WHAT ARE THE NEIGHBORS DOING?

MICHAEL D. WARD

Abstract. Civil conflict and civil war are clustered in time and space. I explore new ways to model spatial dependencies in the context of the complexity of civil conflict. Using methods adapted from the social relations model, it is possible to represent social dependencies and clustering among states in a way that incorporates country level as well as dyadic covariates. This clustering can recapture the often-observed clustering of societies that is observed in many empirical data sets on civil war. I describe this approach in the framework of familiar regression models and explore implications for civil war studies of adopting this approach.

Introduction

Beginning with the Uppsala list of civil conflicts, Lacina & Gleditsch (2005) have produced data on battle deaths in civil conflicts that occurred during the period from 1946 through 2000 given by location.[1] Figure 1 provides a cartogram of these data. The cartogram has the area of each country stretched in proportion to the number of battle deaths from civil conflict that occurred in that country from 1946–2002 using the algorithm of Gastner & Newman (2004). Countries are colored so that more democratic countries are shaded in deeper shades of blue while autocratic countries are show in increasing shades of tan; brown illustrates countries in which there is a regime transition underway in 2002–typically not a sign of democratic governance.[2] This map illustrates three simple points. First, civil conflict has been especially deadly in African and Asian locales, even those without large populations. There are a few countries that are currently democratic which were sites of deadly conflicts in the past 50 years, but most of the locations with high levels of deadly civil conflict appear at first glance to be in Africa and Asia. Second, currently autocratic countries are the sites of many, previous and frequently ongoing deadly civil conflicts. Compared to the rest of the world, the Americas have not witnessed the same degree of civil conflict in the last one-half century. This points to the simple fact that civil conflicts are clustered. Few occur west of the prime meridian. The 2005 "Peace and Conflict Ledger" Marshall & Gurr (2005) rates 161 countries in terms of their risk of state failure, which often comes in the form of the onset of civil conflict. Thirty-one countries were adjudged to be in the highest risk category. Only one (Haiti) is in the Western Hemisphere; two-thirds of them lay on the African continent with most of the remainder comprising a so-called Muslim bloc stretching from Armenia through Afghanistan. There is something about the neighbors that does seem to promote regions of violent civil war as well as regions absent such conflict, but what is it?[3]

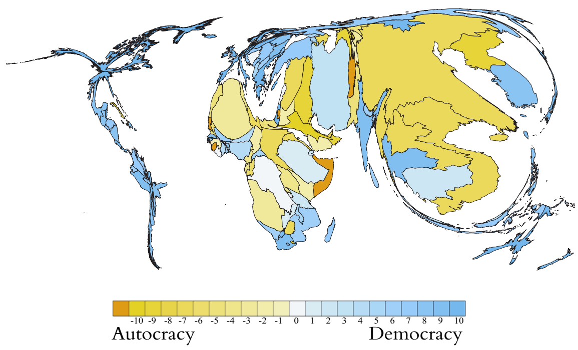

Figure 1. *Cartogram of the Battle Deaths from Civil War over the period from 1946–2002.*

Many scholars have followed Fearon & Laitin (2003) into the mountains to study civil conflict. Walters & Gleditsch (2005), for example, examine the issue of financing and conflict using the degree of mountainous terrain as an important determinant of the onset of civil conflicts. Salehyan (2005) shows that

Date: September 13, 2005 Version 0.8.
Authors' Note: Ward's research was supported by a grant from the Methods, Measurement, and Statistics Program at the National Science Foundation (SES-0417559) and by a Grant from the Human and Social Dynamics cross-directorate program of the National Science Foundation (HSD-04333927). This paper was presented at the conference on Mapping the Complexity of Civil Wars, sponsored by the Institute for Conflict Research, Swiss Federal Institute of Technology Zürich, September 15-17, 2005. Thanks to Peter Hoff, Xun Cao, Randolph M. Siverson, and Anton Westveld for enlightening discussions on the analysis of dyadic data.

[1] The Uppsala data are introduced in Gleditsch, Eriksson, Sollenberg & Strand (2002) and the most recent published description may be found in Harbom & Wallensteen (2005).

[2] Polity data were used for this attribute. Jaggers & Gurr (1995) provide a good summary introduction to these data.

[3] Sambanis (2002) provides a recent review of the literature on civil wars, but as yet no one has been able to answer the question of how geography exactly matters.

the use of neighboring territory for rebel sanctuary provides an important cost avoidance structure for rebels, often furthering their ability to initiate and continue civil conflicts. Raleigh (2004) and Hegre & Raleigh (2005) illustrate that civil war deaths are concentrated geographically within strife torn countries in particular ways. Goldstone, Bates, Gurr, Lustik, Marshall, Ulfelder & Woodward (2005) have shown that political instability is more likely to occur in countries located within regions that have several other politically unstable regimes, a finding replicated for ethnic wars as well as for Muslim countries (Gurr, Woodward & Marshall 2005). Buhang & Rød (2005) illustrate the importance of examining local, geographically specific context in understanding civil conflicts in Africa. Buhaug, Gates & Lujala (2005) also incorporate several geographic factors into their analysis of a model of civil conflict and illustrate that the location of lootable resources are associated with location of enduring civil conflicts.

Ward & Gleditsch (2002) used a simple autologistic model to predict conflicts based solely on the geographical correlation that existed with the level of civil conflict in neighboring states. Recently, Gleditsch (N.d.) focused this approach solely on civil wars, finding that regional, neighboring conflict has a spatial correlation with civil war that is between 0.3 and 0.8 in magnitude, depending on the estimator employed. This is also estimated to be around 0.3 ± 0.2 in Buhang & Gleditsch (2005). Similar findings go back for a couple of decades (O'Loughlin 1986, Kirby & Ward 1987, Ward & Kirby 1987).

Buhang & Gleditsch (2005) examined whether contagion or diffusion might best explain the occurrence and subsequent spread of civil conflict. They find that neighborhood conflicts over territory are more likely to stimulate additional outbreaks of civil conflict. This research is among the first to examine whether civil conflict clusters simply because it is associated with other variables that cluster or instead spreads through a diffusion process.[4] The answer is that more is apparently going on that just the clustering of everything. Buhang & Gleditsch (2005) show that cross border contagion affects those countries already most vulnerable to political instability: poor states with ethno-political groups that have extensive transnational ties. Along with other careful thought, this suggests that "space is more than geography," in the sense that there are important spatial linkages that represent important aspects of the genesis and duration of civil conflict.

We have not come very far along the path to uncovering what it is about proximity that promotes the spread of conflict, but we understand better now that it is an important first step to register the proximity as a placeholder for an unraveling of these social processes, but that the placeholder needs to be replaced by careful thought and empirical analysis. Below I describe a framework to facilitate the de-construction of posited spatial linkages into their substantive components.

Social Distance and Spatial Weights

Getis & Aldstadt (2004) describe the importance of measures of distance in spatial models. Spatial statistics depend on some representation of the spatial structure. This is typically called a spatial weights matrix, most often denoted **W**. This matrix is essentially a graph defined as a formal expression of the spatial dependence among observations. The nasty secret in spatial analysis is that despite its integral role in spatial analysis, **W** is typically an empirical convenience based solely on either distance, contiguity, or both. As a result, **W** may often bear little or no relationship to underlying dependency structures thought to be important. A list of schemes that have been frequently employed in spatial analyses would include

(1) contiguity, in terms of shared borders;
(2) an inverse of distance from some inner point, often a centroid, often raised to some higher power;
(3) lengths of shared borders, normalized by total perimeters;
(4) bandwidth n^{th} nearest neighbor distances;
(5) ranks of distances;
(6) nearest neighbors, defined in terms of other metrics;
(7) bandwidth distance decay; as well as
(8) other social distance measures, such as: the existence of shared language, religion, and or culture; normalized volume of economic exchanges, such as trade; number of shared memberships in certain organizational structures; and many, many others.

Griffith (1996) lists several rules of thumb for constructing **W** matrices. Pride of place in this list is the notion that any measure of distance is better than none, i.e., better than assuming independence of the observations. Lower-order spatial linkages are to

[4]Things that are thought to affect civil war also cluster (vide O'Loughlin, Ward, Lofdahl, Cohen, Brown, Reilly, Gleditsch & Shin 1998, Gleditsch 2002, Gleditsch & Ward 2005). And, the neighborhood effects of civil wars are known to depress economic growth, even outside of the countries in which the deaths occur (Murdoch & Sandler 2002)

be preferred to higher-order ones: i.e., concentrate on direct, not indirect neighbors. It is also better to have too few linked neighbors than too many. Some have suggested choosing a **W** that will maximize the spatial correlation in the data and others have pointed out the major problem of spatial analysis is indeed figuring out how to specify the spatial weights **W**. Getis & Aldstadt (2004) evaluate eight different forms of **W**, ranging from geometric to geo-statistical specifications. Suffice it to say that no one has solved the problem of how to generally specify spatial weights in a way that is not ad hoc from a theoretical point of view. As a result, all of the results in statistical models of spatial processes are conditional on the specified **W** matrix, and most scholars simply use a convenient or available weights matrix. Few scholars have actually used spatial models in the context of civil war studies, but those that have either use contiguity or nearest neighbor distance bands. None have gone beyond the arbitrary approach to constructing **W**. Perhaps a different approach is required.

Let's assume for the time being that some measure of the proximity of countries exists. This measure contains information that is relevant to our understanding of civil war as well as other information that is not. What we would like to do is to capture the informative "information," and discard the rest. What is meant by informative? There is good reason to believe that some aspects of proximity will be important in understanding the onset and duration of civil wars. One example might be the presence of nearby population centers in which rebel forces might be able to retreat and escape detection and capture, such as the Taliban safe houses in Peshawar. Another is the existence of a long and incompletely demarcated border between two countries. However, just the presence of a border might not be so informative: Switzerland and Germany share a border, but there is little evidence that the Bader Meinhoff gang, for example, used Konstanz as a hideout in the early 1970s, especially given the closer possibilities within the German Democratic Republic. There is also a border between Syria and Iraq. Evidence is abundant that many combatants in present day Iraq have used this permeable border for entrance into and exit from Iraq. Even the more tightly controlled Iran-Iraq border might have quasi-official openings from time to time, permitting entrance and egress from civil conflict for certain indivduals and groups. In a similar way, there is a large number of additional hypotheses about what kinds of things comprise or directly affect the social distance among relevant actors in civil conflict situations including:

(1) mountainous terrain as a refuge for rebels;
(2) common ethno-political groups, as a source of support and refuge;
(3) similar ongoing conflict as a source of inspiration and prototype for action;
(4) a source of financing, material resources, and/or human capital; and many others.

Social distance can be thought of as the accumulation of many such factors into a metric that indexes how "close" countries are in terms of the probability that conflict in location will affect conflict countries that are socially nearby. In this way, we can think of social distance as being plausibly related to geography, but not necessarily, nor completely, isomorphic with it.

In what follows I conceptualize the relevant social distance as being comprised of a variety of important components and describe a strategy for modeling them while preserving the ability to incorporate high-level dependencies among countries and their neighbors. Then I suggest a strategy for incorporating this into studies of civil strife.

Bilinear Model of Spatial Weights

For simplicity we describe a social distance matrix in the standard way, as **W**. This matrix is an $n \times n$ matrix, where n indexes the relevant observed units, typically countries. The rows can represent the role of a country n as a potential site of civil conflict and the columns can represent n's role as a neighbor. Thus, every country is represented by a row in this matrix (as a site) and also by a column (representing its role as a neighbor). The diagonals of this matrix will typically be set to 0, but all other entries will be represented One approach for modeling the social distance (proximity) among countries $w_{i,j}$ begins with a hierarchical regression framework:

$$w_{i,j} = \beta_d^{'} x_{d,i,j} + \beta_s^{'} x_{s,i} + \beta_r^{'} x_{r,j} + \epsilon_{i,j}. \tag{1}$$

where $x_{d,i,j}$ represents the d dyadic variables of concern, $x_{s,i}$, indexes the important monadic variables for country as a site s, and $x_{r,i}$ captures the monadic variables pertinent for each country as a neighbor r. Normal regression models require that all of the observations and errors are exchangeable, an assumption that we know to be false. Exchangeability in this context means that the distribution of $\epsilon_{i,j}$ is invariant under any permutation of the order of the units (here the rows and columns of the dyadic weights matrix). If one assumes this weak form of exchangeability as well as the errors following a Gaussian distribution, the joint distribution of errors is decomposed as:

$$(2) \qquad \begin{aligned} \epsilon_{i,j} &= a_i + b_j + \gamma_{i,j} \\ \begin{pmatrix} a_i \\ b_i \end{pmatrix} &\sim N_{mv}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_a^2 & \sigma_{ab} \\ \sigma_{ab} & \sigma_b^2 \end{bmatrix} \right) \\ \begin{pmatrix} \gamma_{i,j} \\ \gamma_{j,i} \end{pmatrix} &\sim \begin{pmatrix} \sigma_\gamma^2 & \rho\sigma_\gamma^2 \\ \rho\sigma_\gamma^2 & \sigma_\gamma^2 \end{pmatrix}, \end{aligned}$$

where σ_a^2 is the dependence of social distances with a common site, σ_b^2 the dependence of distances with a common neighbor, and ρ the correlation of observations within a dyad–often called *reciprocity* in the social relations literature. The covariance pattern implies that $E(\hat{\beta})$ and $\text{Cov}(\hat{\beta})$ for equation (1) are not simple functions of the first and second moments of the data, as is the case in a simple linear regression. Instead, higher order dependencies will affect these quantities of interest. Hoff (2005) has shown that it is possible to add a bilinear effect to capture the third-order characteristics of transitivity, balance, and clusterability. This bilinear effect induces a form of third-order dependence that characterizes dyadic data. This is a function of unobserved, latent characteristic effect and has facile interpretations as random effects or as fixed effects:

$$\epsilon_{i,j} = a_i + b_j + \gamma_{i,j} + u_i^{'} v_j$$

with the unobserved, latent vectors for both sites and neighbors, $u_i^{'} v_j$, shown as an inner product, similar to an error term, suggesting a mean-zero, random effect which can be modeled as a k-dimensional multivariate normal distribution. This results in the following non-zero moments that can be estimated instead of assumed to be non-existent:

$$\begin{aligned} E(\epsilon_{i,j}^2) &= \sigma_a^2 + 2\sigma_{ab} + \sigma^2 + \sigma_\gamma^2 + k\sigma_z^4 \\ E(\epsilon_{i,j}\epsilon_{j,i}) &= \rho\sigma_\gamma^2 + 2\sigma_{ab} + k\sigma_z^4 \\ E(\epsilon_{i,j}\epsilon_{j,k}\epsilon_{k,i}) &= k\sigma_z^4 \\ E(\epsilon_{i,j}\epsilon_{i,k}) &= \sigma_a^2 \\ E(\epsilon_{i,j}\epsilon_{k,j}) &= \sigma_b^2 \\ E(\epsilon_{i,j}\epsilon_{k,i}) &= \sigma_{ab} \end{aligned}$$

This approach is quite flexible and can be displayed as a hierarchical model:

$$\begin{aligned} \theta_{i,j} &= \beta_0 \quad \text{(mean response)} \\ &+ \beta^{'} x_{d,i,j} \quad \text{(dyadic)} \\ &+ \beta_s^{'} x_{s,i} \quad \text{(site specific)} \\ &+ \beta_r^{'} x_{r,i} \quad \text{(neighbor specific)} \\ &+ a_i \quad \text{(site random effects)} \\ &+ b_i \quad \text{(neighbor random effects)} \\ &+ u_i^{'} v_j \quad \text{(latent similarity)} \\ &+ \gamma_{i,j} \quad \text{(good old error).} \end{aligned}$$

This permits the estimation of the social distance $w_{i,j}$ simply. If we have a binary weight matrix, we would employ a logistic link function:

$$P(w_{i,j} = 1 \mid \theta_{i,j}) = \frac{e^{\theta_{i,j}}}{1 + e^{\theta_{i,j}}}.$$

The Poisson and Gaussian link functions can be similarly formed.

What does all this heavy lifting buy? First and perhaps foremost it permits us to specify a model of social distance that can easily be incorporated into other spatial models, either as a preliminary step, or simultaneously. Moreover, that model is a hierarchical model that includes facets of the relations among important actors such as countries, but also permits the inclusion of forces thought to apply separately to potential sites of conflict as well as neighbors of conflicts. Further, by incorporating random effects (which could be interpreted as fixed effects), the model allows for the incorporation of specific, unique aspects of the data for each country as a site and as a neighbor. Beyond this, the model suggests that some underlying similarity or latent position of each country as a potential site and as a potential neighbor of conflict is important. This particular feature will capture the higher-order dependencies in the data. A different way of thinking about this particular feature is that it explicitly captures the clustering of civil conflict, a clustering that we know to be present and important, but ignored in most quantitative analyses. The particular framework chosen will work for social distances that are measured as binary relations using a binomial linkage, as counts of co-memberships via a poisson specification, or as Gaussian distances. These distances may obey or violate the triangle identity, allowing asymmetries to appear in the latent clusterings.

A Bayesian Approach to Estimating Social Distances. Bayesian estimation of model parameters is accomplished with conjugate priors and a Markov chain Monte Carlo algorithm, sampling values of the

parameters from their posterior distributions. We employ a Markov chain in $\{\beta_d, \beta_s, \beta_r, \Sigma_{ab}, P, \sigma_p^2, \Sigma_\gamma\}$ (where P is the $K \times n$ matrix of latent vectors) that eventually samples from the desired target posterior distribution
$p(\beta_d, \beta_s, \beta_r, \Sigma_{ab}, P, \sigma_p^2, \Sigma_\gamma \mid Y)$. There is no analytic solution and there are a large number (> 300) of quantities to estimate. The full conditionals for the regression terms $(\beta_d, s, r, \beta_s, \beta_r, P)$ are multivariate normal, and the covariance terms are modeled as inverse-Wishart conditional distributions. Details on the full conditionals are found in Hoff (2005).

The algorithm iterates three steps:

(1) Resampling of linear effects:
   (a) sample $\beta_d, s, r \mid \beta_s, \beta_r, \Sigma_{ab}, \Sigma_\gamma, \theta, P$;
   (b) sample $\beta_s, \beta_r \mid s, r, \Sigma_{ab}, \Sigma_\gamma, \theta, P$;
   (c) sample $\Sigma_{ab}, \Sigma_\gamma$ from their full conditional distributions.

(2) Resampling of bilinear effects:
   (a) for each i, sample $p_i \mid \{p_j : j \neq i\}, \theta, \beta, s, r, \Sigma_p, \Sigma_\gamma$; and
   (b) sample Σ_p from its full conditional distribution.

(3) Resampling of dyad-specific parameters: update $\{\theta_{i,j}, \theta_{j,i}\}$ using a Metropolis-Hastings step as follows:

$$\text{propose: } \begin{bmatrix} \theta^*_{i,j} \\ \theta^*_{j,i} \end{bmatrix} \sim N\left(\begin{bmatrix} \beta' x_{i,j} + a_i + b_j + p_i' p_j \\ \beta' x_{j,i} + a_j + b_i + p_j' p_i \end{bmatrix}, \Sigma_\gamma \right)$$

$$\text{accept: } \begin{bmatrix} \theta^*_{i,j} \\ \theta^*_{j,i} \end{bmatrix}$$

with probability $\frac{p(y_{i,j}|\theta^*_{i,j})p(y_{j,i}|\theta^*_{j,i})}{p(y_{i,j}|\theta_{i,j})p(y_{j,i}|\theta_{j,i})} \wedge 1$.

Software to estimate this model is available at `www.stat.washington.edu/hoff/Code/GBME/gbme.r`

Examples of this approach can be found in Hoff & Ward (2004), Ward, Hoff & Lofdahl (2003), and Ward, Hoff & Rao (2004).

A Simple Regression Approach. These models can also be simply estimated using standard regression approaches. The essential strategy to follow would be to first estimate equation (1) using a standard regression algorithm. Then the errors from that estimation can be decomposed into various random effects, with the latent dimensions being retrieved using eigenvalue analysis in the binomial case, and via single value decomposition methods for the Poisson and Gaussian linkages. An example of this approach can be found in Ward & Hoff (2005).

Example

Let us assume that we believe that the major transmission mechanism for civil conflict is actually international conflict. For the didactic purposes we can assume apart from its own epigenesis, civil conflict will be perpetuated from one country to the next as a rough function of the geographical proximity and the extent of the international conflict. Proximate countries in international conflict are likely to have civil conflict in one, spill over into the other. This happens quite a lot, since it is frequently difficult to distinguish between civil and interstate conflicts, a point made by Ward & Gleditsch (2002) and others. A good example might be the international war fought between Iran and Iran during the 1980s, in which the role of Kurds and different sects of Islam was an important feature, not only for Iran and Iraq, but also for Turkey.

The model is:

$$\theta_{i,j} = \beta_d' x_{i,j} + \beta_s' x_i + \beta_r' x_j + a_i + b_j + u_i' v_j + \epsilon_{i,j},$$

where

$$\begin{aligned} \beta_d x_{i,j} &= d \in \{\text{joint democracy, imports, joint IO membership, distance}\} \\ \beta_s x_i &= s \in \{\text{population, GDP, democracy}\} \\ \beta_r x_j &= r \in \{\text{population, GDP, democracy}\} \\ a_i &= \text{random effect of sender} \\ b_j &= \text{random effect of receiver} \\ u_i' v_j &= \text{separate latent positions for sender and receiver} \\ \epsilon_{i,j} &= \text{error.} \end{aligned}$$

We modeled the probability of a militarized dispute $y_{i,j}$ as a Poisson link function, by modeling $E(y_{i,j} \mid \theta_{i,j}) = \exp^{\theta_{i,j}}$ and $y_{i,j} \mid \theta_{i,j} \sim \text{Poisson}(\exp^{\theta_{i,j}})$.

The results of estimated this Poisson regression with bilinear random effects are presented partially in Table 1. These results suggest that polity similarity and trade (as well as distance) tend to suppress the outbreak of militarized disputes and somewhat surprisingly that joint membership in International Organizations increases the probability of militarized disputes between countries. More importantly for this illustration, these results also show that the second and higher-order dependencies in these data are very salient, and far outweigh other factors. Each measure of these dependencies is quite large in impact, compared to the weight of the estimated error variance, for example.

An example of the mixing of the Monte Carlo chains is shown in Figure 2.

The latent positions of countries in militarized interstate disputes are given in Figure 3. These

Table 1. *Bayesian estimates for equation (3) are the posterior means for the estimated quantities. Quantile based, empirical credible intervals are presented. The mean posterior (negative) log likelihood is -538.*

		2.5%	*Mean*	*97.5%*
Constant	β_0	−8.172	−6.612	−5.197
Dyadic Effects:				
$Polity_i \times Polity_j$	$\beta_{d=1}$	−0.017	−0.011	−0.006
$Import_{ij}$	$\beta_{d=2}$	−0.057	−0.030	−0.001
IGO_{ij}	$\beta_{d=3}$	0.007	0.036	0.064
$Distance_{ij}$	$\beta_{d=4}$	−0.801	−0.676	−0.573
Sender Effects:				
$Population_i$	$\beta_{s=1}$	−0.003	0.001	0.004
GDP_i	$\beta_{s=2}$	0.000	0.001	0.002
$Polity_i$	$\beta_{s=3}$	−0.162	−0.088	−0.016
Receiver Effects:				
$Population_j$	$\beta_{r=1}$	−0.003	0.000	0.003
GDP_j	$\beta_{r=2}$	0.000	0.001	0.001
$Polity_j$	$\beta_{r=3}$	−0.109	−0.046	0.021
Dependencies:				
Common Sender	σ_a^2		4.359	
Sender-Receiver	$\sigma_{a,b}$		2.467	
Common Receiver	σ_b^2		3.630	
Reciprocity	ρ	0.895	0.959	0.988
Error Variance	σ_ϵ^2		2.806	

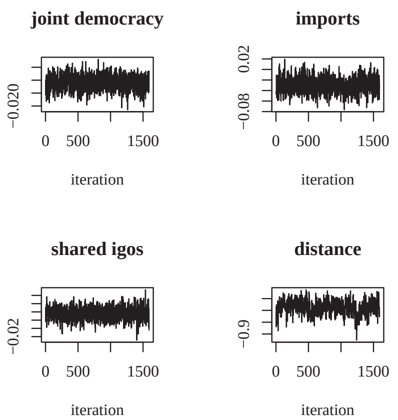

Figure 2. The MCMC Chains

are countries that conditional on the modeled effects have more similar dispute initiation behavior during the 1990s than the model would predict. As can be seen, for example the US and various allies in the upper left quadrant are grouped together. In a similar way targets of disputes originating in these countries are also grouped nearby. If the latent positions did not reflect some underlying higher order clustering to these dyadic data, then the positions of countries would essentially be random on this display. But instead we see groupings that reflect a variety of underlying conflicts in the Middle East and elsewhere across the globe. The two countries which have dispute behavior that are most dissimilar during this period, conditional on other modeled components, are the United States and North Korea. North Korea is also close in its latent position as an initiator to Syria, Jordan, and Iraq. These kinds of asymmetries may provide an insight into how international behaviors might plausibly affect domestic conflicts, since the latent positions reflect the higher order dependencies in these data. On the other hand it might be that the modeled social distances, $\hat{\theta}_{i,j}$ provide a direct linkage into the spatial modeling tradition, by opening up the black box to facilitate modeling of the spatial processes.

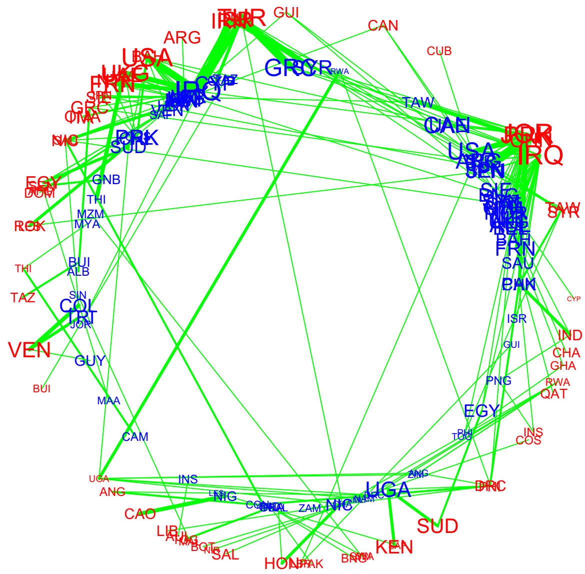

Figure 3. *Latent Positions of Countries on Initiating and Receiving Sides of Militarized Interstate Disputes, 1990-2000. The latent position of initiating countries is shown by red acronyms, while blue acronyms are used to display the latent positions of receiving countries. The actual data–the Militarized Interstate Disputes–are shown as green lines.*

In the context of the paper by Buhang & Gleditsch (2005), for example, this might mean that instead of just adding up a weighted measure of conflict in the neighborhood for some distance band, that $\hat{\theta}_{i,j}$ could be employed as a empirical measure of the closeness of conflict that was likely to be–for example–diffused through the mechanism of militarized disputes. In this way, spatial analysis can be employed to actually model the diffusion process. Several processes can be competitively included, reflecting a variety of mechanisms, not just the interstate dispute mechanism nor just a measure of proximity, but substantive linkages that show how social processes transcend and permeate international boundaries. In this way, it might be possible to actually model how "what the neighbors are doing" matters for the genesis and persistence of civil conflict.

Summary ↑

Maybe this paper is so short it does not require much of a summary?

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Michael D. Ward, Department of Political Science, University of Washington, Seattle, Washington, USA, 98195-3530

E-mail address: `mdw@u.washington.edu`