Natural Disasters, Asymmetric Exposure, and War: Why Empirical Evidence on Climate Conflict Is Mixed

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Abstract

Evidence on the effect of extreme weather events or natural disasters on the risk of armed conflict is mixed. I explain the pattern by arguing that disasters have heterogeneous effects on conflict risks and, consequently, systematically make empirical evidence mixed. Specifically, I develop a model of conflict that focuses on the role of political groups' *asymmetric* resilience/vulnerability to disasters. It presents two contrasting equilibrium strategies arising from disaster-induced power shifts. In the first case, where two groups have similar levels of resilience, one of them opportunistically attacks its rival *after* a disaster if the latter incurred disproportionately severe damage. Disaster events and conflicts are positively correlated. In the second case, where one of the players is inherently more vulnerable to disaster risks, she attacks the relatively resilient side preemptively *before* a disaster occurs. Here, disaster events negatively correlate with conflicts. Based on the theory, this paper (i) draws a new empirical implication and assesses it with the data of intrastate conflicts and droughts in African countries and (ii) formally shows that the conditional average treatment effect (CATE) of disaster events on conflict risks becomes *negative* in the second case, providing a novel interpretation of why the evidence on climate conflict seems mixed.

Keywords: Conflict; natural disasters; climate change; formal political theory; EITM/TIEM

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1 Introduction

The evidence on the effect of climate anomalies and natural disasters on the risk of violent conflict is mixed. On the one hand, these events can threaten peace by generating resource scarcity, opening a window of opportunity to exploit the affected group/country that is temporarily vulnerable, and by reducing the opportunity costs of resorting to violent conflict (e.g., Hsiang et al., 2013; Jun and Sethi, 2021; Roche et al., 2020). On the other hand, because fighting an armed conflict requires belligerents to continually mobilize material resources, climate shocks can rather reduce the risk of conflict by undermining groups' mobilization and their war-fighting capabilities (Devlin and Hendrix, 2014; Salehyan and Hendrix, 2014). Moreover, some studies report little effects of climate factors on the risk of conflict and find that the positive correlation between them is sensitive to the definition of armed conflict (Buhaug, 2010; Theisen et al., 2011). Mach et al. (2019) also report divergent views among researchers. Hence, it seems plausible to state that there does not exist a wide consensus over the effect of natural disasters and climate events on the risk of armed conflict. Why is the empirical evidence mixed? If natural disasters can lead to armed conflict, *when* do they cause wars?

One possible root of the mixed results is that there exist problems with measurements or the methodology used in some studies in the literature. Namely, it might be possible that there exists the true mean effect of climate events on conflict and that one wing of the debate is "correct" and others are not. For example, Hsiang et al. (2013) and Hsiang and Burke (2014) report a "remarkable convergence" in the literature and suggest the presence of a general positive relationship between climate variabilities and conflict risks. On the other hand, Buhaug et al. (2014) point out the arbitrariness in their meta-analysis and find that a replication of Hsiang et al. (2013) leads to divergent results. Salehyan (2014) frames the disagreement as conceptual and empirical problems. This paper aims to conceptually and theoretically contribute to the empirical literature.

Instead of attempting to identify and measure the general effect of climate anomalies on conflicts, this paper focuses on another possibility. Namely, the empirical results in the literature may be divergent because natural disasters affect the risk of conflict in multiple ways and such heterogeneous effects *systematically* make the evidence mixed. That is, the theory presented in this paper allows disasters to be positively associated with conflicts in some cases and negatively associated in others. A game-theoretic model shows that two types of contrasting strategy profiles constitute the unique equilibrium in a broad set of parameter values and that these opposing results arise from a single theoretical dynamic: rapid shifts in power between rival political groups. I briefly preview the two strategic logics in the equilibrium below.

Key concepts that drive the contrasting results are *realized* and *expected asymmetric exposure* to natural disasters. It is plausible to assume that the severity of a certain disaster to different political groups varies. I focus on two sources of such variations in damage from extreme climate events. First, some groups incur disproportionately higher costs than others from a natural disaster that *has just occurred*. Because most natural disasters cause more severe damage to particular areas (e.g., damages from hurricanes depend on each one's course), one group that has incurred only a small cost from a disaster may happen to be temporarily advantaged over its political rival group. Consequently, the former group can commit opportunistic aggression against the latter after an extreme weather event as a result of the realized asymmetric exposure to it.[1]

Second, damage from a disaster is *expected* to vary along with the geographical and social resilience of a political group.[2] Some groups in a coastal area may expect to incur disproportionately high costs from tsunamis and hurricanes. Other groups, such as farmers or pastoralists, may also anticipate that they would be more vulnerable to droughts and

[1]See Kikuta (2019) for an empirical discussion based on post-disaster dynamic commitment problems. Jun and Sethi (2021) also find that natural disasters increase the probability that affected groups are invaded by their rivals.

[2]Note that this paper is not the first to point out this dynamic. It draws on and substantially extends the concept developed by Bas and McLean (2021).

floods than their rival groups. Such groups that are inherently more vulnerable than their political rivals due to the expected asymmetric exposure to an extreme weather event can have a preemptive motive to attack an opponent *before* a devastating disaster occurs because they know that they will be highly vulnerable once the damage of the event materializes.

An important implication drawn from the above two mechanisms is that (i) the actual occurrence of a disaster and armed conflict should be positively correlated in the first equilibrium (because war follows the asymmetric post-disaster balance of power) but (ii) they should be negatively associated in the second (because war erupts in the absence of a disaster). Moreover, based on assumptions drawn from the game-theoretic model, I show that the causal effect of disasters on conflict in the sense of the conditional average treatment effect (CATE) becomes *negative* in the second case. This observation provides a novel theoretical interpretation of why the empirical evidence on climate conflict looks mixed.Namely, I argue that overlooking the second mechanism (i.e., war caused by expected asymmetric exposure to disasters) may lead researchers to underestimate the true conflict-inducing effect of climate anomalies and other natural disasters.

1.1 Intuition

To further facilitate the intuition of the two different types of equilibrium outcomes discussed in the model section, here I present two informal illustrations.[3] As common assumptions, suppose that (i) a climate disaster occurs with a certain probability; (ii) the region that a disaster hits most severely is also randomly determined; (iii) disasters lower political groups' military capabilities because they can directly damage military assets and have negative impacts on power projection capabilities by destroying infrastructures; and (iv) the affected political groups will eventually recover from the costs of a disaster. The two cases below differ in only one aspect: the level of (a)symmetry in expected exposure to disasters.

[3]The following cases correspond to case (R), i.e., Case 1 below, and cases (E_1) and (E_2), i.e., Case 2 below, respectively.

Case 1 (Opportunistic aggression *after* a disaster). Consider two rival political groups, Group 1 and Group 2. They can be two sovereign states or different groups in a single country. Assume that the groups are geographically proximate and have similar levels of economic development, military capabilities, and resilience in social infrastructures. To make a comparison with Case 2 below easier, assume that both of them are in a disaster-prone region. If a natural disaster takes place, the two groups are expected to incur similar costs on average because they are equally vulnerable. We say that Groups 1 and 2 face *symmetric* exposure to disaster risks.

Now suppose that an extreme weather event hits the area in which Groups 1 and 2 are located. Further, because the distribution of damages arising from natural disasters is random, assume that Group 2 incurred disproportionately large costs and that the disaster did not cause large damage to Group 1. Recall the assumption that a disaster negatively affects groups' military capabilities. Because the disaster happened to hit Group 2 severely, Group 1 would find itself temporarily advantaged militarily. In this case, Group 1 can have the incentive for opportunistic aggression before Group 2 recovers.For later use, observe that this opportunistic conflict should erupt *right after* a disaster occurs in this case.

Case 2 (preemptive war *before* a disaster). Next, consider a different pair of hostile political groups, Group 1 and Group 2'. We think of Group 1 as located in the same location as Case 1. On the other hand, unlike Case 1, Group 2' is in a distant region and inherently more resilient to climate anomalies than Group 1 is. Because Group 1 is relatively more vulnerable to extreme weather events, we say that the groups face *asymmetric* risks of exposure to disasters. Suppose that Group 2 in Case 1 and Group 2' have identical attributes other than resilience to disaster risks.

In contrast to Case 1, consider a period of time when there is no disaster in the area. Group 1 knows that it is disproportionately vulnerable to disaster risks compared to its political rival, Group 2'. Thus, it *anticipates* that it can incur severe disaster costs in the

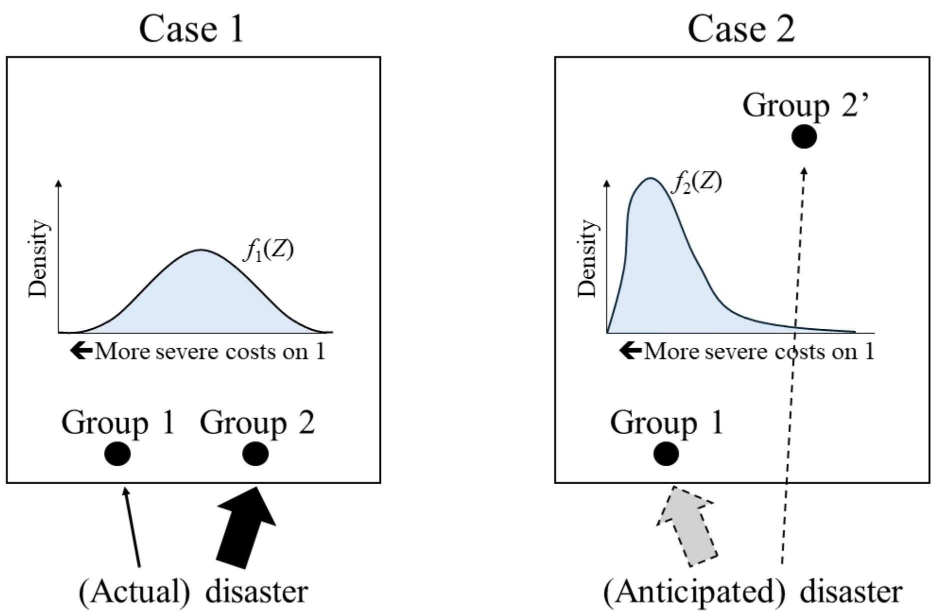

Figure 1: Conflict-prone conditions in the two illustrative cases

future. Further, Group 1 expects that Group 2’ may commit opportunistic aggression when a disaster erupts and the military balance of power rapidly shifts in favor of Group 2’. Predicting this risk, Group 1 has a preemptive motive to attack Group 2’ *before* it actually incurs severe disaster costs.

Contrasting the two cases. Figure 1 highlights the contrast between them. The squares represent the regions in which Groups 1 and 2 or 2’ are located. Groups 1 and 2 are geographically proximate (Case 1) and 1 and 2’ are distant (Case 2). That is, Groups 1 and 2 face similar disaster risks, whereas Group 1 is inherently more vulnerable than Group 2. The solid arrows outside the square region denote the materialized disaster costs (Case 1) and the dashed ones represent expected damages imposed by future disasters (Case 2). The line widths of the arrows indicate the asymmetry of the damages.

We can consider such (a)symmetry in exposure risks to disasters as distributions of random variables. Suppose that a random variable Z with density $f_1(Z)$ (Case 1) and $f_2(Z)$ (Case 2) determines the relative disaster damage on the two groups, where a smaller (larger) value represents a greater disaster cost on Group 1 (2 or 2'). As Figure 1 illustrates, the distribution is symmetric in Case 1, whereas it is skewed in Case 2. In Case 1, because the expected disaster costs are roughly symmetric between the two groups, they do not have the preemptive motive in the absence of a disaster. However, because Z is random, it can be the case that its particular realization *happens to be* extreme. War is possible only in this circumstance in Case 1.

On the other hand, the graph of $f_2(Z)$ is skewed (Figure 1). The density being larger for smaller Z indicates that Group 1 is more likely to incur severe damage from a disaster. Note that a conflict can still erupt right after an extreme climate event in this case as well. Nonetheless, because the relative disaster-related costs are randomly determined, a war may not ensue after it. Namely, if a particular weather event happened to impose roughly equal costs on the two rival groups, neither of them finds itself temporarily (dis)advantaged in terms of the military balance of power. In contrast, in the simple example of Case 2, Group 1 attacks Group 2' with probability one in the absence of a disaster because the former *knows* that $f_2(Z)$ is skewed: in expectation, it will likely be militarily weaker in the future. Consequently, although conflict onset is possible in Case 2 both when a disaster has occurred and when it has not, war is strictly more likely in its absence.

This leads to an empirical implication. Suppose we want to estimate the effects of disasters on violent conflict with data on the timing of extreme weather events and conflict onsets. It is straightforward that the correlation between extreme climate events and conflicts should be positive in Case 1. On the other hand, it should be negative in Case 2 because the vulnerable group is strictly more likely to fight in the absence of such events. However, as Case 2 shows, the expected asymmetric exposure to disasters is responsible for conflict onset. Namely, disasters trigger conflict in *both* cases. Hence, failure to incorporate the dynamic in Case 2 might lead to underestimation of the conflict-inducing effects of natural disasters. The model presented below illustrates the core logic above more formally.

1.2 Related Literature

This study contributes to the growing literature on extreme weather events and armed conflict.[4] In particular, I draw on the findings of a recent paper by Bas and McLean (2021) that the expectations of natural disasters can induce preemptive attacks and that conflicts are associated with disaster *risks*. While I draw on their notion of the expected effects of natural disasters, the model presented here differs in important ways. First, it allows recurrent disasters and recovery of the economy after them. Second, it also models the asymmetry in disaster costs as a random variable. These extensions make the disaster expectation mechanism a special case generated by a single model, which enables us to take the findings of Bas and McLean (2021) one step further and theoretically explain the source of mixed empirical results.

Both Roche et al. (2020) and this study extend Chassang and Padró i Miquel (2009). Whereas Roche et al. (2020) investigate the impact of changes in the distribution of rainfalls and economic shocks as a result of climate change, they assume that players share the same severity of those shocks. In contrast, the present model incorporates the asymmetry in exposure to negative resource shocks. Ide (2023) also focuses on the multiple effects of disasters on armed conflict. While he qualitatively assesses disasters' impacts on the intensity of ongoing conflicts, I develop a game-theoretic model that explains the empirical results that might seem to contradict ostensibly.

The model is also related to the literature on costly conflicts due to dynamic shifts in power (e.g., Fearon, 2004; Krainin, 2017; Powell, 2004, 2006). A recent model by Little and Paine (2023) is of particular relevance. By assuming that, as with the present model, the probability that one group wins in war is randomly drawn each period, Little and Paine (2023) distinguish the sources of the threat of a challenger group into (i) the maximum probability of the challenger's victory in war and (ii) its mean (or the probability of the

[4] For review, see Buhaug and von Uexkull (2021); Burke et al. (2015); Koubi (2019). Jun and Sethi (2021); Kikuta (2019) examine the opportunistic aggression caused by natural disasters.

challenger being “strong”), and show that the combination of a larger maximum challenger threat and a smaller average threat is most prone to conflict.[5] This paper departs by further distinguishing opportunistic and preemptive attacks. In the former, war occurs *under* a shock to the balance of power (i.e., disaster) when one player finds herself temporarily advantaged militarily. In the latter, players can also fight in the *absence* of a shock if one player is inherently vulnerable to it and has a preemptive motive to fight. The coexistence of the two distinct types of conflict enables us to systematically explain why some empirical studies find positive correlations between extreme weather events and conflict and others discover negative ones.

More broadly, this paper is related to the growing movement of Theoretical Implications of Empirical Models (TIEM). The TIEM approach aims to theoretically comprehend empirical findings (e.g., Bueno de Mesquita and Tyson, 2020; Slough, 2023, 2024; Wolton, 2019, 2021). One can situate the present paper in this literature in that, based on the theoretical model presented below, it proposes a new interpretation of the mixed empirical evidence on the causal effects of natural disasters and extreme weather events on violent conflict. It also points out the possibility that some empirical approaches, including the potential outcome framework that estimates the average treatment effect or the conditional average treatment effect of natural disasters on conflict, might not always be suitable if those events generate rapid shifts in military power.

The remainder of this paper proceeds as follows. After formally presenting the two opposing cases by developing a simple infinite-horizon game, I draw a new empirical prediction from the model and assess if it explains patterns in data on armed conflicts and water scarcity in African countries. Next, I point out that the potential outcome framework might underestimate the effect of disasters on conflict risks. Then, based on this implication, I revisit the case of drought to reinterpret the seemingly contradictory results of some existing studies.

[5] See also Benson and Smith (2023); Sawada (2024) for a similar dynamic, where the source of power shifts is external intervention. On the other hand, Smith (2019) develops a model in which arms transfers from an ally mitigate such fluctuations in the balance of power.

2 The Model

This paper develops a simple infinite horizon game that incorporates the two contrasting types of asymmetry in exposure to disasters. A key feature is that asymmetric exposure is a necessary condition for conflict in the model. Thus, war on any equilibrium path is triggered by the actual occurrence or expectation of natural disasters that can impose disproportionate damage on one of the players.

2.1 Setup

Two players (e.g., rival political groups in the context of domestic conflict or neighboring states in the context of interstate conflict) 1 and 2 interact each period $t = 1, 2, \ldots$. Both groups have a fixed amount of resources, θ. At the beginning of each period, Nature determines the presence/absence of a natural disaster as a draw of an identically and independently distributed random variable D following a Bernoulli distribution with mean π: in each t, a disaster occurs (i.e., $D_t = 1$) with probability π and does not (i.e., $D_t = 0$) with probability $1 - \pi$.[6] We model asymmetric exposure to a disaster as another independently and identically distributed random variable Z_t over the unit interval with mean μ. Suppose that (i) Z_t follows a distribution with a continuously differentiable cumulative distribution function F whose density is f and that (ii) it has a full support over $[0, 1]$. In a disaster period t, the materialized value of Z_t, denoted as z_t, discounts (i) the resources of Player 1 to $z_t\theta$ and (ii) those of Player 2 to $(1 - z_t)\theta$. Namely, after $D_t = 1$, Nature determines the level of asymmetry in the damage imposed on each player.

After Nature's moves, players observe the state (D_t, Z_t) and simultaneously decide whether to attack the other or not.[7] In this model, we assume that a conflict is a unilateral act: war

[6]We call the period in which a natural disaster has occurred a "disaster period." Similarly, we label a period without a disaster as a "no-disaster period".

[7]Players do not have a bargaining process in the model discussed in the main text. In Appendix C, I show that the key insights remain even when we allow an arbitrary bargaining protocol between Nature's move and players' decision about whether to fight.

ensues when at least one player chooses to fight. If neither player fights, players receive a flow payoff equal to the amount of their wealth in the period (θ when there is no disaster or $z_t\theta$ and $(1-z_t)$ when a disaster has erupted in the period), and the game proceeds to the next period.

When either player attacks the opponent, a game-ending war ensues. Its outcome is determined by the amount of players' resources: the probability that player i wins a war is

$$
\begin{aligned}
p_i^{\neg\mathtt{d}} &\equiv \frac{\theta}{2\theta} \\
&= \frac{1}{2} \text{ (when a disaster did not occur); or} \\
p_1^{\mathtt{d}}(Z_t) &\equiv \frac{Z_t\theta}{Z_t\theta + (1-Z_t)\theta} \\
&= Z_t \text{ (when a disaster occurred in } t\text{) and} \\
p_2^{\mathtt{d}}(Z_t) &\equiv 1 - p_1^{\mathtt{d}}(Z_t) \\
&= 1 - Z_t.
\end{aligned}
$$

Because a war is costly, it discounts the amount of resources in the society by $c \in (0,1)$: the remaining resource is $\theta(1-c)$ or $2\theta(1-c)$ when war erupts in disaster and no-disaster periods, respectively. If a war ensues, the game ends and the winner receives all remaining resources in the society in the current period ($\theta(1-c)$ or $2\theta(1-c)$) and a long-term benefit from its dominance over resources. By a long-term benefit, we mean that the victor gains the entire pie 2θ that can be discounted in half with probability π for infinitely many periods. Formally, the long-term payoff from dominance is:

$$
\begin{aligned}
\overline{\mathcal{V}} &\equiv \mathbb{E}_{D,Z}\left[\sum_{t=1}^{\infty} \delta^{t-1}\left(D_t\left(Z_t\theta + (1-Z_t)\theta\right) + (1-D_t)\,2\theta\right)\right] \\
&= \sum_{t=1}^{\infty} \delta^{t-1}\left[\pi\theta + (1-\pi)\,2\theta\right] \\
&= \frac{\theta(2-\pi)}{1-\delta},
\end{aligned}
$$

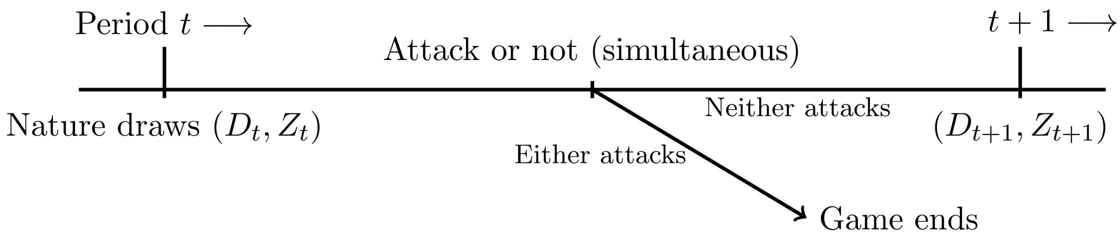

Figure 2: Timeline

where $\delta \in (0, 1)$ is a common discount factor.

Figure 2 summarizes the timeline of the game. We assume complete information. To focus on interesting cases in which disasters affect players' equilibrium strategies, we introduce the following assumption which excludes trivial equilibria such as one in which players attack the opponent after any history.

Assumption 1. Players do not attack the other one when they are indifferent between attacking and not attacking.

This assumption also enables us to focus on pure strategies.

Our solution concept is pure-strategy (stationary) Markov perfect equilibrium (MPE).[8] That is, a strategy in this model is a mapping from the state space $\{0, 1\} \times [0, 1]$ to the action space $\{\texttt{Attack}, \texttt{Not}\}$.

2.2 Comments on the Model

Before analyzing the model, it is useful to discuss the interpretations of its key features. First, the parameter $\mu \equiv \mathbb{E}[Z]$ represents the *expected* asymmetry in players' exposure to the disaster. More specifically, it captures the region-specific vulnerabilities that amplify the costs caused by natural disasters. For example, coastal areas may be more vulnerable to hurricanes (due to storm surges) and post-earthquake tsunamis. Some mountainous regions may also face a higher risk of landslides after excessive rainfall or earthquakes. In the model,

[8]Whereas we focus on MPE in the analysis section, we use subgame perfect equilibrium for the preliminary results (Remarks 1 and 2) presented below.

μ close to $1/2$ implies that the two groups have similar vulnerabilities to natural disasters. On the other hand, a small or large value of μ means that one of the players is more vulnerable to climate risks. A specific draw of Z_t, i.e., denoted as z_t, represents the *realized* asymmetric exposure to a disaster, which varies depending on which region the disaster hits most severely.

Second, disasters matter militarily by shifting the balance of power between players. This process takes place through the following two steps. First, the realized damage of a disaster z_t discounts the players' resources. Second, the affected amounts of resources determine the outcome of conflict via the probability of victory $p_i^{\mathsf{d}}(z_t)$, which is either z_t or $1 - z_t$.

Third, in order to examine the possible causal paths from natural disasters to armed conflict, the possibility of a disaster with asymmetric negative impacts is a necessary condition for war in this model. That is, as the following two results show, the game always proceeds peacefully without (i) the risk of natural disasters and (ii) asymmetric exposure to them.

Remark 1. *Suppose $\pi = 0$. Then, under Assumption 1, the unique subgame perfect equilibrium (SPE) is a strategy profile where both players never attack the opponent.*

Remark 2. *Suppose $\pi \in (0, 1)$ but $z_t = 1/2$ for any t. That is, the damage from a disaster is always symmetric. Then, under Assumption 1, the unique SPE is a strategy profile where both players never attack the opponent.*

These results are straightforward. Consider Remark 1. Because war is costly and there is no asymmetric information or a sudden power shift, a unilateral attack cannot be optimal after any history, which is in line with standard models of armed conflict (Fearon, 1995). The logic behind Remark 2 is also intuitive: the complete symmetry in exposure to a disaster prevents the temporary advantage that incentivizes aggression.[9] The model in which war can occur only under some risk of natural disasters with asymmetric exposure allows us to theoretically identify the effects of those extreme events on the risk of armed conflict.

[9] In the model of Chassang and Padró i Miquel (2009), war erupts under symmetric economic shocks because they assume the presence of offensive advantage: if only one player launches a unilateral attack, her probability of victory is greater than $1/2$, which renders the outcome more conflict-prone. The war outcome in the present model is determined by the asymmetry in resources rather than by who started the war.

Fourth, the assumption that the distribution F and, in particular, its mean μ are common knowledge establishes a scope condition of this model. Namely, we focus on relatively foreseeable disasters because the assumption implies that players can evaluate and take into account future disaster risks. Examples include seasonal climate anomalies such as storms, floods, and droughts. On the other hand, other natural disasters that are difficult to anticipate, including earthquakes, are beyond the scope.

Fifth, the negative impact of disasters on social welfare is fixed. Namely, any extreme weather event always halves the resources in the society composed of players 1 and 2. While the distribution of discounted resources varies according to Z_t, a disaster cannot make the total amount of resources more or less than $1/2$. This simplifying assumption makes clear how *asymmetric* exposure to extreme weather events, rather than their magnitude itself, affects players' incentive for maintaining intergroup peace and gambling on a costly war.

3 Analysis

This section presents two different equilibrium strategies in which realized and unrealized (expected) asymmetric costs of natural disasters cause armed conflict. The disproportionate vulnerability to natural disasters has two opposing effects depending on whether (i) the cost of a disaster has actually materialized following its outbreak or (ii) a disaster is expected in the future but has not occurred yet. In the first case, a player can attack the other to exploit the opponent's temporary vulnerability arising from the latter's disproportionate damage from a disaster in the current period. In the second case, a player has the incentive to fight in a no-disaster period when she expects she will become disproportionately vulnerable in the future.

Appendix B shows (i) the existence of an equilibrium of the game and (ii) the condition under which there exists a unique optimal cutoff strategy in disaster periods in each strategy profile that can constitute an equilibrium.

3.1 War Caused by *Realized* Disproportionate Damage

First, I present an equilibrium in which a conflict erupts as a result of opportunistic aggression by a player who is temporarily advantaged in a disaster period. To derive the equilibrium, we consider the following stationary strategies:

(R-I): In a disaster period, i.e., t such that $D_t = 1$, either one of the players attacks the other if the realized cost of the disaster is disproportionately incurred.

- When z_t is larger than a threshold $\overline{z}^{\mathtt{R}}(\mu)$ given μ, Player 1 attacks 2.
- When z_t is smaller than a threshold $\underline{z}^{\mathtt{R}}(\mu)$ given μ, Player 2 attacks 1.

(R-II): In a no-disaster period, i.e., t such that $D_t = 0$, neither player fights.

Slightly abusing notation, we often write the threshold values as $\overline{z}^{\mathtt{R}}$ and $\underline{z}^{\mathtt{R}}$ instead of $\overline{z}^{\mathtt{R}}(\mu)$ and $\underline{z}^{\mathtt{R}}(\mu)$, which are functions of μ as we discuss below.

When we assume the players follow the above strategies, on the equilibrium path, a war occurs if the damage inflicted by a disaster in the current period is highly asymmetric. The following result specifies the condition under which they are an equilibrium.

Proposition 1 (Realized asymmetric exposure). *Consider an interval $M^{R} \equiv \left[\underline{\mu}^{R}, \overline{\mu}^{R}\right]$, where the thresholds $\underline{\mu}^{R}$ and $\overline{\mu}^{R}$ are defined below. When $\mu \in M^{R}$, the strategies* (R-I) *and* (R-II) *constitute an MPE.*

- *Given $\mu \in M^{R}$, the thresholds above/below which one player attacks the other when $D_t = 1$ are given as the solution to the following system of equations.*

$$\begin{cases} \overline{z}^{\mathtt{R}}(\mu) = & \delta \cdot \dfrac{(1-\pi) + \pi\left(\mu + \left(\displaystyle\int_0^{\underline{z}^{R}(\mu)} z\mathrm{d}F(z) + \int_{\overline{z}^{R}(\mu)}^{1} z\mathrm{d}F(z)\right)\left[\delta\dfrac{2-\pi}{1-\delta} - c\right]\right)}{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{R}(\mu), \underline{z}^{R}(\mu)\right)\right)\right)\right)\left[\delta\dfrac{2-\pi}{1-\delta} - c\right]} \\ \underline{z}^{\mathtt{R}}(\mu) = & 1-\delta \cdot \dfrac{(1-\pi) + \pi\left(1-\mu + \begin{bmatrix} 1-\Delta_F\left(\overline{z}^{R}(\mu), \underline{z}^{R}(\mu)\right) \\ -\left(\displaystyle\int_0^{\underline{z}^{R}(\mu)} z\mathrm{d}F(z) + \int_{\overline{z}^{R}(\mu)}^{1} z\mathrm{d}F(z)\right) \end{bmatrix}\left[\delta\dfrac{2-\pi}{1-\delta} - c\right]\right)}{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{R}(\mu), \underline{z}^{R}(\mu)\right)\right)\right)\right)\left[\delta\dfrac{2-\pi}{1-\delta} - c\right]}, \end{cases} \tag{1}$$

where $\Delta_F(b,a) \equiv F(b) - F(a)$ *with* $a \leq b$.

- *The maximum and minimum of* M^{R} *are, respectively, given as part of the solution to a system of three equations composed of each of the following equations and two equations in (1) with* $\mu = \overline{\mu}^{R}$ *or* $\mu = \underline{\mu}^{R}$.

$$\begin{aligned}
\overline{\mu}^{R} &= \frac{1}{2} + \delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^{R}\left(\overline{\mu}^{R}\right)} \frac{1}{2} - z\mathrm{d}F(z) + \int_{\overline{z}^{R}\left(\overline{\mu}^{R}\right)}^{1} \frac{1}{2} - z\mathrm{d}F(z)\right) \\
&\quad + c\left(\int_0^{\underline{z}^{R}\left(\overline{\mu}^{R}\right)} z\mathrm{d}F(z) + \int_{\overline{z}^{R}\left(\overline{\mu}^{R}\right)}^{1} z\mathrm{d}F(z) + \frac{1-\delta}{\delta\pi}\right) \quad \textit{and} \\
\underline{\mu}^{R} &= \frac{1}{2} + \delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^{R}\left(\underline{\mu}^{R}\right)} \frac{1}{2} - z\mathrm{d}F(z) + \int_{\overline{z}^{R}\left(\underline{\mu}^{R}\right)}^{1} \frac{1}{2} - z\mathrm{d}F(z)\right) \\
&\quad - c\left(\int_0^{\underline{z}^{R}\left(\underline{\mu}^{R}\right)} 1 - z\mathrm{d}F(z) + \int_{\overline{z}^{R}\left(\underline{\mu}^{R}\right)}^{1} 1 - z\mathrm{d}F(z) + \frac{1-\delta}{\delta\pi}\right).
\end{aligned}$$

We denote this equilibrium by (R). Note that war can erupt only in disaster periods on the equilibrium path. That is, peace sustains as long as extreme asymmetry in players' resources does not arise from a natural disaster. Conversely, war occurs when highly disproportionate exposure to an extreme weather event generates an opportunistic motive of the temporarily advantaged player. Thus, the equilibrium probability of conflict is (i) zero in a given no-disaster period and (ii) positive in a disaster period.

This result is intuitively straightforward. When μ is in the interval $M^{\mathtt{R}}$, unlike the second case presented below, the players' inherent resilience to natural disasters is relatively symmetric. This means that the military parity between the players is likely to remain even if a disaster occurs. Because, on average, the military parity is not likely to fluctuate under an extreme weather event, neither player obtains a temporary military advantage (and opportunistic motive for war) unless such a balance is disturbed by a disaster that imposes disproportionately high costs on one of them. We shall come back to this point to compare this equilibrium and the one introduced below.

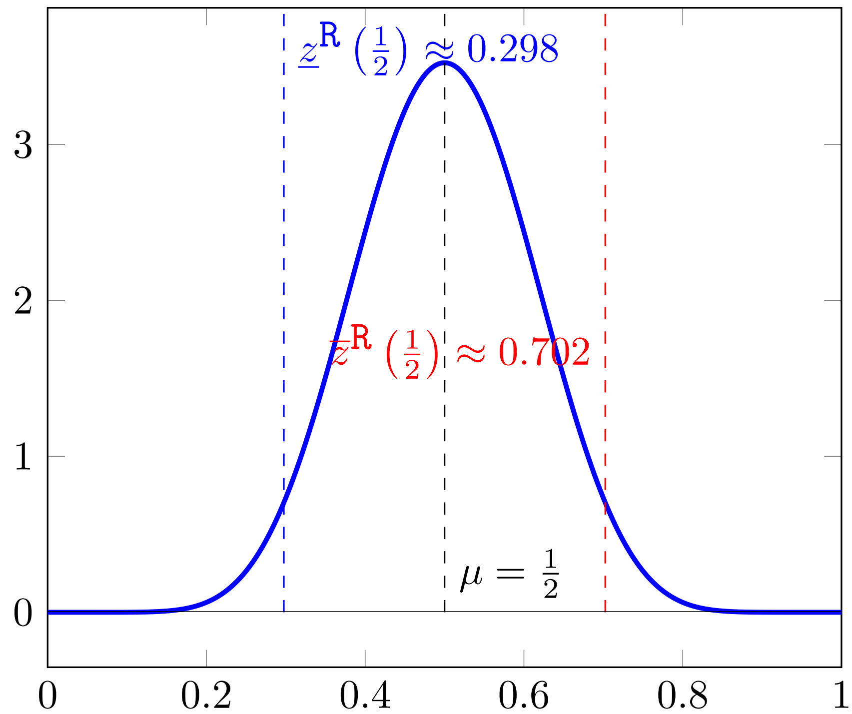

Figure 3: Thresholds in ($\mathtt{R}$) ($c = 0.55, \delta = 0.5, \pi = 0.1, Z_t \sim \text{Beta}(10, 10)$)

The key assumption sustaining the above equilibrium is that the economy of the society will recover from the negative economic shock caused by destructive disasters in the next period (Chassang and Padró i Miquel, 2009; Kikuta, 2019). If post-disaster humanitarian relief helps the players rebuild their economy and military capabilities, the one who incurred disproportionately *small* damage faces a closing window of opportunity: she has the incentive to attack the temporarily vulnerable rival before parity in players' military power is restored.[10]

Figure 3 provides an example. The horizontal axis and vertical axis represent the value of $\mathbb{E}[Z_t] = \mu$ and the density of Z_t, respectively. When $c = 0.55$, $\delta = 0.5$, $\pi = 0.1$, and $Z_t \sim \text{Beta}(10, 10)$ (i.e., $\mu = 0.5$), we have $\underline{z}^{\mathtt{R}}(\mu = 0.5) \approx 0.3$ and $\overline{z}^{\mathtt{R}}(\mu = 0.5) \approx 0.7$. Intuitively, on this equilibrium path, each player attacks the other in period t such that $D_t = 1$ if she has at least a seventy percent chance of winning. To compare the results below, note again that neither has the incentive to fight in a no-disaster period.

[10] Jun and Sethi (2021); Kikuta (2019) provide empirical support for this logic.

3.2 War Caused by *Expected* Disproportionate Damage

Next, we consider the conditions under which a war occurs due to an inherently vulnerable player's fear of future exploitation. To present equilibria that illustrate this case, consider the following stationary strategies.

(E-I): In a disaster period, i.e., t such that $D_t = 1$, either one of the players attacks the other if the realized cost of the disaster is disproportionately incurred.

- When z_t is larger than a threshold $\overline{z}^{\mathtt{E}}(\mu)$, Player 1 attacks 2.
- When z_t is smaller than a threshold $\underline{z}^{\mathtt{E}}(\mu)$, Player 2 attacks 1.

(E-II): In a no-disaster period, i.e., t such that $D_t = 0$, the more vulnerable player attacks the other.

In the strategies above, notice that war immediately ensues if there is no disaster. The following proposition provides the conditions under which (E-I) and (E-II) constitute two equilibria with a different player who attacks at a no-disaster period.

Proposition 2 (Expected asymmetric exposure)**.** *Consider the union of two half-open intervals* $M^{E} \equiv \big[0, \underline{\mu}^{E}\big) \cup (\overline{\mu}^{E}, 1]$*, where the thresholds* $\underline{\mu}^{E}$ *and* $\overline{\mu}^{E}$ *are defined below. When* $\mu \in M^{E}$*, the strategies* (E-I) *and* (E-II) *constitute an MPE.*

- *In no-disaster periods, Player 1 attacks Player 2 when* $\mu < \underline{\mu}^{E}$ *and Player 2 attacks Player when* $\mu > \overline{\mu}^{E}$*.*
- *Given* $\mu \in M^{E}$*, the thresholds* $\overline{z}^{E}(\mu)$ *and* $\underline{z}^{E}(\mu)$ *are given as the solution to the following*

system of equations.

$$\begin{cases} \overline{z}^E(\mu) = & \delta \cdot \dfrac{\left[\begin{array}{l}(1-\pi)\left[\dfrac{1-\delta\pi/2}{1-\delta}-c\right]+ \\ \pi\left(\mu+\left(\displaystyle\int_0^{\underline{z}^E(\mu)} z\mathrm{d}F(z)+\int_{\overline{z}^E(\mu)}^1 z\mathrm{d}F(z)\right)\left[\delta\dfrac{2-\pi}{1-\delta}-c\right]\right)\end{array}\right]}{\left(1-\delta\pi\Delta_F\left(\overline{z}^E(\mu),\underline{z}^E(\mu)\right)\right)\left[\delta\dfrac{2-\pi}{1-\delta}-c\right]} \\ \underline{z}^E(\mu) = & 1-\delta \cdot \dfrac{\left[\begin{array}{l}(1-\pi)\left[\dfrac{1-\delta\pi/2}{1-\delta}-c\right]+ \\ \pi\left(1-\mu+\left[\begin{array}{l}1-\Delta_F\left(\overline{z}^E(\mu),\underline{z}^E(\mu)\right) \\ -\left(\displaystyle\int_0^{\underline{z}^E(\mu)} z\mathrm{d}F(z)+\int_{\overline{z}^E(\mu)}^1 z\mathrm{d}F(z)\right)\end{array}\right]\left[\delta\dfrac{2-\pi}{1-\delta}-c\right]\right)\end{array}\right]}{\left(1-\delta\pi\Delta_F\left(\overline{z}^E(\mu),\underline{z}^E(\mu)\right)\right)\left[\delta\dfrac{2-\pi}{1-\delta}-c\right]}. \end{cases} \tag{2}$$

- *The values of* $\overline{\mu}^E$ *and* $\underline{\mu}^E$ *are, respectively, given as part of the solution to the system of three equations composed of each of the following equations and two equations in (2) with* $\mu = \overline{\mu}^E$ *or* $\mu = \underline{\mu}^E$*.*

$$\begin{aligned} \overline{\mu}^E &= \frac{1}{2}+\delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^E(\overline{\mu}^E)}\frac{1}{2}-z\mathrm{d}F(z)+\int_{\overline{z}^E(\overline{\mu}^E)}^1\frac{1}{2}-z\mathrm{d}F(z)\right) \\ &\quad +c\left(\int_0^{\underline{z}^E(\overline{\mu}^E)} z\mathrm{d}F(z)+\int_{\overline{z}^E(\overline{\mu}^E)}^1 z\mathrm{d}F(z)+\frac{1-\delta}{\delta\pi}\right) \\ \underline{\mu}^E &= \frac{1}{2}+\delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^E(\underline{\mu}^E)}\frac{1}{2}-z\mathrm{d}F(z)+\int_{\overline{z}^E(\underline{\mu}^E)}^1\frac{1}{2}-z\mathrm{d}F(z)\right) \\ &\quad -c\left(\int_0^{\underline{z}^E(\underline{\mu}^E)} 1-z\mathrm{d}F(z)+\int_{\overline{z}^E(\underline{\mu}^E)}^1 1-z\mathrm{d}F(z)+\frac{1-\delta}{\delta\pi}\right). \end{aligned}$$

Denote these equilibria by ($\mathtt{E}_1$) when $\mu < \underline{\mu}^{\mathtt{E}}$ and ($\mathtt{E}_2$) when $\mu > \overline{\mu}^{\mathtt{E}}$, respectively. In contrast to the first case ($\mathtt{R}$), these ($\mathtt{E}_1$) and ($\mathtt{E}_2$) depict how *expected* (or *inherent*) asymmetry in disaster costs leads to war. To see this, suppose μ is geographically vulnerable to disaster risks, i.e., case ($\mathtt{E}_1$), so that Player 1 attacks 2 when $D_t = 0$ for sure. Her incentive to fight arises in two steps. First, as in case ($\mathtt{R}$) above, observe that the opportunistic motive for aggression is also at work here. Because we have assumed that μ is small (by case ($\mathtt{E}_1$)), it is likely that Player 2 becomes temporarily advantaged if there is a disaster.

Second, anticipating this, Player 1 faces a fear of future aggression and exploitation by the opponent (Bas and McLean, 2021). That is, Player 1 knows that Player 2 will face the temptation to fight in a disaster period if the realized z_t is very small. If Player 1 were to acquiesce to this possibility, she would not win the war because her probability of victory, $p_i^{\mathtt{d}}(z_t) = z_t$, is also very small. As a result, the inherent vulnerability of Player 1 generates a preemptive motive: she has the incentive to attack Player 2 in order to fight under a relatively favorable balance of power.

Figure 4 shows an example when $c = 0.55$, $\delta = 0.5$, $\pi = 0.1$, and $Z_t \sim \text{Beta}(10/9, 10)$ (i.e., $\mu = 0.1$). Observe that the values of the parameters are identical to those in Figure 3 except for the first parameter of the Beta distribution. Compared to the symmetric case ($\mathtt{R}$), the region of μ under which war occurs in a disaster period is larger, i.e., $[0, 0.455) \cup (0.475, 1]$. The strategic logic is as follows. First, the inherently vulnerable Player 1 expects that she will likely be disadvantaged and that Player 2 will have an opportunistic motive for conflict once a disaster erupts. Thus, incorporating this risk, Player 1 is willing to fight even when she does not have a military advantage in a disaster period.[11] Second, Player 2 anticipates Player 1's preemptive motive. Therefore, although Player 2 should be militarily advantaged in a disaster period on average (i.e., $\mu = 0.1$), she is also willing to fight even when her actual advantage is not very large.[12]

3.3 Summary and Comparison

The result below shows that ($\mathtt{R}$), ($\mathtt{E}_1$), and ($\mathtt{E}_2$) exhaust all possible equilibria for any value of μ. Because we consider multiple CDFs of Z_t with different means, denote a CDF whose

[11] Notice $p_1^{\mathtt{d}}\left(\bar{z}^{\mathtt{E}}(\mu = 0.1)\right) \approx 0.475 < p_1^{\neg d} = 0.5$. In other words, Player 1 can launch opportunistic aggression when she is slightly *disadvantaged* militarily.

[12] Compare $p_2^{\mathtt{d}}(\mu = 0.1) = 0.9$ and $p_2^{\mathtt{d}}(\underline{z}^{\mathtt{E}}(\mu = 0.1)) = 0.545$.

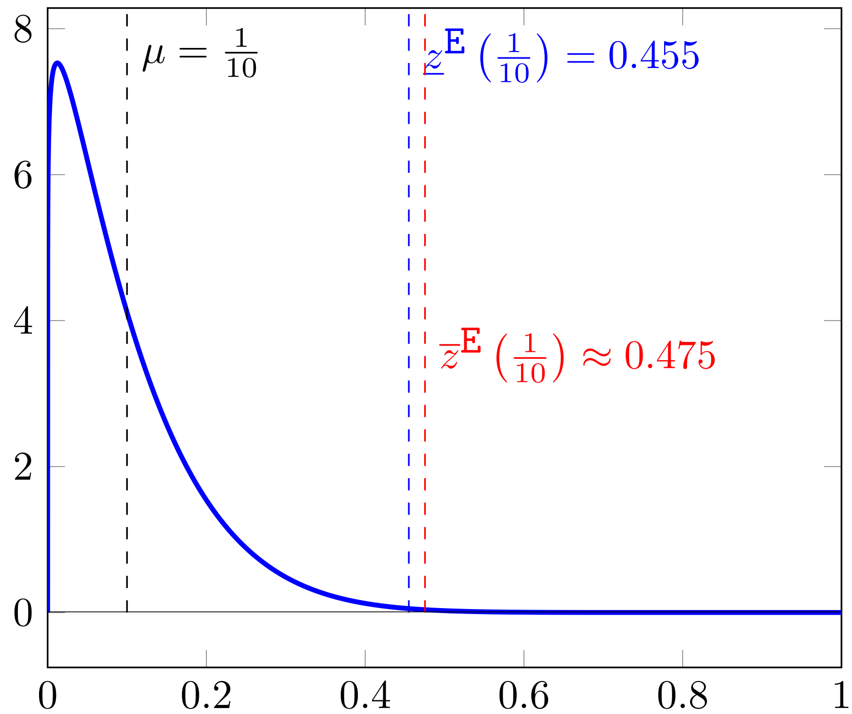

Figure 4: Thresholds in ($\mathtt{E}_1$) ($c = 0.55, \delta = 0.5, \pi = 0.1, Z_t \sim \text{Beta}(10/9, 10)$)

mean is μ by F_μ.

Proposition 3. *Fix all parameters other than μ, and suppose $\overline{\mu}^R$ and $\underline{\mu}^R$ satisfy*

$$c < \min\left\{\begin{array}{c}\dfrac{\frac{1}{2} - \delta\frac{2-\pi}{1-\delta}\left(\displaystyle\int_0^{\underline{z}^R\left(\overline{\mu}^R\right)} \frac{1}{2} - z\mathrm{d}F_{\overline{\mu}^R}(z) + \int_{\overline{z}^R\left(\overline{\mu}^R\right)}^1 \frac{1}{2} - z\mathrm{d}F_{\overline{\mu}^R}(z)\right)}{\displaystyle\int_0^{\underline{z}^R\left(\overline{\mu}^R\right)} z\mathrm{d}F_{\overline{\mu}^R}(z) + \int_{\overline{z}^R\left(\overline{\mu}^R\right)}^1 z\mathrm{d}F_{\overline{\mu}^R}(z) + \frac{1-\delta}{\delta\pi}}, \\ \dfrac{\frac{1}{2} + \delta\frac{2-\pi}{1-\delta}\left(\displaystyle\int_0^{\underline{z}^R\left(\underline{\mu}^R\right)} \frac{1}{2} - z\mathrm{d}F_{\underline{\mu}^R}(z) + \int_{\overline{z}^R\left(\underline{\mu}^R\right)}^1 \frac{1}{2} - z\mathrm{d}F_{\underline{\mu}^R}(z)\right)}{\displaystyle\int_0^{\underline{z}^R\left(\underline{\mu}^R\right)} z\mathrm{d}F_{\underline{\mu}^R}(z) + \int_{\overline{z}^R\left(\underline{\mu}^R\right)}^1 z\mathrm{d}F_{\underline{\mu}^R}(z) + \frac{1-\delta}{\delta\pi}}\end{array}\right\}.$$

Then, there exists a unique partition $\left\{0, \underline{\mu}^R, \underline{\mu}^E, \overline{\mu}^E, \overline{\mu}^R, 1\right\}$ such that

- *when $\mu < \underline{\mu}^R$, the unique equilibrium is ($\mathtt{E}_1$),*

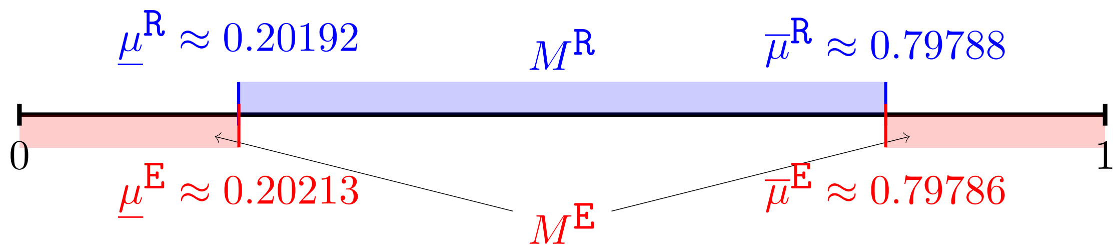

Figure 5: Intervals of μ and equilibrium ($c = 0.08$, $\delta = 0.5$, $\pi = 0.1$, $Z_t \sim \text{Beta}(\alpha, 10)$)

- *when* $\mu \in \left[\underline{\mu}^{R}, \underline{\mu}^{E}\right)$, *(R) and ($E_1$) constitute equilibria,*

- *when* $\mu \in \left[\underline{\mu}^{E}, \overline{\mu}^{E}\right]$, *the unique equilibrium is (R),*

- *when* $\mu \in (\overline{\mu}^{E}, \overline{\mu}^{R}]$, *(R) and ($E_2$) constitute equilibria, and*

- *when* $\mu > \overline{\mu}^{R}$, *the unique equilibrium is (E_2),*

Figure 5 illustrates the result. Parameters are fixed as $c = 0.08$, $\delta = 0.5$, and $\pi = 0.1$. Z_t follows $\text{Beta}(\alpha, 10)$, and μ takes different values as α varies. In this example, a unique equilibrium exists when μ has a middling value (case ($\mathtt{R}$)) and small or large (cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$)). There are also small regions of equilibrium multiplicity. Approximately speaking, when $\mu \in [0.20192, 0.20213)$, both cases ($\mathtt{R}$) and ($\mathtt{E}_1$) constitute equilibria. Similarly, when $\mu \in (0.79786, 0.79788]$, cases ($\mathtt{R}$) and ($\mathtt{E}_2$) are supported as MPE.

We now compare the equilibrium outcomes of the two types of equilibria: ($\mathtt{R}$) on the one hand and ($\mathtt{E}_1$) and ($\mathtt{E}_2$) on the other. First, observe that conflict occurs in both disaster and no-disaster periods in cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$). In a disaster period, because a mechanism similar to one in case ($\mathtt{R}$) (i.e., opportunistic motive) is at work, conflict erupts with a positive probability. In a no-disaster period, recall that war never occurs in case ($\mathtt{R}$). On the other hand, however, because the vulnerable player expects to be disadvantaged in the future in cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$), she preemptively attacks the other with probability one in a no-disaster period. Thus, in the cases of asymmetric inherent disaster risks, i.e., ($\mathtt{E}_1$) and ($\mathtt{E}_2$), war is strictly more likely in the absence of a disaster, whereas it can erupt in both types of periods.

For later use in the following sections, I formally summarize this comparison. Define $Y_t^{\mathtt{game}} = \mathbb{1}\{\text{Conflict occurs at time } t \text{ on the equilibrium path}\}$ and interpret it as a random variable generated by an equilibrium of the model. Further, denote $\mu = \mu^{\mathtt{R}}$ when $\mu \in M^{\mathtt{R}}$ and $\mu = \mu^{\mathtt{E}}$ when $\mu \in M^{\mathtt{E}}$.[13] Then, we obtain the straightforward result below.

Corollary 1. *For any t in each equilibrium, we have*

(i) $\Pr\left(Y_t^{\mathit{game}} = 1 | D_t = 1, \mu^{R}\right) > \Pr\left(Y_t^{\mathit{game}} = 1 | D_t = 0, \mu^{R}\right) = 0$, *and*

(ii) $\Pr\left(Y_t^{\mathit{game}} = 1 | D_t = 1, \mu^{E}\right) < \Pr\left(Y_t^{\mathit{game}} = 1 | D_t = 0, \mu^{E}\right) = 1.$

We shall discuss the implications of this theoretical result in the following sections. Specifically, in the next section, I derive a novel prediction from it and present suggestive evidence to connect data and the theory. Then, given the corollary, I propose theoretical implications for empirical research to make sense of the seemingly mixed results in the literature.

4 Empirical Implications of the Theoretical Model: The Case of Droughts

Here, I present an empirical exercise to draw empirical implications from the asymmetric-exposure model. We focus on a specific type of climate anomaly: drought. We focus on droughts because (i) social scientists have yet to reach a consensus on their effects on conflict and (ii) we will also examine the case of drought (from a different perspective) in the next section.. To begin with, I briefly discuss the datasets and connect them to the model. Next, I draw an empirical implication from Corollary 1 and offer suggestive evidence based on the data.

[13] For simplicity, assume equilibrium $(\mathtt{E}_1)$ or $(\mathtt{E}_2)$ will be played when $\mu \in M^{\mathtt{R}} \cap M^{\mathtt{E}}$.

4.1 Data and Empirical Analogues to the Model Features

Before introducing data, observe that the key parameter in the model μ is a dyadic feature. To see this, recall the hypothetical examples in the introduction. Let Group 1 be the same in Cases 1 and 2. Although Groups 1, 2, and 2' are in the same region (the same country in the context of intrastate conflict), the level of asymmetry in disaster risks between Groups 1 and 2 is different from that between Groups 1 and 2'. This implies that highly aggregated data may not be able to capture the dyadic characteristics of the model.

To incorporate the dyadic nature, we use two sources of geo-referenced data: Armed Conflict Location and Event Data (ACLED, Raleigh et al., 2023) and the Palmer Drought Severity Index (PDSI, Dai et al., 2004). The ACLED provides event-level data on political unrest that occurred in or after 1997. Because we are interested in armed conflict (as opposed to, say, nonviolent demonstrations), we also restrict our attention to observations in the ACLED whose `event_type` variable is coded as "`Battles`". It also specifies the identity of the involved parties in a given conflict event and classifies the type of the group (e.g., state forces; a rebel group). The PDSI dataset assigns the level of water scarcity/abundance to each $2.5° \times 2.5°$ grid cell. A PDSI score takes a value in $[-10, 10]$, where a higher (lower) value indicates water abundance (scarcity). The monthly dataset covers from 1850 to 2018. I attach the corresponding PDSI score to each ACLED event.

We focus on conflict events in African countries for two reasons. First, Africa is a favorable case in Salehyan and Hendrix (2014) (in the sense that their subsample of African countries supports their argument strongly) that we critically discuss in the next section. Thus, although the goal of the empirical exercise below is not to falsify their findings, if it still supports the asymmetric-exposure theory in their "favorite" case, then it would suggest that the findings of Salehyan and Hendrix (2014) are a special case of the theory. Second, focusing on Africa mitigates the risk of biased inferences. Rosvold and Buhaug (2021) point out the possibility that cross-continent comparisons of geo-coded data might lead to biases because of different qualities in reporting by region. Because richer regions tend to have greater capabilities of reporting disaster and conflict events, focusing on a specific (though still diverse) region mitigates the risk of bias. Consequently, our empirical exercise covers conflict events and the levels of water abundance in Africa from 1997 to 2018.

Using the above data, we now define empirical analogues to variables/parameters in the game-theoretic model. Because we are interested in the implications of Corollary 1, we want to relate $Y_t^{\texttt{game}}$, D_t, and μ to data. First, define $Y_{dt}^{\texttt{data}} \in \{0, 1\}$ as a variable that takes the value of one when dyad d of two belligerent groups had a conflict event at time t and zero otherwise. It is important to note that, whereas the ACLED dataset provides geo-referenced and detailed information about political violence and the parties involved, the unit of observation in the dataset is a conflict event rather than, say, country-year. This implies that the ACLED data essentially presents the cases of $Y_{dt}^{\texttt{data}} = 1$. In other words, we are unable to directly compare the observations that take $Y_{dt}^{\texttt{data}} = 1$ and those with $Y_{dt}^{\texttt{data}} = 0$. Although this nature might lead to an issue of selection when we analyze the dataset, I draw a theoretical prediction to avoid this issue below.

Second, we interpret a smaller value of PDSI as the presence of drought. Specifically, we define the PDSI score in the previous month as the severity of drought at the time of conflict in dyad d at time t.[14] Denote it by $\texttt{PDSI}_{d,t-1}$. Note that this is a continuous variable, unlike D_t which represents the presence/absence of a disaster in the model. Namely, a higher value of $\texttt{PDSI}_{d,t-1}$ is an empirical analogue to $D_t = 0$ because it implies water abundance, whereas a smaller $\texttt{PDSI}_{d,t-1}$ is analogous to $D_t = 1$ (i.e., presence of drought) because it stands for water scarcity.

Third, we are interested in the level of asymmetry in disaster risks of dyad d. Although this is the key parameter in the theory (μ in the model), it is at least challenging to measure the relative risks of disaster exposure for every dyad of all politically relevant groups in

[14] The one-month lag guarantees that the climate condition in a certain region proceeds the occurrence of conflict in the location.

African countries and assign it to each dyad. I assume the following statement to derive an informative analogue to μ from the ACLED dataset.

Assumption 2. An intrastate conflict involving the government as one of the belligerents tends to be between groups with asymmetric disaster risks than a conflict involving only non-state actors.

In other words, given that two groups are engaged in a conflict, we interpret that they face a symmetric risk of exposure to disasters if the types of the involved parties are similar. Conversely, they tend to have asymmetric disaster risks when one side of the parties is part of the government forces and the other is not. Though an imperfect measure, it is natural to assume that, on average, government forces tend to be more resilient to disasters than rebel groups are.[15]

Under this assumption, we reinterpret μ (given parameter in the model) as a random variable. For later use, let $\mu^{\texttt{RV}} \in [0, 1]$ a random variable that represents the level of asymmetry in disaster risks for two relevant groups.[16] As an empirical analogue of $\mu^{\texttt{RV}}$ in the ACLED dataset, define a binary variable $\texttt{gov}_{dt} \in \{0, 1\}$ that indicates if (i) an incident involved the government forces or (ii) both sides were non-state actors:

$$\texttt{gov}_{dt} \equiv \mathbb{1} \left\{ \begin{array}{l} \text{One of the belligerents in an incident} \\ \text{in dyad } d \text{ at time } t \text{ is state forces} \end{array} \right\}.$$

Given the definition of $\texttt{gov}_{dt}$ and Assumption 2, we say dyad d that had a conflict event at

[15] One possible problem is selection effect: rebel groups that have enough material capabilities to fight government forces may also be resilient. However, relatively weak rebel groups can still continue armed struggles with the (more powerful) government in some environments. For example, conflicts in locations distant from the capital tend to last longer because government control in those regions tends to be weaker (Buhaug et al., 2009). Moreover, even weaker groups may be able to endogenously render their armed struggle last longer by adopting guerrilla tactics (Qiu, 2022).

[16] Recall that μ is an exogenous parameter in the game. However, it is also natural to think of the asymmetry in inherent disaster risks between two rival political groups as randomly distributed among dyads. Here, we take this interpretation to show the connection between the theory and data.

	Model	Empirical analogue	Note
Conflict	$Y_t^{\texttt{game}}$	$Y_{dt}^{\texttt{data}} \in \{0,1\}$	$Y_{dt}^{\texttt{data}} = 1$ for all dt in ACLED
Disaster	D_t	$\texttt{PDSI}_{d,t-1} \in [-10, 10]$	Smaller $\texttt{PDSI}_{d,t-1}$ stands for $D_t = 1$ (drought)
Asymmetry	μ	$\texttt{gov}_{dt} \in \{0,1\}$	μ reinterpreted as a random variable, $\mu^{\texttt{RV}}$

Table 1: Empirical analogues to the model features

time t faces asymmetric disaster risks when $\texttt{gov}_{dt} = 1$ and symmetric risks when $\texttt{gov}_{dt} = 0$.[17] Table 1 summarizes the empirical analogues to the model features.

4.2 Prediction and Results

Given the empirical analogues defined above, we now connect the theory and data. Despite some limitations, such as $Y_{dt}^{\texttt{data}}$ being one for all dt and $\texttt{gov}_{dt}$ being a coarse measure of μ, we are still able to draw an empirical implication from the model and assess it with the data. To this end, recall that we have reinterpreted μ (which was an exogenously given parameter in the game-theoretic model) as a random variable. Let $\Pr(\mu^{\texttt{RV}} \in M^{\texttt{E}}) \in (0,1)$, and suppose that $\mu^{\texttt{RV}}$ and D_t are independent. Then, a direct application of Bayes' rule to Corollary 1-(ii) yields the following result.

Corollary 2. $\Pr(\mu^{RV} \in M^E | Y_t^{game} = 1, D_t = 0) > \Pr(\mu^{RV} \in M^E | Y_t^{game} = 1, D_t = 1)$.

This result is intuitively straightforward. In the game, recall that conflict erupts on the equilibrium path when $D_t = 0$ only in the asymmetric cases. Thus, given that a conflict took place at t such that $D_t = 0$ in the model, it must be that the players are playing an asymmetric equilibrium. As a result, the left-hand side of the above inequality is one. One can see that the inequality holds because the right-hand side is strictly smaller than one: conflict can ensue in both symmetric and asymmetric equilibria, thus $\mu^{\texttt{RV}}$ may or may not be in $M^{\texttt{E}}$ in this case.

[17] To distinguish conflicts in symmetric and asymmetric dyads as clearly as possible, I exclude events between (i) two state forces (e.g., different fractions in military forces in the same country) and (ii) state forces and an external group (e.g., international conflict).

We now translate this theoretical implication into empirical terms. That is, replacing $Y_t^{\texttt{game}}$, D_t, and $\mu^{\texttt{RV}}$ with $Y_{dt}^{\texttt{data}}$, $\texttt{PDSI}_{d,t-1}$, and $\texttt{gov}_{dt}$, respectively, yields a novel prediction below:

Implication 1. Corollary 2 implies

$$\Pr\left(\underbrace{\texttt{gov}_{dt}=1}_{\text{Stands for } \mu^{\texttt{RV}} \in M^{\texttt{E}}} \middle| \overbrace{Y_{dt}^{\texttt{data}}=1,}^{\text{Fixed}=1 \text{ in data}} \ \underbrace{\text{High } \texttt{PDSI}_{d,t-1}}_{\text{Stands for } D_t=0}\right) > \Pr\left(\texttt{gov}_{dt}=1 \middle| Y_{dt}^{\texttt{data}}=1, \underbrace{\text{Low } \texttt{PDSI}_{d,t-1}}_{\text{Stands for } D_t=1}\right).$$

Note that this empirical analogue to the theoretical prediction (Corollary 2) is *not* a causal statement. Rather, by reinterpreting μ in the model as a random variable, it speaks to the probability distribution of the level of asymmetry in disaster risks between belligerent groups ($\texttt{gov}_{dt}$) given that they are engaged in political violence.

Given Implication 1, we are interested in $\Pr\left(\texttt{gov}_{dt}=1 | Y_{dt}^{\texttt{data}}=1, \texttt{PDSI}_{d,t-1}\right)$ for each $\texttt{PDSI}_{d,t-1} \in [-10, 10]$. To assess it, consider the simple logistic regression below:

$$\begin{aligned}\Pr\left(\texttt{gov}_{dt}=1 \middle| Y_{dt}^{\texttt{data}}=1, \texttt{PDSI}_{d,t-1}\right) &= \frac{1}{1+e^{-\left(\tilde{\beta}_0+\beta_1 \texttt{PDSI}_{d,t-1}+\beta_2 Y_{dt}^{\texttt{data}}\right)}} \\ &= \frac{1}{1+e^{-\left(\beta_0+\beta_1 \texttt{PDSI}_{d,t-1}\right)}}. \end{aligned} \tag{3}$$

Because we always have $Y_{dt}^{\texttt{data}}=1$ in the data, we interpret that the effect of $Y_{dt}^{\texttt{data}}$ is captured in the constant β_0 (i.e., $\beta_0 \equiv \tilde{\beta}_0 + \beta_2$). Recall that (i) $\texttt{gov}_{dt}=1$ is assumed to imply that the belligerents face asymmetric disaster risks (i.e., $\mu \in M^{\texttt{E}}$ in the model) and (ii) a higher value represents water abundance (i.e., $D_t = 0$ in the model). Thus, by Implication 1, the (estimated) probability should be an increasing function of the PDSI score ($\texttt{PDSI}_{d,t-1}$) if the above theory is consistent with the data. In sum, our estimand is the pair of the constant and coefficient (β_0, β_1) in expression (3).

Figure 6 illustrates the result. The horizontal and vertical axes represent $\texttt{PDSI}_{d,t-1}$ and

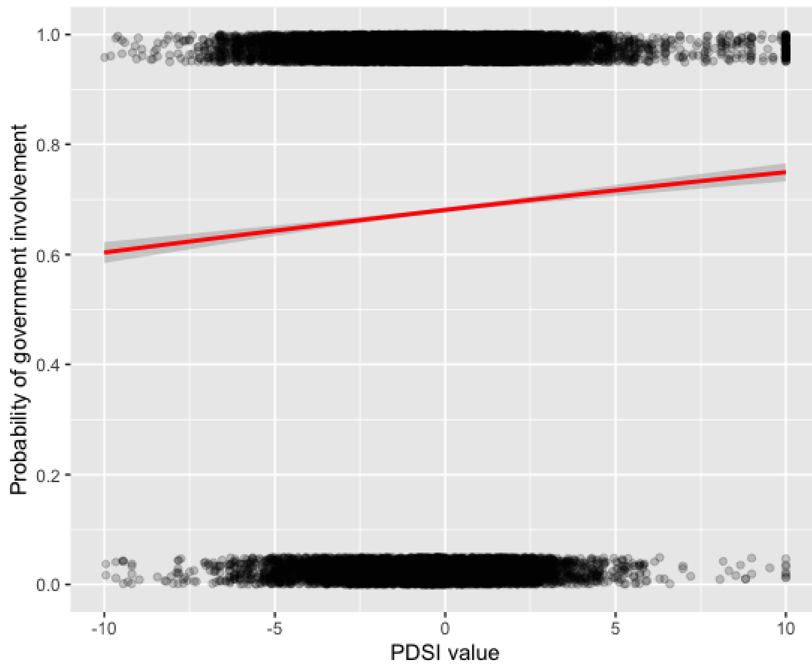

Figure 6: Asymmetry in a belligerent dyad as an increasing function of water abundance

$\texttt{gov}_{dt}$, respectively. Thus, it suggests that $\Pr\left(\texttt{gov}_{dt} = 1 | Y_{dt}^{\texttt{data}} = 1, \texttt{PDSI}_{d,t-1}\right)$ is increasing in $\texttt{PDSI}_{d,t-1}$. Table 4.2 presents a few additional results. First, the distance between the location of a given conflict event and the capital city might be driving the result. A possible logic is that (i) a capital city might tend to be located in geographically resilient regions historically (possible correlation with $\texttt{PDSI}_{d,t-1}$) and (ii) government control tends to be weaker in regions distant from the capital, leading to more conflicts between rebel groups and government forces (possible correlation with $\texttt{gov}_{dt}$). Second, the PDSI score of the month in which the conflict event took place ($\texttt{PDSI}_{dt}$) is also added to see if the score for the previous month seems an appropriate measure. The results remain similar.

While the above result is first-cut evidence, the prediction in Implication 1 drawn from the model is, to the best of my knowledge, novel. This empirical exercise attempts to connect the theory and data as directly as possible and suggests that the model is consistent with real-world data. Now we shall discuss what we can learn from it about empirical research on the climate-conflict nexus based on the theory.

	Dependent variable: $\texttt{gov}_{dt}$			
	(1)	(2)	(3)	(4)
$\texttt{PDSI}_{d,t-1}$	0.034***	0.033***		0.029***
	(0.004)	(0.004)		(0.005)
Distance to capital (standardized)		0.053***		0.053***
		(0.010)		(0.010)
$\texttt{PDSI}_{dt}$			0.025***	0.008
			(0.004)	(0.005)
Constant	0.758***	0.759***	0.754***	0.760***
	(0.011)	(0.011)	(0.010)	(0.011)
Observations	43,194	43,194	43,194	43,194

Note: $^{\dagger}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Table 2: Drought and government involvement in conflict events

5 Theoretical Implications for Empirical Research: The Case of the Potential Outcome Framework

The theoretical discussion leads to important implications for the empirical literature on climate shocks and armed conflict. The model (Corollary 1) implies that disasters have heterogeneous treatment effects on the risk of armed conflict. That is, in the asymmetric case, conflict events should be positively associated with disaster *risks*, rather than actual disaster *events*. In addition to the suggestive evidence presented above, a recent paper by Bas and McLean (2021) also supports this implication empirically. To take their findings one step further, this section provides a possible explanation for why the empirical results of climate conflict research are mixed. First, I show that overlooking the asymmetric case of the model (cases ($\texttt{E}_1$) and ($\texttt{E}_2$)) can lead to an *underestimation* of the effect of natural disasters on conflict risks in the potential outcome framework. Second, based on this discussion, I revisit the case of drought to make sense of the ostensibly mixed empirical results.

5.1 Heterogeneous Effects of Disaster Events

Suppose that we want to employ the potential outcomes framework to study the causal effects of natural disasters and climate anomalies on armed conflict. Let the (binary) potential outcome $Y_{dt}^{\texttt{PO}}(D_{dt}) \in \{0,1\}$ represent the presence ($Y_{dt}^{\texttt{PO}}(D_{dt}) = 1$) and absence ($Y_{dt}^{\texttt{PO}}(D_{dt}) = 0$) of armed conflict at time t in dyad of groups d given treatment D_{dt}.[18] We define the observable treatment D_{dt} in a similar way as in the game-theoretic model. That is, $D_{dt} \in \{0,1\}$ denotes the presence ($D_{dt} = 1$) and absence ($D_{dt} = 0$) of a natural disaster in dyad d in period t, which is independently and identically drawn.

Next, recall that μ is also a *dyadic* concept because it stands for the (a)symmetry in inherent disaster risks *between* two players. Thus, suppose that we have a measure on the level of such asymmetry for dyad d at time t, denoted by $\mu_{dt} \in [0,1]$.[19] Further, as in the game-theoretic model, suppose that we have two sets $M^{\texttt{R}}, M^{\texttt{E}} \subset [0,1]$ such that (i) rival political groups in dyad d face a symmetric risk of exposure to natural disasters when $\mu_{dt} \in M^{\texttt{R}}$ and (ii) they face an asymmetric risk of exposure when $\mu_{dt} \in M^{\texttt{E}}$.[20] In the potential outcomes framework, this formulation implies that $(Y_{dt}^{\texttt{PO}}(D_{dt})|\mu') \neq (Y_{dt}^{\texttt{PO}}(D_{dt})|\mu'')$, where $\mu' \in M^{\texttt{R}}, \mu'' \in M^{\texttt{E}}$. Because we focus on the role of political groups' relative vulnerabilities to natural disasters (measured by μ_{dt}), our quantity of interest here is the conditional average treatment effect (CATE), defined as $\tau(\mu) \equiv \mathbb{E}[Y_{dt}^{\texttt{PO}}(1) - Y_{dt}^{\texttt{PO}}(0)|\mu_{dt} = \mu]$.

To derive implications for empirical research, suppose that we have country-year data of conflict events in dyad d at time t. Denote the presence and absence of conflict by $Y_{dt}^{\texttt{data}} = 1$ and $Y_{dt}^{\texttt{data}} = 0$, respectively. Further, let us tentatively assume that the game-theoretic model captures the true data-generating process.

[18] One can think of d as a pair of rival political groups or sovereign states.

[19] In the discussion below, μ_{dt} does not have to be considered as a random variable, unlike the previous section.

[20] For simplicity, assume that $M^{\texttt{R}}$ and $M^{\texttt{E}}$ are mutually disjoint. The simplest example is the case where μ_{dt} is binary. For instance, in the previous section, I define $M^{\texttt{R}} = \{0\}$ and $M^{\texttt{E}} = \{1\}$, and the measure that represents μ_{dt} (i.e., $\texttt{gov}_{dt}$) only takes zero or one.

Assumption 3. We can interpret $\underbrace{Y_{dt}^{\texttt{data}}}_{\text{Data}} = \underbrace{Y_t^{\texttt{game}}}_{\text{Model}}$ and $\underbrace{D_{dt}}_{\text{Data}} = \underbrace{D_t}_{\text{Model}}$.

In other words, we interpret real-world conflict data as products of equilibrium outcomes in the game of asymmetric exposure to extreme weather events. Then, given that $(Y_{dt}^{\texttt{data}}|D_{dt}=1) = Y_{dt}^{\texttt{PO}}(1)$, we obtain the following.

Corollary 3. *Assumption 3 and Corollary 1 yield:*

(*i*) $\Pr\left(Y_{dt}^{\texttt{PO}}(1)=1|\mu_{dt}=\mu^{\texttt{R}}\right) > \Pr\left(Y_{dt}^{\texttt{PO}}(0)=1|\mu_{dt}=\mu^{\texttt{R}}\right)$ *and*

(*ii*) $\Pr\left(Y_{dt}^{\texttt{PO}}(1)=1|\mu_{dt}=\mu^{\texttt{E}}\right) < \Pr\left(Y_{dt}^{\texttt{PO}}(0)=1|\mu_{dt}=\mu^{\texttt{E}}\right)$.

In words, the result represents the two types of equilibrium outcomes: (i) when two rival political groups face a symmetric risk of exposure to disasters, war is more likely to erupt in a given period t when a disaster has occurred in the same period (i.e., $D_{dt}=1$); (ii) when they face an asymmetric risk of exposure, conflict is more likely when there is no disaster in period t (i.e., $D_{dt}=0$).

This result drawn from the game-theoretic model leads to another, more specific implication. Suppose $\mu_{dt}=\mu^{\texttt{R}}$. Rearranging Part (i) of Corollary 3 immediately yields

$$\begin{aligned}
\Pr\left(Y_{dt}^{\texttt{PO}}(1)=1\middle|\mu^{\texttt{R}}\right) - \Pr\left(Y_{dt}^{\texttt{PO}}(0)=1\middle|\mu^{\texttt{R}}\right) &= 1\cdot\Pr\left(Y_{dt}^{\texttt{PO}}(1)=1\middle|\mu^{\texttt{R}}\right) + 0\cdot\Pr\left(Y_{dt}^{\texttt{PO}}(1)=0\middle|\mu^{\texttt{R}}\right) \\
&\quad -1\cdot\Pr\left(Y_{dt}^{\texttt{PO}}(0)=1\middle|\mu^{\texttt{R}}\right) + 0\cdot\Pr\left(Y_{dt}^{\texttt{PO}}(0)=0\middle|\mu^{\texttt{R}}\right) \\
&= \mathbb{E}\left[Y_{dt}^{\texttt{PO}}(1)\middle|\mu^{\texttt{R}}\right] - \mathbb{E}\left[Y_{dt}^{\texttt{PO}}(0)\middle|\mu^{\texttt{R}}\right] \\
&= \tau\left(\mu^{\texttt{R}}\right) > 0.
\end{aligned}$$

Similarly, from Part (ii) of Corollary 3, we obtain $\Pr\left(Y_{dt}^{\texttt{PO}}(1)=1|\mu^{\texttt{E}}\right) - \Pr\left(Y_{dt}^{\texttt{PO}}(0)=1|\mu^{\texttt{E}}\right) = \tau\left(\mu^{\texttt{E}}\right) < 0$. Implication 2 below summarizes the results.

Implication 2. Corollary 3 implies $\tau\left(\mu^{\texttt{R}}\right) > 0 > \tau\left(\mu^{\texttt{E}}\right)$.

It is important to note that, even if researchers rely on CATE rather than ATE, the potential outcome approach itself could be problematic in this case. To see this, suppose that belligerent groups in dyad d face an asymmetric risk of exposure to disasters (i.e., $\mu_{dt} = \mu^{\mathtt{E}}$). Then, Implication 2 states that the effect of a disaster on conflict onset in the sense of CATE is negative, $\tau(\mu^{\mathtt{E}}) < 0$, under Corollary 3.

However, although the CATE is negative, asymmetric exposure to disaster risks *causes* a war in the game-theoretic model: Remarks 1 and 2 show that the possibility of disasters and variation in Z_t are necessary conditions for a conflict to erupt on the equilibrium path. Therefore, if asymmetric exposure to disasters and climate anomalies generates an *anticipation* of temporary military power shifts in the real world (as empirically tested by Bas and McLean, 2021), overlooking the strategic dynamic of the second equilibrium leads to underestimation of their *true* causal effect on the propensity of war.

Put differently, Implication 2 suggests that some frameworks for causal inference may sometimes not be suitable for particular phenomena. Suppose that researchers have fine data on conflicts that erupted right after a natural disaster. Despite abundant data, the model and Implication 2 show that there can exist conflict episodes that are classified as ones that erupted because of factors other than disasters but were actually triggered by asymmetric exposure to disaster *risks*. If such a case exists, the causal effect of disasters on conflicts in terms of CATE should not be appropriate.

5.2 Making Sense of Seemingly Mixed Evidence

Given the above discussion on CATE, let us move on to average treatment effect (ATE), defined as $\tau \equiv \mathbb{E}[Y_{dt}^{\mathtt{PO}}(1) - Y_{dt}^{\mathtt{PO}}(0)]$, which is the most common quantity of interest in the empirical literature. Below, I show that we are more likely to obtain a negative estimate for the ATE of natural disasters on conflict when the number of observations involving asymmetric dyads of belligerent groups in the sample is sufficiently large.

To this end, we interpret the parameter μ as a random variable, and denote it by $\mu^{\mathtt{RV}}$. Moreover, as in Proposition 3, suppose there are five regions over $[0,1]$ that determine which strategy profiles constitute equilibria. Then, denote $q^{\mathtt{R}} \equiv \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{R}} \backslash M^{\mathtt{E}}\right)$ and $q^{\mathtt{E}} \equiv \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}} \backslash M^{\mathtt{R}}\right)$ so that $\Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}\right) = 1 - q^{\mathtt{R}} - q^{\mathtt{E}}$. Recall that there are multiple equilibria when $\mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}$. Denote the strategy profile realized as an equilibrium by $(\mathtt{eq})$, and let $\tilde{q} \equiv \Pr\left((\mathtt{eq}) = (\mathtt{R}) | \mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}\right)$ so that $\Pr\left((\mathtt{eq}) = (\mathtt{E}) | \mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}\right) = 1 - \tilde{q}$. Then, by the law of iterated expectations, the ATE is given by

$$\begin{aligned}
\tau &= \mathbb{E}_{\mu^{\mathtt{RV}}}\left[\underbrace{\mathbb{E}\left[Y_{dt}^{\mathtt{PO}}(1) - Y_{dt}^{\mathtt{PO}}(0) \middle| \mu^{\mathtt{RV}}\right]}_{=\tau(\mu^{\mathtt{RV}})}\right] \\
&= \tau\left(\mu^{\mathtt{R}}\right)\left[q^{\mathtt{R}} + \underbrace{\left(1 - q^{\mathtt{R}} - q^{\mathtt{E}}\right)\tilde{q}}_{\Pr(\mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}, (\mathtt{eq}) = (\mathtt{R}))}\right] + \tau\left(\mu^{\mathtt{E}}\right)\left[q^{\mathtt{E}} + \underbrace{\left(1 - q^{\mathtt{R}} - q^{\mathtt{E}}\right)(1 - \tilde{q})}_{\Pr(\mu^{\mathtt{RV}} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}, (\mathtt{eq}) = (\mathtt{E}))}\right].
\end{aligned}$$

This leads to the following theoretical result.

Corollary 4. *If* $-\dfrac{\tau\left(\mu^{R}\right)}{\tau\left(\mu^{E}\right)} < \dfrac{q^{E}}{1 - q^{E}}$, *then* $\tau < 0$.

This result is intuitive. It states that, assuming that μ is now random, the ATE of natural disasters on conflict in the model becomes negative if the asymmetric case is more likely to arise as an equilibrium. This is because $\tau\left(\mu^{\mathtt{E}}\right)$ is negative and a higher $q^{\mathtt{E}}$ allocates a larger weight on the negative CATE.

We now draw an implication for empirical research from this result. Suppose there are observations over m dyads and T periods in a given sample. Denote the number of all observations by $n = mT$. As above, assume that (i) we have a measure of the relative vulnerabilities of groups in dyad d at time t, denoted by μ_{dt}, and (ii) we obtain either $\mu_{dt} \in M^{\mathtt{R}}$ or $\mu_{dt} \in M^{\mathtt{E}}$. Here, suppose $\mu_{dt} \in M^{\mathtt{R}}$ when $\mu_{dt} \in M^{\mathtt{R}} \cap M^{\mathtt{E}}$, which generates a more conservative result. Then, let $n^{\mathtt{R}} \equiv \sum_{d=1}^{m} \sum_{t=1}^{T} \mathbb{1}\left\{\mu_{dt} \in M^{\mathtt{R}}\right\}$ be the number of observations of the symmetric case. Similarly, define $n^{\mathtt{E}} \equiv \sum_{d=1}^{m} \sum_{t=1}^{T} \mathbb{1}\left\{\mu_{dt} \in M^{\mathtt{E}}\right\}$ for the asymmetric case so that $n^{\mathtt{R}} + n^{\mathtt{E}} = n$. Finally, let $\hat{\tau}_n(\mu)$ be an unbiased estimator for the CATE when the sample size is n.[21]

Now we are ready to define the sample analogue of Corollary 4. Suppose we have obtained a positive $\hat{\tau}_n(\mu^{\mathtt{R}})$ and a negative $\hat{\tau}_n(\mu^{\mathtt{E}})$. Then, an estimate for the ATE becomes negative when

$$\frac{\hat{\tau}_n(\mu^{\mathtt{R}})}{-\hat{\tau}_n(\mu^{\mathtt{E}})} < \frac{n^{\mathtt{E}}}{n^{\mathtt{R}}}.$$

To see this, take the expectation of both sides of the inequality:

$$\begin{aligned} \mathbb{E}\left[\frac{\hat{\tau}_n(\mu^{\mathtt{R}})}{-\hat{\tau}_n(\mu^{\mathtt{E}})}\right] &= -\frac{\tau(\mu^{\mathtt{R}})}{\tau(\mu^{\mathtt{E}})} \\ < \quad \mathbb{E}\left[\frac{n^{\mathtt{E}}}{n^{\mathtt{R}}}\right] &= \mathbb{E}\left[\frac{\sum_{d=1}^{m}\sum_{t=1}^{T}\mathbb{1}\{\mu_{dt} \in M^{\mathtt{E}}\}}{n - \sum_{d=1}^{m}\sum_{t=1}^{T}\mathbb{1}\{\mu_{dt} \in M^{\mathtt{E}}\}}\right] = \frac{mTq^{\mathtt{E}}}{n - mTq^{\mathtt{E}}} = \frac{q^{\mathtt{E}}}{1 - q^{\mathtt{E}}}. \end{aligned}$$

Recall that $n^{\mathtt{E}}$ is the number of observations such that $\mu_{dt} \in M^{\mathtt{E}}$. Thus, we can summarize the above result as follows.

Implication 3. *If the number of observations involving dyads with asymmetric vulnerabilities is sufficiently large in the sample, then the estimate for the ATE of natural disasters on conflict is more likely to be small.*

Recall that, if natural disasters generate a random and large negative shock to political groups' military capabilities, they can trigger conflict in *both* symmetric and asymmetric dyads due to either the opportunistic or preemptive motive. However, if an empirical study contains disproportionately more dyads of groups with asymmetric vulnerabilities to disasters than symmetric ones in its sample, then such a study is more likely to underestimate the

[21] For example, the difference-in-means estimator for the symmetric case is

$$\hat{\tau}_n(\mu^{\mathtt{R}}) = \frac{\sum_{d=1}^{m}\sum_{t=1}^{T} D_{dt}\mathbb{1}\{\mu_{dt} \in M^{\mathtt{R}}\} Y_{dt}^{\mathtt{data}}}{\sum_{d=1}^{m}\sum_{t=1}^{T} D_{dt}\mathbb{1}\{\mu_{dt} \in M^{\mathtt{R}}\}} - \frac{\sum_{d=1}^{m}\sum_{t=1}^{T}(1 - D_{dt})\mathbb{1}\{\mu_{dt} \in M^{\mathtt{R}}\} Y_{dt}^{\mathtt{data}}}{\sum_{d=1}^{m}\sum_{t=1}^{T}(1 - D_{dt})\mathbb{1}\{\mu_{dt} \in M^{\mathtt{R}}\}}.$$

conflict-triggering effect of natural disasters.

5.3 Reconsidering the Possible Pacifying Effect of Disasters

Here, I reinterpret a specific existing empirical result from a theoretical perspective. I discuss the results presented by Salehyan and Hendrix (2014), who find a pacifying effect of droughts, and point out that their findings could be due to the ostensible negative effect of droughts. To be clear, the discussion below is not aimed at falsifying Salehyan and Hendrix (2014). Rather, I demonstrate that my theory and theirs generate *observationally equivalent* predictions. That is, some empirical findings on the negative causal effects of climate disasters on conflict could be driven by a particular form of their *positive* effect, namely, the preemptive mechanism in the asymmetric cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$) of the model.

Salehyan and Hendrix (2014) argue that water scarcity can decrease armed conflict. Droughts harm agricultural production in affected areas and reduce economic resources. As a result, water scarcity impairs the mobilization capabilities of rival political groups, and thus organized armed conflict should decline under such conditions. Utilizing data on water scarcity (including the PDSI data) and armed conflict, Salehyan and Hendrix (2014) find that water abundance positively correlates with conflict.

Their interpretation of the correlation might be problematic. To see this, observe the implicit assumption in the logic of Salehyan and Hendrix (2014) that water scarcity affects groups' mobilization capabilities symmetrically. Namely, conflict becomes a less attractive option under water scarcity because, in their theory, *both* sides of a given dispute face a lower mobilization capability. However, if one drought happens to cause water scarcity in a particular region, such an (implicit) assumption does not necessarily remain plausible. Rather, if water scarcity is more severe in one region than others, then only one side of a political dispute can lose its power to mobilize. In this case, the rival group that has incurred less severe water scarcity remains its mobilization capability. As the formal model suggests, such asymmetry in power can generate an incentive for rival political groups to fight, rather than deescalate.

Given the demanding implicit assumption on the symmetry in disaster damages, the findings of Salehyan and Hendrix (2014) may be a product of preemptive motives arising from the asymmetric equilibrium ($\mathtt{E}_1$) or ($\mathtt{E}_2$). Whereas Salehyan and Hendrix (2014) argue that droughts and water scarcity decrease conflict, the equilibrium suggests that conflict is strictly more likely in periods *without* water scarcity due to preemptive motives. The empirical results should look similar: the former logic predicts that "*more* droughts in the present period make conflict *less* likely due to the mobilization-capability logic," whereas the latter states that "*fewer* droughts in the present period make conflict *more* likely due to the preemptive motive." However, recall that what triggers conflict in the latter logic is the asymmetric exposure to disaster risks. Hence, opposing two reasonings, i.e., pacifying effects of extreme weather events on the one hand and destabilizing effects of their risks on the other, lead to the same empirical pattern.

Implication 4. Despite their opposing (destabilizing versus pacifying) conclusions, the preemptive-attack logic and the mobilization-capability logic generate observationally equivalent predictions.

Figure 7 illustrates the intuition. Consider the horizontal and vertical axes as time and the risk of conflict, respectively. The green line represents the risk of conflict as a function of time and other variables than water scarcity. Then, let the shaded areas on the horizontal axis denote the periods during which the region experienced droughts. In this simplified setting, the mobilization-capability logic by Salehyan and Hendrix (2014) predicts that the value of the function should be smaller under water scarcity (blue line in Figure 7). On the other hand, the preemptive-war logic in the second equilibrium of the above model suggests that the value should be greater under relative water abundance (red line). Based on the former logic, the graph of the function consists of the blue segments (in the shaded periods) and

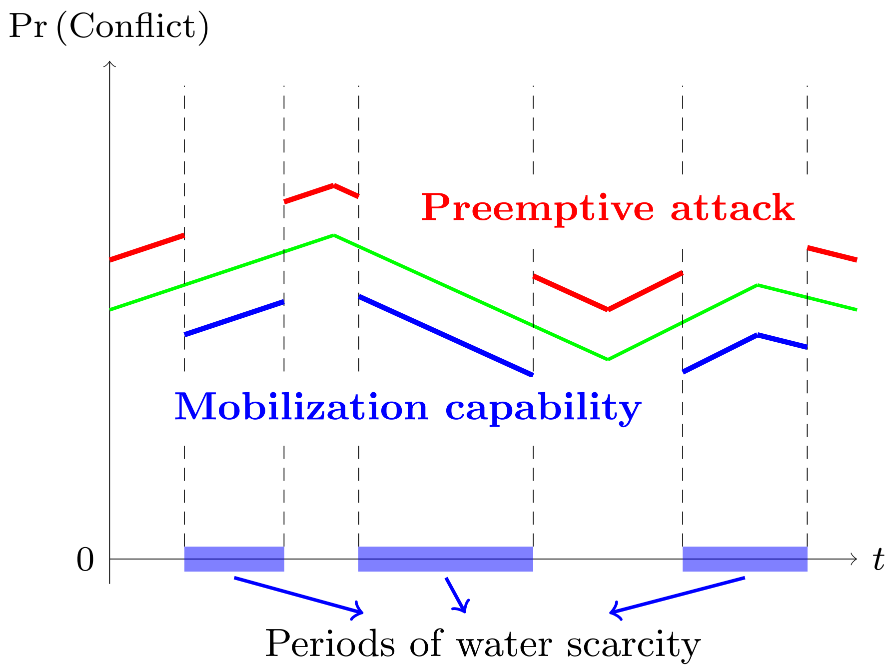

Figure 7: Opposing theories leading to similar empirical patterns

green lines (periods without water scarcity), whereas the latter logic draws a graph composed of the red segments (periods without water scarcity) and green lines (in the shaded periods). Observe that the shapes of the two graphs should look similar, although the latter one is strictly greater than the former.

The data in Salehyan and Hendrix (2014) suggest that their findings might be driven by the logic of asymmetric exposure to disaster risks. Recall that, in the game-theoretic model, the equilibrium outcomes vary across the value of μ, which represents the level of (a)symmetric exposure to disaster risks. The second, preemptive-war equilibrium ($\mathtt{E}_1$) or $\mathtt{E}_2$ emerges when μ is close to zero or one, where one group is inherently more vulnerable to future extreme weather events. Moreover, for the second equilibrium to arise, natural disasters in question and their expected damage should be, at least to some extent, foreseeable: as Remarks 1 and 2 suggest, the preemptive war in the second equilibrium never erupts if the risk and asymmetric costs are not perceptible in the first place.

These conditions seem to be satisfied in Salehyan and Hendrix (2014). First, their unit of observation is country-year. Thus, it is more likely that relevant rival groups are geographically distant. Consequently, the level of asymmetry in disaster risks should be greater (μ close to zero or one) in country-year data than in more geographically disaggregated ones, where relevant groups are inevitably more proximate in the geographical unit and should be facing similar disaster risks. Second, droughts are seasonal disasters. Thus, at least, they are relatively more foreseeable than other natural disasters such as earthquakes. The relative predictability of droughts renders the preemptive motive in the second equilibrium a plausible strategic logic connecting future disaster risks to conflict in the present period.

One can also situate other studies that seem to contradict Salehyan and Hendrix (2014) in the context of the asymmetric-exposure theory. For example, Fjelde and von Uexkull (2012) find that negative rainfall anomalies are associated with more communal conflicts between non-state actors in sub-Saharan Africa. Recall the variable $\texttt{gov}_{dt}$ defined in the previous section: based on the measure, the conflict data in Fjelde and von Uexkull (2012) should have $\texttt{gov}_{dt} = 0$ (symmetric dyads) because they focus on non-state conflicts. If we assume $\texttt{gov}_{dt} = 0$ captures $\mu \in M^{\mathtt{R}}$, the theory also predicts that droughts and communal conflicts are positively correlated.

Moreover, Bell and Keys (2018) argue that the effect of drought on conflict in sub-Saharan Africa is conditional on other factors related to conflict risks, such as social vulnerability (e.g., inadequate food supply), equal distribution of or access to emergency resources (e.g., ethnic exclusion), and state capacity (e.g., low urbanization). For instance, they find a significant positive association between drought and conflict contingent on low ethnic exclusion. If inclusive distribution of resources among different ethnic groups implies that those groups have relatively symmetric resilience/vulnerability to extreme weather events ($\mu \in M^{\mathtt{R}}$ in the model), this finding exemplifies Corollary 1. Hence, it is also consistent with the asymmetric-exposure theory.

In sum, some of the seemingly contradictory empirical results can be driven by one of the two heterogeneous effects of disasters conditional on the level of (a)symmetry in disaster risks. We may be able to make sense of them by taking theory and the data-generating process behind them more seriously.

5.4 Policy Implication

The theory also has a policy implication that decision-making on which regions to prioritize for policy intervention to improve resilience is not straightforward. To see this, recall that the two strategy profiles that can constitute an asymmetric equilibrium, ($\mathtt{E}_1$) and ($\mathtt{E}_2$), state that the inherently vulnerable player fights for sure in any no-disaster period. Hence, denoting the ex ante probability of war on the equilibrium path under strategy profile $\mathtt{s}$ at any period t as $\mathcal{P}(\mathtt{s})$, where $\mathtt{s} \in \{\mathtt{R}, \mathtt{E}_1, \mathtt{E}_2\}$, we have the simple result below.

Corollary 5. *Suppose that, depending on the shape of F, strategy profiles ($\mathtt{R}$), ($\mathtt{E}_1$), and ($\mathtt{E}_2$) constitute an equilibrium. Then, whenever $\pi < 1/2$, we have $\mathcal{P}(\mathtt{R}) < \min\{\mathcal{P}(\mathtt{E}_1), \mathcal{P}(\mathtt{E}_2)\}$.*

Namely, if disasters are not too likely, then the asymmetric case is strictly more conflict-prone. This result is straightforward. Because the conditional probability of conflict given $D_t = 0$ (which occurs with probability $1-\pi$) is one in cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$) and zero in case ($\mathtt{R}$), the ex ante probabilities of conflict in the former two cases become strictly greater whenever "no disaster" is likely enough, irrespective of the conditional probability of conflict in disaster periods. Note that this result does not depend on the shape of F and that it solely arises from the existence of the preemptive motive for conflict.

To see that the result leads to an interesting policy implication, recall Implication 2: the CATE of a disaster *event* on conflict for dyads of rival political groups with asymmetric vulnerabilities is negative. Now suppose that, given limited resources, policy-makers are considering which regions to focus on when they allocate budgets for improving the society's robustness to disaster risks and the subsequent conflict risks. In empirical data, regions where those asymmetric dyads are located may not seem susceptible to conflict arising from climate shocks because disaster and conflict events are negatively correlated. However, it is such regions that display a higher risk of conflict due to the preemptive motive. Therefore, regions that appear to be experiencing climate-event-induced conflicts (case (R) in the theory) may not always be the most fragile targets in need of policy interventions such as climate adaptation efforts.

6 Conclusion

This paper has shown that a single process of asymmetric exposure to climate anomalies and other natural disasters generates two qualitatively distinct equilibrium strategies. The key parameter is the asymmetry in the inherent vulnerability to extreme weather events and other natural disasters. It determines the source of conflict in the equilibrium path. In the first case, conflict erupts as a consequence of an actual disaster that causes a rapid shift in the balance of power. The sole trigger of a conflict is an opportunistic motive of the temporarily advantaged side. In the second, war is more likely before a disaster occurs because of the anticipated asymmetry of its costs. While the opportunistic and preemptive motives coexist in this case, the latter overwhelms the former. Put differently, although disasters trigger conflict in both cases either through their actual occurrence or their future risks, in the asymmetric case, the probability of conflict onset is strictly larger in the absence of a disaster than right after it.

This theoretical result yields a novel (i) empirical prediction and (ii) theoretical interpretation of why the results of empirical research on climate conflict are inconclusive. Although it does not directly dispute specific empirical results, the game-theoretic model implies that we might be *underestimating* the causal effect of disasters and extreme weather events on armed conflict. Specifically, in the second (asymmetric) case, the actual occurrence of a natural disaster and conflict onset should be negatively correlated, but those conflicts are also caused by disaster risks. Therefore, if extreme weather events have multiple effects, including the one studied in this paper (randomness and asymmetry in relative vulnerabilities to future disasters), the seemingly mixed results may be mixed only ostensibly. Namely, it is possible that the conflict-inducing effects of natural disasters are larger than shown in empirical studies if they overlook the heterogeneous impacts.

Limitations of this study suggest directions for future research. First, while the empirical prediction in this paper is novel, it is a descriptive statement. Building a measurement of relative vulnerabilities to disasters for all politically relevant groups is methodologically challenging. This paper partly circumvents it by using Bayes' rule and treating the relative vulnerabilities as a dependent variable. Future research can propose the measurement and causally assess the feasibility of the theory. Second, the players do not have the ability to prepare for future disasters in the current model. A possible extension is to allow them to invest their resources to reduce their vulnerability. This extension is theoretically interesting because an excessive investment by one player can generate the other's preemptive motive to fight before such an investment project is completed. Moreover, it has policy implications for the effectiveness and welfare effects of climate adaptation efforts.

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Appendix for

"Natural Disasters, Asymmetric Exposure, and War"

A Proofs of the Statements in the Main Text

A.1 Proof of Remark 1

Proof. We want to show that (i) a strategy profile in which both players never fight constitutes an SPE and (ii) it is the unique equilibrium. First, consider an arbitrary subgame, and suppose that one player is following a strategy in which she never attacks the opponent at any decision node. Let $\mathcal{V}^0$ and $\mathcal{W}^0$ denote the other player's continuation payoff and expected war payoff, respectively. Then, we have

$$\begin{aligned}
\mathcal{V}^0 &= \theta + \delta \mathcal{V}^0 \\
\mathcal{W}^0 &= \frac{1}{2}\left[2\theta(1-c) + \delta \sum_{t=1}^{\infty} \delta^{t-1} \cdot 2\theta\right] + \frac{1}{2} \cdot 0 \\
&= \theta\left[\frac{1}{1-\delta} - c\right].
\end{aligned}$$

Since solving the first equation for $\mathcal{V}^0$ yields $\mathcal{V}^0 = \theta/(1-\delta)$, we obtain $\mathcal{V}^0 > \mathcal{W}^0$ for any $c \in (0,1)$. Because any deviation (attacking the opponent) ends the game, we do not need to check off-path strategies. Hence, the strategy profile in which neither player ever fights constitutes an SPE.

The above equilibrium is unique under Assumption 1. To see this, suppose to the contrary that there exists another SPE. If so, because such an equilibrium is different from the one shown above in which neither attacks the other at any history, it implies that war must occur in some history. Assumption 1 rules out strategy profiles in which both players attack in the same period. Thus, it leaves a strategy profile where one player unilaterally attacks the other at some history t'. Consider the attacker's incentive at such period t'. For an arbitrary continuation game, a one-step deviation of not attacking at period t' would yield a path of play on which peace is maintained for $\tau \geq 1$ periods and war erupts in the $(\tau+1)$th period (unless $\tau = \infty$). Such deviation would generate a continuation payoff $\sum_{t=1}^{\tau} \delta^{t-1}\theta + \delta^{\tau}\mathcal{W}^0$. In sum, the incentive of the attacker at period t' has to satisfy

$$\begin{aligned}\underbrace{\mathcal{W}^0}_{\text{Attack at } t'} &\geq \underbrace{\frac{1-\delta^\tau}{1-\delta}\theta + \delta^\tau \mathcal{W}^0}_{\text{Deviation}} \\ -c &\geq 0,\end{aligned}$$

which never holds by $c \in (0,1)$. Therefore, any potential attacker has the incentive to deviate to sustain peace in any strategy profile where war occurs at some history t'. This result contradicts the assumption that there is another SPE, which proves that no other equilibrium is possible under Assumption 1. □

A.2 Proof of Remark 2

Proof. As in Remark 1, we want to show that the completely peaceful strategy profile is the only SPE. To show this, first define players' continuation payoff from the strategy profile:

$$\begin{aligned}\mathcal{V}^{\mathtt{sym}} &\equiv (1-\pi)\left(\theta + \delta \mathcal{V}^{\mathtt{sym}}\right) + \pi\left(\frac{1}{2}\theta + \delta \mathcal{V}^{\mathtt{sym}}\right) \\ \mathcal{V}^{\mathtt{sym}} &= \theta \cdot \frac{1-\pi/2}{1-\delta}.\end{aligned}$$

Next, let $\mathcal{W}^{\mathtt{d,sym}}$ and $\mathcal{W}^{\neg\mathtt{d,sym}}$ be the expected war payoff when a war occurs in a disaster and no-disaster periods, respectively.

$$\begin{aligned}\mathcal{W}^{\mathtt{d,sym}} &= \frac{1}{2}\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right) \\ \mathcal{W}^{\neg\mathtt{d,sym}} &= \frac{1}{2}\left(2\theta(1-c) + \delta\overline{\mathcal{V}}\right).\end{aligned}$$

Not attacking is the best response in disaster and no-disaster periods if $\frac{1}{2}\theta + \delta\mathcal{V}^{\mathtt{sym}} > \mathcal{W}^{\mathtt{d,sym}}$ and $\theta + \delta\mathcal{V}^{\mathtt{sym}} > \mathcal{W}^{\neg\mathtt{d,sym}}$, respectively. Simple computation reduces both inequalities to $c > 0$, which always holds. Because not attacking is the best response to the other player not attacking in any subgame, the strategy profile in which both players never fight is an SPE.

The same logic as Remark 1 proves the equilibrium uniqueness: no other equilibrium is possible given that (i) not attacking is strictly more beneficial when the other player is following the peaceful strategy (in which she never attacks the opponent) and (ii) mutual attacks do not occur under Assumption 1. □

A.3 Proof of Proposition 1

Proof. I prove the proposition in three simple steps. Before doing so, for simplicity, let us introduce the following notation. Notice that the game is symmetric except for variables related to Z. Then, for a variable/parameter $x \in \{Z, z_t, \mu\}$, denote its relevant value to each player by $\tilde{x} \equiv \mathbb{1}\{i=1\} \cdot x + \mathbb{1}\{i=2\}(1-x)$. For example, $\tilde{z}_t\theta$ represents the remaining amount of resources for Player 1 (i.e., $z_t\theta$) and Player 2 (i.e., $(1-z_t)\theta$) in a disaster period.

Step 1 (Preliminaries). First, we identify the players' expected payoffs when they follow strategies ($\mathtt{R}$-I) and ($\mathtt{R}$-II). First, consider war payoffs. Suppose that Nature has determined the presence/absence of a disaster and its asymmetric exposure z_t if one occurred. Let $\mathcal{W}_i^{\mathtt{d}}(z_t)$ and $\mathcal{W}_i^{\neg\mathtt{d}}$ denote player i's expected war payoff in a disaster and no-disaster periods, respectively. Then, we have

$$
\begin{aligned}
\mathcal{W}_i^{\mathtt{d}}(z_t) &= p_i^{\mathtt{d}}(z_t)\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right) \\
&= \tilde{z}_t\theta\left[\frac{1+\delta(1-\pi)}{1-\delta} - c\right] \\
\mathcal{W}_i^{\neg\mathtt{d}} &= p_i^{\neg\mathtt{d}}\left(2\theta(1-c) + \delta\overline{\mathcal{V}}\right) \\
&= \theta\left[\frac{1-\delta\pi/2}{1-\delta} - c\right].
\end{aligned}
$$

Next, consider the expected peace payoffs. Let $\mathcal{V}_i^{\mathtt{R}}$ denote player i's continuation payoff when both players follow strategies ($\mathtt{R}$-I) and ($\mathtt{R}$-II). We can see that $\mathcal{V}_i^{\mathtt{R}}$ consists of four components: cases where (i) a disaster does not take place; (ii) a disaster erupts and neither player fights; (iii) a disaster takes place and z_t is small so that Player 2 attacks 1; and (iv) a disaster occurs and z_t is large so that Player 1 attacks 2. Thus, we have

$$
\begin{aligned}
\mathcal{V}_i^{\mathtt{R}} &= \overbrace{(1-\pi)\left(\theta+\delta\mathcal{V}_i^{\mathtt{R}}\right)}^{(i)\ \text{No-disaster period}} \\
&\quad \underbrace{+\pi\left[\begin{array}{l}
\overbrace{\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)}^{(ii)\ \text{Pr(Peace)}}\left(\mathbb{E}\left[\tilde{Z}\middle|Z\in\left[\underline{z}^{\mathtt{R}},\overline{z}^{\mathtt{R}}\right]\right]\theta+\delta\mathcal{V}_i^{\mathtt{R}}\right) \\
+\quad \underbrace{F\left(\underline{z}^{\mathtt{R}}\right)}_{(iii)\ \text{Pr(P2 attacks)}}\ \underbrace{\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{R}}\right]\theta\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right]}_{\mathbb{E}\left[\mathcal{W}_i^{\mathtt{d}}(z_t)\middle|Z<\underline{z}^{\mathtt{R}}\right]} \\
+\ \underbrace{\left(1-F\left(\overline{z}^{\mathtt{R}}\right)\right)}_{(iv)\ \text{Pr(P1 attacks)}}\ \underbrace{\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{R}}\right]\theta\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right]}_{\mathbb{E}\left[\mathcal{W}_i^{\mathtt{d}}(z_t)\middle|Z>\overline{z}^{\mathtt{R}}\right]}
\end{array}\right]}_{\text{Disaster period}},
\end{aligned}
$$

where $\Delta_F(b,a)=F(b)-F(a)$ with $a\leq b$. Solving this for $\mathcal{V}_i^{\mathtt{R}}$ yields

$$
\begin{aligned}
\mathcal{V}_i^{\mathtt{R}} &= \theta\cdot\frac{(1-\pi)+\pi\left[\begin{array}{l}\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z\in\left[\underline{z}^{\mathtt{R}},\overline{z}^{\mathtt{R}}\right]\right] \\ +\left(F\left(\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{R}}\right]+\left(1-F\left(\overline{z}^{\mathtt{R}}\right)\right)\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{R}}\right]\right)\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right]\end{array}\right]}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)} \\
&= \theta\cdot\frac{(1-\pi)+\pi\left[\begin{array}{l}\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z\in\left[\underline{z}^{\mathtt{R}},\overline{z}^{\mathtt{R}}\right]\right] \\ +F\left(\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{R}}\right]+\left(1-F\left(\overline{z}^{\mathtt{R}}\right)\right)\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{R}}\right] \\ +\left(F\left(\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{R}}\right]+\left(1-F\left(\overline{z}^{\mathtt{R}}\right)\right)\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{R}}\right]\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\end{array}\right]}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)} \\
&= \theta\cdot\frac{(1-\pi)+\pi\left[\tilde{\mu}+\left(F\left(\underline{z}^{\mathtt{R}}\right)\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{R}}\right]+\left(1-F\left(\overline{z}^{\mathtt{R}}\right)\right)\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{R}}\right]\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right]}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)},
\end{aligned}
$$

where the last equation holds by the law of iterated expectations. By $\mathbb{E}\left[Z|Z\in[\underline{z},\overline{z}]\right]=$

$\frac{\int_{\underline{z}}^{\overline{z}} z f(z)\mathrm{d}z}{\int_{\underline{z}}^{\overline{z}} f(z)\mathrm{d}z}$, we obtain

$$\mathcal{V}_i^{\mathtt{R}} \;=\; \theta \cdot \frac{(1-\pi)+\pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{R}}} \tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1 \tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}.$$

When players follow strategies (R-I) and (R-II), player i's expected peace payoff at any information set in a no-disaster period is $\theta+\delta\mathcal{V}_i^{\mathtt{R}}$. On the other hand, i's expected peace payoff in a disaster period when the realized asymmetric exposure is z_t is $\tilde{z}_t\theta+\delta\mathcal{V}_i^{\mathtt{R}}$.

Step 2 (R-I). Consider an arbitrary disaster period. Strategy (R-I) states that when the realized asymmetric exposure z_t is extreme, the (temporarily) advantaged side attacks the other. Given that the opponent is playing (R-I) and (R-II), if $\mathcal{W}_i^{\mathtt{d}}(z_t) > \tilde{z}_t\theta+\delta\mathcal{V}_i^{\mathtt{R}}$, it is the best response for player i to attack the other in a disaster period t after any history. The above inequality yields

$$\begin{aligned}
\tilde{z}_t\theta\left[\frac{1+\delta(1-\pi)}{1-\delta}-c\right] \;&>\; \tilde{z}_t\theta+\delta\theta\cdot\frac{(1-\pi)+\pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{R}}} \tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1 \tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}\\
\tilde{z}_t \;&>\; \delta\cdot\frac{(1-\pi)+\pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{R}}} \tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1 \tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]}.
\end{aligned}$$

Recall that $\tilde{z}_t=z_t$, $\tilde{\mu}=\mu$, and $\tilde{Z}=Z$ for Player 1. Hence, the threshold $\overline{z}^{\mathtt{R}}$ above which Player 1 attacks 2 is given implicitly by

$$\overline{z}^{\mathtt{R}}=\delta\cdot\frac{(1-\pi)+\pi\left(\mu+\left(\int_0^{\underline{z}^{\mathtt{R}}} z\mathrm{d}F(z)+\int_{\overline{z}^{\mathtt{R}}}^1 z\mathrm{d}F(z)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]}.$$

On the other hand, by $\tilde{z}_t=1-z_t$, $\tilde{\mu}=1-\mu$, and $\tilde{Z}=1-Z$ for Player 2, $\underline{z}^{\mathtt{R}}$ below which

Player 2 attacks 1 is implicitly characterized by,

$$\underline{z}^{\mathtt{R}} = 1-\delta\cdot\frac{(1-\pi)+\pi\left(1-\mu+\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)-\left(\int_0^{\underline{z}^{\mathtt{R}}} z\mathrm{d}F(z)+\int_{\overline{z}^{\mathtt{R}}}^1 z\mathrm{d}F(z)\right)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]}.$$

Solving the system of the two equations for $\overline{z}^{\mathtt{R}}$ and $\underline{z}^{\mathtt{R}}$ determines the thresholds in realized asymmetric exposure above and below which either one player attacks the other, respectively.

Step 3 ($\mathtt{R}$-II). Finally, consider a no-disaster period. Neither player attacks the opponent when $\mathcal{W}_i^{\neg\mathtt{d}} \leq \theta+\delta\mathcal{V}_i^{\mathtt{R}}$, i.e.,

$$\frac{1}{2}\left[2\theta(1-c)+\delta\frac{\theta(2-\pi)}{1-\delta}\right] \quad\leq\quad \theta+\delta\theta\frac{(1-\pi)+\pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{R}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}.$$

Rearranging this yields

$$\begin{aligned}\tilde{\mu} \quad\geq\quad & 1-\frac{1}{\pi}+\delta\frac{2-\pi}{1-\delta}\left[\frac{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}{2\delta\pi}-\left(\int_0^{\underline{z}^{\mathtt{R}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\right]\\ & -c\left[\frac{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}{\delta\pi}-\left(\int_0^{\underline{z}^{\mathtt{R}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\right].\end{aligned}$$

By $\frac{1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^{\mathtt{R}},\underline{z}^{\mathtt{R}}\right)\right)\right)}{2\delta\pi}=\frac{1-F\left(\overline{z}^{\mathtt{R}}\right)+F\left(\underline{z}^{\mathtt{R}}\right)}{2}+\frac{1-\delta}{2\delta\pi}$, factoring out the second term leads to

$$\begin{aligned}\tilde{\mu} \quad\geq\quad & \frac{1}{2}+\delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^{\mathtt{R}}}\frac{1}{2}-\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1\frac{1}{2}-\tilde{z}\mathrm{d}F(\tilde{z})\right)\\ & -c\left(\int_0^{\underline{z}^{\mathtt{R}}}1-\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{R}}}^1 1-\tilde{z}\mathrm{d}F(\tilde{z})+\frac{1-\delta}{\delta\pi}\right),\end{aligned}$$

where $\tilde{\mu}$ for which the above expression holds with equality is the threshold value. Note that we have a system of three equations with three unknowns (i.e., $\underline{z}^{\mathtt{R}}(\mu)$, $\overline{z}^{\mathtt{R}}(\mu)$, and μ). By solving the system of equations, by $\tilde{\mu}=\mathbb{1}\{i=1\}\cdot\mu+\mathbb{1}\{i=2\}(1-\mu)$ and $\tilde{z}=\mathbb{1}\{i=1\}\cdot$

$z + \mathbb{1}\{i=2\}(1-z)$, we obtain the desired result. $\square$

A.4 Proof of Proposition 2

Proof. We can prove this proposition in a similar manner to Proposition 1.

Step 1 (Preliminaries). From the proof of Proposition 1, we know players' expected war payoffs, i.e., $\mathcal{W}_i^{\mathtt{d}}(z_t)$ and $\mathcal{W}_i^{\neg\mathtt{d}}$. Let $\mathcal{V}_i^{\mathtt{E}}$ represent player i's continuation payoff when both players are following strategies ($\mathtt{E}$-I) and ($\mathtt{E}$-II):

$$\begin{aligned}\mathcal{V}_i^{\mathtt{E}} \;=\; & \overbrace{(1-\pi)\,\mathcal{W}_i^{\neg\mathtt{d}}}^{\text{No-disaster period}} \\ & \underbrace{+\pi\left[\begin{array}{l} \overbrace{\Delta_F\left(\overline{z}^{\mathtt{E}}, \underline{z}^{\mathtt{E}}\right)}^{\Pr(\text{Peace})}\left(\mathbb{E}\left[\tilde{Z}\middle|Z\in\left[\underline{z}^{\mathtt{E}}, \overline{z}^{\mathtt{E}}\right]\right]\theta+\delta\mathcal{V}_i^{\mathtt{E}}\right) \\ +\quad \underbrace{F\left(\underline{z}^{\mathtt{E}}\right)}_{\Pr(\text{P2 attacks})}\;\underbrace{\mathbb{E}\left[\tilde{Z}\middle|Z<\underline{z}^{\mathtt{E}}\right]\theta\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right]}_{\mathbb{E}\left[\mathcal{W}_i^{\mathtt{d}}(z_t)\middle|Z<\underline{z}^{\mathtt{E}}\right]} \\ +\underbrace{\left(1-F\left(\overline{z}^{\mathtt{E}}\right)\right)}_{\Pr(\text{P1 attacks})}\underbrace{\mathbb{E}\left[\tilde{Z}\middle|Z>\overline{z}^{\mathtt{E}}\right]\theta\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right]}_{\mathbb{E}\left[\mathcal{W}_i^{\mathtt{d}}(z_t)\middle|Z>\overline{z}^{\mathtt{E}}\right]} \end{array}\right]}_{\text{Disaster period}}.\end{aligned}$$

Solving this for $\mathcal{V}_i^{\mathtt{E}}$, we obtain

$$\mathcal{V}_i^{\mathtt{E}} = \theta\cdot\frac{(1-\pi)\left[\dfrac{1-\delta\pi/2}{1-\delta}-c\right]+\pi\left(\tilde{\mu}+\left(\displaystyle\int_0^{\underline{z}^{\mathtt{E}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\dfrac{2-\pi}{1-\delta}-c\right]\right)}{1-\delta\pi\Delta_F\left(\overline{z}^{\mathtt{E}}, \underline{z}^{\mathtt{E}}\right)}.$$

Step 2 ($\mathtt{E}$-I). Consider an arbitrary disaster period t and suppose that the opponent is playing strategies ($\mathtt{E}$-I) and ($\mathtt{E}$-II). Then, it is optimal for player i to attack the other when

$\mathcal{W}_i^{\mathtt{d}}(z_t) > \tilde{z}_t\theta + \delta\mathcal{V}_i^{\mathtt{E}}$. That is,

$$
\begin{aligned}
\tilde{z}_t\theta\left[\frac{1+\delta(1-\pi)}{1-\delta}-c\right] &> \tilde{z}_t\theta + \delta\theta\cdot\frac{\begin{bmatrix}(1-\pi)\left[\frac{1-\delta\pi/2}{1-\delta}-c\right]+\\ \pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{E}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)\end{bmatrix}}{1-\delta\pi\Delta_F\left(\overline{z}^{\mathtt{E}},\underline{z}^{\mathtt{E}}\right)} \\
\tilde{z}_t &> \delta\cdot\frac{\begin{bmatrix}(1-\pi)\left[\frac{1-\delta\pi/2}{1-\delta}-c\right]+\\ \pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{E}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)\end{bmatrix}}{\left(1-\delta\pi\Delta_F\left(\overline{z}^{\mathtt{E}},\underline{z}^{\mathtt{E}}\right)\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]}.
\end{aligned}
$$

By $\tilde{z}_t = z_t$ for player 1 and $\tilde{z}_t = 1 - z_t$ for player 2, substituting them in the above inequality yields the thresholds $\underline{z}^{\mathtt{E}}$ and $\overline{z}^{\mathtt{E}}$.

Step 3 ($\mathtt{E}$-II). Similarly, consider an arbitrary no-disaster period. When the other player is playing strategies ($\mathtt{E}$-I) and ($\mathtt{E}$-II), it is optimal to attack the other when $\mathcal{W}_i^{\neg\mathtt{d}} > \theta + \delta\mathcal{V}_i^{\mathtt{E}}$. Namely,

$$
\begin{aligned}
\frac{1}{2}\left[2\theta(1-c)+\delta\frac{\theta(2-\pi)}{1-\delta}\right] &> \theta + \delta\theta\cdot\frac{\begin{bmatrix}(1-\pi)\left[\frac{1-\delta\pi/2}{1-\delta}-c\right]+\\ \pi\left(\tilde{\mu}+\left(\int_0^{\underline{z}^{\mathtt{E}}}\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1\tilde{z}\mathrm{d}F(\tilde{z})\right)\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)\end{bmatrix}}{1-\delta\pi\Delta_F\left(\overline{z}^{\mathtt{E}},\underline{z}^{\mathtt{E}}\right)} \\
\tilde{\mu} &< \frac{1}{2}+\delta\frac{2-\pi}{1-\delta}\left(\int_0^{\underline{z}^{\mathtt{E}}}\frac{1}{2}-\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1\frac{1}{2}-\tilde{z}\mathrm{d}F(\tilde{z})\right) \\
&\quad -c\left(\int_0^{\underline{z}^{\mathtt{E}}}1-\tilde{z}\mathrm{d}F(\tilde{z})+\int_{\overline{z}^{\mathtt{E}}}^1 1-\tilde{z}\mathrm{d}F(\tilde{z})+\frac{1-\delta}{\delta\pi}\right).
\end{aligned}
$$

As in the case of Proposition 1, we obtain the desired results by $\tilde{\mu} = \mu$ and $\tilde{z} = z$ for Player 1 and $\tilde{\mu} = 1 - \mu$ and $\tilde{z} = 1 - z$ for Player 2. $\square$

A.5 Proof of Proposition 3

To prove Proposition 3, consider the following lemmas.

Lemma 1. *Under Assumption 1, there is no mixed-strategy equilibrium.*

Proof. This directly stems from the fact that players are indifferent between pure strategies in the support of any mixed (equilibrium) strategy. Namely, if a player were to mix attacking and not attacking at some t, she must be indifferent between the two actions. Assumption 1 assigns "not attack" in this case, which rules out mixed-strategy equilibria. $\square$

Lemma 2. *The set of values of z_t under which a player fights when $D_t = 1$ constitutes a one-sided interval.*

Proof. We know that $\mathcal{W}_i^{\mathrm{d}}(z_t)$ is monotonic in z_t: it is strictly increasing and decreasing for player 1 and player 2, respectively. Let $\mathcal{V}_i$ represent a continuation payoff generated by arbitrary equilibrium strategies. Also recall we have denoted $\tilde{z}_t = \mathbb{1}\{i=1\} \cdot z_t + \mathbb{1}\{i=2\}(1-z_t)$. Then, player i attacks the other in this equilibrium at period t such that $D_t = 1$ when

$$\begin{aligned} \tilde{z}_t\theta\left[(1-c)+\delta\frac{2-\pi}{1-\delta}\right] &> \tilde{z}_t\theta+\delta\mathcal{V}_i \\ \tilde{z}_t &> \frac{\delta\mathcal{V}_i}{\theta\left[\delta\frac{2-\pi}{1-\delta}-c\right]}. \end{aligned}$$

Note that the continuation payoff $\mathcal{V}_i$ is not a function of the current realized damage $\tilde{z}_t$. Hence, whenever $\frac{\delta\mathcal{V}_i}{\theta\left[\delta\frac{2-\pi}{1-\delta}-c\right]} \in (0,1)$, we can conclude that the set of values of $\tilde{z}_t$ under which i fights is $\left(\frac{\delta\mathcal{V}_i}{\theta\left[\delta\frac{2-\pi}{1-\delta}-c\right]}, 1\right]$, which is a one-sided interval. $\square$

Lemma 3. *Fix all parameters and suppose $\mu \in M^R \cap M^E \neq \emptyset$. Then,*

$$\underline{z}^R(\mu) \leq \underline{z}^E(\mu) \quad \text{and} \quad \overline{z}^E(\mu) \leq \overline{z}^R(\mu).$$

Proof. Suppose to the contrary that $\underline{z}^{\mathtt{R}}(\mu) > \underline{z}^{\mathtt{E}}(\mu)$ or $\underline{z}^{\mathtt{E}}(\mu) > \underline{z}^{\mathtt{R}}(\mu)$. However, recall that, in cases $(\mathtt{E}_1)$ and $(\mathtt{E}_2)$, the vulnerable player will fight for sure in any no-disaster period. Without loss of generality, consider case $(\mathtt{E}_1)$. Because Player 1 (the vulnerable one) will fight once there is no disaster in $(\mathtt{E}_1)$, Player 2 can profitably deviate by setting a smaller $\overline{z}^{\mathtt{E}_1}(\mu)$ not to miss an advantage when there is a disaster, leading to a contradiction. Similarly, knowing that (i) Player 2 is at least as willing as in $(\mathtt{R})$ to fight in a disaster period and that (ii) Player 1 will initiate a war without an advantage in any no-disaster period, Player 1 must be more willing to fight in a disaster period and has a profitable deviation by setting a larger $\underline{z}^{\mathtt{E}_1}(\mu)$. This contradicts the assumption that $\underline{z}^{\mathtt{R}}(\mu) > \underline{z}^{\mathtt{E}_1}(\mu)$. Analogous discussions apply to $\overline{z}^{\mathtt{E}_1}(\mu) \leq \overline{z}^{\mathtt{R}}(\mu)$. □

Lemma 4. *Fix all parameters, and suppose $\mu \in M^{\mathtt{R}} \cap M^{\mathtt{E}} \neq \emptyset$ and that Player i is more vulnerable. Then, the expected probability of her victory in war at a disaster period, $\mathbb{E}_{Z_t}\left[p_i^{\mathtt{d}}(Z_t)\right]$, is greater in $(\mathtt{R})$ than in $(\mathtt{E}_1)$ or $(\mathtt{E}_2)$.*

Proof. Without loss of generality, consider case $(\mathtt{E}_1)$, where Player 1 is the vulnerable one. Suppose to the contrary that $\mathbb{E}_{Z_t}\left[p_1^{\mathtt{d}}(Z_t)\right]$ is greater for $(\mathtt{E}_1)$ than for $(\mathtt{R})$. That is, Player 1 has a better chance of winning in a disaster period under cutoffs $\underline{z}^{\mathtt{E}_1}$ and $\overline{z}^{\mathtt{E}_1}$ than under $\underline{z}^{\mathtt{R}}$ and $\overline{z}^{\mathtt{R}}$.

Because we have assumed $\mu \in M^{\mathtt{R}} \cap M^{\mathtt{E}}$, there exist multiple equilibria (in this case, $\mu \in \left[\underline{\mu}^{\mathtt{R}}, \underline{\mu}^{\mathtt{E}}\right)$). The assumption that strategy profile $(\mathtt{R})$ constitutes an equilibrium implies that Player 1 does not have the incentive to deviate to fighting when $D_t = 0$, i.e., $\mathcal{W}_1^{\neg\mathtt{d}} \leq \theta + \delta\mathcal{V}_1^{\mathtt{R}}$. Because strategy profile $(\mathtt{E}_1)$ also constitutes an equilibrium, we have $\mathcal{W}_1^{\neg\mathtt{d}} > \theta + \delta\mathcal{V}_1^{\mathtt{E}_1}$.

Now consider Player 1's deviation to a stationary strategy in which she (i) never attacks Player 2 when $D_t = 0$ but (ii) still uses cutoff $\underline{z}^{\mathtt{E}}$ for $D_t = 1$. Denote her continuation value under this deviation by $\mathcal{V}_1^{\mathtt{dev}}$. By the assumption (for the sake of contradiction) that Player 1 has a higher (expected) probability of victory in a disaster period under cutoffs $\underline{z}^{\mathtt{E}_1}$ and

$\overline{z}^{\mathtt{E}_1}$, we have $\mathcal{V}_1^{\mathtt{R}} < \mathcal{V}_1^{\mathtt{dev}}$. Consequently, we have established

$$\theta + \delta\mathcal{V}_1^{\mathtt{E}_1} < \mathcal{W}_1^{\neg\mathtt{d}} \leq \theta + \delta\mathcal{V}_1^{\mathtt{R}} < \theta + \delta\mathcal{V}_1^{\mathtt{dev}}.$$

By $\mathcal{W}_1^{\neg\mathtt{d}} < \theta+\delta\mathcal{V}_1^{\mathtt{dev}}$, Player 1 has the incentive to deviate to the above strategy profile, which contradicts the assumption that ($\mathtt{E}_1$) constitutes an equilibrium. Analogous discussions apply to the case of ($\mathtt{E}_2$). $\square$

Lemma 5. *Fix parameter values and the functional form of F. Then, we have*

$$\underline{\mu}^{R} < \underline{\mu}^{E} \quad \textit{and} \quad \overline{\mu}^{E} < \overline{\mu}^{R}.$$

Proof. Focus on $\underline{\mu}^{\mathtt{R}} < \underline{\mu}^{\mathtt{E}}$. Denote $\mathcal{V}_1^{\mathtt{R}}$ and $\mathcal{V}_1^{\mathtt{E}_1}$ when $\mu = \underline{\mu}^{\mathtt{R}}$ by $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$ and $\mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$. First, we want to show $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) > \mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$. Then, we show that it is a sufficient condition for $\underline{\mu}^{\mathtt{R}} < \underline{\mu}^{\mathtt{E}}$.

Step 1 ($\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) > \mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$). By the definition of $\underline{\mu}^{\mathtt{R}}$, recall $\mathcal{W}_1^{\neg\mathtt{d}} = \theta + \delta\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$. Thus, we have

$$\begin{aligned}
\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) &= (1-\pi)\mathcal{W}_1^{\neg\mathtt{d}} + \pi \begin{bmatrix} \Delta_F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right), \underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\left(\mathbb{E}\left[Z \middle| Z \in \left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right), \overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right]\theta + \delta\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right) \\ +F\left(\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\mathbb{E}\left[Z \middle| Z < \underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\theta\left[(1-c) + \delta\dfrac{2-\pi}{1-\delta}\right] \\ +\left(1 - F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\right)\mathbb{E}\left[Z \middle| Z > \overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\theta\left[(1-c) + \delta\dfrac{2-\pi}{1-\delta}\right] \end{bmatrix} \\
\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) &= \theta \cdot \frac{(1-\pi)\mathcal{W}_1^{\neg\mathtt{d}} + \pi\left(\mu + \begin{pmatrix} F\left(\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\mathbb{E}\left[Z \middle| Z < \underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right] \\ +\left(1 - F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\right)\mathbb{E}\left[Z \middle| Z > \overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right] \end{pmatrix}\left[\delta\dfrac{2-\pi}{1-\delta} - c\right]\right)}{1 - \delta\pi\Delta_F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right), \underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}.
\end{aligned}$$

Next, observe

$$\mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right) = \theta \cdot \frac{(1-\pi)\mathcal{W}_1^{\neg\mathtt{d}} + \pi\left(\mu + \begin{pmatrix} F\left(\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\mathbb{E}\left[Z\middle|Z<\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right] \\ +\left(1-F\left(\overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\right)\mathbb{E}\left[Z\middle|Z>\overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\end{pmatrix}\left[\delta\frac{2-\pi}{1-\delta}-c\right]\right)}{1-\delta\pi\Delta_F\left(\overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right),\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}.$$

To compare these two quantities, observe that, by Lemma 3, $\Delta_F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right) > \Delta_F\left(\overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right),\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)$. Hence, the denominator of $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$ is smaller than that of $\mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$. Then, the only difference in the numerators is the quantities in the inner parentheses. To compare them, write Player 1's expected probability of victory in a disaster period under strategy profile $(\mathtt{R})$ as, by the law of iterated expectations,

$$\begin{aligned}
\mathbb{E}\left[p_1^{\mathtt{d}}(Z)\right] &= \mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\Pr\left(\text{War, } Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right) \\
&\quad +\mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z\in\left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right]\Pr\left(\text{War, } Z\in\left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right) \\
&\quad +\mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\Pr\left(\text{War, } Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right) \\
&= \mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\underbrace{\Pr\left(\text{War}\middle|Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}_{=1\text{ (Player 2 fights)}}\underbrace{\Pr\left(Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}_{F\left(\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)} \\
&\quad +\mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z\in\left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right] \\
&\quad \times\underbrace{\Pr\left(\text{War}\middle|Z\in\left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right)}_{=0}\underbrace{\Pr\left(Z\in\left[\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\right)}_{\Delta_F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right),\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)} \\
&\quad +\mathbb{E}\left[p_1^{\mathtt{d}}(Z_t)\middle|\text{War, } Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right]\underbrace{\Pr\left(\text{War}\middle|Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}_{=1\text{ (Player 1 fights)}}\underbrace{\Pr\left(Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}_{1-F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)}.
\end{aligned}$$

By $p_1^{\mathtt{d}}(Z)=Z$, we obtain

$$\mathbb{E}\left[p_1^{\mathtt{d}}(Z)\right] = F\left(\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\mathbb{E}\left[Z\middle|Z<\underline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right] + \left(1-F\left(\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\right)\mathbb{E}\left[Z\middle|Z>\overline{z}^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)\right],$$

which coincides with the quantity in the inner parentheses in the numerator of $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$. Similarly, the analogous quantity in $\mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$ is $F\left(\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\mathbb{E}\left[Z\middle|Z<\underline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right]+\left(1-F\left(\overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right)\right)$

$\mathbb{E}\left[Z \middle| Z > \overline{z}^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)\right]$, which is also Player 1's expected probability of victory in a disaster period under strategy profile ($\mathtt{E}_1$). By Lemma 4, because $\mathbb{E}\left[p_1^{\mathtt{d}}(Z)\right]$ is greater under ($\mathtt{R}$), we have established that the numerator of $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$ is greater than that of $\mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$. Because the numerator is greater and the denominator is smaller in $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right)$, we obtain $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) > \mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$.

Step 2 ($\underline{\mu}^{\mathtt{R}} < \underline{\mu}^{\mathtt{E}}$). Because $\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) > \mathcal{V}_1^{\mathtt{E}_1}\left(\underline{\mu}^{\mathtt{R}}\right)$ holds, by the definition of $\underline{\mu}^{\mathtt{R}}$, we have $\mathcal{W}_1^{\neg\mathtt{d}} = \theta + \delta\mathcal{V}_1^{\mathtt{R}}\left(\underline{\mu}^{\mathtt{R}}\right) > \theta + \delta\mathcal{V}_1^{\mathtt{E}}\left(\underline{\mu}^{\mathtt{R}}\right)$. Also, because Player 1 strictly prefers fighting to not fighting at $\mu = \underline{\mu}^{\mathtt{R}}$ under strategy profile ($\mathtt{E}_1$), there exists $\varepsilon > 0$ such that $\mathcal{W}_1^{\neg\mathtt{d}} = \theta + \delta\mathcal{V}_1^{\mathtt{E}}\left(\underline{\mu}^{\mathtt{R}} + \varepsilon\right)$. By the definition of $\underline{\mu}^{\mathtt{E}}$, we write $\underline{\mu}^{\mathtt{E}} = \underline{\mu}^{\mathtt{R}} + \varepsilon$. By $\varepsilon > 0$, we obtain $\underline{\mu}^{\mathtt{E}} > \underline{\mu}^{\mathtt{R}}$. Analogous discussions apply to $\overline{\mu}^{\mathtt{E}} < \overline{\mu}^{\mathtt{R}}$. □

Lemma 6. *Fix all parameters other than μ. When $\overline{\mu}^{R}$ and $\underline{\mu}^{R}$ satisfy*

$$c < \min\left\{\begin{array}{c} \dfrac{\dfrac{1}{2} - \delta\dfrac{2-\pi}{1-\delta}\left(\displaystyle\int_0^{\underline{z}^R\left(\overline{\mu}^R\right)} \frac{1}{2} - z\mathrm{d}F_{\overline{\mu}^R}(z) + \int_{\overline{z}^R\left(\overline{\mu}^R\right)}^1 \frac{1}{2} - z\mathrm{d}F_{\overline{\mu}^R}(z)\right)}{\displaystyle\int_0^{\underline{z}^R\left(\overline{\mu}^R\right)} z\mathrm{d}F_{\overline{\mu}^R}(z) + \int_{\overline{z}^R\left(\overline{\mu}^R\right)}^1 z\mathrm{d}F_{\overline{\mu}^R}(z) + \dfrac{1-\delta}{\delta\pi}}, \\ \dfrac{\dfrac{1}{2} + \delta\dfrac{2-\pi}{1-\delta}\left(\displaystyle\int_0^{\underline{z}^R\left(\underline{\mu}^R\right)} \frac{1}{2} - z\mathrm{d}F_{\underline{\mu}^R}(z) + \int_{\overline{z}^R\left(\underline{\mu}^R\right)}^1 \frac{1}{2} - z\mathrm{d}F_{\underline{\mu}^R}(z)\right)}{\displaystyle\int_0^{\underline{z}^R\left(\underline{\mu}^R\right)} z\mathrm{d}F_{\underline{\mu}^R}(z) + \int_{\overline{z}^R\left(\underline{\mu}^R\right)}^1 z\mathrm{d}F_{\underline{\mu}^R}(z) + \dfrac{1-\delta}{\delta\pi}} \end{array}\right\},$$

we have $\underline{\mu}^{R} > 0$ and $\overline{\mu}^{R} < 1$.

Proof. Using expressions in Proposition 1, rearranging inequalities $\underline{\mu}^{\mathtt{R}} > 0$ and $\overline{\mu}^{\mathtt{R}} < 1$ immediately leads to the condition in the lemma. □

Now we are ready to prove Proposition 3.

Proof of Proposition 3. Assumption 1 and Lemma 1 guarantee that, in stationary strategies, each player either fights for sure or never fights in no-disaster periods. This observation and Lemma 2 imply that there are only three combinations of equilibrium strategies in our equilibrium concept (stationary MPE in pure strategies): (i) Neither attacks when $D_t = 0$;

(ii) Player 1 attacks when $D_t = 0$; and (iii) Player 2 attacks when $D_t = 0$, all with one-sided intervals of z_t under which players fight when $D_t = 1$. They correspond to strategy profiles (R) ($\mathtt{E}_1$), and ($\mathtt{E}_2$), respectively. Lemma 5 shows that there are regions of equilibrium multiplicity, $\left[\underline{\mu}^{\mathtt{R}}, \underline{\mu}^{\mathtt{E}}\right)$ and $(\overline{\mu}^{\mathtt{E}}, \overline{\mu}^{\mathtt{R}}]$. Finally, Lemma 6 implicitly specifies conditions under which the partition exists in $[0, 1]$. □

A.6 Proof of Corollary 1

Proof. By Proposition 1, we have

$$\begin{aligned}
\Pr\left(\text{Conflict at } t \text{ such that } D_t = 1 \text{ in case } (\mathtt{R})\right) &= \Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 1, \mu^{\mathtt{R}}\right) \\
&\in (0,1) \quad \text{and} \\
\Pr\left(\text{Conflict at } t \text{ such that } D_t = 0 \text{ in case } (\mathtt{R})\right) &= \Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 0, \mu^{\mathtt{R}}\right) \\
&= 0.
\end{aligned}$$

Similarly, Proposition 2 yields

$$\begin{aligned}
\Pr\left(\text{Conflict at } t \text{ such that } D_t = 1 \text{ in cases } (\mathtt{E}_1) \text{ or } (\mathtt{E}_2)\right) &= \Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 1, \mu^{\mathtt{E}}\right) \\
&\in (0,1) \quad \text{and} \\
\Pr\left(\text{Conflict at } t \text{ such that } D_t = 0 \text{ in cases } (\mathtt{E}_1) \text{ or } (\mathtt{E}_2)\right) &= \Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 0, \mu^{\mathtt{E}}\right) \\
&= 1.
\end{aligned}$$

which completes the proof. □

A.7 Proof of Corollary 2

Proof. This result follows directly from Bayes' rule. First, we can rewrite the left-hand side of the inequality $\left(\Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}} | Y_t^{\mathtt{game}} = 1, D_t = 0\right)\right)$ as follows.

$$
\begin{aligned}
& \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}} \middle| Y_t^{\mathtt{game}} = 1, D_t = 0\right) \\
= \; & \frac{\Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 0 | \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}{\begin{array}{l}\Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 0 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) + \\ \Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 0 \middle| \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right) \left(1 - \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)\right)\end{array}} \\
= \; & \frac{\overbrace{\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 0, \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{=1} \overbrace{\Pr\left(D_t = 0 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{=1-\pi} \overbrace{\Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{\in(0,1)}}{\begin{array}{l}\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 0, \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(D_t = 0 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) + \\ \underbrace{\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 0, \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right)}_{=0} \underbrace{\Pr\left(D_t = 0 \middle| \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right)}_{=1-\pi} \underbrace{\left(1 - \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)\right)}_{\in(0,1)}\end{array}} \\
= \; & 1.
\end{aligned}
$$

Similarly, we have

$$
\begin{aligned}
& \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}} \middle| Y_t^{\mathtt{game}} = 1, D_t = 1\right) \\
= \; & \frac{\Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 1 | \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}{\begin{array}{l}\Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 1 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) + \\ \Pr\left(Y_t^{\mathtt{game}} = 1, D_t = 1 \middle| \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right) \left(1 - \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)\right)\end{array}} \\
= \; & \frac{\overbrace{\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 1, \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{\in(0,1)} \overbrace{\Pr\left(D_t = 1 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{=\pi} \overbrace{\Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)}^{\in(0,1)}}{\begin{array}{l}\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 1, \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(D_t = 1 \middle| \mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right) + \\ \underbrace{\Pr\left(Y_t^{\mathtt{game}} = 1 \middle| D_t = 1, \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right)}_{\in(0,1)} \underbrace{\Pr\left(D_t = 1 \middle| \mu^{\mathtt{RV}} \notin M^{\mathtt{E}}\right)}_{=\pi} \underbrace{\left(1 - \Pr\left(\mu^{\mathtt{RV}} \in M^{\mathtt{E}}\right)\right)}_{\in(0,1)}\end{array}} \\
< \; & 1,
\end{aligned}
$$

which yields the desired result. □

A.8 Proof of Corollary 3

Proof. By Corollary 1 and the identity $Y_{dt}^{\texttt{data}} = D_{dt}Y_{dt}^{\texttt{PO}}(1) + (1 - D_{dt})Y_{dt}^{\texttt{PO}}(0)$, direct substitutions yield part (i) of the statement:

$$\begin{aligned}
& \Pr\left(Y_t^{\texttt{game}} = 1 \middle| D_t = 1, \mu^{\texttt{R}}\right) > \Pr\left(Y_t^{\texttt{game}} = 1 \middle| D_t = 0, \mu^{\texttt{R}}\right) \\
\overset{\text{Assumption 3}}{\Longrightarrow} \quad & \Pr\left(Y_{dt}^{\texttt{data}} = 1 \middle| D_{dt} = 1, \mu^{\texttt{R}}\right) > \Pr\left(Y_{dt}^{\texttt{data}} = 1 \middle| D_{dt} = 0, \mu^{\texttt{R}}\right) \\
\Longrightarrow \quad & \Pr\left(Y_{dt}^{\texttt{PO}}(1) = 1 \middle| \mu^{\texttt{R}}\right) > \Pr\left(Y_{dt}^{\texttt{PO}}(0) = 1 \middle| \mu^{\texttt{R}}\right).
\end{aligned}$$

Part (ii) is derived in the same manner. □

A.9 Proof of Corollary 4

Proof. From the discussion in the main text, we know

$$\tau \in \left[\tau\left(\mu^{\texttt{R}}\right) q^{\texttt{R}} + \tau\left(\mu^{\texttt{E}}\right)\left(1 - q^{\texttt{R}}\right), \tau\left(\mu^{\texttt{R}}\right) q^{\texttt{E}} + \tau\left(\mu^{\texttt{E}}\right)\left(1 - q^{\texttt{E}}\right)\right],$$

where the minimum and maximum are obtained by letting $\tilde{q} = 0$ and $\tilde{q} = 1$, respectively. Then, rearranging $\tau\left(\mu^{\texttt{R}}\right) q^{\texttt{E}} + \tau\left(\mu^{\texttt{E}}\right)\left(1 - q^{\texttt{E}}\right) < 0$ yields the result, which guarantees $\tau < 0$. □

A.10 Proof of Corollary 5

Proof. Denote $\mathcal{P}(\texttt{E}) = \min\{\mathcal{P}(\texttt{E}_1), \mathcal{P}(\texttt{E}_2)\}$, and denote the CDFs corresponding the two cases by $F_{\texttt{R}}$ and $F_{\texttt{E}}$, respectively. Then, $\mathcal{P}(\texttt{R})$ and $\mathcal{P}(\texttt{E})$ are given as

$$\begin{aligned}
\mathcal{P}(\texttt{R}) &= (1 - \pi) \times 0 + \pi \left(\underbrace{F_{\texttt{R}}\left(\underline{z}^{\texttt{R}}\right)}_{\text{Player 2 fights}} + \underbrace{1 - F_{\texttt{R}}\left(\overline{z}^{\texttt{R}}\right)}_{\text{Player 1 fights}} \right) \\
\mathcal{P}(\texttt{E}) &= (1 - \pi) \times 1 + \pi \left(F_{\texttt{E}}\left(\underline{z}^{\texttt{E}}\right) + 1 - F_{\texttt{E}}\left(\overline{z}^{\texttt{E}}\right)\right).
\end{aligned}$$

Then, rearranging $\mathcal{P}(\mathtt{R}) < \mathcal{P}(\mathtt{E})$ yields

$$\pi \left(1 + \Delta_{F_{\mathtt{E}}}\left(\overline{z}^{\mathtt{E}}, \underline{z}^{\mathtt{E}}\right) - \Delta_{F_{\mathtt{R}}}\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)\right) < 1.$$

Because $\Delta_{F_{\mathtt{E}}}\left(\overline{z}^{\mathtt{E}}, \underline{z}^{\mathtt{E}}\right) - \Delta_{F_{\mathtt{R}}}\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)$ cannot exceed one for any $F_{\mathtt{R}}$ and $F_{\mathtt{E}}$, the above inequality holds whenever $\pi < 1/2$. $\square$

B Existence and Uniqueness of Equilibrium

Here, we discuss details on the existence of equilibria and the conditions under which uniqueness holds. Below, uniqueness means the uniqueness of the cutoff strategies $\overline{z}^{\mathtt{eq}}, \underline{z}^{\mathtt{eq}}$ in disaster periods, where $\mathtt{eq} \in \{\mathtt{R}, \mathtt{E}_1, \mathtt{E}_2\}$. Proposition 3 shows that there are regions of equilibrium multiplicity in the sense that two of the three strategy profiles $(\mathtt{R}, \mathtt{E}_1, \mathtt{E}_2)$ coexist even if the equilibrium cutpoints are unique.

B.1 Strategic Complementarity

First, we introduce the following observation that, when one player becomes more willing to fight, the other does, too.

Lemma 7. *The subgame that starts from $D_t = 1$ features strategic complementarities.*

Proof. Denote by $\mathcal{V}_i$ player i's continuation payoff. Also, let $\overline{z}$ be Player 1's cutoff in Z_t above which she attacks Player 2 in a disaster period, and analogously, $\underline{z}$ be Player 2's cutoff. Below, focus on Player 1's decision-making.

Now suppose that $\underline{z}$ increases, i.e., Player 2 is more willing to fight after a disaster. Such an increase must weakly reduce $\mathcal{V}_1$. To see this, observe that, if Player 2 fights, Player 1 loses her option *not* to fight. When Player 1 would have preferred peace and would not have otherwise fought, then Player 2's attack must lower Player 1's continuation payoff. When

Player 1 would fight in any case, then Player 2's higher willingness to fight does not affect Player 1's payoff. Thus, $\mathcal{V}_1$ is weakly decreasing in $\underline{z}$.

Now recall that the cutoff $\overline{z}$ is defined as the value of Z_t such that $\overline{z}\theta+\delta\mathcal{V}_1 = \overline{z}\left[\theta(1-c)+\overline{\mathcal{V}}\right]$ holds, which yields $\overline{z} = \frac{\delta\mathcal{V}_1}{\theta\left[\delta\frac{2-\pi}{1-\delta}-c\right]}$. We have shown that $\mathcal{V}_1$ is weakly decreasing in $\underline{z}$, and this equality shows that a change in $\underline{z}$ affects the optimal $\overline{z}$ only through $\mathcal{V}_1$. Consequently, $\overline{z}$ is weakly decreasing in $\underline{z}$. An analogous logic shows that $\underline{z}$ is decreasing in $\overline{z}$. □

B.2 Equilibrium Existence

Proposition 4. *An equilibrium exists in the game.*

Proof. First, when $D_t = 0$, players merely compare θ plus the (discounted) continuation payoff and the war payoff, neither of which depends on Z_t. Because Assumption 1 excludes mixed strategies (Lemma 1), each player has a unique optimal action when $D_t = 0$.

Consider periods with $D_t = 1$. By Lemma 7 above and by Milgrom and Roberts (1990), any disaster-period game is a supermodular game. Hence, there exist extremal equilibria that are found by iterating the players' best-response functions starting from (i) the case where players always fight when $D_t = 1$ and (ii) the case where they never do so when $D_t = 1$. □

B.3 Condition for Optimal Cutoff Uniqueness

The result below shows that there exists a unique equilibrium when the density of Z_t is not too large around the equilibrium cutoffs.

Proposition 5. *Suppose*

$$f\left(\overline{z}^{eq}\right) f\left(\underline{z}^{eq}\right) < \min\left\{\begin{array}{l}\left(\dfrac{\left(1-\delta\left(1-\pi\left(1-\Delta_F\left(\overline{z}^R,\underline{z}^R\right)\right)\right)\right)\left(\delta\overline{\mathcal{V}}-c\theta\right)}{\delta\pi\sqrt{\delta\mathcal{V}_1^R-\underline{z}^R\left(\delta\overline{\mathcal{V}}-c\theta\right)}\sqrt{\delta\mathcal{V}_2^R-\left(1-\overline{z}^R\right)\left(\delta\overline{\mathcal{V}}-c\theta\right)}}\right)^2, \\ \left\{\left(\dfrac{\left(1-\delta\pi\Delta_F\left(\overline{z}^E,\underline{z}^E\right)\right)\left(\delta\overline{\mathcal{V}}-c\theta\right)}{\delta\pi\sqrt{\delta\mathcal{V}_1^E-\underline{z}^E\left(\delta\overline{\mathcal{V}}-c\theta\right)}\sqrt{\delta\mathcal{V}_2^E-\left(1-\overline{z}^E\right)\left(\delta\overline{\mathcal{V}}-c\theta\right)}}\right)^2\right\}_{E\in\{E_1,E_2\}}\end{array}\right\},$$

where $\texttt{eq} \in \{R, E_1, E_2\}$*. Then, the equilibrium cutoffs are uniquely determined, which leads to equilibrium uniqueness.*

Proof. We want to show that the mapping from an optimal cutpoint to an updated cutpoint, via the other player's best response to the former, is a contraction mapping so that the extremal equilibria converge to the unique fixed point. Consider Player 1 in the case (R). First, it is easy to see $\frac{\partial \overline{z}^{\mathtt{R}}}{\partial \mathcal{V}_1^{\mathtt{R}}} = \frac{\delta}{\theta\left[\delta\frac{2-\pi}{1-\delta} - c\right]}$. Next, because $\overline{z}^{\mathtt{R}}$ is the optimal cutpoint given $\underline{z}^{\mathtt{R}}$, the envelop theorem implies $\frac{\mathrm{d}\mathcal{V}_1^{\mathtt{R}}}{\mathrm{d}\underline{z}^{\mathtt{R}}} = \frac{\partial \mathcal{V}_1^{\mathtt{R}}}{\partial \underline{z}^{\mathtt{R}}}$, which is given by

$$\frac{\partial \mathcal{V}_1^{\mathtt{R}}}{\partial \underline{z}^{\mathtt{R}}} = -\pi f\left(\underline{z}^{\mathtt{R}}\right) \cdot \frac{\delta \mathcal{V}_1^{\mathtt{R}} - \underline{z}^{\mathtt{R}}\left(\delta\overline{\mathcal{V}} - c\theta\right)}{1 - \delta\left(1 - \pi\left(1 - \Delta_F\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)\right)\right)}.$$

Then, denoting $\overline{z}^{\mathtt{R}}$ as a function of $\underline{z}^{\mathtt{R}}$, we obtain

$$\begin{aligned}
\frac{\partial \overline{z}^{\mathtt{R}}\left(\underline{z}^{\mathtt{R}}\right)}{\partial \underline{z}^{\mathtt{R}}} &= \frac{\partial \overline{z}^{\mathtt{R}}}{\partial \mathcal{V}_1^{\mathtt{R}}} \cdot \frac{\partial \mathcal{V}_1^{\mathtt{R}}}{\partial \underline{z}^{\mathtt{R}}} \\
&= -f\left(\underline{z}^{\mathtt{R}}\right) \cdot \frac{\delta\pi\left(\delta \mathcal{V}_1^{\mathtt{R}} - \underline{z}^{\mathtt{R}}\left(\delta\overline{\mathcal{V}} - c\theta\right)\right)}{\left(1 - \delta\left(1 - \pi\left(1 - \Delta_F\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left(\delta\overline{\mathcal{V}} - c\theta\right)}.
\end{aligned}$$

Analogously, for Player 2, we have

$$\begin{aligned}
\frac{\partial \underline{z}^{\mathtt{R}}\left(\overline{z}^{\mathtt{R}}\right)}{\partial \overline{z}^{\mathtt{R}}} &= \frac{\partial \underline{z}^{\mathtt{R}}}{\partial \mathcal{V}_2^{\mathtt{R}}} \cdot \frac{\partial \mathcal{V}_2^{\mathtt{R}}}{\partial \overline{z}^{\mathtt{R}}} \\
&= -f\left(\overline{z}^{\mathtt{R}}\right) \cdot \frac{\delta\pi\left(\delta \mathcal{V}_2^{\mathtt{R}} - \left(1 - \overline{z}^{\mathtt{R}}\right)\left(\delta\overline{\mathcal{V}} - c\theta\right)\right)}{\left(1 - \delta\left(1 - \pi\left(1 - \Delta_F\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left(\delta\overline{\mathcal{V}} - c\theta\right)}.
\end{aligned}$$

By the contraction mapping theorem, the optimal cutoff given the other player's cutoff converges to a unique fixed point when

$$\begin{aligned}
\frac{\partial \overline{z}^{\mathtt{R}}\left(\underline{z}^{\mathtt{R}}\right)}{\partial \underline{z}^{\mathtt{R}}} \cdot \frac{\partial \underline{z}^{\mathtt{R}}\left(\overline{z}^{\mathtt{R}}\right)}{\partial \overline{z}^{\mathtt{R}}} &< 1 \\
f\left(\overline{z}^{\mathtt{R}}\right) f\left(\underline{z}^{\mathtt{R}}\right) &< \left(\frac{\left(1 - \delta\left(1 - \pi\left(1 - \Delta_F\left(\overline{z}^{\mathtt{R}}, \underline{z}^{\mathtt{R}}\right)\right)\right)\right)\left(\delta\overline{\mathcal{V}} - c\theta\right)}{\delta\pi\sqrt{\delta \mathcal{V}_1^{\mathtt{R}} - \underline{z}^{\mathtt{R}}\left(\delta\overline{\mathcal{V}} - c\theta\right)}\sqrt{\delta \mathcal{V}_2^{\mathtt{R}} - \left(1 - \overline{z}^{\mathtt{R}}\right)\left(\delta\overline{\mathcal{V}} - c\theta\right)}}\right)^2.
\end{aligned}$$

Finally, recall that Assumption 1 imposes a unique optimal action in no-disaster periods. Consequently, when the above inequality holds, there exists a unique equilibrium in the game. We can derive the conditions for cases ($\mathtt{E}_1$) and ($\mathtt{E}_2$) in the same manner. $\square$

C Allowing Bargaining

For simplicity, the model in the main text assumes that players do not bargain over resources to avoid an inefficient conflict. Here, I show that the key insights of the model hold even when we allow players to bargain. Now assume that, in each period, players have an arbitrary bargaining protocol between Nature's move and their decision-making about war. During this bargaining process, they can transfer the resources they possess in the given period. Namely, in a no-disaster period, each player can offer up to θ to the other. In a disaster period, Players 1 and 2 can transfer up to $z_t\theta$ and $(1 - z_t)\theta$, respectively. Hence, a player can obtain a flow payoff up to θ (disaster period) or 2θ (no-disaster period) as a result of bargaining. In summary, the timeline for each period of the game with bargaining is as follows.

1. Nature draws D_t and Z_t.
2. Players observe D_t and Z_t, and bargain over the division of the pie (θ when $D_t = 1$ and 2θ when $D_t = 0$) via an arbitrary protocol.
3. Players decide whether or not to attack the other.

C.1 Opportunistic Motive

It is intuitive that the possibility of bargaining should expand the prospect of peace because (i) the militarily disadvantaged side can offer the remaining resources to the advantaged side and (ii) the side that is more robust to disasters can compensate the vulnerable player in a no-disaster period in order to avoid an inefficient conflict. Thus, rather than constructing a specific equilibrium with bargaining, we are interested in whether there can be a completely peaceful equilibrium in which war never occurs. If war is still possible on the equilibrium path, the key observations in the main text still hold.

Definition 1. A *peaceful equilibrium* is a subgame perfect equilibrium in which no player attacks the other side on the equilibrium path.

The following result shows that the opportunistic motive for conflict remains, as long as the cost of war is sufficiently small and Z_t can take extreme values close enough to zero or one.

Proposition 6. *Suppose (i) the cost of conflict, c, is sufficiently small and (ii) Z_t has full support over* $[0, 1]$. *Then, a peaceful equilibrium does not exist in the game with bargaining, where war occurs due to an opportunistic aggression at t such that $D_t = 1$.*

Proof. Suppose to the contrary that there exists a peaceful equilibrium. To derive a contradiction, focus on Player 1's decision-making when $D_t = 1$. Denote her continuation in the peaceful equilibrium by $\mathcal{V}_1^{\texttt{peace}}$. First, observe $\mathcal{V}_1^{\texttt{peace}} < \overline{\mathcal{V}}$. To see this, recall that $\overline{\mathcal{V}} = \frac{\theta(2-\pi)}{1-\delta}$ is the long-term payoff that the victor in war receives, where she is assumed to dominate all the resources (i.e., $Z_t\theta + (1 - Z_t)\theta = \theta$ or $\theta + \theta = 2\theta$) in the society for an infinite number of periods. This quantity also represents the pie to be divided via bargaining between players. Thus, $\mathcal{V}_1^{\texttt{peace}} = \overline{\mathcal{V}}$ would imply Player 2 receives a flow payoff of zero every period. However, observe that the minmax payoff that Player 2 can secure each period is

$$\mathcal{W}_2^{\texttt{d}}(z_t) = (1 - z_t)\left(\theta(1 - c) + \delta\overline{\mathcal{V}}\right) > 0 \quad \text{or} \quad \mathcal{W}_2^{\neg\texttt{d}} = \frac{1}{2}\left(2\theta(1 - c) + \delta\overline{\mathcal{V}}\right) > 0.$$

The strictly positive minmax payoffs of Player 2 imply that, to sustain a peaceful equilibrium, Player 1 has to offer a strictly positive amount of resources. Otherwise, Player 2 would unilaterally deviate to conflict, and peace would break down. This establishes $\mathcal{V}_1^{\texttt{peace}} < \overline{\mathcal{V}}$.

We consider Player 1's decision-making in a disaster period to check if a peaceful equilibrium exists based on the one-shot deviation principle. By maintaining peace under an arbitrary bargaining protocol, Player 1 can earn at most $z_t\theta + (1 - z_t)\theta + \delta\mathcal{V}_1^{\mathsf{peace}}$ in a disaster period. Then, rearranging $\theta + \delta\mathcal{V}_1^{\mathsf{peace}} \geq \mathcal{W}_1^{\mathsf{d}}(z_t) = z_t\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right)$ yields

$$\theta(1 - z_t) + \delta\mathcal{V}_1^{\mathsf{peace}} \geq z_t\left(\delta\overline{\mathcal{V}} - \theta c\right).$$

Observe that, as z_t approaches one, the left-hand side and the right-hand side converge to $\delta\mathcal{V}_1^{\mathsf{peace}}$ and $\delta\overline{\mathcal{V}} - \theta c$, respectively. Then, by $\mathcal{V}_1^{\mathsf{peace}} < \overline{\mathcal{V}}$ and by the assumption of full support, if c is sufficiently small, there exists a value of z_t above which the inequality does not hold and Player 1 attacks Player 2 in a disaster period. This violates the one-shot deviation principle, which is a contradiction with the assumption that a peaceful equilibrium exists. □

C.2 Preemptive Motive

Next, we are interested in whether the insights in the second, asymmetric case still hold under bargaining. The following result shows that, when one of the players is disproportionately vulnerable to future disasters, the preemptive motive for conflict remains in the game with bargaining.

Proposition 7. *Suppose (i) the discounting factor, δ, and the probability of a disaster, π, are sufficiently large. Then, there exist values of μ under which a peaceful equilibrium does not exist in the game with bargaining, where war occurs due to a preemptive aggression at t such that $D_t = 0$.*

Proof. Focus on Player 1's decision-making in any subgame that starts from a period such that $D_t = 0$. We apply Powell's inefficiency condition (Powell, 2004). Proposition 1 of Powell (2004) shows that there cannot be an efficient equilibrium in a stochastic game with complete information and bargaining when a player's minimax payoff is greater than the difference between (i) the pie to be divided and (ii) the other player's largest concession in the current state and her (discounted) expected minimax payoff. To represent the inefficiency condition in the context of the current model, let $\mathcal{W}_2(d, z)$ be Player 2's war payoff when $D_t = d$ and $Z_t = z$.

Then, we can express the inefficiency condition when $D_t = 0$ as

$$\underbrace{\mathcal{W}_1^{\neg\mathtt{d}}}_{\text{P1's minmax payoff when } D_t=0} > \underbrace{\overline{\mathcal{V}}}_{\text{Pie to be divided}} - \left(\underbrace{0}_{\text{P2's largest concession}} + \underbrace{\delta \mathbb{E}_{D_t, Z_t}\left[\mathcal{W}_2(D_t, Z_t)\right]}_{\text{P2's (discounted) expected minmax}} \right)$$

This leads to

$$\begin{aligned}
\mathcal{W}_1^{\neg\mathtt{d}} &> \overline{\mathcal{V}} - \delta\left((1-\pi)\mathcal{W}_2^{\neg\mathtt{d}} + \pi \mathbb{E}_{Z_t}\left[\mathcal{W}_2^{\mathtt{d}}(Z_t)\right]\right) \\
&= \overline{\mathcal{V}} - \delta\left((1-\pi)\mathcal{W}_2^{\neg\mathtt{d}} + \pi \int_0^1 (1-z)\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right) f(z)\mathrm{d}z\right) \\
&= \overline{\mathcal{V}} - \delta\left((1-\pi)\mathcal{W}_2^{\neg\mathtt{d}} + \pi(1-\mu)\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right)\right).
\end{aligned}$$

Given that $\mathcal{W}_1^{\neg\mathtt{d}} = \mathcal{W}_2^{\neg\mathtt{d}} = \frac{1}{2}\left(2\theta(1-c) + \delta\overline{\mathcal{V}}\right)$, rearranging the inequality yields

$$\mu < \frac{\overline{\mathcal{V}}\left[\frac{1}{2}\delta\left(1 + \delta(1+\pi)\right) - 1\right] + \theta(1-c)(1+\delta)}{\delta\pi\left(\theta(1-c) + \delta\overline{\mathcal{V}}\right)}.$$

Observe that both the denominator and the second term of the numerator are strictly positive and that the first term of the numerator is positive when δ and π are sufficiently large, which completes the proof. □

D Supplementary Information for Empirical Implications

D.1 Distribution of Water Abundance in Conflict Locations

Recall that Implication 1 predicts the distribution of belligerent group types given a violent event and the level of water abundance. Namely, if the theory is consistent with real-world data, then the observation (of a violent event) should be more likely to have the government as one of the belligerents when water abundance is high (absence of drought).

Figure 8 represents the distribution of the PDSI value for each observation by country. Higher values in the horizontal axis indicate water abundance (high PDSI scores). The curve shaded in red represents the case where one of the parties is the government ($\texttt{gov}_{dt} = 1$), and the blue area denotes non-state-actor dyads ($\texttt{gov}_{dt} = 0$). Intuitively, the theory predicts that the "red" areas should tend to be located to the right compared to the "blue" areas. This is because, based on the theory, conflict between groups with asymmetric robustness is more likely to occur under water abundance (absence of a natural disaster) due to the prevalence of the preemptive motive.

While the logistic regression at the aggregate level in the main text confirms the consistency of the theory and the data, as Figure 8 shows, I report that there exists variation by country. For example, the distributions of the PDSI scores of Mauritania, Sierra Leone, Somalia, and South Africa seem to align with the theory. On the other hand, countries such as Cameroon, Namibia, and Zimbabwe display patterns inconsistent with the theory.

D.2 Excluding "Extremely Wet" Observations

The PDSI defines scores larger than four as "extremely wet" conditions. Recall that we have treated observations with larger PDSI scores as cases without a natural disaster (drought). However, an extremely high value of PDSI can imply other types of climate disasters, such

	Dependent variable: $\texttt{gov}_{dt}$			
	(1)	(2)	(3)	(4)
$\texttt{PDSI}_{d,t-1} \leq 4$	0.024^{***}	0.022^{***}		0.015^{**}
	(0.005)	(0.005)		(0.006)
Distance to capital (standardized)		0.068^{***}		0.067^{***}
		(0.011)		(0.011)
$\texttt{PDSI}_{dt} \leq 4$			0.021^{***}	0.012^{*}
			(0.004)	(0.005)
Constant	0.747^{***}	0.747^{***}	0.743^{***}	0.749^{***}
	(0.011)	(0.011)	(0.011)	(0.011)
Observations	41,932	41,932	41,932	41,932

Note: $^{\dagger}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Table 3: Results excluding "extremely wet" observations

as storms and floods. Hence, the results in the main text might not appropriately reflect the theory. To address this issue, I excluded observations with $\texttt{PDSI}_{d,t-1} > 4$ or $\texttt{PDSI}_{dt} > 4$ and used the same logistic regression. As Table 3 shows, we still obtain similar results. Namely, an event of political violence under water scarcity (i.e., climate disaster) still predicts that the belligerents constitute a dyad with asymmetric robustness (i.e., the government forces and nonstate armed groups).

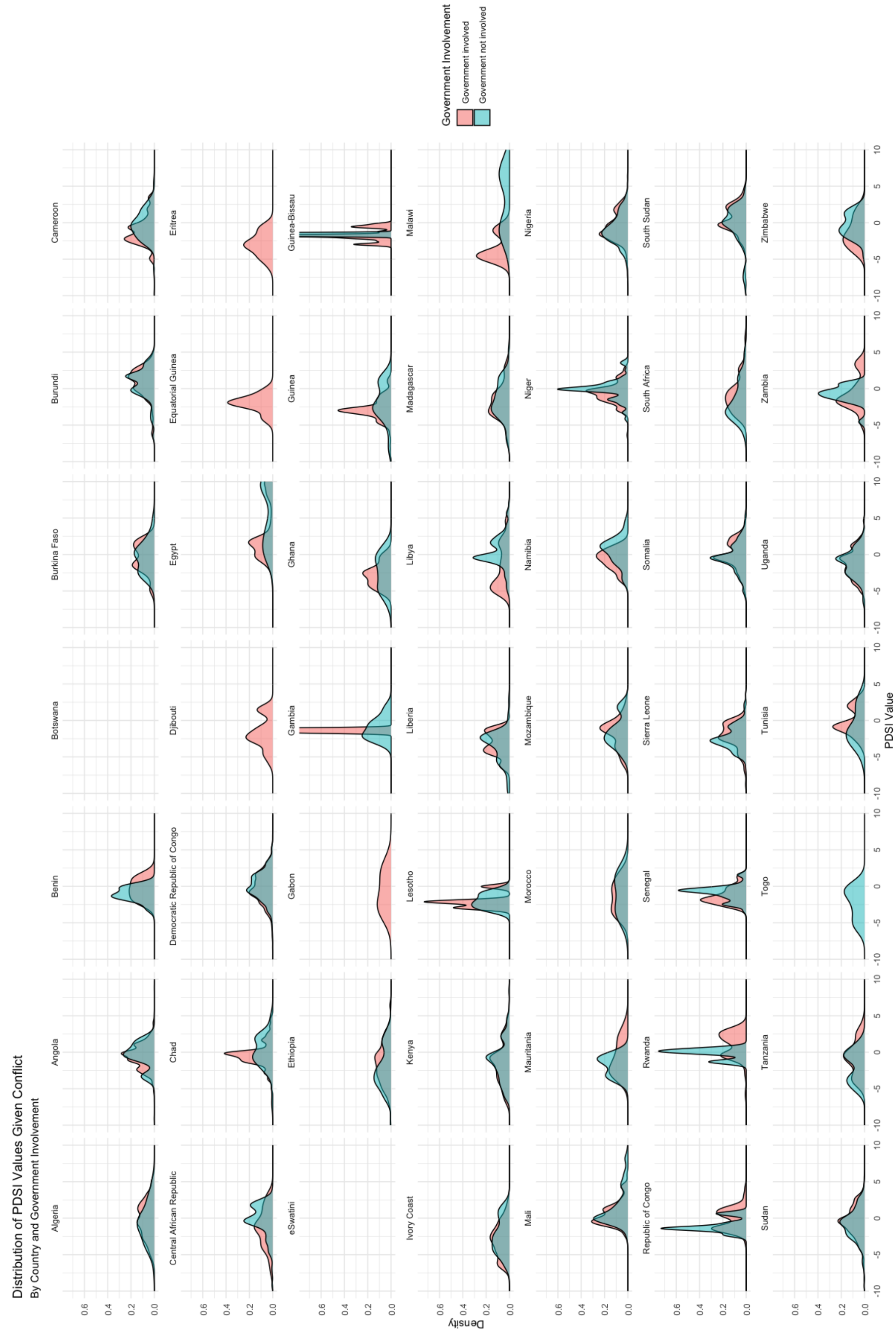

Figure 8: Distribution of PDSI values in conflict locations by country (red: $\texttt{gov}_{dt} = 1$)