviation results for Afghanistan attenuated slightly but increased somewhat substantially for the temperature deviation results for Iraq (maximum $\rho > 11\%$).

our findings: namely, that immediate, day-to-day effects are relatively modest and likely shrouded by the noise of wartime activities. However, they are cumulatively significant. If these immediate effects were particularly large, this phenomenon would presumably be detected by combatants. Such a discovery would lead organizations that produce political violence to engage in efforts to mitigate them – as they do in other instances in which the actions of agents are likely to deviate from their principals' directives (Shapiro 2015).

In contrast, the evidence does not support Hypothesis 2. The patterns reported above are not reflected in the relationship between maximum daily temperature and the respectively most organizationally constrained insurgent violence and roadside bomb attacks. This is direct evidence that the observed relationships between temperature and small arms and temperature and direct fire attacks were not driven by target movement. In the temperature response results, these variables either revealed no meaningful change with temperature and/or were statistically insignificant. Specifically, see the results for "Most Constrained" attacks and "IED Attacks" in Figure 2, which depict expected attack counts across different count model specifications: As the maximum daily ambient temperature increases, levels of constrained violence display little to no estimated increase while levels of IED attacks show different, inconsistent changes across model specifications.

In the temperature deviation results, roadside bomb attacks were generally uncorrelated with temperature fluctuations. In Figures 3 and 4, this can seen in the plots labelled "IED". In both figures, temperature deviations are consistently associated with statistically insignificant changes in the number of these attacks regardless of the range of temperatures that we consider. Constrained violence was also generally uncorrelated with fluctuations, particularly along the lower temperature ranges that we observe associating strongly with changes in least constrained violence. However, we were unable to rule out increases in constrained violence when temperature deviations occurred at the highest temperatures (see the middle plot labelled "Constrained" of Figures 3). In any case, these patterns were effectively the opposite of what we observed in patterns of least constrained attacks.

The results are highly stable:

1. They are consistent across ordinary least squares and generalized linear models (see Appendix A.12).

2. The results are replicated in country-wide analyses (see Appendix A.6).

3. The patterns that we uncovered were consistent when we substituted maximum daily temperatures with mean and, separately, median daily temperatures (see Appendix A.7 and A.8).

4. For temperature responses, OLS-based results were robust to using inverse hyperbolic sine transformations of the dependent variables.

5. For the temperature deviations, the results were robust to a variety of alternative more parsimonious specifications. In addition to plotting estimates from our primary model specifications (blue), we included estimates from a variety of alternative specifications (gray), as shown in Figures 2 to 6 and throughout the appendices.[34]

6. The results obtained using binned regression and generalized additive models are consistent with our primary findings (see Appendix A.9).

7. Finally, the results are consistent and the substantive significance of the temperature deviation results were strengthened when the lowest and highest temperatures were excluded from our samples.

[34]This approach involved 1) replacing weekly with monthly fixed effects; 2) dropping all vectors of lagged controls; and 3) dropping all vectors of lagged controls and replacing weekly with monthly fixed effects.

4.4 Results for hostile attitudes

In Iraq, there was a positive association between maximum daily temperature and support for the use of violence against international forces (see Figures 5 and 6). Consistent with the previously reported results, attack support diminished as temperatures reached their highest levels. As expected by Hypothesis 4, this relationship is dependent on income level since this serves as a proxy for whether respondents were able to regulate their dwelling's temperature.

The results are substantively significant. In moving from days with maximum temperatures of $\approx 60°$F into over $100°$F, the predicted probability of an Iraqi male expressing support for violence against multinational forces increased by tens of percentage points in the full sample results (see the left plot of Figure 5) and by even more when respondents most likely to have access to cooling technologies were excluded (see the upper plot of Figure 5).

Figure 6, which displays the temperature deviation results, shows that – at its maximum – ρ indicates a more than 5% increase in the probability of respondents expressing support for violence following a σ temperature spike, relative to mean levels of support for violence. Consistent with the other deviation results, we find that positive increases in support of violence are more pronounced when the temperature threshold indicator is set to values below 95 °F. This can be seen by looking at the magnitude and statistical significance of plotted coefficients moving from the lowest threshold values on the left of the x-axis to the highest values on the right.

When all combat-age male respondents were included, the statistical and substantive magnitudes attenuated. The results are more pronounced when those most likely to have access to air-conditioning units or fans are excluded, i.e., the top-earning quarter of respondents. The effect of temperature disappeared entirely in an analysis of only these top income earners. This can be seen in the right side plots of Figure 5. The upper right plot represents predicted probabilities of support among respondent groups in which high-income earners are excluded. Each group corresponds to a different income threshold used to show that

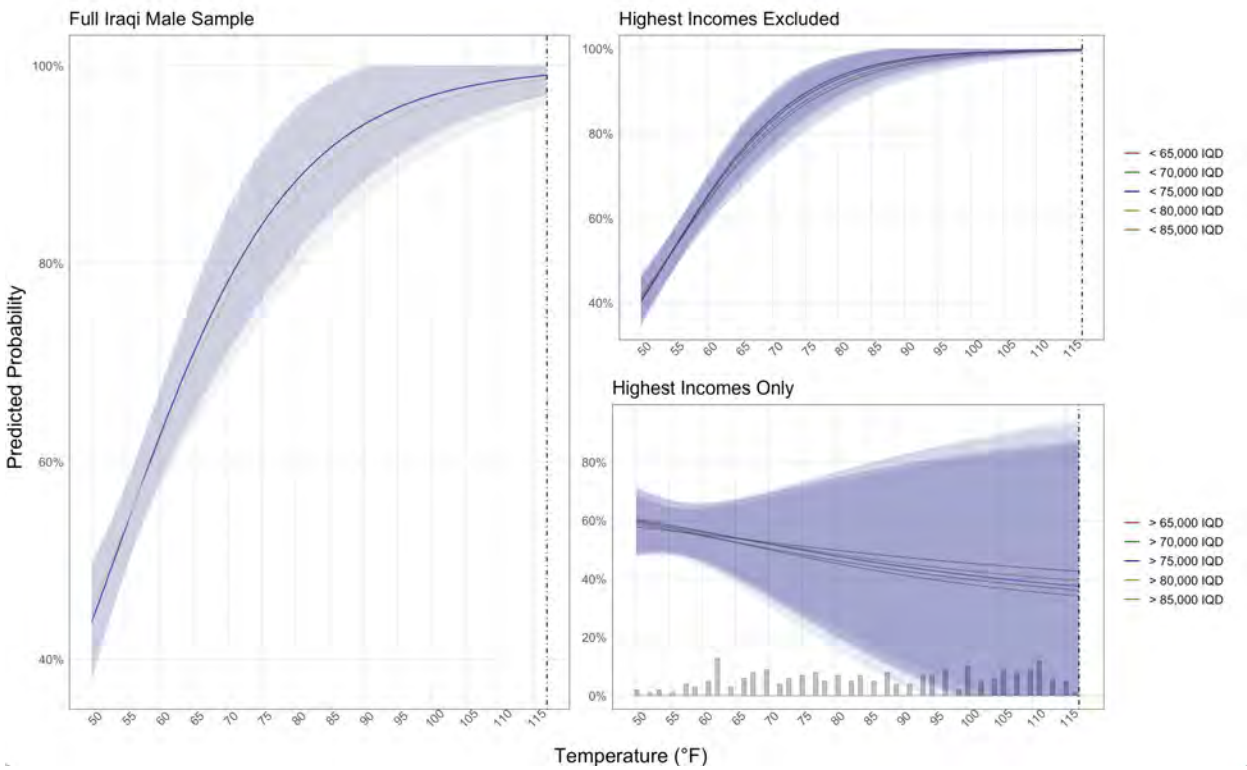

Figure 5: This figure depicts the predicted probability of expressed support for violent attacks on multinational forces by combat-age Iraqi males as a function of mean daily temperature (°F) with 95% confidence intervals. Neighborhood fixed effects are in blue with survey block fixed effects in gray. The distribution of daily mean temperatures observed across the surveys is plotted at the bottom.

the results are robust to different high-income thresholds. In contrast, the bottom right plot represents the same relationship for high income earners, again with different thresholds used to show robustness to the incomes threshold used.

4.5 Robustness checks

4.5.1 Country-wide analyses

We replicate the results using complete district-day panel datasets for both countries with alternative maximum daily temperature data and daily precipitation in millimeters data. These data allow us to replicate our empirical analyses across all Afghan and Iraqi districts

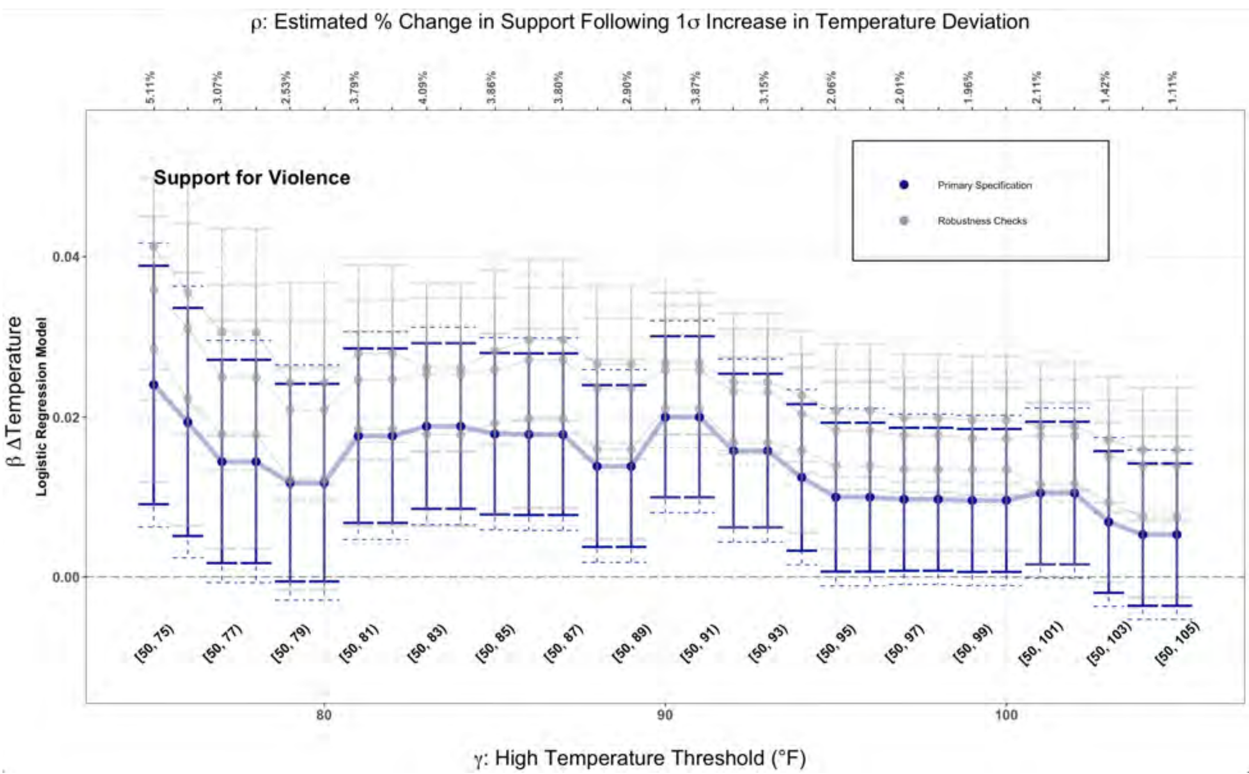

Figure 6: This figure depicts estimated daily changes in expressed support for violence against multinational forces among combat-age males living in Baghdad following random fluctuations in temperature ($\Delta T_{i,t}$). ρ gives the estimated changes in support for violence following a one standard deviation increase in temperature deviation ($\approx$3.98°F), expressed as percentage of mean support and displayed on the upper x-axis. Linear probability model results appear in Appendix A.12.

over almost all years of both conflicts. This approach lacks some of the controls included in our primary specifications. However, the consistency of its results serves to externalize our core findings. This analysis is described in full in Appendix A.6.

4.5.2 Binned regression and generalized additive models

We conduct two additional sets of tests that allow for flexible estimations of the temperature-violence/aggression relationship as indicated by the underlying data. Specifically, we estimate the relationship between our key outcomes of interest–least constrained violence and civilian support for violence–using binned regression and, separately, generalized additive models (GAM). For the former, we regress indicator variables for all temperatures in 3°F increments, omitting the first bin to serve as the baseline. For the GAM models, we calculate 95% Bayesian credible intervals (Marra and Wood 2012).

4.5.3 Other meteorological variables

We also present the estimated relationships between other meteorological variables (precipitation, wind speed, maximum wind speed, dew point, and visibility) and least constrained violence. These results, which appear in Appendix A.10, show that no other meteorological variable consistently correlates in the same way as temperature with this violence measure.

4.5.4 Alternative specifications

We replicate results using various alternative and more parsimonious specifications throughout our analyses, typically presented in gray (e.g., lines, point estimates, or error bars) alongside the primary results in color. As we demonstrate, results are very stable across settings and specifications.

5 Concluding discussion

Elevated ambient temperatures induce more aggressive human behavior within the scope of vehicles, homes, bars, and streets. Insurgent commanders in Iraq and Afghanistan did not prevent this effect from impacting their combatants' battlefield operations against U.S. and other international forces. In this concluding discussion, we situate the implications of these findings for the study of organized violence, the micro-foundations of the temperature-violence link, and future conflicts in a changing climate.

5.1 Embodied motivations in conflict settings

To illustrate how these embodied individual-level effects compare with other drivers of aggression and violence, we apply additional analyses of the Iraq War. First, we compare our day-level results with variations in violence based on the day of the week, following research by Reese et al. (2017), who demonstrated that insurgents in Iraq and Afghanistan avoided violence on religious days, including during Friday congregational prayers. We estimate levels of violence on Fridays and other days of the week. The results in Appendix Figure 19 show that Fridays typically experienced approximately two fewer attacks than other days. This magnitude is similar to the estimated effect of moving from the coldest maximum daily temperatures to maxima of twenty to thirty Fahrenheit degrees warmer.

We further analyze how respondents in the survey data differed in their support for violence against multinational forces as a function of their perceptions of security conditions, family safety, government effectiveness, and the availability of electricity and jobs.[35] Appendix Figure 20 shows that respondents who negatively evaluated these conditions are

[35] On a five-point Likert scale, respondents evaluated expected conditions for their city, family, government, police effectiveness, employment availability, electricity, and security over the next three months. "Don't Know" responses are excluded. We collapse the outcome into a binary measure to simplify the presentation of predicted probabilities using logistic regression.

roughly fifteen percentage points more likely to endorse the use of violence against government forces. This magnitude of dissatisfaction is similar to moving from the coldest maximum daily temperatures experienced in Baghdad during the study period to those $\approx 20°F$ warmer.

Temperature is not the sole individual-level contributor to acts of violence and is responsible for a relatively small incidence of wartime violence on its own. However, the magnitude of its effect challenges the view that "individual motivations alone are unlikely to result in large-scale violence over a long period" (Kalyvas et al. 2006: p. 26). These current findings supply evidence that other, more powerful stimuli acting upon individuals that are far more integral to conflict than ambient temperature shape the type and frequency of political violence, however difficult it is to measure this effect in observational settings. Clausewitz articulated a duality between hostile feelings experienced by warriors and the hostile intentions of their political leadership, focusing his research on the latter (Von Clausewitz et al. 2011: p. 137-8).

Contemporary conflict research now has some tools to balance this emphasis. Instead of assuming that any observed violence results from political strategy, the conditions under which violence manifests can be better understood if we see the combination of organization- and individual-level motivations as creating or preventing violent outcomes. Consequently, we do not argue for discarding the analytical leverage of organizational rationality models. Instead, we have used observational data to demonstrate how this approach can be synthesized with psychological theories to better explain patterns of violence in conflict, especially with regard to combat conditions in which individual fighters have a significant measure of autonomy.

5.2 Ranges of aggression

Previous empirical examinations suggest that rising temperature leads individuals to commit more violence–up to a point. Beyond this inflection point, the relationship reverses and higher temperatures inhibit violence. Studies have found a broad range of inflection points that extend from slightly above room temperature to scorching heat. We find that the effects linking temperature and violence operate as much at moderately warm temperatures as they do in more extreme heat. Changes at cooler temperatures were more influential in producing the observed pattern of violence and expressed aggression than suggested by the focus on heat. Our findings suggest that the effects of moderate warming in relatively cool environments are significant and that sociological, psychological, and criminological investigations into the link between temperature and violence may have missed them in the search for the effects of heat.

The context in which an individual combatant's body is affected by temperature was also a probable contributor. The temperature recorded by a thermometer was different from what was subjectively experienced by affected combatants, who were often in motion and carrying heavy equipment.[36] Movement-induced thermal stress is a well-established physiological factor. This may partially explain why the range of temperatures in this study was on the lower end, especially when compared to laboratory studies in which the action on an aggressive stimulus involves little physical effort.

Future work should seek out even higher resolution spatio-temporal measures to better investigate these psychological and physiological mechanisms. As an exploratory exercise, we used hour-level data from weather stations and direct fire attack time stamps from the respective SIGACTs datasets to study temporally proximate changes in temperature and violence. We replicate our temperature response models, adopting the hour as the unit of

[36] For an example of the conditions experienced by combatants on one side of the war, see Press (2009).

analysis. Our Iraq panel consisted of time series data for the areas of Baghdad, Basra, and Mosul. The panel for Afghanistan included Kabul and Kandahar. Rather than incorporating lag vectors over the preceding week, we include lags for each of the preceding 24 hours.[37] Finally, we replace weekly fixed effects with unique date and separate time of day fixed effects. The results are ambiguous. For the Iraq panel, results are consistent with daily analyses: a strong, positive relationship at which violence levels peaked at $\approx$ 88°F. But for the Afghanistan panel, the association is generally negative. The manner in which the effects of temperature manifest to ultimately produce the day-level patterns that we observed remains open to further inquiry.

5.3 Effects of long-term temperature changes

The broad range of temperatures over which violence and aggression manifest expands our knowledge of the effects of climate on social phenomena. While the greatest levels of violence and aggression occur as temperatures approach their highest levels (see the expected attack counts and predicted probabilities of support for violence in Figures 2 and 5), the results speak to a relationship that is more complicated and persistent than one in which "people get uncomfortably hot, [and] their tempers, irritability, and likelihood of physical aggression and violence increase" (Plante and Anderson 2017). With the exception of the highest temperatures, we find that escalations in aggression and violence predictably follow increases in temperatures regardless of the level at which they started.

The deviation results and associated estimates of magnitude (ρ) depict this clearly: Positive deviations in temperature are typically associated with the greatest returns to violence and aggression when γ falls between 75° and 90° (i.e., when the effects of temperature devi-

[37]As noted earlier, the set of meteorological variables was slightly different for hourly weather station data.

ations are estimated based on shocks occurring in $[min(T_{i,t}), 75° \text{ to } 90°])$.[38] In other words, the phenomenon is driven as much or more by temperature increases during relatively cool periods as by increases when temperatures are already relatively high. Sociological, psychological, and criminological investigations into the temperature-violence link appear to have overlooked these effects.

Previous findings regarding short-term embodied motivations for violence provide micro-foundational evidence for the observed long-term link between climate and violence. Incorporating the results of 60 prior studies, Hsiang et al. (2013) found that "for each 1 standard deviation (1σ) change in climate toward warmer temperatures or more extreme rainfall, median estimates indicate that the frequency of interpersonal violence rises 4% and the frequency of intergroup conflict rises 14%" (p. 1). Such research frequently assumes that the effect works through the economic consequences of temperature, especially agriculture. The empirical finding that sub-state violence retains its association with temperature in non-agricultural areas suggests that past conflict research may have focused too narrowly on long-term, large-scale mechanisms (Bollfrass and Shaver 2015).

Our findings suggest that an observed temperature-conflict correlation in non-agricultural parts of the world partly reflects aggregate and emergent patterns of individual-level drivers of violence. Such a correlation could be incorporated into future models predicting the economic, political, and social effects of a changing climate. This means that not only those parts of the world that currently have warm climates will become more prone to experiencing individual-level human aggression, but that temperate climates are also at risk.

Two other trends boost the salience of individual-level drivers of violence. The first is the seeming erosion of effective control that institutions have over individual behavior. The second trend is technological advances that place the potential for lethality into the hands

[38] As discussed above, changes in γ allow us to identify more precisely the range of temperatures across which effects on violence and aggression are most pronounced.

of more individuals. In combination, the means and motives for individual violence may increase simultaneously and congruently with a greater potential for damage. If both of these trends manifest, scholars of conflict must calibrate their toolkit in order to measure the relative importance of strategically and embodied motives for drawing inferences about organized violence.

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A Appendix

A.1 Descriptive Statistics

Table 1: Descriptive Statistics: Baghdad-Basrah Panel

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
District	104	–	–	–	–	–	–
Date (Baghdad)	1848	2007-01-28	–	2005-01-01	–	–	2009-02-24
Date (Basrah)	1848	2006-02-10	–	2004-02-04	–	–	2008-02-17
Daily Temperature	2,991	76.577	18.127	36.500	60.400	93.900	106.500
Precipitation	2,991	0.004	0.044	0	0	0	1
Wind Speed	2,991	7.059	4.112	0.700	4.100	8.850	26.100
Dew Point	2,991	42.538	7.619	11.300	38.200	46.900	72.900
Visibility	2,991	5.534	1.200	0.300	5.000	6.200	7.000
Maximum Wind Speed	2,991	13.467	6.962	1.900	8.900	16.900	44.900
Daylight	2,991	12.136	1.445	10	10.8	13.5	14
Hours of Power	2,355	10.673	4.410	0.000	7.000	14.000	24.000
Least Constrained Violence	2,991	5.513	7.998	0	0	8	50
Indirect Fire	2,991	2.376	4.314	0	0	3	35
IED Attacks	2,991	7.171	9.167	0	0	13	43
Constrained Violence	2,991	0.883	1.799	0	0	1	16

Table 2: Descriptive Statistics: Afghanistan's Most Violent Districts Panel

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Province	5	–	–	–	–	–	–
Date (Across Provinces)	3000	2010-10-29	–	2005-01-01	–	–	2014-12-31
Daily Temperature	7,765	65.985	19.242	0.000	51.100	81.400	107.100
Precipitation	7,051	0.014	0.080	0.000	0.000	0.000	2.850
Wind Speed	7,723	4.826	2.361	0.000	3.200	6.000	20.500
Dew Point	7,761	29.384	12.377	−13.900	21.700	36.800	69.800
Visibility	7,613	6.232	1.155	0.200	5.900	7.000	10.000
Maximum Wind Speed	7,720	10.774	4.652	1.000	8.000	13.000	40.000
Daylight	7,765	12.269	1.598	9.850	10.750	13.867	14.467
Direct Fire	7,765	5.081	7.730	0	0	7	88
Indirect Fire	7,765	0.429	0.858	0	0	1	14
IED Attacks	7,765	1.456	2.248	0	0	2	19

A.2 Derivation of $\Delta T_{i,t}$ Graphically Illustrated

Figure 7 provides two sample illustrations of our derivation of $\Delta T_{i,t}$.

Table 3: Descriptive Statistics: Baghdad Survey Dataset

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
Survey Block	549	–	–	–	–	–	–
Date	223	2006-12-04	–	2005-01-01	–	–	2008-09-16
Daily Temperature	39,875	88.376	17.894	50.000	71.600	105.800	116.600
Precipitation	36,966	0.003	0.020	0.000	0.000	0.000	0.310
Wind Speed	39,875	4.427	1.717	0.700	3.400	5.300	13.200
Dew Point	39,875	41.180	6.715	22.100	37.600	46.700	62.400
Visibility	39,875	5.313	1.186	0.700	4.600	6.300	7.000
Maximum Wind Speed	39,875	9.487	3.579	2.900	7.000	11.100	26.000
Daylight	39,875	12.229	1.390	9.967	11.067	13.633	14.350
Age	39,875	36.844	12.444	18	26	46	65
Hours Worked per Week	39,875	25.300	21.635	0	0	40	100
income.w	39,875	59,062.140	50,581.310	0.000	30,000.000	75,000.000	2,000,000.000
Household Size	39,875	7.444	3.600	1	5	9	40
Past Week Insurgent Violence	39,875	25.855	31.824	0.000	6.000	30.000	153.000
Perceptions of Electricity	31,140	0.878	0.328	0	1	1	1

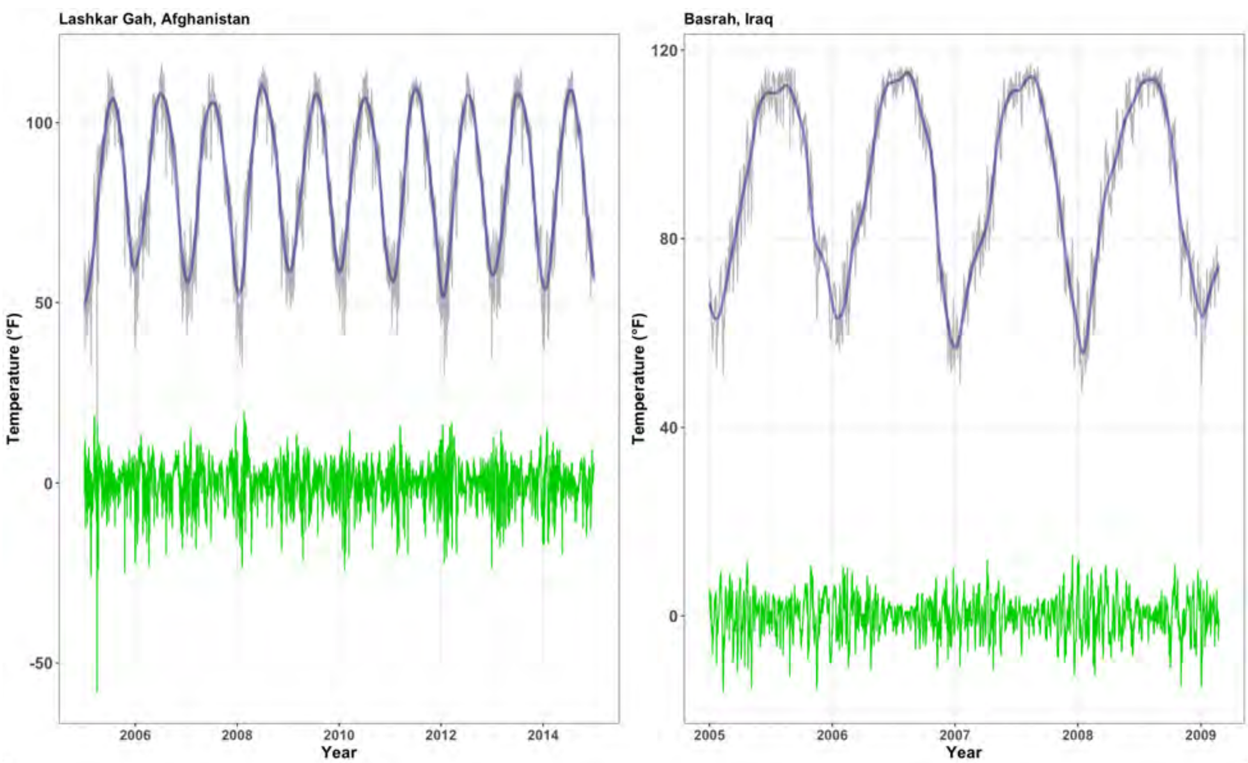

Figure 7: This figure provides two sample illustrations of our derivation of $\Delta T_{i,t}$. For the Afghan and Iraqi districts of Lashkar Gah and Basrah, we plot i) the actual temperature time series for each district (gray); ii) the estimated trend from local polynomial regression (blue); and, finally, $\Delta T_{i,t}$ (green), residual variation in day-to-day temperatures estimated from the difference in observed and fitted temperature values.

A.3 Primary Insurgent Violence Model Controls (Temperature Response and Deviation)

Insurgent Violence by Type: As indicated previously, we controlled for other types of insurgent violence (e.g., indirect fire, IED attacks, and constrained violence) in our model of least constrained attacks. We also included vectors of each of these lagged variables. *Hours of Daylight:* Longer days are warmer. We included daily daylight hours in the model to account for the possibility that more attacks occurred in warmer weather because greater numbers of daylight hours affected insurgents' opportunities to attack (Astronomical Applications Department). *Meteorological Conditions:* Weather patterns related to temperature may influence some insurgent tactics. For instance, sandstorms reportedly provided cover to insurgents firing rockets and mortars against international positions in Baghdad (Samuels 2008). $\boldsymbol{V}$ therefore includes data on visibility, wind speed, maximum wind speed, precipitation, and dew point (National Climatic Data Center; Manual).

Hours of Power: Temperatures in Baghdad, Basra, Helmand, and Kandahar reach extreme highs. During the study period, they extended beyond 120°F. As temperatures increased, especially at such high levels, electricity demand for cooling was likely to have grown concurrently. The electricity supply was irregular. Community dissatisfaction with the government's inability to supply electricity, particularly during warmer periods when most needed, may have facilitated an increase in insurgent attacks through two mechanisms. First, by diminishing the willingness of civilians to share intelligence about insurgents with Afghan/Iraqi and international forces; second, by increasing their motivation to take part in the insurgency. To address this possibility, for Baghdad and Basra, we controlled for the number of hours of power supplied per day (Shaver and Tenorio 2015). Unfortunately, we lacked such data for Afghanistan. *Seasonal Factors:* Early findings associating ambient temperatures with violent crime levels were challenged because seasonal factors such as "vacation time, students being out of school, and alcohol consumption" might account for statistical results (Anderson 1987). While alcohol consumption patterns are not relevant to patterns of insurgency in predominately Muslim Afghanistan and Iraq, growing seasons and whether schools are in session were plausible confounding factors. Evidence from modern insurgencies suggests that students in recess are sometimes recruited (O'Connell and Benard 2006; Ki-moon et al. 2013). The model's weekly fixed effects generated estimates through within-week comparisons, effectively controlling for any remaining potential seasonal factors.

A.4 The Use of Direction Questions in Our Analysis

Although direct questions on sensitive topics can elicit biased responses, we do not believe this was a concern in this case. First, just under 90% (116,102 of 130,676) of those questioned provided a direct answer despite being offered a response choice of "Don't Know". Therefore, there is minimal indication that respondents sought to avoid answering this question. Second, IIACSS' Iraqi enumerators introduced themselves as unaffiliated researchers, which should have eased concern over the destination of the survey data. Most importantly, even if respondents feared answering this question because of possible retaliation, we would expect this to result in an overall shift in the baseline response but not in changes in responses to temperature levels/deviations.

A.5 Baghdad Nighttime (Curfew) Results

Temperature response and deviation results for the Baghdad nighttime (curfew-restricted) results appear in Figure 8.

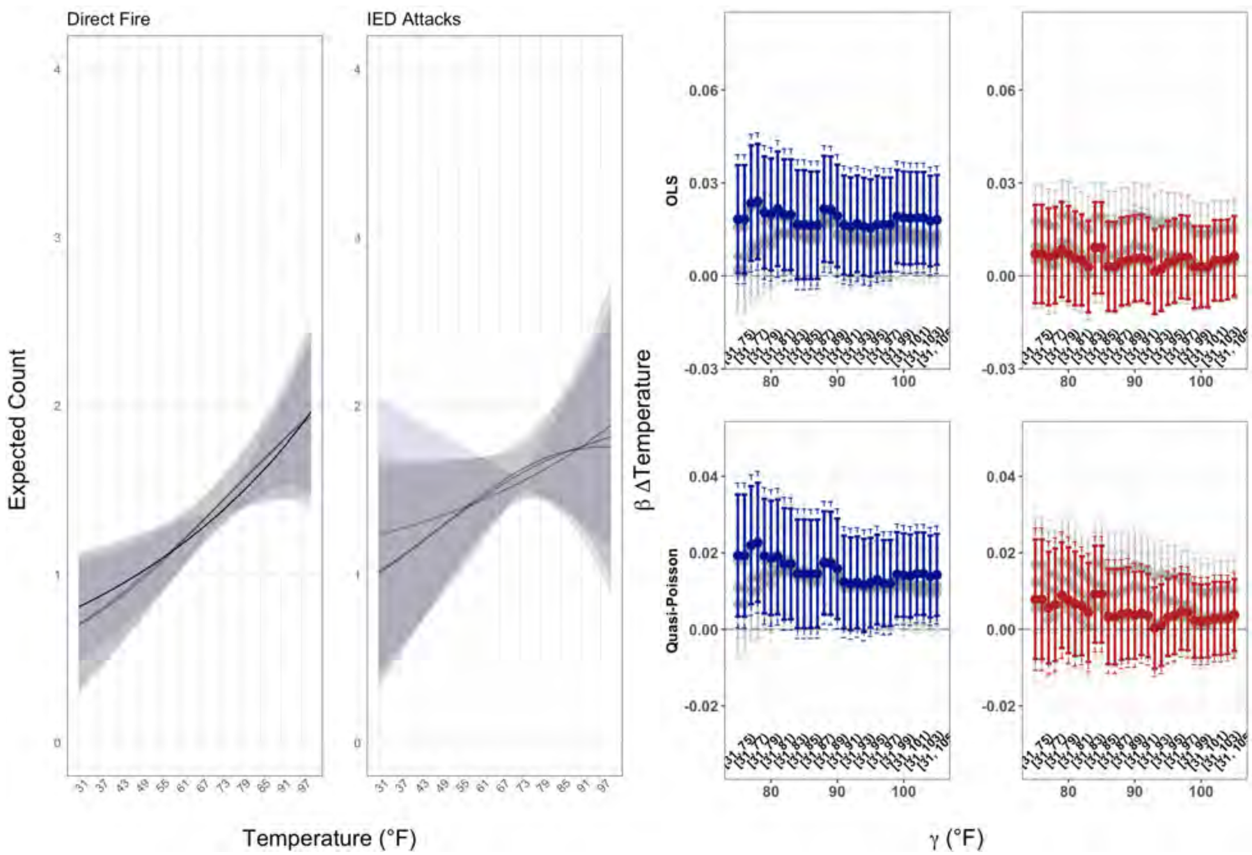

Figure 8: This figure displays temperature response and deviation results for direct fire and improvised explosive device attacks for the subset of attacks in Baghdad between 11:00 pm and 5:00 am when a nighttime curfew held civilian movement constant. The times and routes of relatively slow-moving military supply convoys were purposefully varied. Together, these results help to confirm that military target movement did not drive the systematic variation in the observed temperature-violence relationship.

A.6 Country-Wide Analyses

In this section, we replicated the day-level analyses for all districts in Afghanistan and Iraq.[39] This approach externalized our findings. The results demonstrate substantial effects of ambient temperature on relatively unconstrained violence.

[39] Given the extensive spatio-temporal coverage of these analyses, we lacked some of the controls included in our primary regressions. For this reason, the more focused models for Baghdad and Basra remain our preferred specifications.

A.6.1 Afghanistan

For Afghanistan, we studied insurgent violence between January 01, 2005 and December 31, 2014, when U.S. Operation Enduring Freedom/NATO's International Security Assistance Force ended. This was a total of 1,453,496 (district-day) observations.[40] Following the statistical tests described in the article, we analyzed variation in direct fire attacks and ambient temperature across the entire country.

A.6.2 Iraq

For Iraq, our panel spanned from January 01, 2005 to February 24, 2009, producing 157,664 district-day observations.[41] Following the statistical tests described in the article, we analyzed variation in the least constrained forms of insurgent violence and ambient temperature.

A.6.3 Temperature and Precipitation Data

For each of the subnational country-wide analyses carried out, we used ambient maximum daily temperature and precipitation (daily millimeters) data from Chen et al. (2021b,a).[42] Descriptive statistics are shown in Table 4.

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[40] Formally, these missions ended on December 28, 2014. However, the SIGACTs data extend to the end of the year. Therefore, we included the three extra days in our analysis. Although the U.S. invaded Afghanistan earlier than 2005, from extensive use of the SIGACTS datasets in other projects and discussions with officials involved in their production, it is our understanding that insurgent data were not systematically collected before this period. The same goes for our analysis of Iraq, described below.

[41] Although Operation Iraqi Freedom did not come to an end until the end of December 2011, the final date for available SIGACTs data, released by Berman et al. (2011), is February 24, 2009. In any case, the overwhelming majority of wartime violence occurred before this date.

[42] Precipitation data are missing for a small number of days, negligibly reducing panel observations.

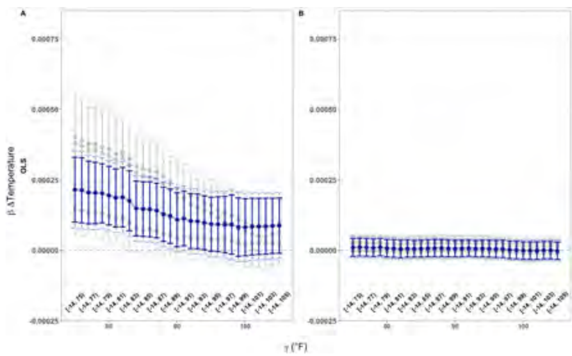
Table 4: Afghanistan Country-Wide Analysis Descriptive Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
District	398	–	–	–	–	–	–
Date	3,652	2009-12-31	–	2005-01-01	–	–	2014-12-31
Daily Temperature	1,453,496	67.186	21.597	−14.010	50.530	84.390	118.850
Precipitation	1,453,098	0.989	3.493	0.000	0.000	0.115	124.605
Direct Fire	1,453,496	0.082	0.543	0	0	0	77
Indirect Fire	1,453,496	0.019	0.165	0	0	0	12
IED Explosions	1,453,496	0.026	0.201	0	0	0	11

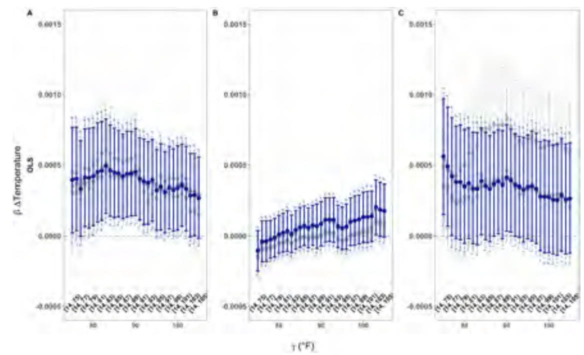
Table 5: Iraq Country-Wide Analysis Descriptive Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
District	104	–	–	–	–	–	–
Date	1,516	2007-01-28	–	2005-01-01	–	–	2009-02-24
Daily Temperature	157,560	84.161	20.699	13.880	67.420	103.120	124.130
Precipitation	157,560	0.598	2.526	0	0	0	83
Least Constrained Violence	157,560	0.242	1.000	0	0	0	29
Most Constrained Violence	157,560	0.035	0.237	0	0	0	8
IED Explosions	157,560	0.364	1.130	0	0	0	24

A.6.4 Results



(a) Afghanistan



(b) Iraq

Figure 9: These figures display the results of the Afghanistan and Iraq country-wide temperature deviation analyses. For Afghanistan, changes in direct fire and improvised explosive device attacks appear to the left and right, respectively. For Iraq, changes in least constrained violence, most constrained violence, and improvised explosive device attacks appear in the left, center, and right, respectively.

A.7 Mean Daily Temperature

A.8 Median Daily Temperatures

A.9 Binned Regression and Generalized Additive Model Results

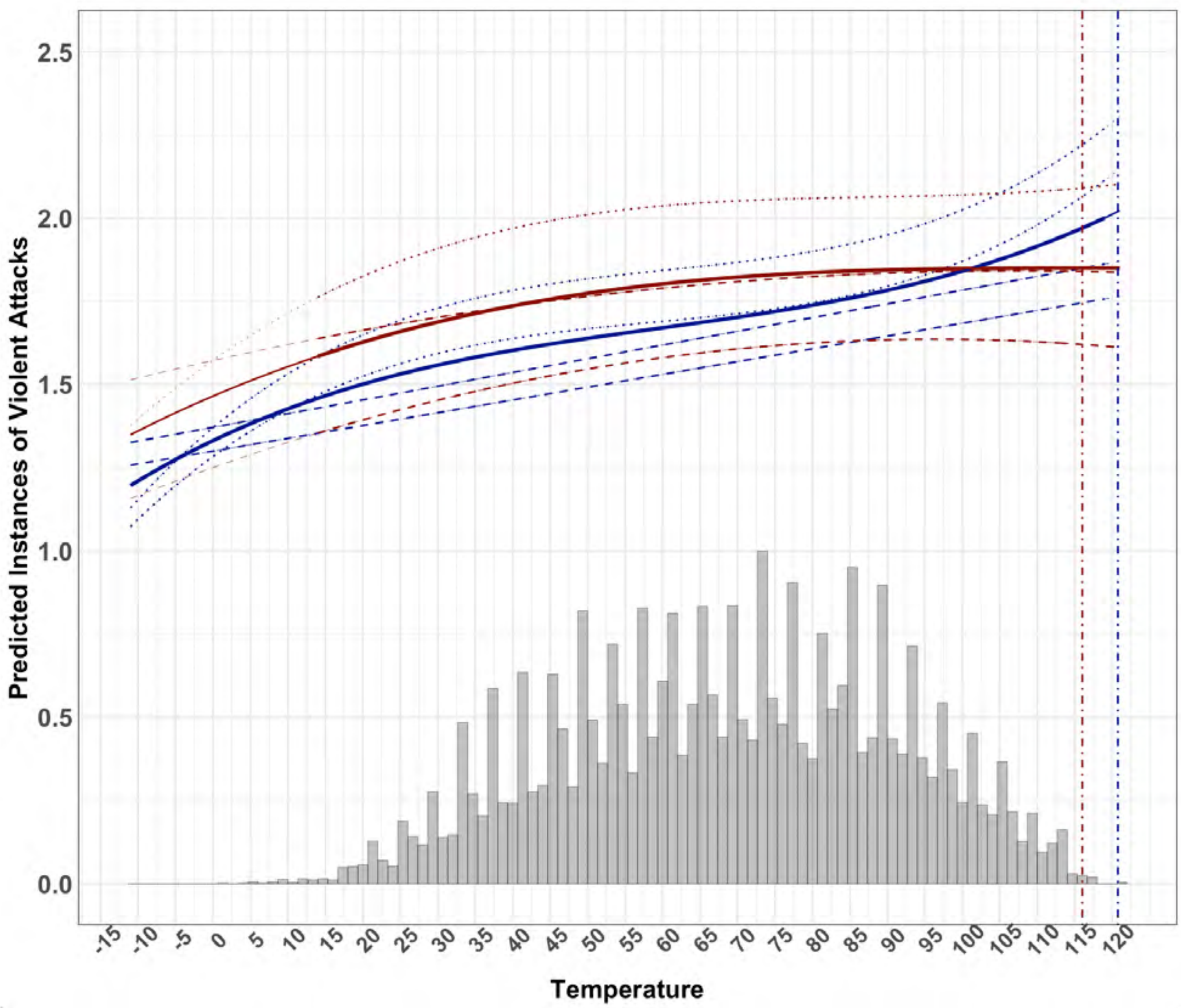


Figure 10: This figures display the results of the Afghanistan and Iraq country-wide temperature response function analyses.

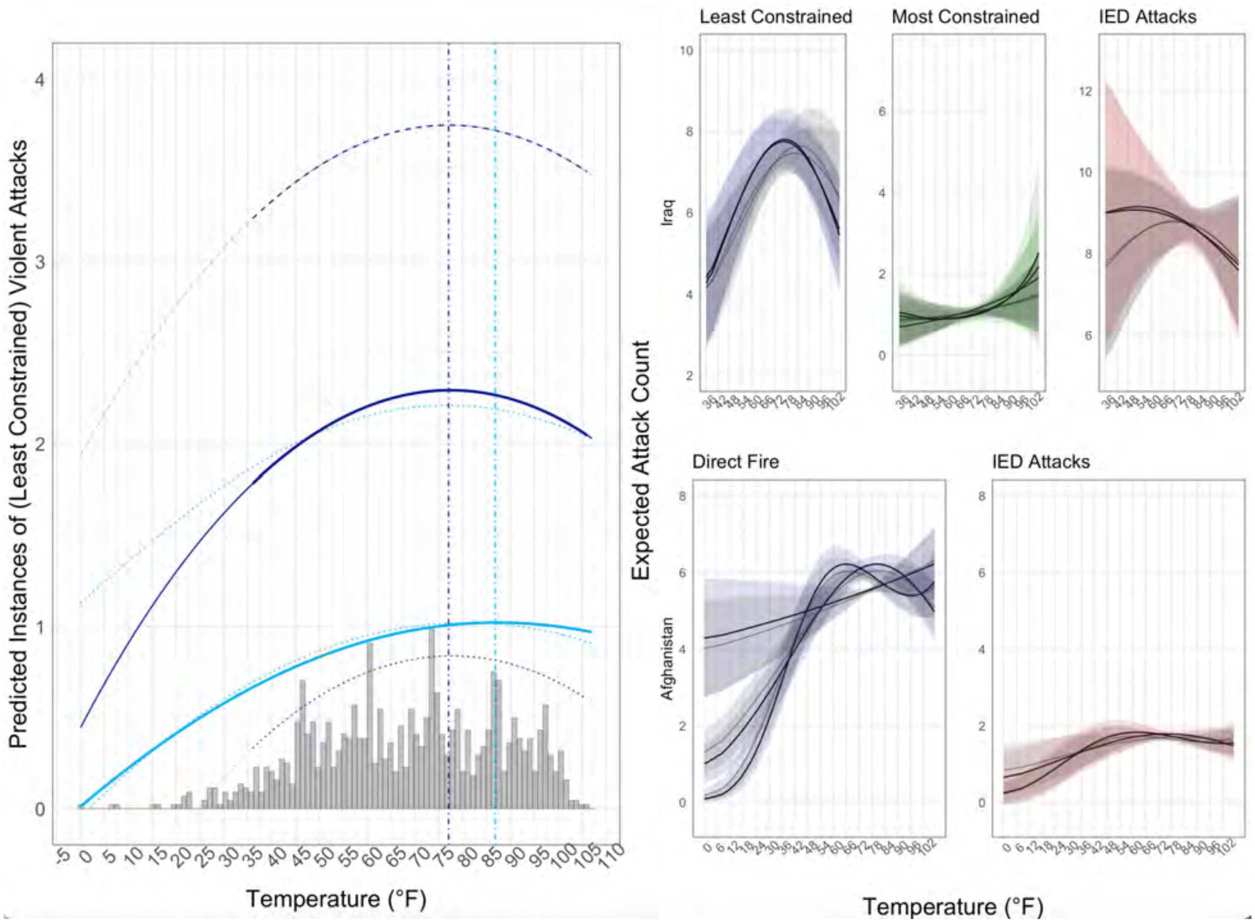


Figure 11: The figure replicates Figure 2, replacing daily maxima with daily mean temperatures.

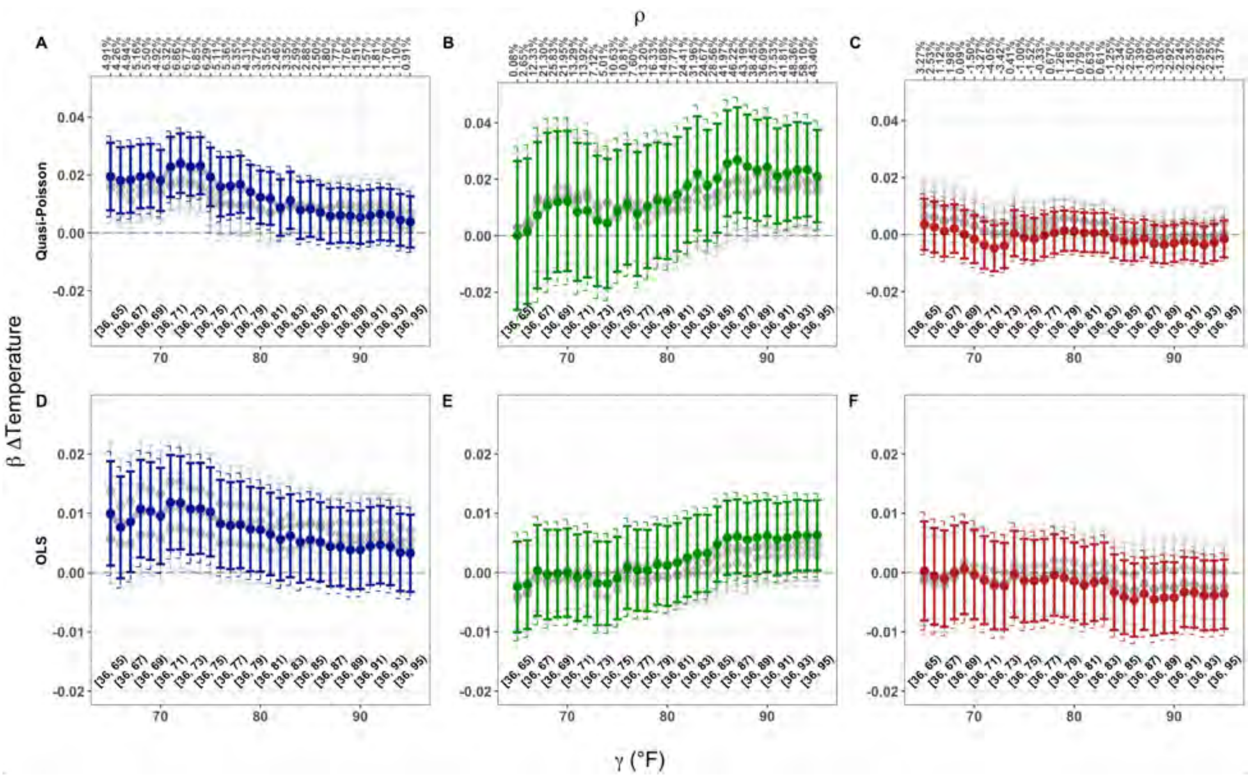


Figure 12: The figure replicates Figure 3, replacing daily maxima with daily mean temperatures, and adds OLS model results.

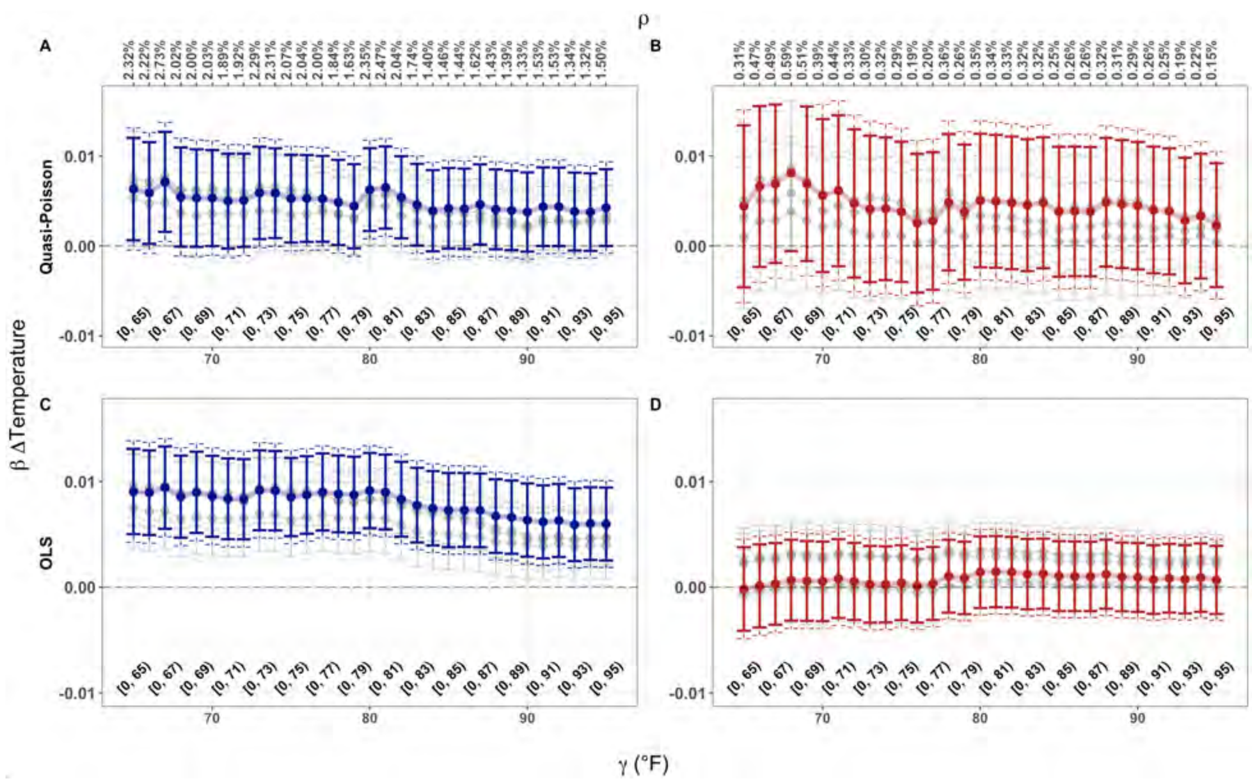


Figure 13: The figure replicates Figure 4, replacing daily maxima with daily mean temperatures, and adds OLS model results.

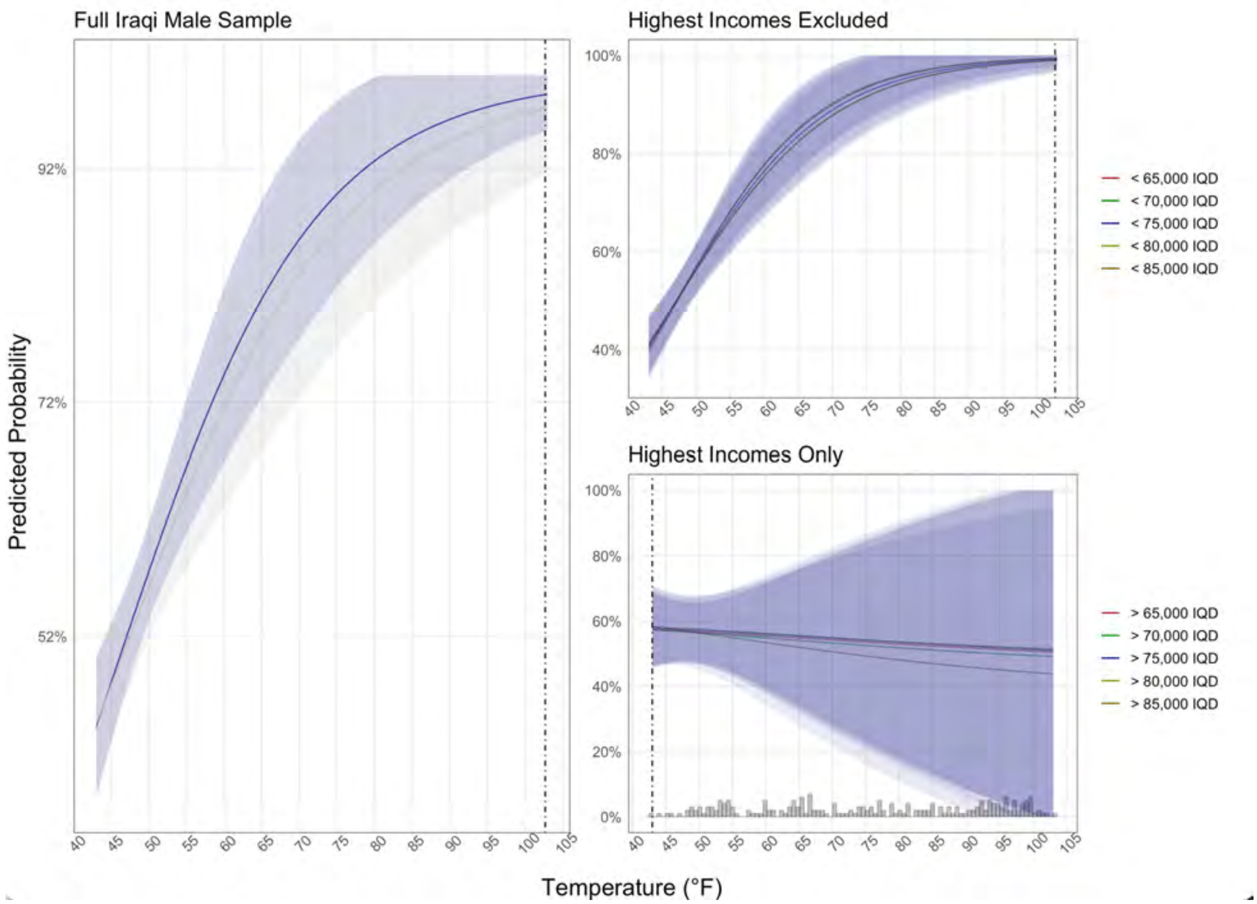


Figure 14: The figure replicates Figure 5, replacing daily maxima with daily mean temperatures.

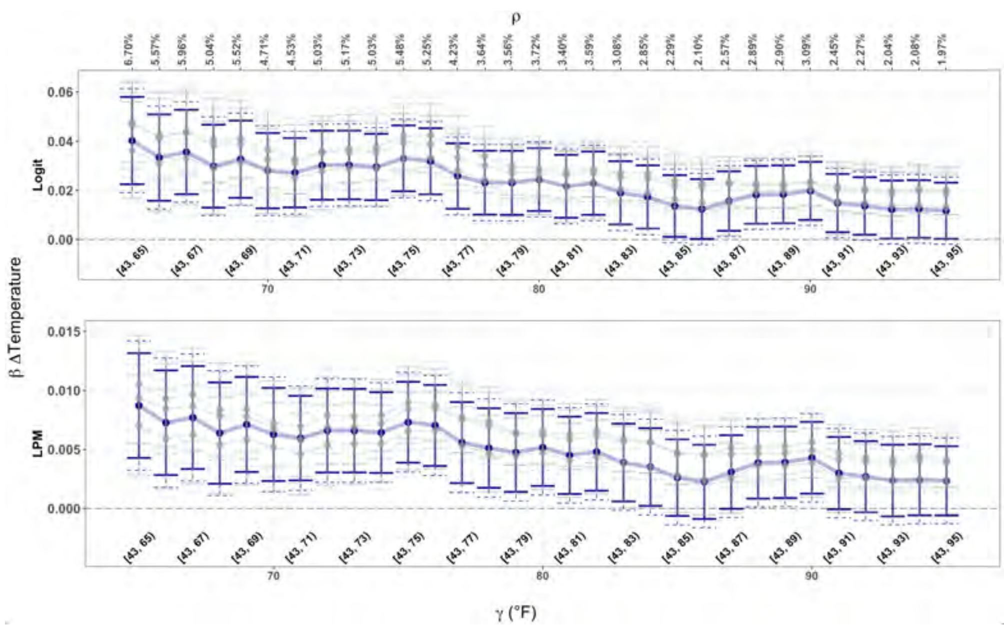


Figure 15: The figure replicates Figure 6, replacing daily maxima with daily mean temperatures, and adding linear probability model results.

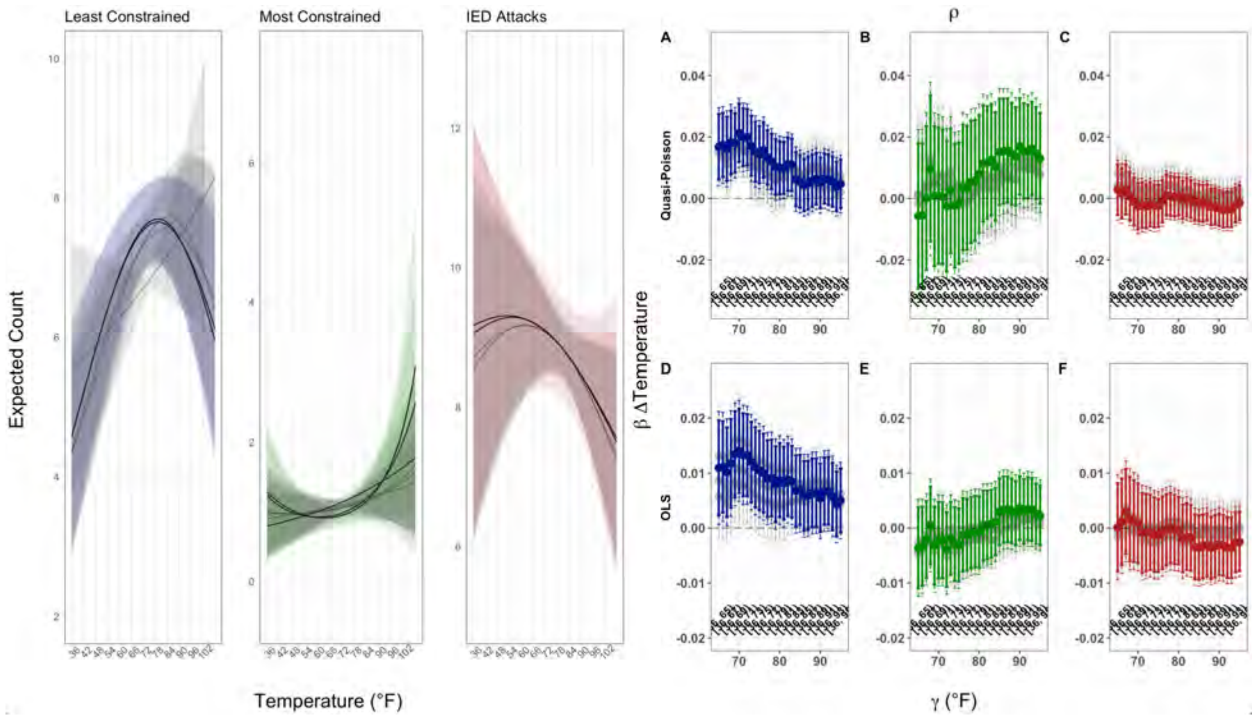


Figure 16: This figure plots temperature response and deviation results for the Baghdad-Basra panel, substituting daily maximum temperatures with daily median temperatures, derived from hourly weather station data. This analysis considered whether, as the most frequently experienced temperature each day changed, levels of violence by type tended to vary. We estimated that those days with most common temperature of around the low 80's °F were the most likely to experience the greatest levels of least organizationally constrained violence.

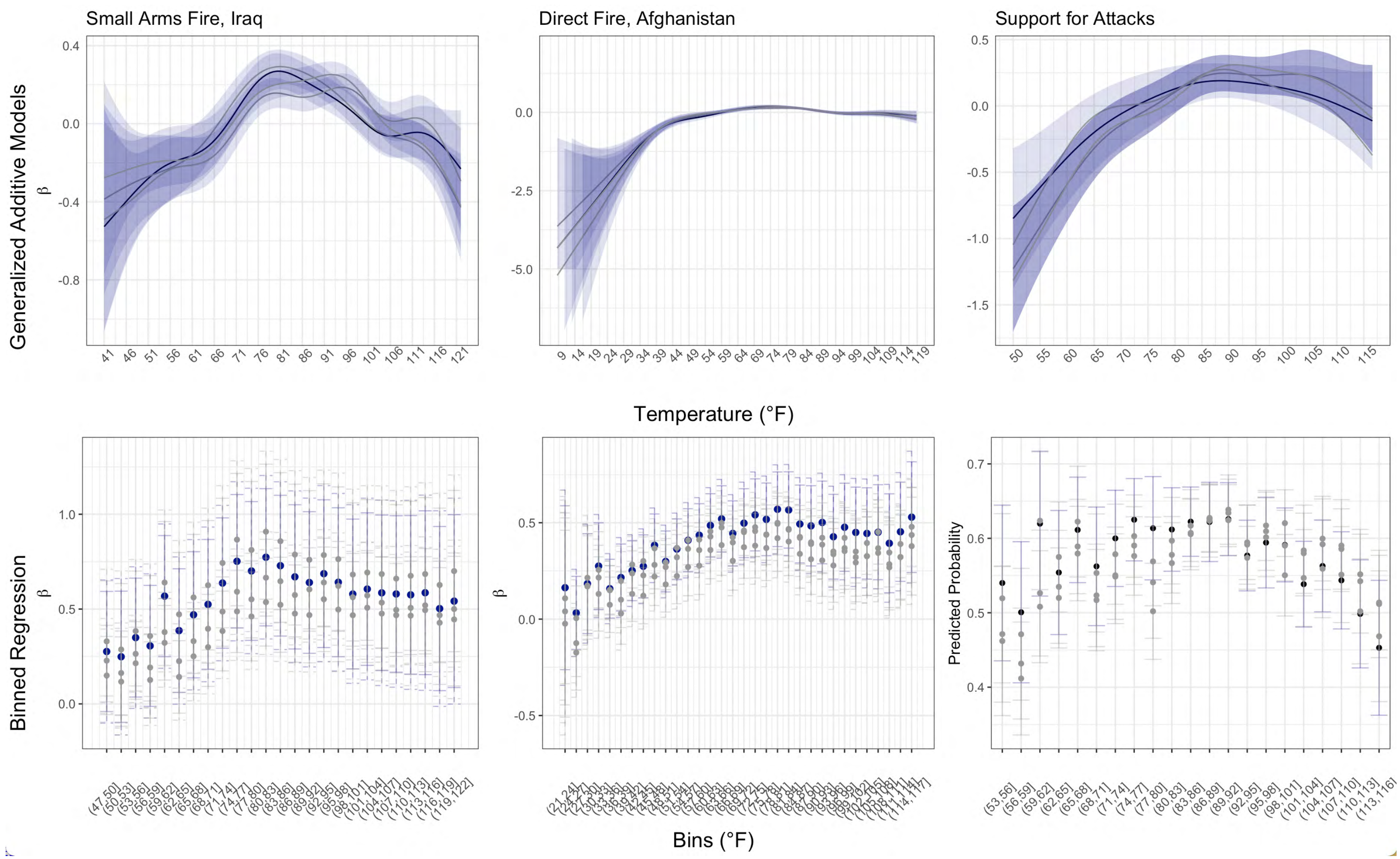


Figure 17: This figure displays the binned regression and generalized additive model results associating maximum daily temperatures and small arms fire (Iraq sample), direct fire (Afghanistan sample), and expressions of support for violence against international forces among survey respondents (Baghdad survey sample). For binned regression estimates, standard errors were "robust". 90% and 95% confidence intervals are displayed in solid and dashed lines, respectively. Point estimates and confidence intervals in gray denote alternative specifications described in the text. GAM results include 95% Bayesian credible intervals.

A.10 Other Meteorological Variables

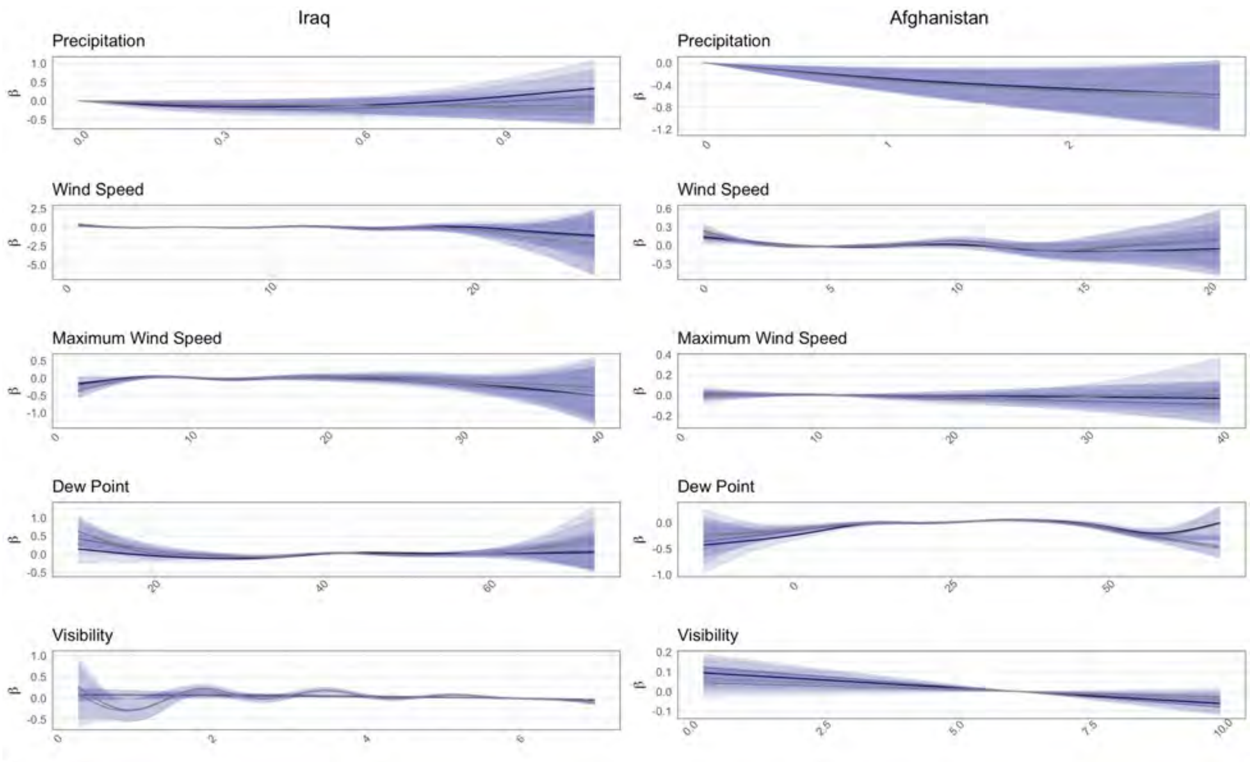


Figure 18: The figure shows the estimated associations between small arms fire (Iraq) and, separately, direct fire attacks (Afghanistan), as well as measures of precipitation, wind speed, maximum wind speed, dew point, and visibility. The results show that no other meteorological variable consistently correlated with this violence measure in the way that temperature did. Results were generated using generalized additive models with 95% Bayesian credible intervals.

A.11 Substantive Comparisons

A.12 Primary Replicated Using OLS/LPM

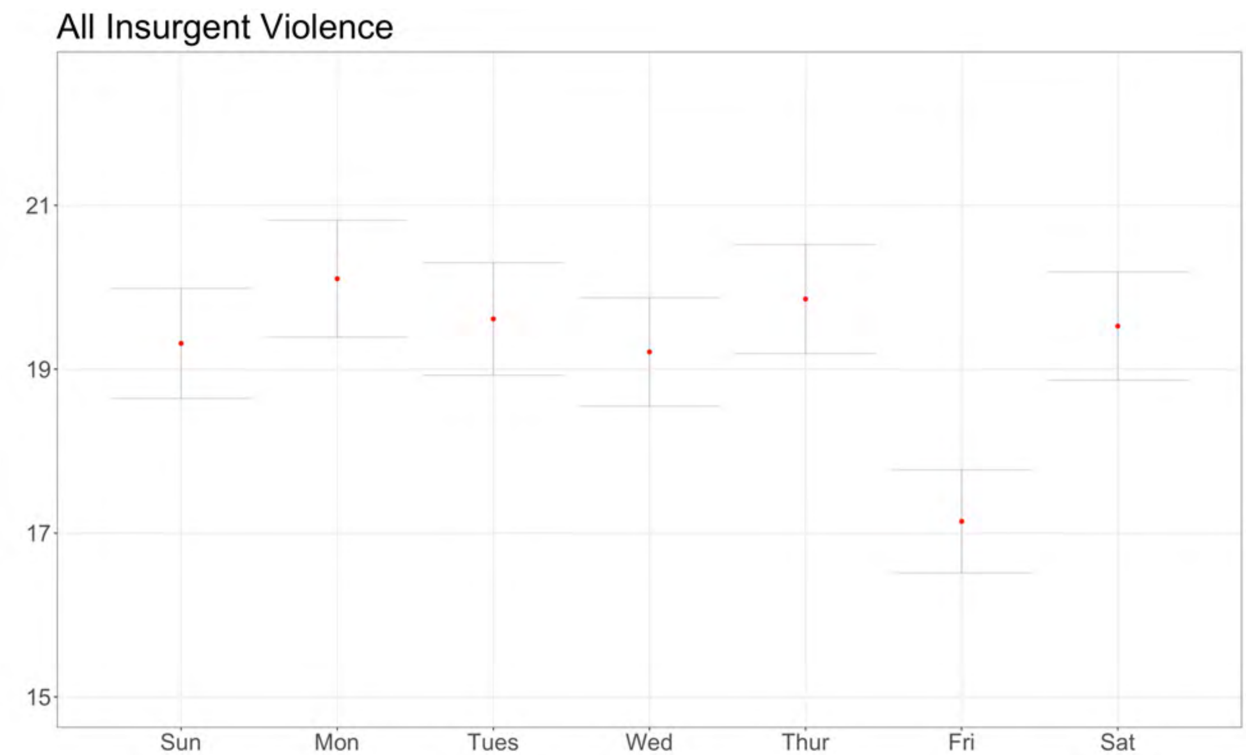


Figure 19: Following research by Reese et al. (2017), this figure shows that Fridays typically experienced approximately two fewer attacks than other days of the week during the days included in our study. This magnitude is similar to the estimated effect of moving from the coldest maximum daily temperatures to maxima twenty to thirty degrees warmer.

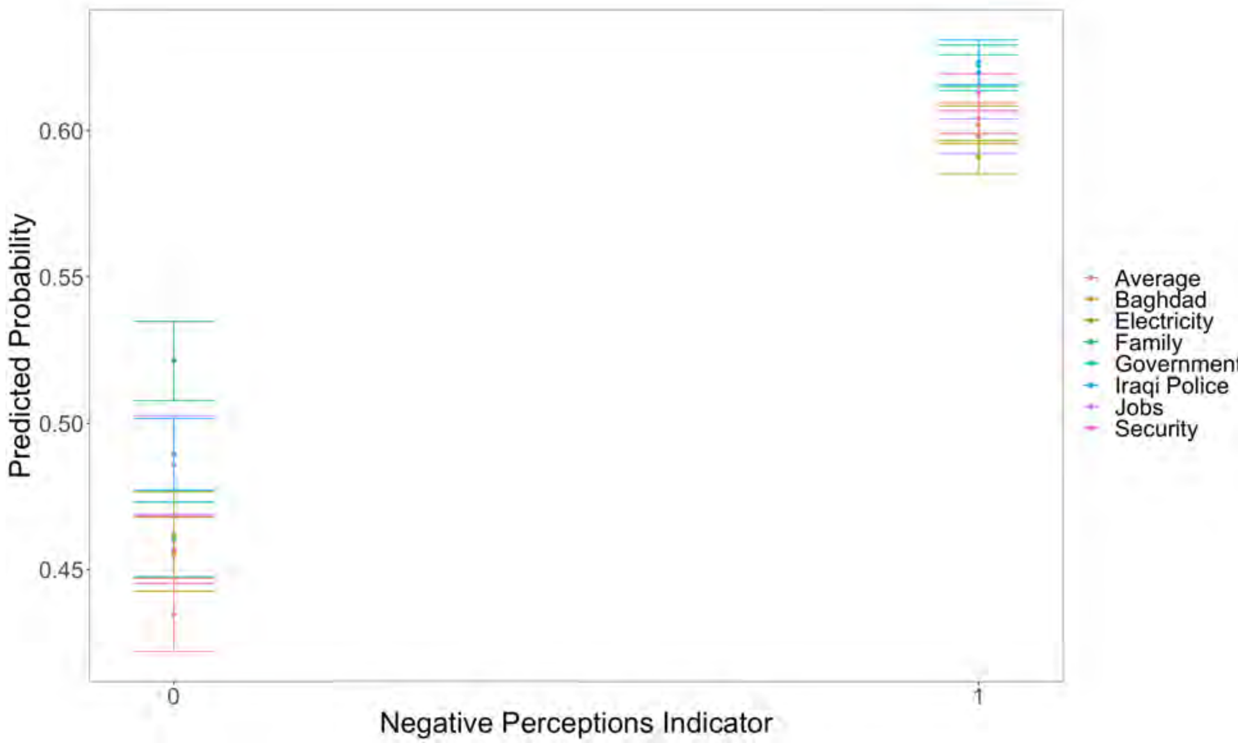


Figure 20: This figure shows that Iraq male respondents from whom we generated temperature-aggression estimates were roughly fifteen percentage points more likely to endorse the use of violence against government forces when they negatively evaluated recent changes in a variety of local conditions, including overall conditions in Baghdad, overall conditions for their families, the effectiveness of the government, the availability of jobs, the availability of electricity, general security, and the ability of the Iraqi police to provide security. This dissatisfaction magnitude is similar to moving from the coldest maximum daily temperatures experienced in Baghdad during the study period to those ≈ 20°F warmer.

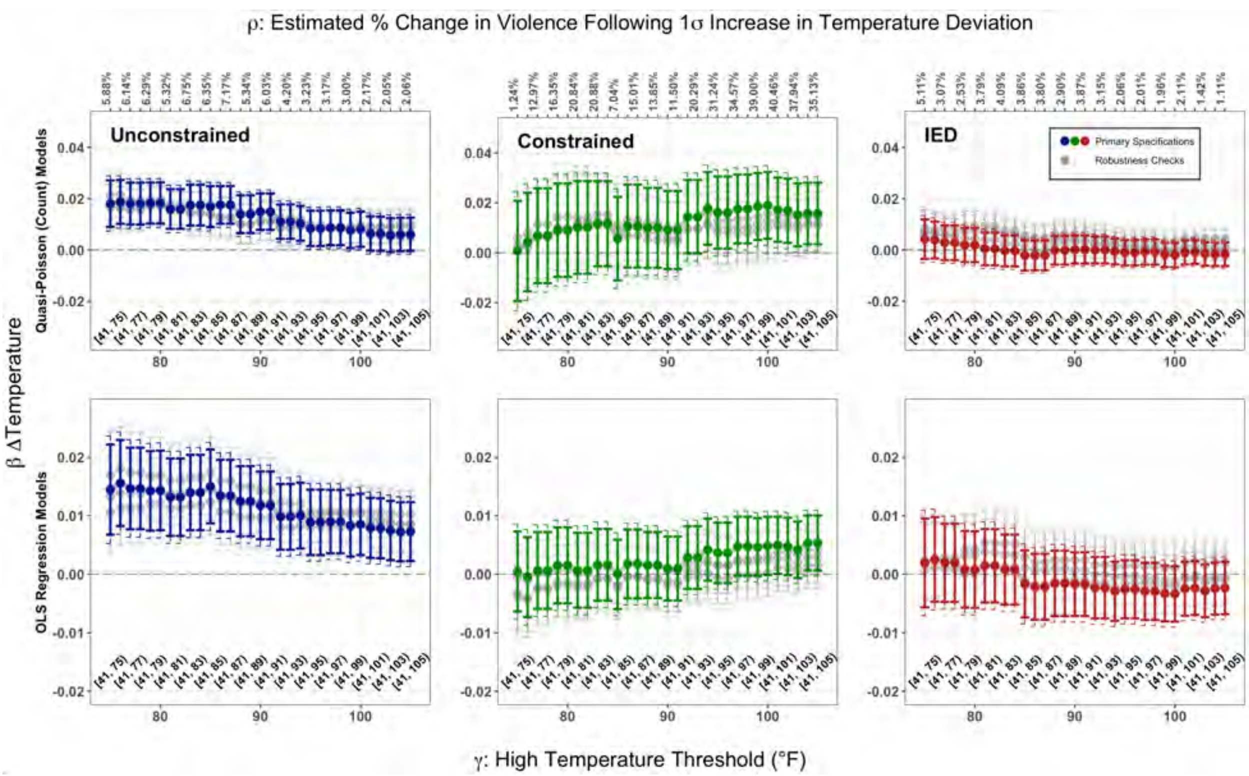


Figure 21: This figure replicates Figure 3 of the paper, adding OLS results as well.

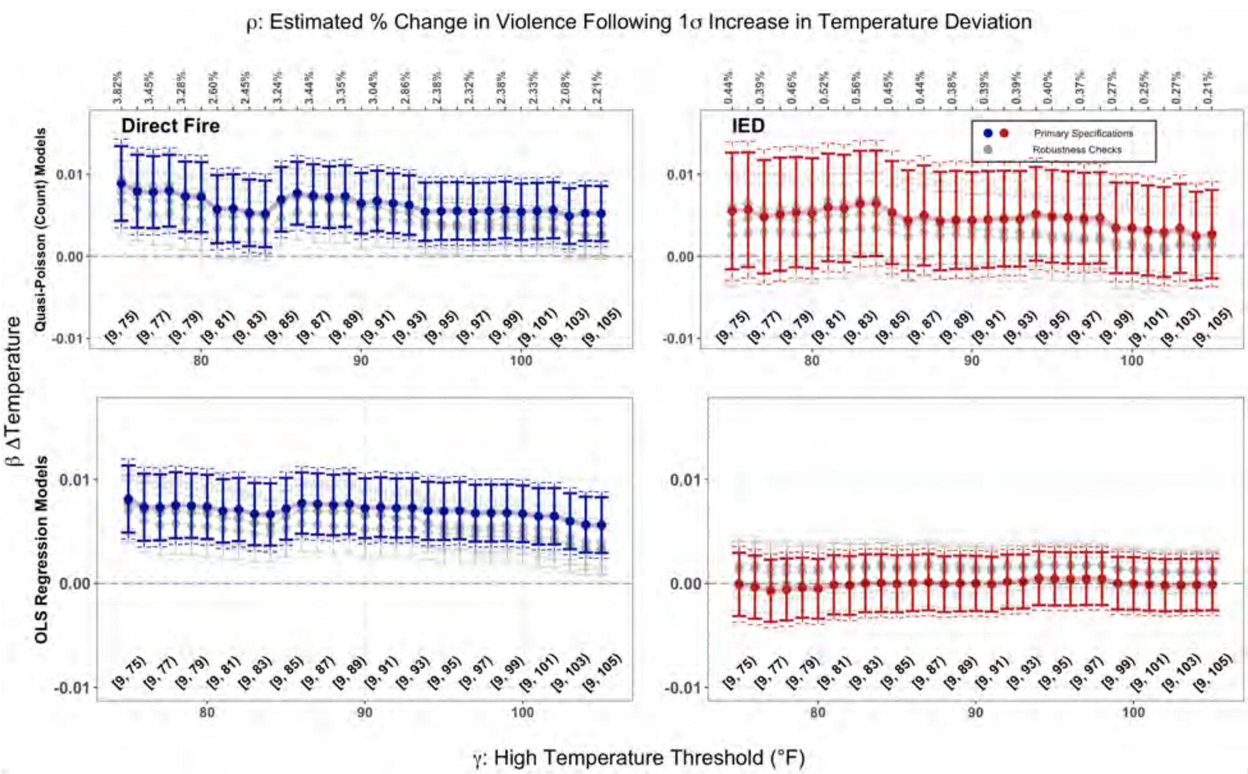


Figure 22: This figure replicates Figure 4 of the paper, adding OLS results as well.

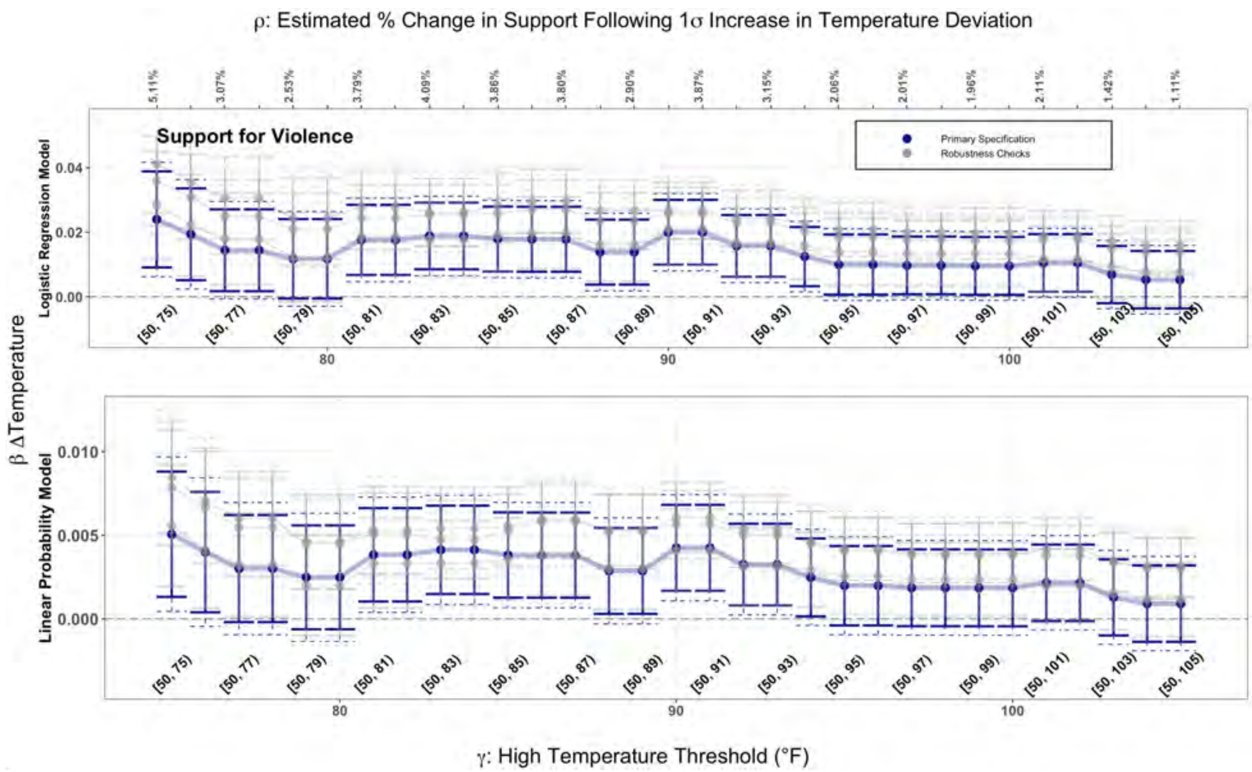


Figure 23: This figure replicates Figure 6 in the paper, adding linear probability model results as well.