Location, Location, Location: An MCMC Approach to Modeling Spatial Context with Categorical Variables in the Study and Prediction of War[1]

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Abstract

Prior work has shown the strong presence of regional and spatial context in linkages between regime characteristics and involvement in civil and international conflict, but no adequate statistical model has explicitly captured these forces. Models that adequately reflect the interdependence of actors and actions in world politics are faced with difficult problems of estimation since the classical likelihood becomes intractable in the presence of the dependencies among observations. Most current solutions to this problem are based on approaches that were developed decades ago during a period of expensive computing. However, these approaches are no longer neither necessary nor appropriate. Using data from 1988, we use an autologistic formulation, estimated by Monte Carlo Markov Chain approximation, to extend our work exploring the link between authority structures and peace, one of the most salient present research topics in international relations. Our estimated model allows us to predict about half of the violent domestic and international conflicts that emerged in the subsequent decade.

1 Tracking the analysis of conflict

The study of geography as a component of world politics has a checkered history. The term geopolitics was introduced by a Swedish scholar and politician, Rudolf Kjellen (1916) who applied Darwinian notions to the putative organic nature of states imbued with an innate propensity for growth. Kjellen's theories gained considerable influence and were instrumental in popularizing the term *lebensraum* which Friedrich Ratzel (1879) introduced into the political dialogue in Europe in 1899 (Glassner 1993). Kjellen's ideas were especially salient with a retired German general and university professor, the director of the Munich Institute of Geopolitics and editor of *Zeitschrift für Geopolitik*, Karl Haushofer. One of Haushofer's most impressionable students was Rudolf Hess. Hess, Hitler, and Haushofer had many long discussions, and the rest, as they say, is history; Hitler's expansionist foreign policy was rationalized, if not based, on the geopolitics as introduced by Ratzel, Kjellen, and especially Haushofer. About this same time Sir Halford John Mackinder proposed a similar notion: the heartland concept.[1] Mackinder's Heartland Theory, suggests that there was a pivotal area "in the closed heart-land of Euro-Asia" which was most likely to become the seat of world power, because of its inaccessibility. Nicholas Spykman, a political scientist who founded the Institute of International Studies at Yale, was an influential realist who emphasized the control of Eurasian coastal regions (Rimland).

Despite its prominent place in the development of the field of world politics, the legacy of World War II and the end of the colonial area left geopolitics rather out of favor in policy circles. Though the geographical basis of military strategy has received some interest in the field of strategic studies, geopolitics in the classical sense has been confined to political geographers.[2] However, the idea that geography plays and important role in international politics need not be limited by the its political misuses.[3] In fact, the analysis of the role of geography has gradually re-emerged, and is working its way back into the scientific study of world politics and foreign policy.

In this article we explore the properties of deadly conflicts from a spatial perspective to gain insight on how they have evolved *grosso modo* after the birth of modern Europe in 1876, using techniques developed to study similar phenomenon in other

[1] mackinder's classic paper (1904) and his later summary (1919) have remained a more popular and politically correct summary of the notion that a territorial imperative is "stabilizing":

> Who rules East Europe commands the Heartland;
> Who rules the heartland commands the World Island;
> Who rules the World Island commands the World.

The National Anthem of England, *Land of Hope and Glory* (better known by its tune, Elgar's *Pomp and Circumstance* March No. 1.), for example, extols the virtue of expansion in the following way: "Wider and still wider, shall thy bounds be set".

[2] For a broad discussion see Ó Tuathail (1996); Glassner (1993); and Taylor and Flint (1999).

[3] If you think these notions are ignored in contemporary Eurasian politics visit the web site of Alexander Dugin at http://www.arctogaia.com.

arenas. Despite widespread recognition of the importance of geography, only recently have scholars begun to explore systematically international conflict using a perspective that encourages understanding the context of conflict from a spatial perspective. Most of this work has not benefitted from the breakthroughs that have occurred in the past three decades in the statistical analysis of spatial patterns. As yet, no published studies incorporate the most recent modeling and statistical frameworks for modeling spatial processes.

2 The statistical analysis of conflict

Although the causes of war and peace have long generated interest among social scientists, historians, and philosophers, the statistical analysis of war and peace is a relatively novel endeavor. In this section we review the development of the statistical analysis of conflict and its relations to the spatial analysis of conflict

2.1 Pioneers

Somewhat surprisingly, the first scholars to undertake systematic attempts at collecting empirical data on conflict were all from fields other than international relations. Initial data development efforts were carried out by an historian, Quincy Wright (1942), a sociologist, Pitrim Sorokin (1957), as well Lewis Fry Richardson (1960*b*), a physicist turned meteorologist who later developed an interest in psychology.

Richardson went considerably further than the the other pioneers in terms of statistical analysis. Based on the data he compiled on *deadly quarrels*, defined as events involving more than 35 casualties, Richardson analyzed whether the risk of conflict seemed related to factors such as shared language, religion, relative wealth, poverty, and distance, and considered whether the distribution of outbreaks of conflict displayed evidence of contagion over time.

Richardson also took an interest in the spatial aspects of conflict: He noted a strong relationship between a state's propensity for conflict and its number of borders. He later expanded on this in an insightful theoretical essay on spatial topology and how the shape of territorial entities would influence the opportunities for conflict (Richardson 1992).

Richardson's work, though written in the 1930s and 1940s, was not widely available until the 1960s, and remained virtually unnoted by scholars of conflict at the time. In the 1960s, mathematical psychologists such as Rashevsky (1949) and Rapoport (1963) revived Richardson's (1960*a*) model of action-reaction dynamics in armament processes, and this lead to somewhat of a resurgence in interest and appreciation of Richardson's work among statistically oriented scholars in international relations. However, as pointed out by Hess (1995) and Nicholson (1999), Richardson remains largely unknown among the mainstream of international relations. Political geographers and scholars of geopolitics appear to have ignored Richardson altogether.

2.2 Settlers

The second wave of interest in statistical analysis of conflict in the 1960s followed in part ideas and suggestions found in the work of the pioneers. The behavioral revolution in political science led to a more prominent position for systematic empirical research and statistical analysis in international relations

Most of the contemporary work on conflict has been influenced by the *Correlates of War* project (commonly know as COW), founded at the University of Michigan by J. David Singer in the 1960s. (Singer 1979; Singer 1980). The COW project started collecting a comprehensive data set on armed conflict (Singer and Small 1972; Small and Singer 1982), classified as either *interstate* conflict between nation states, *civil* wars within states and extra-systemic imperial or colonial wars, where members of the international system engage in conflict with actors that COW did not consider members of the international system.

Despite the broad view of "deadly quarrels" that was taken initially, most of the subsequent empirical research has limited itself almost exclusively on interstate conflict among nation states.[4] Moreover, most of the extant research looks at conflict, especially international conflict, through a lens that is constructed somewhat artificially. Most studies of conflict view it from one of three perspectives. At a *monadic* level, either a country participates in a conflict–or not–and has a duration, extent, and scope of involvement in that conflict. At a *dyadic* level, pairs of countries are involved in a conflict, with each node in the so-called dyad having certain conflict specific characteristics. At the *systemic* level, conflict can be judged by whether war is taking place somewhere in system. Sometimes, the extent of conflict is assessed by the share of countries or dyads that are deemed to be involved in conflict. In this way, deadly quarrels have been filtered, deconstructed, and reconstructed to match extant and (slowly) evolving databases and data-analysis strategies.

The original research in the COW project was particularly interested in examining the relationships postulated in "classical international relations theory" linking conflict to attributes of the international system itself - such as the number of poles or distribution of military capabilities. However, few, if any, robust generalities have between system attributes and conflict have emerged.

In recognition that war is a process or outcome of interaction among decision-makers in states, one main thrust of current research is to focus on *dyads* or pairs of countries, and examine whether sets of covariates associated with theories of conflict behavior seem to affect the observed likelihood of conflict at the margin (Bremer and Cusack 1995; Most and Starr 1989).

Even though the behavioral trust of the dyadic approach has been somewhat more successful strategy for empirical research, its track record is nonetheless rather mixed, with a large number of "non-findings" or no strong systematic relationships. There seems, for example, to be no general, stable relationship between the distribution of

[4] In Gleditsch and Ward (2000*a*) we address this issue more completely.

power and the propensity of dyadic conflict. Nor do arms race processes between states seem strongly associated with outbreaks of war. Many of the strongest empirical regularities obtain for historical or geographical covariates; Countries are more likely to fight other proximate states, and conflicts are likely to spread geographically across borders or recur between parties over time.

3 Toward a new geopolitics of deadly quarrels

We believe that a return to Richardson's notion of deadly quarrels and his focus on the spatial aspects of conflict has much to offer both in terms of improving theories of conflict and furthering empirical research. In the following, we first discuss why we believe an exclusive focus on interstate conflict as defined by the COW project may be overly limiting. Based on our previous work on democratization and war, we then show how explicitly incorporating space can contribute to furthering empirical research on conflict.

3.1 (Re-)defining conflict

There is a strong tendency in international relations to assume that it is self-evident what would constitute violent conflict and not. Most applied researchers tend to assume that the commonly used data probably by and large will accurately reflect their theoretical concepts. To be sure, scholars generally acknowledge that there may be large amounts of measurement error. But such error would be merely random noise and essentially wash out in the aggregate, provided there are no systematic sources of bias and misleading attributions. The availability of the COW interstate war data has enabled researchers to proceed to analyze data on conflict without too much concern about defining the events of interest. In the following, we discuss some non-trivial problems indicating that measurement in the study of conflict often seems out of touch with our general understanding of what the concept entails.

The term *conflict* denotes some form of incompatibility between parties. Most definitions stress incompatibility which is explicitly perceived by the parties involved, rather than contrary goals based upon some form of objective function of the actors' interest or the structure of their relationship.[5] Boulding (1963, 5), for example, defines conflict as "a situation of competition in which the parties–of which there are at least two –are aware of the incompatibility of potential future positions, and in which each party wishes to occupy a position that is incompatible with the wishes of the other."

Although some degree of conflict may be inherent in any social relation, researchers usually draw a fundamental distinction between violent and non-violent forms of conflict, and focus on overt resort to violence and its absence. Violence is, of course,

[5]Concepts such as *structural violence* (see Høivik and Galtung (1971) for an example) generated considerable interest in the 1960s and 1970s, but is not central in current research.

by no means the only way of inflicting punitive measures, and final resort to violence is arguably the result of larger processes that may or may not lead to violence. It is thus desirable to distinguish between qualitatively different forms of "no-war" in statistical analysis (Gleditsch 1999).

Violent social conflict must furthermore be distinguished from other interpersonal violence. The former encompasses hostile interactions between some reasonably well-defined set of parties or actors that involve violence above some magnitude and which persist for some period of time. Domestic or urban violence may affect a larger number of persons directly than interstate conflict, but would not be considered social conflict as neither perpetrators nor victims constitute actors or parties in the sense of a unified group.[6]To ensure tractability, most introduce some threshold of violence for something to constitute evidence of conflict. For our purposes, the Correlates of War criterion of more than 1,000 battle deaths for something to constitute a "major war" provides a reasonable approach to delineating violent armed conflict (Singer and Small 1982, 1972).[7]

Unlike much of other contemporary research, we find it limiting to restrict attention to conflict between nation states only. Interstate conflict is a relatively limited share of the armed conflict involving nation states. According to Wallensteen and Sollenberg (1998), only six out of 103 armed conflicts in the period 1989-97 were strictly interstate conflicts (see also Holsti 1996: 22). Some argue that the relative share of "civil" versus "international" conflict has increased over the 20th century. We have strong doubts about the accuracy of data on civil war (say, in Africa) at the beginning of the century. However, any increase in civil wars nonetheless seems to run counter to what one would expect from the proliferation of states over the period, which would suggest that civil wars might be converted to interstate wars.

If our broader substantive interest as political scientists is understanding what conditions underlie the violence that aggravates and threatens the health and well being of millions of individuals, it is not obvious why we should restrict our focus exclusively to a small subset. Even at a time when many see the world approaching something akin to an end of international war, the extent of warfare in the international system and its consequences still seem substantial. The consequences of nuclear war might be catastrophic, yet, very simple weapons have claimed vastly more lives than than nuclear missiles. In our view, the most common justifications for the exclusive focus on interstate conflict in research on conflict do not seem sufficiently substantiated.

[6]Similarly, acts of "democide" or a government violence against its own population would generally not be considered social conflict, because the victims do not constitute a group. Rummel (1995) estimates that democide have claimed five times more casualties than international wars in the 20^{th} century.

[7]We thus limit ourselves to the COW international and civil war data set rather than so-called militarized disputes which include events below this level of casualties. We find the so-called MID data problematic (Gleditsch 1999, ch. 4), moreover this data only includes disputes between states.

3.2 The internationalized nature of deadly quarrels

That states constitute the principal actors is somewhat of an article of faith in the field of international relations. Much of international relations theory holds relations between states to be fundamentally different from relations within formally sovereign states given the condition of anarchy and absence of formal authority. Although the question is rarely addressed explicitly, researchers tend to be skeptical as to whether theories of international conflict are applicable to conflict within countries or transnational conflict involving both state and non-state entities.

A probably not fully intended side effect of the assumption of sovereignty is that most researchers simply assume that sovereignty *is* effective within nations, thereby making civil war qualitatively different from interstate conflict. Yet, sovereignty is obviously less than fully effective within many existing states, and similar problems of enforcement and contracting under anarchy could obtain within states as well. When relating "Warre" to anarchy, Hobbes had relations within states in mind, not the international system.

Restricting analyzes to interstate wars is in practice more problematic than often assumed by practitioners in the sense that researchers seem unaware of what events become excluded. In the COW terminology, international wars encompass in addition to interstate wars also extra-systemic wars, in which system members engage in war with a political entity not considered to be a system member. Many armed conflicts in the postwar era, however, are classified as "civil wars" with outside intervention rather than interstate wars. Events regarded as internal or "civil" wars such as Afghanistan, Angola, Lebanon, and Bosnia-Herzegovina, nonetheless display obvious international dimensions.

Whether something is judged to be an external or internal conflict in retrospect is quite sensitive to legal and definitional aspects in themselves unrelated to properties of the conflict. The Vietnam war, for example, is regarded as an international war once the United States intervenes, having been previously classified as a civil war that grows out of an initial extra-systemic war involving France prior to independence.

More generally, a conflict becomes an international or civil war depending on how the conflict and foreign intervention unfolds. As intervention often occurs in connection with attempts to replace the existing government, the outcome of interventions or which party is considered to be the legitimate government at the time of intervention can "determine" whether an intervention involves interstate war or constitutes international intervention in an ongoing civil conflict. If the anticommunist *Herat* uprising in Afghanistan had succeeded in actually toppling the government, a Soviet intervention could conceivably have become an event marking the onset of an interstate war.[8] Additional ambiguities arise as to whether conflicts revolving around the breakup of entities and the emergence of new states as seen as in the former Yugoslavia constitute wars between sovereign nations or "internal" wars.

[8]The 1956 invasion of Hungary, for example, *is* considered an interstate war.

Upon closer scrutiny, lists of interstate wars cover only a subset of what observers perceive as armed conflict and war. Merely a cursory view indicate that many scholars seem unaware of these implications. Mansfield and Snyder's (1995) work on democratization and war, for example, repeatedly refers to conflicts in the former Soviet Union and the Balkans to illustrate their argument. However, neither Chechnya nor Bosnia are considered international wars, and are as such not included in the empirical data that they rely on. Mansfield and Snyder (1997) similarly cite Rwanda as evidence of how democratization leads to war, though this is a "civil war" not included in their empirical analysis limited to international wars. Our aim is not to single out particular research. However, these examples indicate that large discrepancies between theory and data are quite widespread in research on international conflict.

Our argument is not so much that the COW classifications are "wrong" or that civil and extra-systemic wars are fully equivalent to interstate wars. However, this terminology might impose a distinction that is theoretically untenable. If this partition gained a great deal, such a tradeoff may be worth the cost. Our view is that the limitations far outweigh the gains. Civil wars carry a potential for diffusion and escalation to interstate wars, and are classified as one or the other based in part on whether they do or not. Such classification problems underscore why limiting conflict to clear-cut cases of interstate war fails to fully correspond to the general phenomenon of interest. To understand regional formations of conflict and peace, "civil" conflicts which contribute to regional insecurity cannot merely be excluded out of hand.

The standard formal model of conflict as interaction between two parties X and Y has come to be identified with states, and does not always translate easily to situations with constellations of other types of actors. However, a simplification or abstraction which we invoke in a modeling device is not necessarily an appropriate theoretical criteria for defining conflict or a suitable empirical case selection device.

Taking a broader view of conflicts as violent events that have various degrees of international dimensions and implications, we relax the criterion that both of the principal opposing parties must be system members We consider all events in the Correlates of War international and civil war data as indicators of whether a country participates in violent conflict. Although the original COW data are available only up to 1992, we have updated them to 1998 using information from Wallensteen and Sollenberg (1999).

We identify outbreaks of new conflicts by the COW classifications as to what constitutes separate conflicts. We recognize that it is difficult to identify what constitutes a *new* conflict and that successive events may not be entirely independent.

3.2.1 The meaning of y=1 in studies of conflict

The decisions above do not solve all the ambiguities in data on conflict. Most notably, it is clear that the condition "state A is involved in war at time t" being true could mean a variety of different things. Not all incidents of conflict participation seem

equivalent or symmetric between the parties.

A given incident of conflict which a country is involved in may take place either on (i) a country's own territory (or in the immediate proximity) or (ii) outside its own regional context. The consequences of conflict and the element of threat to a state's vital security and territory differ considerably with the specific location.

Consider the case of the Vietnam war, where the US becomes involved in a civil war between the two Vietnams growing out of a colonial war with France. However, the conflict was fought entirely in Indochina, and affected North and South Vietnam in a very different ways than the US. Although the US may define its security interest to encompass objectives beyond its regional context, it was spared most of the physical destruction and the risk of the conflict spreading to the US territory or home turf was essentially minimal. Similarly, Cuba commits large number of troops in support of the MPLA government in the civil war in Angola, but no civil war is taking place on Cuba itself.

These problems become more severe when we are interested in the spatial aspects of conflict. The prospects for diffusion of conflict are greater the closer a state is to the actual locus on conflict. The recent events in Kosovo clearly involves a risk of violent conflict in Macedonia. Spanish forces participating in UN operations in Kosovo, however, would not be expected to lead to diffusion to Morocco.

The existing COW data tell us on what continents conflict is waged. Ideally, however, our data on conflict would include disaggregated information on extension and location of the various battles.

3.3 Diffusion of conflict

Many have hypothesized that conflicts may spread or diffuse over time and among countries across space. Richardson examined whether outbreaks of war seemed to be randomly distributed events by comparing his data to a Poisson distribution. Richardson found that the distribution seemed within the range of variation that could be expected under a Poisson distribution, and concluded that conflicts seemed to be random over time. He also discarded other arguments about secular trends on the basis of similar probabilistic reasoning.

However, it would be incorrect to conclude that Richardson considered conflicts entirely random phenomena. Richardson (1960*b*, 176-183, 288) observed a strong 0.7 correlation between a country's number of borders and its extent of war involvement, which he attributed to the opportunities for contact. He further explored the relationship between contiguity and conflict through mathematical models, and noted that existing political division of the world displayed several regularities or "remarkable political facts" not mandated by the geometry of closed polyhedra. Almost no countries are completely surrounded by another, and almost every vertex (or points where more than two entities meet) has the simplest possible structure, consisting either of three countries or two countries meeting water (1960*b*, 290-1). Though Richardson

is not explicit on this point, he seems to recognize that this simplicity of structure is not incidental, but has resulted as the outcome of political processes. "Simple" territorial structures are generally more compact, and thus easier to defend or fortify than complex shaped territory.

The later settlers first approached diffusion by examining whether the distribution of outbreaks of conflict conformed to statistical distribution for independent events such as the Poisson distribution. Davis, Duncan, and Siverson (1978) examined diffusion of conflict over time on the system level, or whether outbreaks of war tended to be followed by an increased likelihood of subsequent outbreaks of war. In general, however, most concorded with Richardson on that outbreaks seemed to be indistinguishable from a random process.

The weak evidence for diffusion from this line of research seems at odds with casual evidence of diffusion. Most and Starr (1980) noted several difficulties with the "does-the-outbreaks-of-war-conform-to-a-Poisson-distribution?" approach. Such tests against a nil model of independence say little about the specific form of dependence hypothesized to exist between observations if the model should be rejected. Most and Starr (1980, 933) delineated a series of possible positive and negative dependent relationship between war outbreak and participation over space and time.

Diffusion may induce positive or negative reinforcement of conflict involvement, making future war participation more likely, as suggested by the concept of"enduring rivalries", or less likely, as suggested by "weariness of war" hypotheses. However, wars may also diffuse between nations so that an outbreak of war in one country increases (or decreases) the subsequent likelihood of outbreaks of wars in other countries. Most and Starr examined such *positive* and *negative* spatial diffusion by testing empirically whether new cases of war participation were more likely to occur in countries with warring border nations. Using a series of different data sets on conflict, they found that the presence of warring border nations indeed appeared to increase the likelihood of war.

The diffusion through "war in bordering nations" research program has contributed to international relations research by clarifying some of the opportunities and constraints for interaction and the spatial dependence between units. It taught us that the spatial correlation of conflict seems to be strong. Most and Starr (1980, 936) pointed out that spatial non-dependence would have statistical consequences similar to serial correlation in time, and suggested that the lack of attention to spatial dependence or diffusion of conflict could have lead to biased results and impeded progress in research on the causes of war. However, Most and Starr and later contributors did not provide adequate statistical models for dealing with the spatial correlation.

3.4 Towards a geography of violent conflict

Later statistical research on diffusion and the spatial aspects of conflict and cooperation was strongly influenced by approaches developed in regional science. The so-called *spatial econometric* approach surveyed by Anselin (1988) popularized introducing spatial context in statistical models through a matrix specification of dependence between entities and a "spatial lag" term that accounts for the spatial correlation of the dependent variable. This is based upon work now 25 years old (Besag and Moran 1975; Ord 1975) that demonstrates how the computational difficulties with the maximum likelihood estimator for autoregressive models for spatial interaction could be solved by a simplified computational scheme based on a trick involving the eigenvalues of the spatial weights matrix too arcane to discuss.

These approaches have been used in several studies (O'Loughlin 1986; Kirby and Ward 1987; Ward and Kirby 1987; Shin and Ward 1999). However, the framework has a series of drawbacks for studies of conflict. This class of models have been developed for continuous dependent variables, whereas most data on conflict is categorical, typically binary.[9] Even though models for spatially correlated categorical variables have been developed over the past three decades in the statistical analysis of spatial patterns (Besag 1972; Besag 1974), the work of conflict has not benefitted from these breakthroughs that have occurred. Estimation has usually been based on computational methods that initially were introduced as convenient solutions for seemingly intractable problems, but no longer seem necessary.

4 Democracy, conflict, and peace

In this section we present a brief overview of the evolution in previous research of the model we propose to analyze. The seeming absence of war between democracies was first noted by Babst, but what has later become known as the *democratic peace* entered into the mainstream of empirical research on international conflict through a series of articles by Rummell and the controversies it generated. The democratic peace has provided a boost to empirical research and generated interest in numerous related propositions.

In a series of papers (Ward and Gleditsch 1998; Gleditsch and Ward 2000*c*), we have re-examined the controversy surrounding whether democratization is associated with improved prospects or greater risk of war as suggested by Mansfield and Snyder (1995).[10] Mansfield and Snyder (1995) aggregated changes in authority structures over a ten-year period, and examined whether democratization seemed to be associated with incidents of conflict in the subsequent ten years through χ^2 tests of

[9] We leave aside the question of whether conflict is inherently discrete events or more continuous phenomena. Even if conflicts can differ greatly in degree, most classification opt for coding presence/absence.

[10] For other contributions, see Thompson and Tucker (1997) and Enterline (1998).

independence.

In light of some of the problems in this tabular analysis approach, Ward and Gleditsch (1998) proposed examining the likelihood of conflict as a function of changes in authority structures over a prior ten-year period. Instead of dichotomizing "change" versus "no-change," they proposed disaggregating changes into their *direction* or *sign*, *magnitude of change*, and *variability of change* or the variance in authority structure over the period. The results indicated that substantial democratization would reduce the likelihood of war, whereas smaller changes or transitions to democracy that are followed by reversals to autocracy could increase the risk of war.

4.1 War and peace in time and space

Ward and Gleditsch (1998), essentially ignored any dependence between the pooled observations, both over time and across space. Gleditsch and Ward (2000*c*) and Gleditsch (1999) estimated revised versions of the original model to address these issues.

Gleditsch and Ward (2000*c*) examined the duration dependence of war and peace over time as well as investigated the effects of democratization on outbreaks and continuation/termination of wars separately. In addition, the model was revised in an attempt to take into account dependence across units in space. First, we evaluated the extent of clustering of conflict. If conflict is distrubuted non-randomly in space, statistical models ignoring diffusion or the dependence of war and peace among countries could be ridden by serially correlated error terms. Second, we considered whether conflict was related to the extent of democracy in neighboring countries. Gleditsch (1999) found that the likelihood of conflict for a given country seemed more consistently related to the authority structures in the larger surrounding region than the attributes of each individual country.

Space was treated as fixed in these studies, however, though the number of states in the system and their proximity and borders change quite considerable between 1875 and the contemporary era. Gleditsch and Ward (2000*c*) tested explicitly whether the relationship of the continuous variables to the likelihood of the event occuring seemed linear in log odds through a *Generalized Additive Model* specification. Their results indicate that though many of the effects did not seem fully linear in the log odds, only the effects of democracy displayed monotonicity.

In the next section we focus on two basic aspects of this model: the negative impact of high levels of democracy on conflict propensity and the contagion effects of conflicts in surrounding regions.

5 A Parsimonious Model of Democracy and War

The basic insight we propose herein is that state i's probability of conflict is highly dependent upon the existence of conflict in all other states $-i$. Curiously, such in-

terdependence is typically lacking in empirical models of international relations and world politics.

Our basic model is an autologistic model of the likelihood that a state i will be involved in a conflict at time t. We specify the dependencies between the N countries in our sample by a binary $N \times N$ distance based connectivity matrix, where entries $W_{i,j}$ acquire a value of 1 if states i and j are considered adjacent or "close". We generate the W matrix from a new data set on the minimum distances between polities in the international system (Gleditsch and Ward 2000*b*). Two independent covariates capture the level of democracy and the regional context of democracy: $d_{i,t}$ the level of democracy at time t in country i for all countries $(1, \ldots, n)$, ranging from -10 for highly autocratic to $+10$ for highly democratic and $d'_{i,t}W^s$, the average level of democracy in contiguous countries, with W^s denoting a connectivity matrix W that has been row standardized.

A simple, linear statement of these independent aspects to which an intercept α and a spatial covariate y'_iW are added is given as

$$\alpha + \beta_1 d_i + \beta_2 d'_i W^s + \gamma y'_i W$$

where y'_iW is the sum of neighbors in conflict for a given definition of neighbors contained in the contiguity matrix, W.

Collecting into η_i the k exogenous terms in a $k \times i$ matrix of exogenous variables $\mathbf{X}_i$, and the associated parameters into a vector $\vec{\beta_k}$, and defining the neighborhood sum or spatial lag, y'_iW, as $\widetilde{y}_i$, yields

$$\eta_i = \alpha + \mathbf{X}'_i\vec{\beta_k} + \gamma\widetilde{y}_i$$

which permits a simple statement of the autologistic:

$$Pr[y_i = 1|\widetilde{y}_i] = \frac{e^{\eta_i}}{1 + e^{\eta_i}} \tag{1}$$

If $\gamma = 0$ this is a standard logistic; if all β_k are 0, this becomes the standard autologistic without covariates. The autologistic model is widely known in statistics and has been widely used for applications in ecology and natural science, but appears to have been completely ignored in the social sciences.

It is widely know that this model has a likelihood function which is mathematically intractable since the y_i are conditionally dependent upon each other (Besag 1974). Three computational methods have been proposed to solve this problem. Besag (1974) devised a coding method that reduced the dependencies to a few adjacencies, assuming all other observations are independent and exchangeable. The resulting scheme permits maximum likelihood estimation. This method is inefficient and is little used in practice (e.g., Huffer and Wu 1998). A maximum pseudolikelihood method was developed (Besag 1975) that uses a weighted average of different coding methods, and its efficiency examined (Huffer and Wu 1998; Besag 1977; Besag and

Moran 1975). This has been found to be inefficient, *especially* when spatial interaction is strong.

The third class of estimation approaches is Markov Chain Monte Carlo (*MCMC*) methods. These approaches originate in statistical physics.[11] These methods are computationally intensive and allow one to approximate maximum likelihood estimates for any family of distributions with probability densities known up to a constant of proportionality. This approach has been widely and recently used in image recognition/reconstruction (Hoeting, Leecaster and Bowden 1999) as well as parameter estimation (Gumpertz, Wu and Pye 1999; Gumpertz, Graham and Ristaino 1997; Gotway and Stroup 1997).

In our earlier work, in particular Gleditsch and Ward (2000*c*), we employed a version of the pseudolikelihood approach to estimation. One major disadvantage of this approach is that it tends not to work in the situations which we are most interested in studying: strong spatial patterns. More recently, however, it has become possible to use simulation approaches –namely the Markov Chain Monte Carlo (MCMC) method– to get approximations that are closer to the full likelihood function.

The basic approach introduced in Geyer and Thompson (1992) is quite simple in conception and has been used by Wu and Huffer (1998) as well as Hoeting, Leecaster, and Bowden (1999). If $\vec{\theta} = (\alpha, \vec{\beta_k}, \gamma)$, then a probability measure of a random map generated from this model forms an exponential family defined by the parameters $\vec{\theta}$ and the sufficient statistics, $\vec{s}(y)$, given by

$$\vec{s}(y) = \Big(\sum_{i=1}^{n} y_i, \sum_{i=1}^{n} X_i y_i, \frac{1}{2} \sum_{i=1}^{n} \tilde{y_i} \Big).$$

For any chosen vector of parameters corresponding to θ, say ψ, a sample of maps containing simulated values for y_i can be obtained. Typically, the pseudolikelihood estimates of the parameters are used for ψ. A Gibbs sampler (Geman and Geman 1984) is then used for data augmentation generating a large set of samples based on ψ. These simulated samples are then used to derive a set of sufficient statistics. Using the sufficient statistics from these samples it is possible to determine an approximation to the likelihood function for θ based on the approximation found in the sample. The Markov Chain maximum likelihood, found through these approximations, is obtained by solving the score equation, typically by use of Newton-Raphson methods:

$$\frac{\sum_{j=1}^{m} \vec{s}(y_m) e^{(\hat{\theta}-\psi)' \vec{s}(y_m)}}{\sum_{j=1}^{m} e^{(\hat{\theta}-\psi)' \vec{s}(y_m)}} = \vec{s}(y_{observed}) \tag{2}$$

where m is the number of sampled simulated maps and $\vec{s}()$ is the vector of sufficient statistics.[12]

[11] Alan Sokal (1996), of *Social Text* fame, has written a good overview of the foundations and algorithms with applications to physics. See Gelman *et alia* (1995) for an accessible introduction in the context of Bayesian methods.

[12] Newton-Raphson methods are a crude, iterative way to minimize a function modulo a set of

5.1 Empirical results

We examine this simple model for data from 1988, taken from Polity 98 and a W matrix using a 475 km minimum distance threshold. Pseudolikelihood and MCMC estimates of the parameters can be found in Table 1. This is an exceedingly parsimonious model with only two covariates: the level of democracy in a country and the average level of democracy in the surrounding countries. We have kept the model quite simple to provide a difficult test for the autologistic formulation. This should enable us to see how much information exists in the spatial distribution of conflict itself and further enable us to examine its diffusion.

In general the MCMC estimates ($\hat{\theta}$) are smaller than the corresponding pseudolikelihood estimates ($\hat{\psi}$). MCMC standard errors are quite small for each estimate. As would be expected, democracy shows a strong negative effect on the probability of conflict, while the spatial context of conflict shows evidence of strong spatial correlation. The spatial context of democracy is very close to zero, with a fairly large standard error; by traditional standards this would not be seen to be a powerful covariate. In short, all other things being set aside as "controlled for," democracy influences a robust negative influence on the likelihood that a country will be involved in a domestic or international conflict of substantial magnitude. At the same time, there is a stronger, independent (same scale) locational effect. Countries that are surrounded by conflictual countries will also have a much higher likelihood of being involved in a conflict, either civil or international.

Table 1: MCMC and Pseudolikelihood Parameter Estimates

			Spatial Parameters	
	Intercept	Democracy	Democracy	Conflict
Estimator	α	β_1	β_2	γ
MCMC Maximum Likelihood $\hat{\theta}$	-1.712	-0.053	-0.003	0.261
Pseudolikelihood $\hat{\psi}$	-1.840	-0.020	0.013	0.298
MCMC $\hat{\sigma}$	0.0601	0.0061	0.0099	0.0133

It has been noted that many studies of international conflict have fairly low predictive capabilities. Beck, King and Zheng (2000) have argued that virtually no studies of international conflict have predicted probabilities greater than the typical threshold used in many other fields, $\hat{\pi} > .5$. This is true for the pseudolikelihood estimates shown above. However, the MCMC estimates that we provide do in fact exceed this

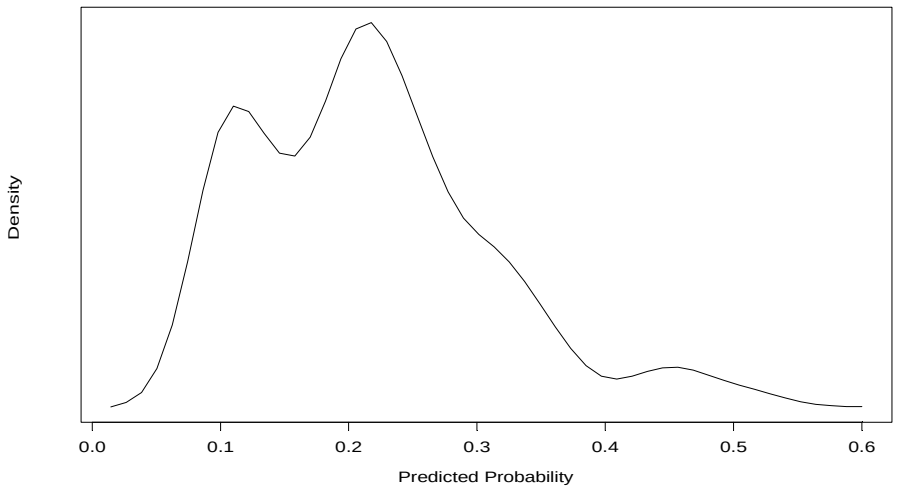
parameters θ. The basic iteration is given by: $\theta_{i+1} = \theta - G^{-1}(\theta_i)g(\theta_i)$, with $g(\theta_i)$ a vector of derivatives of f with respect to the θ_i and $G(\theta_i)$ is the $m \times m$ matrix of second derivatives of f.This method is very fast if it begins close to the minimum, but slow and thorny if it doesn't: G may in such cases become negative definite. "May" means "does" in this context. Newton-Raphson algorithms also can produce exploding parameter vectors as well as cyclical results.

threshold (see Table 2) in 7 of the 138 cases, admittedly a small proportion, but certainly not an empty set. Moreover, of the seven conflicts that are postdicted, two of them are actual conflicts that did occur. Iraq and Syria both were involved in conflict in 1988. Figure 1 presents the probability density for the estimates from the autologistic model.

Table 2: Actual and Predicted Conflict States

	Observed	
Predicted	No	Yes
No	109	29
Yes	5	2

Figure 1: Density Function for Predicted Probability of Conflict



However such a comparison leaves unincorporated any errors that might be introduced by the model itself, and is therefore not an adequate reflection of the model's predictive power. We conduct a simulation, using the estimate $\hat{\theta}$ to produce estimates, but instead of using the observed data on conflict (i.e., the data that were used in generating the estimates) we allow conflict values to be produced by the model on the fly.[13] This requires a starting value for conflict. We use the current state of conflict in 1988. The model is then simulated and conflict is turned on or off in each country based on the autologistic equation. Then the simulated current state of conflict is

[13]Based on Figure 1 we use 0.4 as a cut-off value for predicting conflict.

used as input values, and the process is repeated until it settles down, usually after several iterations. Table 3 shows that such a dynamic use of the estimate coefficients, produces somewhat stronger results in addition to being more faithful to the autologistic formulation. In this instance, we are able to correctly predict eight conflicts, and have an equal number of false positives.

Table 3: Actual and Predicted Conflict States 1988

	Observed	
Predicted	No	Yes
No	99	23
Yes	8	8

Finally, we use the estimated parameters for 1988 ($\hat{\theta}$) along with the data on democracy and the spatial lag of democracy for 1988 to *predict* the state of conflict in the subsequent decade to 1998, using a cut-off value of 0.35 obtained from inspecting the density function. We are basically predicting whether there will be a domestic or international conflict in the next ten years, based on knowledge about the current state of conflict in all countries, coupled with knowledge of whether they are democracies or autocracies in 1988.

Table 4: Using 1988 Estimates to Predict Conflict from 1988 through 1998

	Observed	
Predicted	No	Yes
No	73	29
Yes	8	26

As shown in Table 4 there are twenty six successful predictions of conflict (along with 73 successful predictions of no conflict), tempered by eight false predicted conflicts and twenty nine missed conflicts. Stated differently, the simple autologistic model estimated on the 1988 data classifies about 75 percent of the annual observations in the subsequent year correctly. More interestingly, it successfully classifies almost 50 percent of the conflicts. The correctly classified conflicts are listed in Table 5.[14]

[14]Our model misses cases of war participation for Afghanistan, Algeria, Angola, Cambodia, Canada, Colombia, Cuba, El Salvador, France, Guinea-Bissau, India, Italy, Liberia, Liberia, Morocco, Myanmar, Mozambique, Nicaragua, Peru, Philippines, Rumania, Russia, South Africa, Sierra Leone, Sri Lanka, United Kingdom, United States, Vietnam, Yugoslavia, Zimbabwe. In many of these cases (e.g., UK) conflict was not actually waged on the state's own territory. Some countries involved in war in the period did not exist in 1988 (e.g., Bosnia), and are as such not part of the prediction set.

Table 5: Profile of Correctly Predicted Conflicts

Country	Type of War	Date of Onset
Bahrain	International	1991
Burundi	Civil	1988, 1991, 1998
Chad	International	
Congo-Brazzaville	Civil	1997
Democratic Republic of Congo – Zaire	Civil	1997
Egypt	International	1991
Ethiopia	International	1998
Iran	International	
Iraq	Civil, International	1991
Israel	Civil	
Kuwait	International	1991
Lebanon	Civil	
Libya	International	
Nigeria	Civil	1992, 1994, 1996
Oman	International	1991
Qatar	International	1991
Rwanda	Civil	1990, 1998
Saudi-Arabia	International	1991
Somalia	Civil	
Sudan	Civil	1995
Syria	Civil, International	1991
Tanzania	Civil	
Turkey	Civil	1991
United Arab Emirates	International	1991
Uganda	Civil	
Yemen	Civil	1994

These results seem quite promising, but should not be cited as evidence of the ability to predict war and turmoil. The model is very preliminary, containing only one powerful covariate, ignoring many other forces that are known to be important. At the same time it fails to predict conflict in the majority of cases where conflict emerges. Wars are relatively rare events so that results could be quite erratic from one time period to another. In the longer run, the evolution of hostility and conflict as well as appeasing factors must be incorporated explicitly in the model.

Despite these limitations, to our knowledge this effort is unique in successfully bringing a strategic interaction perspective into a predictive mode for a large number of cases. Our results clearly demonstrate that a rejection of the notion that all international actors are sovereign and independent still permits considerable statistical investigation of the patterns of international conflict. To our knowledge it is also

unique in its success rate in predicting conflict, *ex post ante*.

6 Conclusion

International relations proclaims to study the interdependence of the forces in world politics, especially countries and organizations. However, virtually all scholarship that is statistically based has made the assumption that all countries are exchangeable (Ward 1988) and their data are statistically independent. This has blinded us to the substantial evidence of associative interactions in world politics.

Anselin (1988) and LeSage (1999) so-called spatial econometrics, using the insights from Besag and Moran (1975) and Ord (1975) to circumvent the computing problems involved with complicated likelihood functions, was a fundamental breakthrough which allowed likelihood estimates to be computed without solving the Jacobian matrix for each observation for each iteration. A quarter of a century ago, Besag formulated the pseudolikelihood approach to estimating parameters for the autologistic formulation. This was necessary since the likelihood function of this specification was mathematically intractable, owing to the fact that everything is dependent on everything else. However, this pseudolikelihood approach for binary variables remained ignored in political science and geography until very recently.

In the era of expensive computing both of these computational solutions made sense. Two things have happened in the nonce, however. First, computers are now surpassing the 1 GigaHertz speed marks. Computing and memory, as well as object oriented languages, have made computationally intensive methods very affordable and readily available. At the same time, the growth of MCMC approaches to solving difficult likelihood functions has allowed researchers to undertake the analysis of problems that were previously too difficult to tackle. As a result of these two trends, the old tricks are no longer relevant and may in fact serve to give us the wrong answers as well as point us in the wrong direction. The range of opportunities for a full-fledged spatial approach to deadly quarrels (and other discrete and continuous social phenomena) is clearly very wide and the potential benefits seem substantial, judging from these simple steps.

References

Anselin, Luc. 1988. *Spatial Econometrics: Methods and Models.* Dordrecht, the Netherlands: Kluwer.

Beck, Neal, Gary King and Langche Zheng. 2000. "The Problem with Quantitative Studies of Conflict: A Conjecture." *American Political Science Review* 94:in press.

Besag, Julian E. 1972. "Nearest-neighbour Systems: A Lemma With Application to Bartlett's Global Solutions." *Journal of Applied Probability* 9:418.

Besag, Julian E. 1974. "Spatial Interaction and the Statistical Analysis of Lattice Systems (with Discussion)." *Journal of the Royal Statistical Society, Series B, Methodological* 36:192–225.

Besag, Julian E. 1975. "Statistical Analysis of Non-lattice Data." *The Statistician* 24:179.

Besag, Julian E. 1977. "Efficiency of Pseudolikelihood Estimation for Simple Gaussian Fields." *Biometrika* 64:616.

Besag, Julian E. and Patrick A. P. Moran. 1975. "On the Estimation and Testing of Spatial Interaction in Gaussian Lattice Processes." *Biometrika* 62:555.

Boulding, Kenneth E. 1963. *Conflict and Defense: A General Theory.* New York: Harper and Row.

Bremer, Stuart A. and Thomas R. Cusack. 1995. *The Process of War: Advancing the Scientific Study of War.* Luxembourg and Philadelphia, PA: Gordon and Breach.

Davis, William, George Duncan and Randolph M. Siverson. 1978. "The Dynamics of Warfare, 1816-1965." *American Journal of Political Science* 22:772–792.

Enterline, Andrew J. 1998. "Regime Changes, Neighborhoods, and Interstate Conflict, 1816-1992." *Journal of Conflict Resolution* 42:804–29.

Gelman, Andrew, John B. Carlin, Hal S. Stern and David B. Rubin. 1995. *Bayesian Data Analysis.* Chapman & Hall.

Geman, Stuart and Donald Geman. 1984. "Stochastic Relaxation, Gibbs Distributions and the Bayesian Restoration of Images." *IEEE Transactions on Pattern Analysis and Machine Intelligence* 6:721–741gem.

Geyer, Charles J. and Elizabeth A. Thompson. 1992. "Constrained Monte Carlo Maximum Likelihood for Dependent Data, (with Discussion)." *Journal of the Royal Statistical Society, Series B, Methodological* 54:657–699.

Glassner, Martin Ira. 1993. *Political Geography.* New York: John Wiley & Sons.

Gleditsch, Kristian S. 1999. Peace Has Its Victories, No Less Renowned Than War: A Local Interaction Approach to Regional Conflict, Integration, and Democratization Ph. D. thesis. University of Colorado Boulder, Colorado, USA.

Gleditsch, Kristian S. and Michael D. Ward. 2000*a*. "Interstate System Membership: A Revised List of Independent States since 1816." *International Interactions* 25:393–341.

Gleditsch, Kristian S. and Michael D. Ward. 2000*b*. "The Role of Geography in World Politics: A Minimum Distance Database, 1875–Present." *tba* NA:NA.

Gleditsch, Kristian S. and Michael D. Ward. 2000*c*. "War and Peace in Space and Time: The Role of Democratization." *International Studies Quarterly* 44:1–29.

Gotway, Carol and Walter Stroup. 1997. "A Generalized Linear Model Approach to Spatial Data Analysis and Prediction." *Journal of Agricultural, Biological, and Environmental Statistics* 2:157–178.

Gumpertz, Marcia L., Chi-tsung Wu and John M. Pye. 1999. Logistic Regression for Southern Pine Beetle Outbreaks with Spatial and Temporal Autocorrelation. Technical Report 2513 Institute of Statistics, North Carolina State University, Raleigh, NC.

Gumpertz, Marcia L., Jonathan M. Graham and Jean B. Ristaino. 1997. "Autologistic Model of Spatial Pattern of Phytophthora Epidemic in Bell Pepper: Effects of Soil Variables on Disease Presence." *Journal of Agricultural, Biological, and Environmental Statistics* 2:131–156.

Hess, Gregory D. 1995. "An Introduction to Lewis Fry Richardson and His Mathematical Theory of War and Peace." *Conflict Management and Peace Science* 14:77–113.

Hoeting, Jennifer A., Molly Leecaster and David Bowden. 1999. "An Improved Model for Spatially Correlated Binary Responses." *Journal of Agricultural, Biological and Environmental Statistics* 4.

Høivik, Tord and Johan V. Galtung. 1971. "Structural Violence: A Note on Operationalization." *Journal of Peace Research* 7:73–76.

Huffer, Fred W. and Hulin Wu. 1998. "Markov Chain Monte Carlo for Autologistic Regression Models with Application to the Distribution of Plant Species." *Biometrics* 54(2):509.

Kirby, Andrew M. and Michael D. Ward. 1987. "The Spatial Analysis of Peace and War." *Comparative Political Studies* 20:293–313.

Kjellen, Rudolf. 1916. *Staten som Lifsform [The State as an Organism]*. Stockholm: Hugo Geber.

LeSage, James P. 1999. *Spatial Econometrics using MATLAB*. The Web: www.econ.utoledo.edu.

Mackinder, Halford J. 1904. "The Geographical Pivot of History." *The Geographical Journal* 23:421–444. paper read to the Royal Geographical Society, April 1904.

Mackinder, Halford J. 1919. *Democratic Ideas and Reality: A Study in the Politics of Reconstruction*. London: Constable.

Mansfield, Edward and Jack Snyder. 1995. "Democratization and the Danger of War." *International Security* 20:5–38.

Mansfield, Edward and Jack Snyder. 1997. "A Reply to Thompson and Tucker." *Journal of Conflict Resolution* 41:457–461.

Most, Benjamin A. and Harvey Starr. 1980. "Diffusion, Reinforcement, Geo-Politics and the Spread of War." *American Political Science Review* 74:932–946.

Most, Benjamin A. and Harvey Starr. 1989. *Inquiry, Logic, and International Politics*. Columbia, SC: University of South Carolina Press.

Nicholson, Michael. 1999. "Lewis Fry Richardson and the Study of the Causes of War." *British Journal of Political Science* 29:541–563.

O'Loughlin, John V. 1986. "Spatial Models of International Conflict: Extending Current Theories of War Behavior." *Annals of the American Association of Geographers* 76:60–83.

Ord, J. Keith. 1975. "Estimation Methods for Models of Spatial Interactions." *Journal of the American Statistical Association* 70:120–126.

Ó Tuathail, Gearóid. 1996. *Critical Geopolitics*. London: Routledge.

Rapoport, Anatol. 1963. Mathematical Models of Social Interaction. In *Handbook of Mathematical Psychology*, ed. R. Duncan Luce, Robert R. Bush and Eugene Galanter. New York: Wiley pp. 493–579.

Rashevski, Nicholai. 1949. *Mathematical Theory of Human Relations.* Bloomington: IN: Principia Press.

Ratzel, Friedrich. 1879. *Politische Geographie.* Munich: Oldenburg.

Richardson, Lewis F. 1960*a*. *Arms and Insecurity.* Chicago and Pittsburgh, PA: Quadrangle/Boxwood.

Richardson, Lewis F. 1960*b*. *Statistics of Deadly Quarrels.* Chicago and Pittsburgh, PA: Quadrangle/Boxwood.

Richardson, Lewis F. 1992. The Problem of Contiguity: An Appendix to Statistics of Deadly Quarrels. In *Collected Papers of Lewis Fry Richardson*, ed. Oliver M. Ashford, P.G. Drazin, J.C.R. Hunt, Paul Smoker and Ian Sutherland. Cambridge, New York: Cambridge University Press.

Rummel, Rudolph J. 1995. *Death by Government.* New Brunswick, NJ: Transaction.

Shin, Michael E. and Michael D. Ward. 1999. "Lost in Space: Political Geography and the Defense-Growth Trade-off." *Journal of Conflict Resolution* 43:793–816.

Singer, J. David, ed. 1979. *The Correlates of War I: Research Origins and Rationale.* New York: Free Press.

Singer, J. David, ed. 1980. *The Correlates of War II: Testing Some Realpolitik Models.* New York: Free Press.

Singer, J. David and Melvin Small. 1972. *The Wages of War, 1816-1965: A Statistical Handbook.* New York: Wiley.

Small, Melvin and J. David Singer. 1982. *Resort to Arms: International and Civil Wars, 1816-1980.* Beverly Hills, CA: Sage.

Sokal, Alan D. 1996. Monte Carlo Methods in Statistical Mechanics: Foundations and New Algorithms: Lectures from the Cargese Summer School on "Functional Integratin: Basics and Applications". Technical report Department of Physics, New York University.

Sorokin, Pitirim A. 1957. *Social and Cultural Dynamics.* London: Owen.

Taylor, Peter and Colin Flint. 1999. *Political Geography: World-Economy, Nation-State and Locality.* London: Longman.

Thompson, William R. and Richard M. Tucker. 1997. "A Tale of Two Democratic Peace Critiques." *Journal of Conflict Resolution* 41:428–54.

Wallensteen, Peter and Margareta Sollenberg. 1999. "Armed Conflict, 1989-98." *Journal of Peace Research* 36:593–606.

Ward, Michael D. 1988. "Cargo Cult Social Science and Eight Fallacies of Comparative Political Research." *International Studies Notes* 13(1):75–77.

Ward, Michael D. and Andrew M. Kirby. 1987. "Re-examining Spatial Models of International Conflict." *Annals of the American Association of Geographers* 77:86–105.

Ward, Michael D. and Kristian S. Gleditsch. 1998. "Democratizing for Peace." *American Political Science Review* 92(1):51–61.

Wright, Quincy. 1942. *A Study of War*. Reprinted 1957 ed. Chicago: University of Chicago Press.