Hot Under the Collar: A Latent Measure of Interstate Hostility

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Abstract

Studies on conflict escalation use a variety of measures of hostility including the use of force, reciprocity, and the number of fatalities. The use of different measures, however, leads to different empirical results and creates difficulties when testing existing theories of interstate conflict. This paper presents a new measure of interstate hostility, created using latent variable modeling and data on international interactions from a number of sources. The model I construct (1) provides a granular, conceptually precise, and validated measure of hostility, (2) allows for the systematic evaluation of how existing measures relate to the construct of hostility and (3) enables for accurate predictions of conflict dynamics. The model will enhance the ability of researchers to understand factors affecting escalation and de-escalation processes.

1 Introduction

Despite the existence of relatively large body of theoretical and empirical studies on conflict escalation, there is still no consensus among international relations scholars on why some interstate disputes lead to war while other do not. One of the explanations for this is the lack of the agreement on a measure of escalation itself. For instance, Schultz (2001), in his model of signaling behavior, operationalizes conflict escalation using three: the reciprocation of force, the mutual use of force, and war. Palmer, London and Regan (2004) argue that the concept of escalation cannot be measured directly. In their study on effects of the domestic constraints on international conflict behavior, they use two variables: disputes that have more than twenty-five battle fatalities, and the reciprocation by the target at a level of

hostility at least as high as the initiator's first action. Finally, in order to test the effect of international trade on interstate conflict escalation in Asia and the Pacific, Goldsmith (2013) uses disputes that have incurred over two hundred-fifty battle-related deaths. While it is possible that different operationalizations are useful in answering different questions related to the topic, the existence of a theoretically motivated and valid measurement model would not only allow us to adjudicate between competing theoretical explanations for why some conflicts escalate while others do not, but also enhance researchers' ability to explain and predict conflict dynamics processes. The question that arises then is how to measure conflict escalation.

This paper looks at escalation of interstate conflict in terms of a change in the hostility level of the dispute. However, this approach requires a granular and validated measure of a hostility - a variable we cannot observe directly, but manifestations of which we can study. In this paper, I create a latent measure of interstate hostility by applying Bayesian ordinal item-response theory (O-IRT) model to a conflict events dataset, which I have created using data from Militarized Interstate Disputes (MID), Integrated Crisis Early Warning System (ICEWS), and International Crisis Behavior (ICB) datasets.

This project makes important contributions to political science research. First, the model presented in this article combines several conflict data collections, such as MIDs, ICB, and one of the most recent and largest events datasets - ICEWS. As a result, it provides a range of states' conflict interactions starting from verbal expressions of hostility to full-scale warfare.

Second, it allows for the systematic evaluation of how existing measures relate to the construct of hostility. By integrating some of these measures, this model enables one to make inferences about their quality *inter alia* (Jackman, 2009).

Third, the novel measure of hostility helps to answer theoretical questions related to the conflict dynamic processes. For example, it allows us not only to identify factors that increase probability of escalation or de-escalation, but also to study the effect of interstate hostility on terrorism.

This paper proceeds as follows. First, I will review the literature on interstate conflict escalation. Second, I will discuss existing measures of hostility/dispute severity. Third, I will apply Bayesian ordinal item-response theory (O-IRT) model to a conflict events dataset, which I have created using data from MIDs, ICEWS, and ICB datasets. Fourth, I will validate the new measure of hostility by linking it to the use transnational terrorism.

2 Literature Review

The concept of escalation is central to the numerous theories of conflict including democratic peace (Maoz and Abdolali, 1989; Senese, 1997; Dixon and Senese, 2002; Huth and Allee, 2002), deterrence theory (Brams and Kilgour, 1987; Huth and Russett, 1988; Geller, 1990), bargaining theory (Schelling, 1960, 1966; Snyder and Diesing, 1977; Fearon, 1994, 1995), the steps-to-war explanation (Vasquez and Henehan, 2001; Vasquez, 1996, 1987; Vasquez and Gibler, 2001; Senese and Vasquez, 2003, 2008; Gibler, 1996, 1997), power preponderance explanation (Kenneth, 1979; Moul, 1988), and power transition theory (Organski and Kugler, 1981; Lemke and Reed, 1996; Lemke, 2002).

Most of the early attempts to address the question of escalation, however, have been concerned with escalation of the dispute to war thus often ignoring dynamics of states' interactions short of war. Nevertheless, there are strong reasons to believe that states are likely to use different rates of escalation depending on their perceptions of their adversaries' capabilities, issue at stake or information they try to convey with escalation as a signal about their willingness to bear the fighting costs (Carlson, 1995, 514).

Few studies look at the effect of the operationalization of conflict escalation on what we learn about the concept. The importance of measurement in conflict studies, however, was emphasized in a study conducted by Braithwaite and Lemke (2011), who compare a variety of measures of escalation in their test of five correlates associated with conflict escalation. The list of the correlates include regime type, issue at stake, satisfaction of a state with status

quo, power preponderance, joint alliance membership. Braithwaite and Lemke (2011) use six measures of conflict escalation, which are based on the information from the Militarized Interstate Dispute (MID) Dataset and include: reciprocation of act in the dispute; use of force; mutual use of force; and the number of fatalities with thresholds at 0, 250 and 1000 battle-deaths. They found that among five considered causes of escalation only territory as an issue at stake has been a consistent predictor of the dependent variable.

This finding illustrates that the absence of a conceptually precise and validated measure of conflict escalation hinders our understanding of escalation processes. Furthermore, the majority of existing measures are based on states' behavior once militarized conflict has already started (and often when the use of force has already occured) thus completely ignoring states' interaction before militarization of the dispute. As a result, we are not aware of the processes that lead from non-militarized threat or accusation to the armed conflict. This can be important, for example, in the case of rivalry, when states perceive each other as enemies and the source of a threat that is likely to be militarized in the future (Thompson, 2001). The measure of escalation, which can capture non-militarized conflict interactions can be useful in identifying the reasons why some militarized disputes lead to war but also why some conflicts become militarized while others stay at the same level or get resolved.

In order to address this issue, I make two theoretical assumptions. First, conflict escalation is an increase in the level of dispute hostility. Zinnes and Muncaster (1984) define the level of hostility in the system as "the intensity of hostility that ... nations "feel" toward any other nation in the defined system at the time t"(p.188). In this paper, I focus on the dyadic level and, thus, define the level of hostility as an intensity of hostility states in a dyad "feel" toward each other. Similarly to Zinnes and Muncaster (1984), I assume that hostility is a continious variable and varies relatively smoothly over time.

Second, hostility is a latent trait, which can be estimated using observed outcomes - disputes. While the idea of disputes as manifestations of states' hostile behavior is not new in the conflict literature (Klein, Goertz and Diehl, 2006; Zinnes and Muncaster, 1984), this

project is the first, to my knowledge, that directly incorporates this theoretical assumption into the empirical model.

3 Hostility and Conflict Escalation

Hostility is a hardly new concept in the conflict escalation literature. In particular, there are numerous studies that operationalize escalation using the level of hostility in the dispute (Palmer, London and Regan, 2004; Bueno de Mesquita and Lalman, 2008; Schultz, 2001; Senese, 1996). However, there is a variation in the use of this term in the international conflict literature. For example, while Senese (1997) distinguishes between the level of hostility in the dispute, based on the nature of states' actions, and the level of severity, based on the number of battle deaths incurred by both sides, Maoz (1982) and Diehl and Goertz (2001) use these two terms almost interchangeably. Therefore, in this section, I am going to discuss measures of hostility and severity and as they are both used in operationalization of conflict escalation.

The most widely used measure of hostility, the COW Militarized Interstate Disputes (MID) dataset (Palmer et al., 2015), contains 5-level scale of hostility, starting from the absence of militarized action to full-scale war (Table 1). One of the major concerns related to this scale, however, is a lack of theoretical and empirical evidence for its ordinal character (Diehl and Goertz, 2001; Maoz, 1982). For example, does blockade necessarily indicate more hostile behavior that the explicit threat to use force? Is a seizure a more hostile act than the mobilization of troops? Furthermore, in this 5-level scale, blockade and occupation of territory are almost equally important in states' interaction behavior which might not be the case in the real world.

Maoz (1982) converted the COW ordinal hostility scale into a 14-category scale interval measure of dispute severity with the threat to blockade as the least severe and war as the most severe actions. His measure is based on three assumptions. First, there is an order in

TABLE 1: *MID Hostility Scale*

Hostility level	**Action**
1 = No militarized action	No militarized action
2 = Threat to use force	Threat to use force
	Threat to blockade
	Threat to occupy territory
	Threat to declare war
	Threat to use CBR weapons
	Threat to join war
3 = Display of force	Show of force
	Alert
	Nuclear alert
	Mobilization
	Fortify border
	Border violation
4 = Use of force	Blockade
	Occupation of territory
	Seizure
	Attack
	Clash
	Declaration of war
	Use of CBR weapons
5 = War	Begin interstate war
	Join interstate war

patterns of dispute escalation and de-escalation. Second, the higher the frequency with which two consecutive militarized actions are followed by each other, the closer they are related in terms of severity. Third, disputes involving at least one major power are representative of the larger population of disputes with respect to severity.

Crisis severity concept is also embedded in the ICB dataset, in which crises are described using seven dimensions: (1) source or trigger mechanism, (2) gravity, (3) complexity, (4) intensity, (5) duration, (6) communication pattern, and (7) the outcome (Brecher, 1977). Note that majority of these dimensions do not reflect crisis actors' behavior. In addition, *Gravity* dimension already contains potential cause of a crisis which might lead to the confounding problem when used in the measurement model (Diehl and Goertz, 2001).

In their attempt to construct more precise indicators of dispute severity that would

capture low-level conflicts, Diehl and Goertz (2001) came up with their own interval-level-200-scale measure of dispute severity, based on the level of hostility and number of fatalities provided by the MID (Jones, Bremer and Singer, 1996) and COW war data sets (Sarkees and Wayman, 2010). The distinct feature of this measure is the fact that wars and non-war MIDs are scaled together, thus providing a range in levels of severity even among wars (Diehl and Goertz, 2001).

4 Limitations of the existing measures and solution

All of the measures outlined above rely almost solely on MID and ICB data sets, which focus mainly on militarized conflicts. As a result, the conflict escalation variables constructed using these suffer from the problem discussed in the previous section: they lack the information on states' interaction prior to the conflict militarization. Furthermore, as Diehl and Goertz (2001) acknowledge, the existing measures of hostility/dispute severity are often crude and do not allow researchers to make any inferences on relatively small changes in conflict dynamics. The example they discuss is the rivalry behavior. As the militarized dispute data provides the information about the rivalry only at the time of the armed conflict, the use of finer-grained data can provide a more precise picture of rivalry (Diehl and Goertz, 2001, 265).

I solve this problem by combining MID and ICB datasets with the most recent machine-coded conflict event datasets, Integrated Crisis Early Warning System (ICEWS) (O'brien, 2010). The ICEWS program was designed to help US military commanders to monitor, analyze, and predict a variety of crises including both international and domestic conflicts. It provides information on states' both cooperative and conflict behavior, including conflicts short of the threshold for militarized interstate disputes. The only possible disadvantage of using this data set is the fact that machine-coded data is often noisy. For instance, by having analyzed the ability of the machine coders to reproduce militarized interstate incidents data, D'Orazio et al. (2016) found that the accuracy, meaning initiator, target, and actor were

coded correctly, was less than forty percent.

5 Latent measure of hostility

The model, I construct in this article, assumes that hostility is a unidimensional trait that can be measured only using observed outcomes. I employ an item-response theory (IRT) model, which is a type of latent variable model used to generate estimates of a latent trait of interest (hostility) by combining information from observable items or manifest variables (conflict events). It has been used increasingly in political science enabling researchers to estimate the number of unobservable concepts.[1]

In this study, I use dyad-year as a unit of analysis. In particular, I focus on politically relevant undirected dyads from 1993 to 2010. The choice of the time is explained by the availability of datasets the latent measure of hostility is based on. Some of the manifest variables (described later) are ordinary. Therefore, I use the ordinal item-response model (O-IRT). A similar model was used, for example, by Treier and Jackman (2008) in their study on modeling democracy as a latent variable.

In the remainder of this section I discuss the data sources and the modeling strategy I use to create the latent measure of hostility. Furthermore, I will describe the model output, results of the posterior predictive checks and predictive validity check.

5.1 Data

I incorporate fifteen variables I use in my model obtained from three data sets: Militarized Interstate Incident Data (Palmer et al., 2015), ICB (Brecher, 1977), and ICEWS (O'brien, 2010) (summarized in Table 2).

For the purpose of this project, I use incident-level MID data. A militarized incident is

[1]See Poole and Rosenthal (1991); Poole (2005); Martin and Quinn (2002); Voeten and Brewer (2006); Treier and Jackman (2008); Fariss (2014); Schnakenberg and Fariss (2014)

defined as a "single military action involving an explicit threat, display, or use of force by one system member state towards another system member state" (Jones, Bremer and Singer, 1996). Use of incident- rather than dispute-level data allows me to get a more granular measure on interstate hostility. The information comes from the Militarized Interstate Incident (MII) data set, which covers disputes from 1993 to 2010. The variables include: *Threat to use force, Show of force, Alert, Mobilization, Fortify border, Border violation, Blockade, Occupation of territory, Seizure, Attack, Clash*, and *Join interstate war*.[2] All the variables in the original data set are binary. However, I incorporated the data on fatalities in the variables indicating the use of force: *Attack, Clash* and *Begin interstate war*.

In case of *Attack* and *Clash*, I assigned 0 to the variables, if no attack/clash occurred; 1 - if the attack/clash occured, the number of fatalities is known and equal to 0; 2 - if the attack/clash occured, but the number of fatalities is unknown; and 3 - if the attack/clash lead to fatalities. *Begin interstate war* is equal to 0 if action is absent, 1 - with beginning of war present but the number of fatalities is missing, and 2 - if there were fatalities (Table 2).

TABLE 2: *Combination of fatalities and variables indicating the use of force*

	Attack	*Clash*	*Begin interstate war*
Level 0	No attack	No clash	No beginning of war
Level 1	Attack, no fatalities	Clash, no fatalities	Beginning of war, data on fatalities is missing
Level 2	Attack, data on fatalities is missing	Clash, data on fatalities is missing	Beginning of war with fatalities
Level 3	Attack with fatalities	Clash with fatalities	

Such MID's actions as nuclear alert, declaration of war, and joining interstate war were excluded from the list of variables due to the lack of variation within the time period of interest.

Crisis management technique indicates the primary technique states use in a crisis. The

[2] *Threat to use force* variable combines threat to use force, threat to blockade, threat to occupy territory, threat to declare war, threat to use CBR weapons, and threat to join war.

information on this variable comes from the ICB data set. The nature of this variable is ordinal ranging from pacific techniques, such as negotiation and arbitration, to full-scale violence. At lower levels of hostility, I expect this variable to be at the lowest level of negotiation while violent acts would correspond to the high level of hostility.

Finally, *Verbal conflict* and *Material conflict* are quad categories from the ICEWS dataset. Quad categories represent a high level of aggregation of Conflict and Mediation Event Observations (CAMEO) framework. *Verbal conflict* variable indicates such actions as demand, disapproval, rejection, threat and protest, while *Material conflict*'s category includes exhibition of force posture, reduction in relations, coercion, assault, fight, and engagement in unconventional mass violence (Gerner et al., 2002). I converted both categories into ordinal variables, where 0 indicates the absence of any dispute and 2 identifies 10+ events. *Verbal conflict* variable is likely to capture low levels of interstate hostility, while *Material conflict* is likely to be observed at medium and high levels of hostility within a dyad.

Figure 1 displays distribution of conflict events in the dataset. As expected, the ICEWS variables capture the highest number of manifestations of conflict behavior, thus providing more information about interactions among dyads.

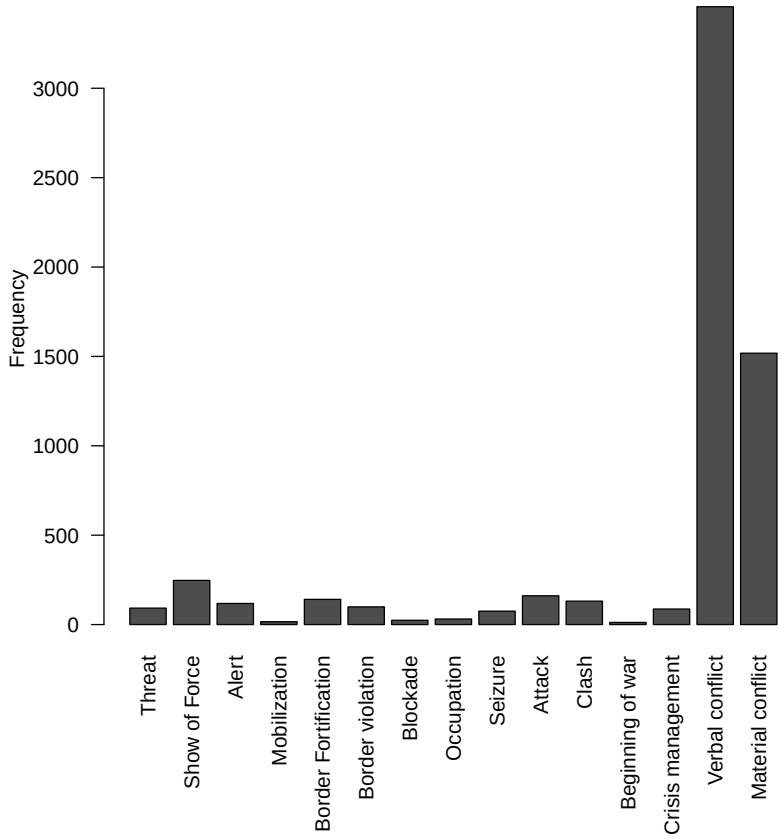
5.2 Model

In order to construct a latent measure of hostility, I use a static ordinal item-response (O-IRT) model. Static model accounts for the fact that hostility between states follows punctuated equilibria with long periods of relative stability and rare sudden and rapid change (Diehl and Goertz, 2001). The goal of this model is to estimate hostility, where θ_{it} is the hostility estimate for dyad i in year t using the observable manifestations of hostility outlined in the previous section, y_{itj}. Each item is indexed j = 1, . . . , J and is observed at the dyad-year level, where dyads are indexed i = 1,...,N and time is indexed t = 1,...,T. K_j is the total number of values that each item y_j can take on. If item $_j$ is binary, $K_j = 2$ and, if item $_j$ is

TABLE 3: *Observing interstate hostility; Data Variables and Description*

Data Source	Variable Name	Description
Militarized Interstate Incident (1993-2010)	*Threat to use force*	Includes threat to use force, to blockade, to occupy territory, to declare war, to use CBR weapons, and threat to join war
	Show of force	Public demonstration by a state of its military forces, not involving combat operations
	Alert	Reported increase in the military readiness of a state's regular armed forces
	Mobilization	Activation by a state of all or part of its previously inactive forces
	Fortify border	Explicit attempt to demonstrate control over a border area through the construction/reinforcement of military outposts
	Border violation	Crossing of a recognized land, sea or air boundary for a period of less than 24 hours by official forces of one state, without any use of force being used
	Blockade	Use of ships, planes or troops by one state to seal off the territory of another state so as to prevent entry or exit of goods or personnel
	Occupation of territory	Use of military force by one state to occupy the whole or part of another state's territory for a period of more than twenty-four hours
	Seizure	Capture of material/official forces from another state, or the detention of private citizens operating within contested territory. Lasts at least 24 hours
	Attack	Use of regular armed forces of a state to fire upon the armed forces/population/territory of another state
	Clash	"outbreak of military hostilities between regular armed forces of two or more system members, in which the initiator may or may not be clearly identified"
	Join interstate war	Entering an ongoing war
International Crisis Behavior (1816-2011)	*Crisis management technique*	The primary technique used in an international crisis
Integrated Crisis Early Warning System (1995-2015)	*Verbal conflict*	A spoken criticism, threat, or accusation, often related to past or future potential acts of material conflict
	Material conflict	Physical acts of a conflictual nature, including armed attacks, destruction of property, assassination, etc.

Figure 1: Interstate dyads, 1993-2010



Note: This figure shows the count of conflict events across variables in the combined dataset. ICEWS variables capture the highest number of manifestations of conflict behavior

ordinary, $K_j > 2$.

For each item, there are two types of parameters. The first is an "item discrimination" parameter β_j, which indicates the extent to which a change in the value of one of the manifest variables corresponds to a change in the latent trait. The second is an "item difficulty " parameter,α_j, which shows the proportion of observations in each category of the manifest variables when the latent trait is equal to zero (Jackman, 2009, 455). These parameters are similar to a slope and intercept in a logistic regression.

The IRT model is presented in Equation 1:

$$
\begin{aligned}
P[y_{ij} = 1] &= F(\alpha_{j1} - \beta_j \theta_{it}) \\
&\vdots \quad \vdots \\
P[y_{ij} = k] &= F(\alpha_{jk} - \beta_j \theta_{it}) - F(\alpha_{jk-1} - \beta_j \theta_{it}) \\
&\vdots \quad \vdots \\
P[y_{ij} = K_j] &= 1 - F(\alpha_{jK-1} - \beta_j \theta_{it})
\end{aligned} \tag{1}
$$

where F(.) denotes the logistic cumulative distribution function.

The likelihood function for β, α and θ given the data is presented in Equation 2.

$$
\mathcal{L}(\beta, \alpha, \theta | y) = \prod_{i=1}^{N} \prod_{t=1}^{T} \prod_{j=1}^{J} [F(\alpha_{j y_{itj}} - \theta_{it}\beta_j) - F(\alpha_{j y_{itj}-1} - \theta_{it}\beta_j)] \tag{2}
$$

Since θ_{it} cannot be fully observed, all of the parameters of interests, namely θ, β, and α must be estimated simultaneously. The use of Bayesian estimation, in which the model identification is achieved through the assignment of prior distributions is one of the most common approaches to solve this issue (Fariss, 2014; Jackman, 2009). In particular, the prior for the latent trait is set to $\theta_{it} \sim$ Normal(0, 1). This constraint reflects an assumption that the population of dyads is roughly normally distributed across the spectrum of hostility. Slightly informative prior $\beta_j \sim$ Gamma(4, 3) restricts the value of the item discrimination parameter to be positive and reflects an assumption that all indicators contribute significantly (and in the same direction) to the latent variable. Under this model specification, increases on the values of each indicator y_j correspond to the higher values of the latent trait. The item difficulty parameters α were given N(0,4) priors with $\alpha_{j1} > \alpha_{j2}$ for all $_j$.

The model is estimated using Stan, a C++ program, which performs Bayesian inference using a No-U-Turn sampler (Hoffman and Gelman, 2014), an adaptive form of Hamiltonian Monte Carlo sampling (Neal et al., 2011).

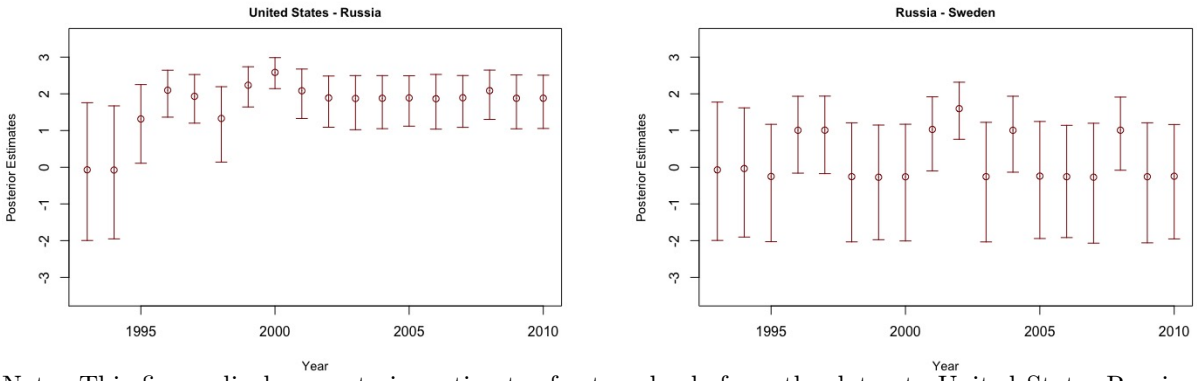
The model presented above assumes that given the level of hostility and the item parameters, the ordinal responses are conditionally independent across subjects and items. Theoretical and empirical evidence, however, suggest strong presence of temporal and spatial dependencies in dyads' interactions (Cranmer, Desmarais and Menninga, 2012; Ward, Siverson and Cao, 2007). For instance, Diehl and Goertz (2001) argue that it is very likely that rivalry in one dyad is strongly dependent on a rivalry in another dyad. For instance, states involved in multiple rivalries are less likely to escalate in any of these conflicts in order to avoid a costly armed conflict that might weaken the already-strained state (Akcinaroglu, Radziszewski and Diehl, 2011). Furthermore, the level of hostility within a dyad at time t is likely to affect hostility at time $t+1$. As the static does not account for this dependency, it results in the loss of efficiency. However, as the aim of this paper is to suggest a framework of studying conflict escalation and improve upon the existing measure using the best currently available method, development of a latent variable model which would account for these dependencies lies out of scope of this paper.

5.3 Model Output

Figure 2 presents example of posterior estimates for two dyads: United States-Russia and Russia-Sweden. The first dyad has consistently higher levels of hostility across years of observation than the second dyad. Furthermore, it has narrower confidence intervals, indicating higher levels of certainty about the measure.

Figure 3 displays the difficulty and discrimination parameters for each item. Recall that in this specific context the discrimination parameter reflects the extent to which change in the level of hostility corresponds to the change in the each of the manifestation variables. For instance, Figure 3 shows that if the level of hostility within a dyad increases, we are more likely to observe mobilization or attack incident than seizure or occupation. Overall, according to the model, the change in the level of hostility is reflected the most in *Threat,*

Figure 2: Posterior estimates for the United States-Russia and Russia-Sweden dyads, 1993-2010



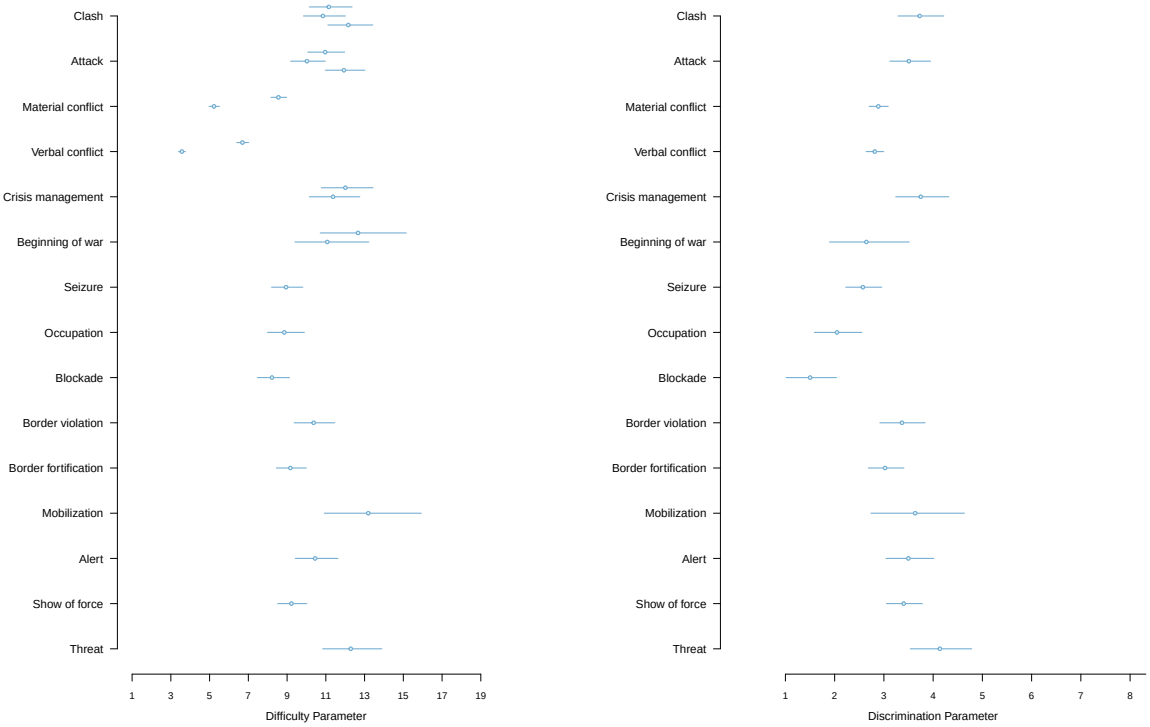
Note: This figure displays posterior estimates for two dyads from the dataset. United States-Russia dyad has consistently higher levels of hostility than Russia-Sweden dyad, which suggests face validity of the interstate hostility measure

Mobilization, Beginning of war, Crisis management technique, Clash, and *Attack*. This is important, as it indicates that, for example, *Threat to use force* is a more hostile action than *Show of force* or *Seizure*. This observation, however, contradicts the MID's hostility level scale. It suggests that the use of an ordinal scale for measuring hostility and conflict escalation might bias the results as the measure would not necessarily reflect the reality. The difficulty parameter corresponds to the probability of an indicator of hostility being in a particular category when the level of hostility is zero. For a given hostility level, the probability of an occurence of conflict event increases as item difficulty decreases.

In this context, probability of the occurrence of the incidents involving *Threat to use force, Mobilization, Attack*, and *Clash* is low irrespective of the level of hostility.

To sum up, these observations suggest that, while ICEWS data contain the highest number of observations, MID and ICB data provide more information for identification of conflicts with higher levels of hostility. Furthermore, the model provides evidence for the fact that threats to use force are better reflection of hostile behavior than show of force.

Figure 3: Model Parameters



Note: This figure displays the difficulty and discrimination parameters for each item. Dots indicate means of the cutpoints. Lines indicated 95% confidence intervals. The change in the level of hostility is reflected the most in *Threat, Mobilization, Beginning of war, Crisis management technique, Clash*, and *Attack*. *Threat to use force, Crisis management, Attack*, and *Clash* are more likely to be in the higher category at zero level of hostility.

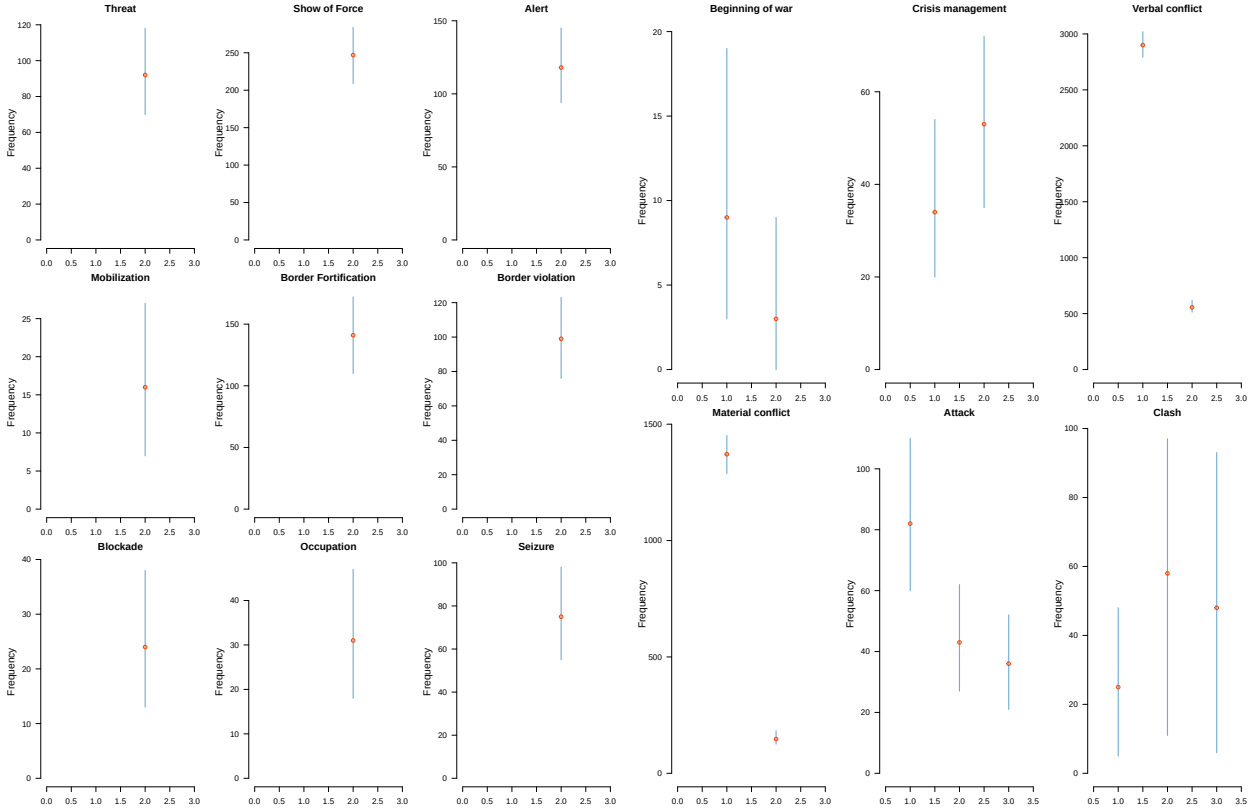
5.4 Posterior Predictive Checks

Posterior predictive checks are a direct way of assessing the fit of the model. It allows one to analyze the extent to which data generated from the model deviate from original data (Gelman and Hill, 2007). In order to do this, I simulate replicated data and then compare these to the observed dataset. If the model fits, then replicated data generated under the O-IRT model should look similar to observed data from the combined conflict data set. Using 1,000 draws from the posterior distribution, I predict each of the j items y_{itj} for every dyad-year observation, for each y_{itj} observed. I then compute a sum of squared differences of observed y_{itj} and d posterior predicted values $\hat{y}_{itjd}$ to measure the accuracy of each set of predictions. This calculation is expressed in Equation 3:

$$S_{itj} = \sum_{d} (y_{itj} - \hat{y}_{itjd})^2 \tag{3}$$

Figure 4 displays the results of the predictive checks. Blue lines correspond to the inferred means with 95% confidence intervals. Orange dots correspond to the actual sample means. The fact that real values fall within the confidence intervals of simulated values provides an evidence that the model fits data well.

Figure 4: Posterior Predictive Checks



Note: This figure displays the results of the predictive checks. Blue lines correspond to the inferred means with 95% confidence intervals. Orange dots correspond to the actual sample means. Real values fall within the confidence intervals of simulated means suggesting that the model fits data well

5.5 Predictive Validity Check

In this section, I will discuss predictive validity of my hostility measure. If this measure is valid, it should be able to predict the processes it should theoretically be able to predict (Trochim, 2006). In particular, I am extending Findley, Piazza and Young (2012)'s study on terrorism in international rivalries.

In their article, Findley, Piazza and Young (2012) test a theoretical assumption that states hostile to each other are more likely to use transnational terrorism than other states. For example, (Byman, 2005, 35) argues that one of the motivations behind state sponsorship is to advance their international and strategic position by destabilizing their neighbor or/and their rivals. According to Conrad (2011), sponsoring terrorism gives the state in question such tactical advantages as plausible deniability and disproportionate effectiveness. Increasing costs of conventional warfare makes terrorism a viable option for states, which try to avoid direct confrontation with their rivals (Jenkins, 1975; O'Ballance, 1978; Conrad, 2011; Kupperman, Van Opstal and Williamson Jr, 1982). Furthermore, a total effect of terrorist attacks tend to be greater than the attack itself (Conrad, 2011). Findley, Piazza and Young (2012) identify four processes which can possibly explain the use of terrorism by states in international rivalries. First, by using terrorism, states impose the strategic and political costs of rivalries. Second, the use of terrorism allows a state to compensate their military weaknesses. Third, in some cases, state sponsorship gives sponsors an advantage in the bargaining process. Fourth, sometimes states use terrorism to manipulate their domestic audience.

In order to test their theory, Findley, Piazza and Young (2012) use two measures of rivalry. The first measure is the one suggested by Klein, Goertz and Diehl (2006), who identify a rivalry through the issue linkages in repeated militarized conflicts between two states (Klein, Goertz and Diehl, 2006). The second one is the operationalization used by (Rasler and Thompson, 2006, 151), where rivalries are defined as "relationships among actors who

mutually perceive their adversary to be a competitor." The dependent measure is the number of terrorist attacks. The unit of analysis is dyad-year. The sample is limited to politically relevant directed state dyads from 1968 to 2002. Regardless of the operationalization of the independent variable, Findley, Piazza and Young (2012) find that transnational terrorist attacks are more likely to occur in the presence of interstate rivalry.

I extend Findley, Piazza and Young (2012)'s study by looking at the effect of hostility on the number of terrorist attacks. Based on the previous theoretical and empirical studies, if the measure of interstate hostility is valid, I expect the level of hostility to have a strong positive effect on the count of transnational terrorist attacks.

The model specification is very similar to the one used by Findley, Piazza and Young (2012). The unit of analysis is dyad-year. The analysis includes only politically relevant directed dyads from 1995 to 2002. The dependent variable is the count of terror events. Similarly to Findley, Piazza and Young (2012), I used two approaches in estimating the effect of hostility on the dependent variable. In both approaches, the origin country is defined as the nationality of the terrorists. However, in the first approach, the target country is defined as the country in which the terrorist event occurred, while, in the second approach, the target country is the nationality of the victims. Finally, I preserve the set of control variables used in the Findley, Piazza and Young (2012)'s article.[3] The small set, includes only dyadic variables: rivalry, hostility, joint democracy, contiguity, and capability ratio. In addition to these covariates, the fully specified model includes the history of terrorism, interstate war, and civil war in both the origin and target states.

Table 4 presents the result of replication and extension of Findley, Piazza and Young (2012)'s analysis for 1995-2002. Models 1-4 display the results of negative binomial regression using rivalry as an independent variable, while Models 4-8 display the results of negative

[3] *Cold war* was excluded due to the lack of variation over this time period in question

binomial regression using the hostility measure.[4] The results of the replication are very similar to the one reported in the original article: rivalry has positive and significant effect on the number of transnational terrorist attacks across all models. The coefficient for interstate hostility is also positive and significant across all models, which provides support for my hypothesis. While the limited temporal domain of the data might make it harder to get significant effects, these preliminary results shows that dyads with higher levels of hostility are more likely to experience more transnational terrorist attacks.[5]

With respect to the fit of the models, the Akaike Information Criterion (AIC) is consistently smaller for the models with the interstate hostility as an independent variable, which suggests that these models fit the data slightly better than the Findley, Piazza and Young (2012)'s models.

This preliminary analysis illustrates the ability of a new interstate hostility measure to predict the number of transnational terrorist attacks, which is consistent with theoretical expectations and suggests that this measure has a predictive validity. In addition, as this measure allows to look at the smaller changes in conflict dynamics, the future research in this area can provide a significant contribution to the international conflict field. For example, in this particular context, while the relationships between interstate rivalries and the use of terrorism has been already established, it is not clear when exactly states are more likely to prefer the use of terrorism over other foreign policy tools.

6 Conclusion

Current discussion of interstate conflict escalation is hindered by the lack of a single framework, which could be used for studying conflict dynamics. Understanding the process of con-

[4]I used the posterior mean as a point estimate of interstate hostility in each dyad-year

[5]I also run the alternative specification model with the hostility variable lagged by one year. The results do not differ substantively from those presented here. The table with the results is reported in the Appendix.

TABLE 4: *Negative Binomial Models of Transnational Terrorist Attacks using Dyads 1995–2002*

	Replication of Findley, Piazza, and Young (2012)				Predictive validity check			
	(1) Terror Counts	(2) Terror Counts 2	(3) Terror Counts	(4) Terror Counts 2	(5) Terror Counts	(6) Terror Counts 2	(7) Terror Counts	(8) Terror Counts 2
Rivalry	1.501***	1.369***	0.994**	0.739***				
	(0.321)	(0.233)	(0.349)	(0.210)				
Hostility					0.819***	0.982***	0.531***	0.519***
					(0.117)	(0.087)	(0.129)	(0.077)
Joint Democracy	0.151	0.235	-0.395	-0.384*	0.021	0.136	-0.476	-0.460**
	(0.327)	(0.212)	(0.378)	(0.232)	(0.311)	(0.209)	(0.355)	(0.216)
Log(Capability ratio)	-0.088	-0.412***	-0.066	-0.645***	-0.093	-0.467***	-0.064	-0.656***
	(0.069)	(0.035)	(0.119)	(0.088)	(0.072)	(0.042)	(0.122)	(0.086)
Contiguity	1.427***	-0.184	2.206***	1.030***	1.379***	-0.392*	2.129***	0.852***
	(0.314)	(0.207)	(0.279)	(0.209)	(0.334)	(0.214)	(0.296)	(0.206)
Past Terror (Origin)			0.363***	0.680***			0.322***	0.644***
			(0.099)	(0.071)			(0.094)	(0.068)
Past Terror (Target)			0.506***	0.831***			0.462***	0.770***
			(0.116)	(0.091)			(0.112)	(0.091)
Interstate War (Origin)			-0.013	-0.121			-0.108	-0.191
			(0.485)	(0.266)			(0.518)	(0.274)
Interstate War (Target)			0.173	0.240*			0.085	0.190
			(0.377)	(0.137)			(0.388)	(0.143)
Civil War (Origin)			1.089***	1.515***			1.048**	1.462***
			(0.331)	(0.209)			(0.327)	(0.197)
Civil War (Target)			-0.541*	-0.173			-0.473	-0.101
			(0.315)	(0.181)			(0.300)	(0.180)
Constant	-5.806***	-3.932***	-6.809***	-6.494***	-5.804***	-4.061***	-6.695***	-6.390***
	(0.351)	(0.240)	(0.315)	(0.326)	(0.337)	(0.221)	(0.306)	(0.319)
Number of observations	17954	17954	17954	17954	17954	17954	17954	17954
AIC	1198.016	3290.243	1102.419	2655.630	1174.723	3149.772	1094.234	2615.183
BIC	1244.789	3337.016	1195.966	2749.176	1221.497	3196.545	1187.781	2708.730

Standard errors in parentheses

* $p < 0.1$, ** $p < .05$, *** $p < 0.001$

flict escalation, however, is highly important for numerous theories on international conflict. In this paper, I suggest a new granular measure of interstate hostility that can potentially solve this issue by enabling international relations scholars to observe the changes in states' interactions with a range from verbal dispute to a full-scale violence. The ability to look at the smallest changes in the hostility levels within dyads not only to allows testing of existing theories but also can motivate a new theories both on escalation and de-escalation processes. While relatively few studies in quantitative conflict literature focus on the latter, it can be particularly important for conflict resolution

Furthermore, the model presented in this paper suggests the necessity for re-evaluation of existing measures of dispute severity and hostility in terms of their relation toward the concept. For example, the model shows the importance of verbal threats in identification of hostile behavior within dyads. Therefore, in some case, focus on the verbal interstate interaction in studying conflict escalation can be almost as important as focus on other manifestations of hostile behavior.

This project constitutes a first step in the analysis of conflict escalation. Moving forward, incorporation of dependencies existing in international structure into the study of escalation seems to be a fruitful area of research. For instance, studying the impact of the conflict escalation process within one dyad on the conflict/cooperation in other dyads or the relationship between the alliance network structure and probability of the conflict escalation are examples of such lines of inquiry .

Appendix

TABLE 5: *Negative Binomial Models of Transnational Terrorist Attacks using Dyads, 1993-2002*

	(1) Terror Counts	(2) Terror Counts 2	(3) Terror Counts	(4) Terror Counts 2
Hostility$_{t-1}$	0.848***	0.971***	0.572***	0.492***
	(0.109)	(0.088)	(0.131)	(0.078)
Joint Democracy	0.121	0.243	-0.337	-0.336
	(0.340)	(0.213)	(0.384)	(0.216)
Log(Capability ratio)	-0.079	-0.479***	-0.071	-0.686***
	(0.077)	(0.044)	(0.127)	(0.091)
Contiguity	1.472***	-0.306	2.179***	0.926***
	(0.338)	(0.216)	(0.304)	(0.210)
Past Terror (Origin)			0.307**	0.617***
			(0.096)	(0.069)
Past Terror (Target)			0.399***	0.711***
			(0.112)	(0.094)
Interstate War (Origin)			-0.118	-0.097
			(0.504)	(0.269)
Interstate War (Target)			0.186	0.222
			(0.377)	(0.147)
Civil War (Origin)			1.050**	1.498***
			(0.347)	(0.205)
Civil War (Target)			-0.494	-0.132
			(0.319)	(0.186)
Constant	-5.900***	-4.118***	-6.718***	-6.352***
	(0.367)	(0.239)	(0.341)	(0.337)
N	15714	15714	15714	15714
AIC	1021.881	2774.129	960.911	2327.620
BIC	1067.855	2820.103	1052.859	2419.568

Standard errors in parentheses

* $p < 0.1$, ** $p < .05$, *** $p < 0.001$

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