Climate Change and Civil War

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Abstract

In this paper I examine the effect of climate change on violent conflict. I employ a dataset on global frequency of climate-change-related natural disasters to explain the probability of the start and occurrence, in a given year, of civil war, and duration, during the last half of the 20th century. Extreme cold events are found to have a measurable positive effect on the probability of civil war starting in the affected countries; previous years extreme heat events are found to have a positive effect on the probability of a civil war occurring in a given year; and droughts are found to have a positive effect on civil war duration. These findings may be used by policymakers as they contemplate climate change adaptation and mitigation policies.

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1 Introduction

Climate change is predicted to have a range of potentially serious consequences in both the short and long terms. Near-term impacts may result from changes in regional temperature and precipitation levels. For example, a complex interaction between climate and geography can lead to a decrease in precipitation in some areas. Ensuing droughts then produce ecological stress which can decrease agricultural production and cause human hardship. Others regions might experience an increase in precipitation, with an associated increase in the risk of flooding. Changes in average temperatures, as well as the frequency and duration of temperature extremes (i.e. heat waves or cold spells) also threaten agricultural productivity. Finally, increased climate variability is expected to trigger an increase in the number and severity of damaging storms. Longer-term impacts may include sea level changes with associated threats to coastal infrastructure and the potential for more frequent and severe outbreaks of vector-borne diseases (European Parliament, 2006).

The scope of these climate-induced challenges to human societies adds urgency to the need to identify and measure the potential effects of different types of disasters on various types of human activities. The goal of this research is to identify some of these effects and thereby inform climate change mitigation or adaptation policies. Recent research has predominantly considered the effects of climate change on economic activity and human health. However, the potential effect of climate change as a contributor to the outbreak of violent conflict has not been addressed in much detail until very recently in the quantitative literature (Blattman and Christopher, 2010). Economists and political scientists have just begun to look at these effects, but have yet to establish a persuasive weight of evidence that identifies the direction or the magnitude of the effects of different climate-related phenomena on violent conflict.

This study provides new evidence concerning the apparent impact of climate change on violent conflict. Specifically, I focus on climate change effects on the outbreak of civil war (*onset*), the persistence of civil war (*incidence*[1]) and the overall *duration* of civil war. I employ a dataset on the occurrence of climate-change-related natural disasters such as droughts, floods, storms, temperature extremes, wildfires and epidemics. I also take advantage of several standard datasets concerning civil wars from the political science literature compiled by Fearon and Laitin (2003) and Fearon (2004). By combining these datasets, I provide the first evidence that (a.) the frequency of extreme cold events and epidemic outbreaks appears to have a measurable effect on civil war *onset*; (b.) the frequency of the previous year's extreme heat events seems to affect civil war *incidence*; and (c.) the frequency of drought events appears to affect civil war *durations*. These climate-related events act as shocks to agricultural production, raising food prices and depressing incomes. In addition to these direct effects, these events also decrease the opportunity costs of conflict for the afflicted groups. The statistical regularities identified in this paper should be important to policymakers who struggle to decide upon optimal policies for international disaster relief related to extreme weather associated with climate change. In a broader context, these findings are also relevant to governments which must decide how aggressively to pursue climate change mitigation and adaptation measures.

Section 2 provides an overview of the related literature. Section 3 discusses the data. Section 4 explains the econometric specification and Section 5 summarizes the main results. Section 6 concludes.

[1] The variable called *incidence* is an indicator for whether there is a state of civil war in each country in each period

2 Literature Overview

2.1 *Civil War Literature*

A literature review by Blattman and Christopher (2010) gives an excellent account of recent developments in research on the determinants of civil war. Using the terminology of Blattman and Christopher, this paper falls into the category of “cross-country empirical conflict research”. This literature, and the associated theoretical research, is still evolving and many hypothesized relationships have yet to be thoroughly explored in empirical contexts. Much of the current quantitative research is based on civil war data collected by Fearon and Laitin (2003) and from Fearon (2004). This particular study uses civil war conflict data from Fearon and Laitin (2003) and from Fearon (2004) and extends specifications proposed in those papers, as well as in research by Collier and Hoeffler (1998).

Fearon and Laitin (2003) are motivated by the observation, in much of the prior descriptive research, that civil wars seem to be sparked by religious and ethnic antagonisms. However, their empirical results fail to confirm this perception. These authors argue that the onset of civil war is best explained by factors that induce or facilitate an armed insurgency against the government. Such factors include terrain accessibility, large populations and, most importantly, low incomes. High income countries are less likely to experience civil wars.

Chassang and Padro-i-Miquel (2008, 2009) develop a global game-theoretic model incorporating information asymmetries between actors. Enemies, in this case, do not know each other’s costs of conflict. Their main finding suggests that higher incomes are linked to lower levels of conflict. Negative economic shocks, on the other hand, increase incentives for violent conflict since opposing groups experience a decrease in their opportunity costs of conflict (in terms of lower returns to production). Miguel et al (2004) address the issue of endogeneity of income growth in civil war incidence models. Specifically, they use rainfall variation as an instrument for economic growth in 41 African countries during 1981–99. This approach, however, cannot be applied in the case of climate-change-related disasters. Unlike rainfall, which is likely to influence civil war incidence only through an income shock to agricultural production, disasters affect the whole society in a variety of ways. They destroy infrastructure, such as schools and roads, and might affect access to education, contribute to migration, change in social customs (if a particular social group is affected, such as elderly and infants), etc.

Fearon (2004) is amongst the first papers that attempt to answer the question of why do certain civil wars last longer than others. He employs duration models in his analysis and finds that civil wars arising from coups or revolutions, and those originating in Eastern Europe and former colonies, tend to have shorter durations. Civil conflicts between ethnic minorities and government-backed migrants of a dominant ethnic group what the author terms “the sons of the soil” wars have longer durations. The same effect is found for conflicts in which the rebels have access to income from contraband (e.g. opium, diamonds or coca). Other notable papers focusing on civil war duration find that outside interventions limit war duration (Reagan, 2002); presence of multiple actors players prolong it (Cunningham, 2006); conflicts located at considerable distance from the main government stronghold, along remote international borders and in regions with valuable minerals last substantially longer (Buhaug et al., 2009); and inequality lengthens civil wars (Collier et al, 2004).

2.2 *Effects of Temperature and Precipitation on Civil War*

In addition to the standard conflict literature, several recent attempts have been made to quantify the potential effects of climate change on various measures of violent conflict. The idea is that climate-change-related alterations in temperature and precipitation act as a negative income shocks which, according to Chassang and Padro-i-Miquel (2008, 2009), implies a higher potential for violent conflict.

A few recent empirical studies link climate change to violent conflict. Hendrix and Glaser (2007) study the determinants of civil war onset specifically in Africa between 1981 and 1999. They use two different civil war datasets by Fearon and Laitin (2003) and use the PRIO/UCDP[2] data to construct their civil war onset variable. The Global Precipitation Climatology Project (GPCP) database provides annual rainfall estimates as one measure of climate change. Fearon and Laitin's three main explanatory variables are (i) climate suitability for agriculture (using the Köppen-Geiger climate system scale), (ii) land degradation (percent of total land area degraded), (iii) and year-to-year interannual variance in rainfall (based on average annual rainfall in milliliters per year). The results suggest that interannual variability in rainfall significantly affects the onset of civil war in Africa.

Burke et al. (2009) also focus on Africa for the period between 1981 and 2002. Their dependent variable is civil war incidence (i.e. the propensity for a country to be in a state of civil war) in country *i* in year *t*. For this variable they also utilize the PRIO/UCDP dataset. Their main contribution lies in modeling the effects of climate change on the incidence of civil conflict using both temperature *and* precipitation variables. Several specifications are proposed. Most control for lagged values of temperature and precipitation, and some include controls for per capita income and type of political regime. The results suggest that higher temperatures tend to increase the incidence of civil war. This result is robust across a variety of specifications, but the statistical significance of the coefficient on temperature diminishes to only 10% level in their most comprehensive model.

[2] Peace Research Institute Oslo (PRIO) / Uppsala Conflict Data Program (UCDP)

Other empirical research has analyzed much longer historical series. Zhang et al. (2006) use the data on frequency of conflict (wars and rebellions in three distinct climate regions) in China between 800 BCE and CE 1911. The climate data for the Zhang study come from Briffa and Osborn (2002) who collect and recalibrate five common climate series over the last millennium for the Northern Hemisphere. Zhang et al. then employ pair-wise correlation analysis and find that the frequency of annual, decadal and "phase level" (cold or warm) rebellions and wars tends to be correlated with the temperature anomalies associated with lowest and average temperatures, but not high temperatures. The results seem to be robust to the inclusion of temperature lags, especially at the annual level.

The results of Zhang et al. (2006) suggest that the correlation between temperatures and conflict is mostly significant for the Central China region. The authors argue that these regional differences in conflicts associated with weather conditions arise from marked local climate fluctuations. Thus, South China, endowed with subtropical and tropical climates, has a greater capacity to adopt alternative crops when climate-related shocks occur. Central China, however, is characterized by monsoon cycles. Monsoons tend to bring a cold Siberian air mass during the winter. If this cold is persistent, it can result in a much greater susceptibility of agricultural production to cold temperature shocks. The Central China region has a lower adaptive capacity in terms of alternative crop introduction (due to its more temperate climate), so wars are more likely to occur as a consequence of a sustained and atypical cold spell. In further research, Zhang et al. (2007) extend their analysis to Europe and find that the frequency of civil wars is again correlated with unusually cold spells.

Tol and Wagner (2010) likewise analyze the effects of changes in average temperature and precipitation changes on the frequency of violent conflict in Europe. For their dependent variable, the authors use data on all historically recognized violent conflicts in Europe between 1000 AD and 1990 AD, while their climate data are drawn from various reconstructions of historical average temperatures and precipitation.[3] These authors utilize regression techniques to estimate several specifications where they model the passage of time by using quadratic time trends. They also model the changing relationship between violent conflict and temperature by using interactions between time and temperature to permit temperature effects to vary systematically over time. Additional autoregressive specifications control for the number of conflicts in the previous two years with additional controls for the period of the Protestant Reformation. The results of the model with interactions suggest that conflict was more prevalent during colder periods. However, the results are not robust to alternative temperature reconstructions or to all sub-periods of the data. For example, the results imply no effect of temperature on conflict frequency during the industrialized era (from 1750 to 1990).[4] Thus the hypothesis that extended periods with poor harvests lead to violent conflict appears to hold only for earlier societies that relied more heavily on agriculture.

2.3 *Extreme Weather Effects on Civil War*

The main argument in this literature is that changes in patterns and frequencies of natural disasters such as droughts, storms, floods, wildfires, and periods of extreme hot or cold temperatures can create negative income shocks via their negative effects on agricultural production. Consequently, these events might decrease the opportunity cost of pursuing conflict, thus increasing the chance that conflict might arise and persist.

[3] Tol and Wagner collect their European conflict data from http://www.warscholar.com/; their historical temperature data are drawn from research conducted by Luterbacher et al. (2004) and NOAA and von Storch et al. (2004); their historical precipitation data comes from research conducted by Pauling et al. (2006).
[4] Autoregressive model presented in Toll and Wagner (2010) Table 6 and 7, pp.12.

Research concerning the effects of different extreme weather events related to climate change (other than temperature and precipitation) on various aspects of civil wars, such as their onset, occurrence (incidence) and duration, has received even less attention. Nel and Righarts (2008) appears to be the only study that attempts to study the influence of climate-change-related disasters on civil war onset. They employ a dataset consisting of 187 political units for the period 1950-2000 and find that natural disasters significantly increase the risk of civil violence. They identify rapid-onset geological and climate related disasters as posing the highest overall risk. These authors aggregate disasters into either "climate" or "geological" groups, so the study has not answered the question about which specific types of disaster events have the greatest tendency to precipitate a civil war. This is an important question to address, since appropriate mitigation or adaptation policies will differ by the type of a disaster. The present paper thus extends Nel and Righarts (2008) by distinguishing and controlling for specific types of events such as: droughts, extreme temperatures, epidemics, floods, storms and wildfires.

Besley et al. (2009) develop a theoretical model for current civil war status (incidence) over time and accross countries and test it empirically. This appears to be the only paper that attempts to measures the impact of climate-change-related disasters on civil war incidence. They use an OLS specification and add time and year fixed effects to control for unobserved heterogeneity related to each country's unique cultural and institutional characteristics. They include an aggregate measure of "weather shock" and find that it has a positive impact on a country's civil war status (incidence). They construct their weather shock variable by aggregating floods and extreme heat events into a single measure. I extend the Besley et al. (2009) paper by disaggregating, to look into the effects of individual disaster types on civil war status.

Fearon (2004) appears to be the only published paper that explores the determinants of civil war duration. Civil war duration is defined as the number of years it takes for the conflict to finish. This is different than civil war incidence, which is the occurrence of conflict in country *i* in year *t*. I am not aware of any papers that have attempted to study the effects of natural disasters or any other measure of climate change on civil war duration.

2.4 *Environmental Conflict and Security Literature*

In addition to aforementioned quantitative conflict literature there is a much older and well established qualitative literature on environment and security. Homer-Dixon (1994) analyzes several case studies and identifies causal links between conflict and environmental degradation. He suggests that environmental scarcity causes conflict that tends to occur at a sub-national level and tends to be persistent. Scarcities in water, forest and agricultural resources are identified as major sources of environmental conflict. Climate change is argued to have an effect as well, but not in its own right, but through interactions with the mentioned resources. The author also argues that population pressures as well as unequal resource distribution contribute to the incidence of environmental conflict.

Homer-Dixon (1991) describes three theoretical perspectives on conflict: frustration-aggression theories, group-identity theories and structural theories. In the first case the conflict is argued to arise from individuals' frustrations with an entity that they perceive is obstructing them from reaching their goals. Group-identity theories approach the issue from the perspective of social psychology and focus on ethnicity, nationality and religious issues as major causes of conflict. Structural theories are consistent with economics approach to conflict. These theories stress that conflict arises from calculations made by rational actors facing external constraints.

Based on the three approaches Homer-Dixon hypothesizes that environmental degradation produces three types of conflicts: simple scarcity conflicts, group identity conflicts and relative-deprivation conflicts. The first type is best explained by structural theories and suggests that conflict arises from key resource scarcity. Author provides an example case in support of this perspective. It involves water access issues between Turkey and Syria whereas Turkey's plans to build massive system of dams and irrigation canals on the Euphrates have come at a cost to water deprived Syria. This, in turn, is suggested to fuel internal civil war in Turkey, between the government and the Kurdish insurgents acting as a proxy for Syria on the issue.

Levy (1995) provides a different perspective on the issue of environment as a national security issue. He argues that much of the concern voiced by many researchers is more of an artifact of time when these studies have been written and the general attention environmental issues have received since the 1980s, than an actual concern that environmental issues could cause conflict. In other words, the author suggests that even is environmental issues affect national security they are of little importance. He points to previous conflict literature that fails to mention environmental issues as a potential national security issue. He does acknowledge that the only environmental degradation cases that might matter are ozone depletion and climate change. Finally, Levy argues that it is better to deepen the understanding of other causes of individual conflicts, endemic to each case, than to focus on smaller causes, such as the environmental degradation.

Several recent studies have summarized major perspectives on environment and security. Khagram and Ali (2006) discuss the differences between two perspectives on environmental conflict: environmental scarcity and environmental abundance theories. Environmental scarcity theories suggest that scarcity can be induced by supply factors such as degradation of natural resources; demand factors, such as increased consumption; and structural factors, such as unequal distribution of resources. The main empirical finding in this literature suggests that environmental scarcity causes civil strife, but not international conflict. Environmental abundance literature, on the other hand, proposes another pathway for conflict. In this case, it is the relative abundance of resources, most often in mineral resource sectors, that causes conflict. Furthermore, conflicts arising from resource abundance tend to be short lived and end in a military defeat of one of the parties in the conflict. Authors conclude that more empirical research is needed to resolve this issue. Furthermore, they advocate moving from anecdotal evidence provided by much of the earlier research to more rigorous empirical work.

Detraz and Betsill (2009) analyze how environmental conflict and environmental security perspectives are adopted by the 2007 United Nations security debate on security aspects of climate change. Environmental conflict perspective is based on the resource scarcity approach as a major source of conflict. Environmental security literature, on the other hand, takes a broader perspective and is more concerned with impact on all of humanity, as opposed to focusing on the state. The aforementioned United Nations security debate is said to be more reliant on the environmental security perspective.

3. Data

Like several other researchers, I also use the civil war database constructed by Fearon and Laitin (2003) as a source for dependent variables: civil war onset and status. [5] A conflict in a particular country is coded as a civil war if the following three selection criteria are satisfied:

[5] Fearon and Laitin were inclined to construct their own database to correct for certain types of exclusions in other existing databases. Their data are available for downloading at http://www.stanford.edu/~jfearon/data/apsr07repdata.zip

(1) the conflict involves fighting between agents of (or claimants to) a state and organized, nonstate groups who seek either to take control of a government, to take power in a region, or to use violence to change government policies;

(2) the conflict kills at least 1,000 people in total over its course, with a yearly average of at least 100 conflict-related deaths;

(3) at least 100 people are killed on each side (including civilians attacked by rebels (Fearon and Laitin, 2003).

There are 6278 country-year observations in the sample and the rate of conflict is 1.67 per 100 country years. Civil war duration data are described in Fearon (2004). [6]

The climate and weather-related disaster data come from a global database on natural and technological disasters called EM-DAT. [7] This database contains disaster-level data on some 18,000 disasters that have occurred since 1900. The database is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the School of Public Health of the Université Catholique de Louvain, Belgium. The data are compiled from various sources including national governments, UN agencies, and other non-governmental organizations (such as the Red Cross). The selection criterion for disasters requires 10 or more people to die in a given disaster, and 100 or more people to be affected by it, a declaration of a state of emergency and a call for international assistance. The database is updated daily with all new disasters satisfying the aforementioned criteria.

For the purposes of this study I utilize the available meteorological data from the EM-DAT database on storms; hydrological data on floods; climatological data on extreme temperatures (low and high), drought and wildfire; and epidemiological data on severe outbreaks

[6] Data available at http://www.stanford.edu/~jfearon/data/jprrepdata.zip
[7] Available at http://www.emdat.be/

of disease. Furthermore, I aggregate the EM-DAT disaster data to country-by-year disaster counts. Summary statistics are presented in Table 1. Note that the average incidence of a given type of disaster is low. Floods occur at the highest average rate of 0.267 per country-year, while extremely hot temperatures (caused primarily by heat waves) take place at rate of only thousand country-years in the data.

The remaining control variables for civil war onset and incidence come from Fearon and Laitin (2003) as well as some additional sources. The measure of "mountainous terrain" is constructed by A. J. Gerrard for the World Bank DECRG project on civil wars. Income per capita comes from the Penn World Tables. Population data come from the World Bank's World Development Indicators (WDI). The so-called Polity IV regime index is a commonly used indicator of political authority. [8] The regime authority spectrum ranges from -10 for a hereditary monarchy to +10 for a consolidated democracy. In the analysis, I use a dummy variable indicating whether the country had a three-or-greater change on the Polity IV regime index in any of the three years prior to the year in question, as do Fearon and Laitin (2003). Countries with mixed democratic and authocratic characteristics, often called anocracies, are included by constructing an indicator that equals 1 if the Polity IV score ranges between -5 and 5, and 0 otherwise, per Fearon and Laitin (2003). Oil exports are obtained from the World Bank's World Development Indicators (WDI) and are included by constructing an indicator for when fuel exports exceed one-third of export revenues. Fearon and Laitin (2003) constructed variables for prior wars, noncontiguous territories (i.e. when a part of the country is physically separated from the "mainland") and new states themselves.

Summary statistics are provided for civil war onset and incidence models in Table 1. They suggest that civil wars occur in some 15% of country-years. Table 2 provides correlations

[8] Available at http://www.systemicpeace.org/polity/polity4.htm

between different types of environmental disasters and Table 3 presents further evidence of multicollinearity between these disasters.

For the civil war duration models, variables coded by Fearon (2004) are used for coups and revolutions, colonial wars, the presence of indigenous populations (sons of the soil) fighting migrants to their areas, and contraband-related financing of war. Summary statistics for duration data and corresponding controls are displayed in Table 4. Table 5 provides correlations between different types of environmental disasters and Table 6 presents further evidence of multicollinearity between these disasters.

4. Econometric Specification

4.1 *Civil War Onset*

To model the determinants of civil war onset, I propose the following logit discrete outcome econometric specification analogous to those common in the conflict literature,

$$\text{Model O1: Civil\_War\_Onset}_{it} = \beta_0 + \beta_1 \text{Disaster}_{it} + \sum \beta \text{X}_{it} + \varepsilon_{it} \qquad (1)$$

The dependent variable *Civil_War_Onset*$_{it}$ is a binary variable equal to 1 if a civil war starts in a country *i* in year *t*, and 0 otherwise. *Disaster*$_{it}$ is the frequency of one given given type of disaster in country *i* in year *t*. These disasters are: droughts, epidemics, extreme cold temperatures, extreme hot temperatures, floods, storms and wildfires. Across a sequence of analogous specifications, I rotate through this list of disaster types, featuring one type of disaster at a time. Vector X_{it} contains the following control variables: occurrence of civil war in the previous year, income per capita lagged one year (thousands of 1985 U.S. dollars), the logarithm of the population density also lagged one year, the logarithm of the percent of the country's terrain classified as "mountainous." an indicator for states with noncontiguous territories, an indicator for whether this is an oil-producing country, an indicator for a newly formed state (such as countries formed after dissolution of the Soviet Union), an index of political instability (Polity IV), indicator for whether the country is in the state called “anocracy”. Possible endogeneity of the GDP per capita variable is addressed by using the lagged values of these variables instead of the contemporaneous ones. Again, this list of auxiliary variables is fairly standard in the literature for the determinants of civil war onset and has been used in previous research, most prominently by Fearon and Laitin (2003).

As measures of climate change, the majority of the previous literature has tended to use only average temperature and precipitation. These variables are constructed from “projection and reconstruction” raster data to produce aforementioned variables.[9] A contribution of this paper is the extension of the model to include individual discrete counts of an array of natural disasters as a measure of climate change. Climate change is likely to be manifested in a wide variety of weather-related phenomena beyond just temperature and precipitation changes, such as an increased frequency of natural disasters like droughts, epidemics, extreme cold and hot temperatures, floods, storms and wildfires.

As a robustness check, the basic specification in equation (1) is expanded by introducing up to three annual lags for each of the pertinent disaster frequencies. Furthermore, I consider alternative specifications with time fixed effects, to control for the impacts, common to all countries, that vary by year. Such a generalization seems warranted since it is plausible that some time periods have unique common effects (for example, the colonial wars for independence that characterized the first few decades of the sample). Time fixed effects may be particularly

[9] Meteorologists produce historical climatological data by dividing the globe into a grid consisting of equal size areas. These areas do not fit country borders, so interpolation is necessary to produce country level data.

important in this application, since natural disasters are more likely to have gone unreported earlier in the sample period and time fixed effects may control for this to a certain extent.[10]

Another possible specification is to include all the different type of disasters simultaneously as explanatory variables in the same specification. Such a model, however, may have difficulty in discriminating between the effects of different types of disasters if these have tended to covary, as may be the case for storms and floods.

Thus the kind of specification where we are most likely to discern the effect of one type of disaster includes time fixed effects as well as varying degrees lagged effects[11],

$$\text{Model O8}: \text{Civil\_War\_Onset}_{\text{it}} = \beta_0 + \sum_{s=0}^{3} \beta \text{Disaster}_{\text{it-s}} + \sum \beta \text{X}_{it} + \delta_t + \varepsilon_{it} \qquad (2)$$

where δ_t are the time fixed effects, and $Disaster_{it\text{-}s}$ is the frequency of a given disaster in country *i* at time *t-s.*

When it comes to control variables countries with higher incomes and prior wars are expected to be systematically less likely to experience the onset of a civil war. The former variable acts as a proxy for government strength relative to that of insurgents. Each of the remaining controls is expected to have a positive effect on the probability of onset of a civil war. Specifically, a greater population density induces greater competition for scarce resources and thus increases the chance that such competition will turn violent within the country. Mountainous terrain makes the country harder to govern, since insurgents could more easily take advantage of the protection afforded by harder-to-access terrain to develop and cultivate their insurgency against the government.

[10] Burke et al.(2009), for example, use country specific time trends to control for variables that evolve over time. This would not be applicable in this case, since natural disaster measurement problems (i.e. potential omission of events during earlier periods) require time fixed effects, not trends. Despite this, I have estimated models with country specific time trends and found no significant differences relative to the model with time fixed effects.

[11] The logic for the labeling of these models will be explained in the appendix section. Intermediate models O2 through O7 are also estimated.

Oil exporting countries tend to have less well-developed bureaucracies, since they do not have as much of a necessity to raise tax revenues from the local population to pay for the services of government. A weaker state thus increases the chance that someone will try to topple it. The ”weaker state” argument also applies to new states, unstable states, noncontiguous states and anocracies.

The main pathway by which climate change affects civil war onset is hypothesized to be through negative shocks to agricultural production. Such shocks increase food prices, depress income, and consequently decrease the opportunity cost of pursuing violent conflict as a means of resolving resource competition between groups. Droughts, extreme hot and cold temperatures, floods, storms and wildfires all affect agricultural production to varying degrees. Thus it is expected that they will tend to increase the probability of civil war onset. Moreover, events such as droughts and extreme hot and cold temperatures are expected to have a more discernable effect on civil war onset since they tend to affect wider areas than do more localized disaster events such as storms, floods and wildfires.

In addition to estimating the aforementioned models using a simple binary logit estimator, I also estimate them using a simple linear probability model (with country and year fixed effects). This model’s results should be interpreted with caution, of course, since linear probability models are often fraught with heteroskedasticity issues, likely making the regression coefficients inefficient. Furthermore, I estimate all of the proposed models using the conditional (fixed effects) logit model, employing both country and year fixed effects. The downside of using this estimation method is that it drops all countries that do not experience onset of civil war in the sample. It wouls do the same for all countries that experience onset of civil war every year in the sample. Thus when there is no variation in the dependent variable for a given country in the sample, this country's contribution to the log-likelihood is zero and as such they have no effect on the estimation. Thus the sample becomes restricted to countries that experienced civil war onset in some years, but not in all years, effectively reducing the sample from 154 to 64 countries and from 6,278 country-year pairs (observations) to only 2,736. Thus the results should be interpreted with caution.

4.2 *Civil War-in-Progress*

Civil war incidence is different from civil war onset. The onset variable takes the value of 1 only in the year the conflict starts. The incidence variable takes on a value of 1 in any year conflict is occurring. I model the determinants of civil war incidence utilizing a commonly used logistic specification in conflict literature,

$$\text{Model P1: Civil\_War\_in\_Progress}_{\text{it}} = \beta_0 + \beta_1 \text{Disaster}_{\text{it}} + \sum \beta \text{X}_{it} + \varepsilon_{it} \qquad (3)$$

where the dependent variable *Civil_War_in_Progress*$_{it}$ is a binary variable equal to 1 if a civil war is under way in country *i* at year *t*, and 0 otherwise. *Disaster*$_{it}$ is the frequency of a given disaster type in country *i* in year *t*. Included disasters are again: droughts, extreme cold temperatures, extreme hot temperatures, epidemics, floods, storms and wildfires. I use identical X_{it} controls (other than "prior war" variable) in the *Civil_War_in_Progress*$_{it}$ model as in the previous *Civil_War_Onset*$_{it}$ specifications.

As a robustness check, the specification in equation (3) is also expanded by introducing up to three lags for pertinent disaster frequencies. Furthermore, again I consider alternative specifications with time fixed effects to control for impacts common to all countries that vary by year. I include all the disasters as explanatory variables at the same time in another alternative specification.

Thus the most general specification includes time fixed effects as well as varying degrees lagged effects,

$$\text{Model P8}: \text{Civil\_War\_in\_Progress}_{it} = \beta_0 + \sum_{s=0}^{3} \beta \text{Disaster}_{it\text{-}s} + \sum \beta X_{it} + \delta_t + \varepsilon_{it} \quad (4)$$

where δ_t are the time fixed effects, and $Disaster_{it\text{-}s}$ is the frequency of a given disaster in country *i* at time *t-s*. Again, I also estimate these models using the linear probability model and conditional (fixed effects) logit model, employing both country and year fixed effects in both specifications.

4.3 *Civil War Duration*

I model civil war duration in a discrete-time framework using several common parametric and non-parametric survival models. Previous researchers have not modeled civil war durations in discrete-time framework. Most common approach is to use non-time varying variables, whose values are measured only at the start of the event whose duration is measured. In contrast, I do allow climate-change-related disasters to vary over the duration of a war.

I test the impacts of various disaster events on civil war duration under different assumptions about the hazard function. I explore a semiparametric Cox proportional hazards model, as well as Exponential, Weibull and Gompertz specifications, as well as a discrete time proportional hazards model (Prentice-Gloeckler, 1978) and logistic regression models. The Cox proportional hazards model is the most flexible with respect to the nature of any form of duration dependence, since the component of the hazard function that captures duration dependence cancels out and need not be specified explicitly, whatever it is. The exponential duration distribution has a constant hazard rate, which is often considered too restrictive of an assumption. The Weibull and Gompertz forms have a flexible hazard function that can that monotonically increase or decrease

(Cameron and Trivedi, 2005). The Prentice-Gloeckler grouped duration data proportional hazards regression model is especially appropriate when the timing of the event of interest is not observed exactly but is only known to occur within some specified time interval.

The dependent variable in these models is civil war duration. The main regressors of interest are the frequencies of annual climate-change-related disaster events. Disaster events are modeled as time-varying covariates. Thus they are included in each model by accounting for the frequency of each type of event for every year during which a given civil war is in progress. While Fearon (2004) does not include any weather related variables, I follow his lead in terms of other types of control variables to include in the model. Control variables are taken from the influential work on civil war duration by Fearon (2004). These include: a binary variable for coups and revolution (measured at start time), another for Eastern Europe (non-time varying covariate), colonial wars (a non-time varying covariate), the presence of indigenous populations ("sons of the soil"), fighting migrants to their areas (a non-time varying covariate), contraband related financing of war(non-time varying covariate), logarithmically transformed population density (a time-varying covariate), lagged GDP/capita (a time-varying covariate) and PolityIV measure of the level of democracy (a time-varying covariate).

Disaster events are expected to increase the expected duration of civil wars (i.e. to reduce the "hazard" of a civil war coming to an end). The pathway by which these events are hypothesized to impact civil war duration is similar to that in the models for $Civil\_War\_Onset_{it}$ and $Civil\_War\_Progress_{it}$ cases. As argued in other cases, disaster events decrease the opportunity costs of using violent conflict as a method to assert power over allocation of scarce resources. The most profound effect of a disaster on civil war duration is expected to come from an event that can keep such opportunity costs low for the duration of the war. This is more likely to be the case with persistent climate-related problems. Long-lasting tendencies, as opposed to one-time events such as local or regional severe storms, are more likely to have discernable effects on civil war durations.

In terms of the control variables, successful coups and revolutions as the provocation for a civil war are expected to shorten the duration of a civil war. Coups are defined as attempts by individuals and groups associated with a government (for example, a faction within the military) to use violence against their government (for example, parliament) in an attempt to seize power. Coups tend to be brief, as there tends to be little underlying support for the goals of an average coup. Revolutions also tend to be brief, as they are characterized by a large groundswell of anti-government sentiment that often unites large portions of society in a common cause. An indicator variable for Eastern Europe controls for the collection of brief civil wars that took place in that region as a part of a transition from socialism to democracy. Similarly, an indicator for anti-colonial wars is included to control for a wars of independence from colonial powers.

Controlling for colonial independence is important since a significant proportion of wars in the 1950s and 1960s were colonial wars. These tended to be brief, since colonial powers tended to be too far away from the locale of the uprising to successfully stop them. Furthermore, colonial powers had to deal with many such uprisings at the same time, spreading their resources thin. "Sons of soil" wars are expected to last longer because they involve an organized group within a country (often ethnic) that opposes in-migration by other groups. Since the insurgents are living within the country and control an area, it is less likely that the insurgents would be quickly dealt with.

Other variables include the existence of significant illegal drug production and trade. Active drug production and trade is expected to increase civil war durations, since these activities provide valuable access to money for the insurgents. Incomes should have a negative impact on civil war durations, since higher income increases the opportunity cost of pursuing violence. Similarly, a higher level of democracy achieved by a given country is expected to shorten the length of a civil war because such countries have institutions that may deal with any grievances more effectively than non-democratic countries. Bleaney and Dimico (2011) provide support for use of different covariates in civil war duration and onset models.

5. Empirical Results

5.1 *Civil War Onset*

For each disaster, I estimate eight models. I start with the specification in equation (1), which I call model O1, and then add lags to this model until there are three lagged disaster terms (i.e. in model O4). Then I add time fixed effects to equation (1), and call it model O5. After adding up to three lagged disaster terms to this model I end up with the specification featured in equation (2), and call this model O8[12]. The complete sets of parameter estimates for all models are presented in Appendix A, Tables A1 through A8.

Since the complete set of results is so voluminous, I will focus on just the key estimated coefficients in the body of this paper. A summary of estimated results from specifications which feature just individual disaster models are presented in Table 7, while the results from a model where all of the disaster effects estimated simultaneously are presented in Table 8. Only the significant coefficients on the disaster variables are summarized in these tables. The first "Significant Coefficients" column shows the ranges of point estimates for the coefficients for which statistical significance is attained for all individual disaster event models without time

[12] See Appendix A, Table A0.

fixed effects. The "Models" column in Tables 7 and 8 provides information about the types of models in which the coefficient on a particular type of a disaster event frequency is significant.

In Table 7, each different row presents estimated coefficients from distinct models associated with just a single type of disaster. For example, Table 7 reports that the coefficient on the Extreme $Heat_{t-2}$ variable is statistically significant at the 10% level only in the model O3 that includes two lags for Extreme Heat. The coefficient on Extreme $Cold_t$, on the other hand, is significant in models with O1 through O4. The second "Significant Coefficients" column shows the estimated coefficients, for all individual disaster event models with time fixed effects, which are individually statistically significant. The second "Models" Lags column again provides information about the types of models with time fixed effects in which the coefficient on a particular type of a disaster event frequency is significant.

Table 8 has the same format as Table 7, but shows significant coefficient estimates for a model that includes all disaster events. As previously mentioned, such model might suffer from multicollinearity. Table 2 presents pair-wise correlation matrix between disaster events and Table 3 presents R^2 for regressions where a given disaster is a dependent variable determined by the remaining disasters. These statistics suggest that multicollinearity is not severe.

The most striking and least ambiguous finding among the estimated results is that the frequency of contemporaneous extreme cold events (Table 7 and Table 8) has a positive and significant effect on the onset of civil war. The estimates are robust across specifications, being significant at the 5% level ot better in all specifications. Similar studies focusing only on incidence of civil war have found similar effects, so these result represent a reassuring confirmation of earlier results. Zhang et al. (2006) attribute the observed effect to a negative shock that agricultural production experiences as a consequence of lower temperatures. This leads to decreased incomes, and lowers the opportunity cost of conflict as a manifestation of competition over scarce food resources (implying higher food prices). In contrast to the findings of Toll however, my estimates suggest that these connections have not been broken in the modern era.

Interestingly, another type of natural disaster is also found to have an effect on the probability of civil war onset, in both individual disaster (Table 7) and all-disaster models (Table 8). This is the contemporaneous frequency of epidemic outbreaks. Although epidemics affect incomes, there are other pathways by which epidemics increase the probability of a civil war. An area affected by an epidemic is simply more vulnerable to attacks, since its inhabitants, weakened by the disease, are unable to fend off their attackers (assuming these attackers are unaffected, or at least less affected, by this disease).

Contemporaneous and lagged frequencies of droughts, extreme heat events, floods, and storms seem to have no persistently significant effects on the probability of civil war onset. There are, however, a few instances that suggest some possible evidence of disaster impacts, though not robustly so. For example, in Tables 7 and 8, a single lag of extreme heat events also seems to increase the probability of civil war onset. Storms occurring two years earlier may have a positive impact on the probability of civil war onset. On the other hand, storms taking place three years earlier may have a negative impact on the probability of civil war onset. These results, if true, suggest that if a country can get past the two-year hurdle after the storm it is safer from civil war. Storms which inflict major damage require that the government expend significant resources on recovery and rebuilding. Oftentimes, the military is used for these purposes. This, in turn, is likely to weaken the government and invite insurgents to attack. Since it takes some time to rebuild and recover, the government may be vulnerable for at least two years.

As a robustness check, I also estimate conditional (fixed effects) logit models and fixed effects linear probability models. These are presented in the Appendix in sections B and C, respectively[13]. The cost of using conditional (fixed effects) logit model is a loss of the majority of observations. The final model is restricted in that it uses only 2736 observations associated with all countries and years in which there is a civil war. The coefficient estimates do lose some significance compared to the random effects logit model, but most of the relations persist. The coefficient estimates on extreme cold events and epidemic outbreaks are consistent with the original panel logit model. In this model, however, additional disasters come to matter. In particular, contemporary extreme heat events seem to be, counter intuitively, negatively related to the probability of civil war onset. Epidemic outbreaks, however, don't seem to have any effects on the probability of civil war onset in these specifications. The fixed effects linear probability models may suffer from heteroskedasticity, however[14].

5.2 *Civil War In Progress*

As in the civil war onset models I estimate eight models. But now, I estimate equation (3), which I call model P1. P1 with an additional lag is P2, while P1 with two lags is P3, and finally P4 has three lags. P1 with time fixed effects is P5; P2 with time fixed effects is P6; P3

[13] See Table B9 for the summary of the individual-disaster model results and B10 for the summary of the all-disaster models estimated using conditional (fixed effects) logit models. See Table C9 for the summary of the individual-disaster model results and C10 for the summary of the all-disaster models estimated using fixed effects linear probability models.

[14] I also estimate the linear probability model using robust standard errors, and find the results to be consistent with those of previous specifications. I also performed additional robustness checks whereby I drop all new countries entering the sample, and find the results to be similar to those of the 'full' models.

with time fixed effects is P7; and P4 with time fixed effects is P8[15]. The complete sets of parameter estimates for all models are presented in Appendix D Tables D1 through D8.

A summary of estimated results from individual-disaster models is presented in Table 9, and the all-disasters model in Table 10. Estimated results suggest that all three lags of extreme heat events increase the probability of civil war in both the individual-disaster and the all-disaster models. Extreme heat events can be characterized as another type of a negative shock to incomes that also decreases the opportunity cost of pursuing violent conflict as means of competing for scarce resources. The results tend to be significant at 10% level for extreme heat events occurring one year prior to any given year in which a civil war is in progress. Second and third lags of extreme heat events bear coefficients which are significant at 5% level. The results persist when all other events are included in the model. No other disaster events seem to have this robust an effect on civil war incidence.

Again, I estimate a conditional (fixed effects) logit model and fixed effects linear probability models.[16] In the first case, I find that second and third lags of extreme heat events increase the chance that a civil war is occurring in a give country in a given year. However, the result is not present for the first lag of extreme heat events. In the linear probability models, I find that the coefficients on the lags of extreme heat events are not significant. Again, another variable seems to have an effect, in this case, the count of flood events and all of its lags. These variables have a positive effect on the probability that the civil war is in progress[17].

[15] See Appendix D, Table D0.
[16] See Table E9 for the summary of the individual-disaster model results and E10 for the summary of all-disaster models estimated using a conditional (fixed effects) logit model. See Table F9 for the summary of the individual-disaster model results and F10 for the summary of the all-disaster models estimated using fixed effects linear probability model.
[17] I also estimate the linear probability model using robust standard errors, and find the results to be consistent with those of previous specifications. I also performed additional robustness checks whereby I drop all new countries entering the sample, and find the results to be similar to those of the 'full' models.

5.3 *Civil War Duration*

Selected results from a set of select civil war duration models are presented in Tables 11 and 12. The complete estimates models are presented in Appendix G, Tables G2 through G9. Each of these tables presents results from a progression of six different non-parametric and parametric survival models. The first column in each table gives the results from the semi-parametric Cox proportional hazards model; the second column contains estimated coefficients from the parametric exponential survival model; the third column, the Weibull model; the fourth column the Gompertz model; the fifth column, the discrete time proportional hazards model (Prentice-Gloeckler, 1978); and column six gives the results from a logistic regression. I estimate these various different survival models to see how the estimates differ under different assumptions regarding the hazard function and possible duration dependence.

The estimated results suggest that civil war duration is primarily affected by drought events. The estimated coefficients tend to be significant at the 5% level across various individual-disaster specifications of these events survival models (Table 11). The drought effects also seem to be robust to the strategy of including all disaster events in a single model (Table 11).[18] No other disaster event in any model suggests a statistically significant impact on civil war duration. Droughts seem to be different than all other disaster events used in this study. Extreme cold and heat, floods, storms and wildfires can all be characterized as sudden and relatively brief (i.e. acute) disaster events. Droughts, on the other hand, tend to be “chronic events” that last much longer. Acute disasters do not seem to provide enough of a shock to agriculture, and thus incomes, to start or perpetuate a civil war. But the persistence of droughts seems to cause enough damage to delay the end of a civil war. Sustained drought conditions probably have this effect by not allowing the opportunity costs of pursuing violent conflict to increase.

[18] Tolerance and pair-wise correlation matrices suggest no serious multicollinearity issues.

6, Conclusion

This study is concerned with potential climate change impacts on the potential for civil war strife. The relationship between climate and potential conflict has received increasing attention in the literature on climate change impacts and many questions remain unanswered. Recently, the IPCC and Al Gore received the Nobel Peace Price for their research on climate change, including a brief mention of climate change impacts on civil conflict. Previous research suggests that low temperatures increase the frequency of conflict frequency in Europe and China during since 1000 A.D. However, there is some evidence that these effects may have weakened during the industrialized era (Tol, 2010). Burke et al. (2009) find that higher temperatures appear to increase the probability of civil war incidence in Africa between 1981 and 2002. Thus the question remained unclear about the probable effect of on future generations.

In this paper, I have expanded the variety of climate-related events used to explain civil wars, and I have expanded the range of outcomes being considered including impacts on civil war onset, civil wars in progress, and civil war durations. As opposed to continuous measures of average temperature and cumulative precipitation, I focus on the counts of impacts of extreme events, primarily natural disasters, all of which are expected to increase in frequency due to climate change. The results point to a conclusion that societies might avoid some of the expected, and otherwise often negative, effects of natural disasters related to climate change. Although this is the case for most types of disasters, extreme cold events and epidemics seem to increase the chance for a civil war to start in countries which experience these types of shocks. I also find that the lags of severe heat waves increase the chance of a civil war being in progress in country i in year t. Finally, I find that duration of civil wars is primarily affected by droughts. Most of these effects are ascribed implicitly to a decrease in agricultural production which leads to an increase in the probability of civil war occurring due to a competition for food resources. In the near future I plan on extending the analysis by incorporating available agricultural data and empirically testing the hypothesis that these climate-change related disasters affect various measures of civil war by the way of a negative shock to agricultural production.

Understanding the policy implications of these results is important. They suggest that any proposed climate change policies should focus on mitigating the negative effects of climate change related extreme events and natural disasters, at least to the extent that this may decrease the potential for civil strife and shorten the duration of civil wars should they develop anyway. This can be achieved by appropriately funding international disaster relief programs and enabling disaster insurance programs.

FIGURES AND TABLES

Table 1. Summary Statistics for Civil War Onset and Incidence Models (n=6278 country-years, from 1945 to 1999)

Variable	Mean	Std. Dev.	Min	Max
Dependent variables:				
1(Civil_War_Onset)	0.0167	0.128	--	--
1(Civil_War_in_Progress)	0.147	0.354	--	--
Additional conflict variable				
Prior war	0.132	0.339		
Counts of climate-related natural disasters				
$Drought_t$	0.0908	0.293	0	2
Extreme $Cold_t$	0.0141	0.130	0	2
Extreme $Heat_t$	0.0103	0.107	0	2
$Epidemic_t$	0.0943	0.397	0	6
$Flood_t$	0.277	0.757	0	14
$Storm_t$	0.269	1.13	0	27
$Wildfire_t$	0.0251	0.184	0	4
Prior war	0.133	0.340	--	--
Sociodemographic, geographic, and political controls				
GDP/capita, lagged	3.66	4.54	0.048	66.7
log(Population $Density_t$)	-3.38	1.54	-14.4	1.55
log(% mountains)	2.17	1.40	0	4.55
1(Noncontiguous state)	0.173	0.379	0	1
1(Oil producer)	0.129	0.336	0	1
1(New State)	0.0294	0.169	0	1
1(Instability)	0.146	0.354	0	1
PolityIV	-0.472	7.52	-10	10
1(Anocracy)	0.223	0.416	0	1

Table 2. Correlation Matrix for All Disaster Events in Civil War Onset and Incidence Models, 1945-1999 (n=6278)

	Drought	Extreme Cold	Extreme Heat	Epidemic	Flood	Storm	Wildfire
Drought	1						
Extreme Cold	0.0459	1					
Extreme Heat	0.0427	0.1203	1				
Epidemic	0.0951	0.1007	0.0917	1			
Flood	0.1311	0.1698	0.1748	0.1965	1		
Storm	0.0866	0.1575	0.2166	0.0711	0.4233	1	
Wildfire	0.0676	0.0803	0.1026	0.0863	0.1726	0.3016	1

Table 3. Tolerance for Each Event in All Disasters Civil War Onset and Incidence Models

Variable	R^2
Drought	0.024879
Extreme Cold	0.048792
Extreme Heat	0.065269
Epidemic	0.054179
Flood	0.226041
Storm	0.25512
Wildfire	0.099035

Table 4 . Summary Statistics for Civil War Duration Models (n=1102 country-years, from 1945 to 1999)

Variable	Mean	Std.	Min	Max
Dependent variable:				
Civil War Finishes	0.0826	0.2750	--	--
Counts of climate-related natural disasters:				
Drought	0.178	0.398	0	2
Extreme Cold	0.046	0.251	0	2
Extreme Heat	0.027	0.178	0	2
Epidemic	0.285	0.731	0	6
Flood	0.758	1.34	0	8
Storm	0.616	1.59	0	11
Wildfire	0.033	0.182	0	2
Sociodemographic, geographic, and political controls				
1(Coup/revolution)	0.0515	0.221	--	--
1(Eastern Europe)	0.0352	0.184	--	--
1(Not contiguous)	0.190	0.392	--	--
1(Sons of the soil)	0.302	0.459	--	--
1(Contraband)	0.256	0.436	--	--
GDP/capita (lagged, in 1000s)	1.93	2.07	0.0500	14.9
log(Population Density$_t$)	-3.00	1.270	-5.98	-0.0674
Democracy (–10 to 10, lagged)	-0.498	6.77	-10	10

Table 5. Correlation Matrix for All Disaster Events in Duration Models, 1945-1999 (n=1102)

	Drought	Extreme Cold	Extreme Heat	Epidemic	Flood	Storm	Wildfire
Drought	1						
Extreme Cold	-0.0113	1					
Extreme Heat	0.0552	0.1294	1				
Epidemic	0.0241	0.1971	0.2505	1			
Flood	0.1116	0.267	0.2363	0.3034	1		
Storm	0.1213	0.2149	0.1448	0.1277	0.4608	1	
Wildfire	0.029	0.0828	0.0268	0.3326	0.1037	0.0338	1

Table 6. Tolerance for Each Event in All Disasters Duration Models

Variable	R^2
Drought	0.0229286
Extreme Cold	0.0992429
Extreme Heat	0.1018733
Epidemic	0.226383
Flood	0.3051134
Storm	0.2287929
Wildfire	0.1153389

Table 7. Determinants of Civil War Onset : Significant Coefficients from Individual Event Panel Logit Models, 1945-1999 (n=6278)

Variables	Significant Coefficients	Models	Significant Coefficients	Models
$Drought_{t-1}$	0.589*	O3	--	--
$Extreme\ Cold_{t}$	1.226** to 1.438***	O1,O2,O3,O4	1.209*** to 1.381***	O5,O6,O7,O8
$Extreme\ Heat_{t-1}$	1.098* to 1.427**	O2,O3,O4	1.273* to 1.581**	O6,O8
$Extreme\ Heat_{t-2}$	1.091*	O3	--	--
$Extreme\ Heat_{t-3}$	1.102*	O4	1.135*	O8
$Epidemic_{t}$	0.299* to 0.380**	O1,O2,O3,O4	0.346* to 0.379**	O5,O6,O7,O8
$Storm_{t-2}$	0.235* to 0.316**	O3,O4	0.353*	O8
$Storm_{t-3}$	--	--	-0.511*	O8
$Wildfire_{t}$	1.125** to 1.247***	O1,O2,O3,O4	1.133** to 1.234**	O5,O6,O7,O8
Control Variables	Yes		Yes	
Time Fixed Effects	No		Yes	

Note: Summary of selected coefficients from Appendix A Tables A1 through A7. Only significant coefficients are presented. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Determinants of Civil War Onset : Significant Coefficients from All Events Panel Logit Models, 1945-1999 (n=6278)

Variables	Significant Coefficients	Models	Significant Coefficients	Models
$Drought_{t-2}$	--	--	-0.862*	O7
$Extreme\ Cold_{t}$	0.913* to 1.205***	O1,O2,O4	0.949* to 1.226***	O5,O6,O8
$Extreme\ Heat_{t-1}$	--	--	1.400*	O8
$Epidemic_{t}$	0.300*	O1	0.345* to 0.391*	O5,O6,O7,O8
$Storm_{t-2}$	0.358**	O4	0.417**	O8
$Storm_{t-3}$	-0.478*	O4	-0.624**	O8
Control Variables	Yes		Yes	
Time Fixed Effects	No		Yes	

Note: Summary of selected coefficients from Appendix A Table A8. Only significant coefficients are presented. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 9. Determinants of Civil War Incidence : Significant Coefficients from Individual Event Panel Logit Models, 1945-1999 (n=6278)

Variables	Significant Coefficients	Models	Significant Coefficients	Models
Extreme $Cold_t$	0.94** to 1.159***	P1,P2,P3,P4	--	--
Extreme $Heat_{t-1}$	1.008* to 1.029*	P2,P3,P4	1.003* to 1.053*	P6,P7,P8
Extreme $Heat_{t-2}$	1.526*** to 1.543***	P3,P4	1.511*** to 1.564***	P7,P8
Extreme $Heat_{t-3}$	1.265**	P4	1.193***	P8
$Flood_t$	0.152* to 0.218***	P1,P2,P3	--	--
$Flood_{t-1}$	0.139* to 0.169**	P2,P3	--	--
$Flood_{t-3}$	0.164*	P4	--	--
$Storm_t$	0.142**	P1	--	--
Control Variables	Yes		Yes	
Time Fixed Effects	No		Yes	

Note: Summary of selected coefficients from Appendix D Tables D1 through D7. Only significant coefficients are presented. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 10. Determinants of Civil War Incidence : Significant Coefficients from All Events Panel Logit Models, 1945-1999 (n=6278)

Variables	Significant Coefficients	Models	Significant Coefficients	Models
Extreme $Cold_t$	0.797* to 0.951**	P1,P2,P3,P4	--	--
Extreme $Heat_{t-1}$	--	--	1.022* to 1.06*	P6,P7,P8
Extreme $Heat_{t-2}$	1.489** to 1.501**	P3,P4	1.601*** to 1.627***	P7,P8
Extreme $Heat_{t-3}$	1.181*	P4	1.258**	P8
$Flood_t$	0.152* to 0.218***	P1,P2,P3	--	--
$Flood_{t-1}$	0.165**	P1	--	--
Control Variables	Yes		Yes	
Time Fixed Effects	No		Yes	

Note: Summary of selected coefficients from Appendix D Table D8. Only significant coefficients are presented. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 11. Determinants of Civil War Duration Controlling for Frequency of Drought Events, 1945-1999 (n=1102)

Models	$Drought_t$
Cox	-0.117*
Exponential	-1.377**
Weibull	-1.485**
Gompertz	-1.415**
Discrete Time Proportional Hazards	-1.400**
Logit	-1.460**

Note: Summary of selected coefficients from Appendix G Tables G1 through G7. Only significant coefficients are presented. All six models include a full set of controls. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 12. Determinants of Civil War Duration Controlling for Frequency of All Disaster Events, 1945-1999 (n=1102)

Models	$Drought_t$
Cox	-0.128**
Exponential	-1.377**
Weibull	-1.488**
Gompertz	-1.412**
Discrete Time Proportional Hazards	-1.418**
Logit	-1.462**

Note: Summary of selected coefficients from Appendix G Table G8. Only significant coefficients are presented. All six models include a full set of controls. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

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The APPENDIX section can be found at
http://pages.uoregon.edu/tsipic/Appendix%20to%20Climate%20Change%20and%20Civil%20War.pdf
It contains 63 pages.