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Spatial Models of International Conflicts: Extending Current Theories of War Behavior

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Abstract. Previous studies on interstate conflict have shown that war is spatially contagious. These studies have, however, suffered from a limited definition of spatial contagion and have ignored other nongeographic explanations. In this paper, the effect of location on war behavior is tested using eight measures of spatial contiguity among 135 states. The tests support the idea that wars tend to cluster spatially, but the relationship is not as simple as had been believed previously. Examination of war data for African states showed that the geographic effect extends beyond first-order (immediate) neighbors. To analyze the global distribution of conflict, two regression models were tested. In the first which used structural predictors (political, social, economic, and military characteristics of the states), only the military variables were found to be significantly related to war, but the residuals showed positive spatial autocorrelation. An alternative regression model, with structural and spatial autoregressive terms, provided a better fit with uncorrelated residuals. The spatial predictor was more important than all other variables except military expenditures in explaining the global distribution of war.

Key Words: war diffusion, contiguity indices, spatial autocorrelation, structural explanation, spatial explanation.

AFTER a hiatus of nearly two decades, scholars have again begun to examine international conflicts through a spatial lens. Sir Lewis Richardson's (1960) classic work relating a nation's war behavior to its geographic location has been dissected and reanalyzed using different data sets and different definitions of neighbors (Starr and Most 1976). These two political scientists have since attempted to isolate the "contagion" element in conflicts (Most and Starr 1980, 1983; Starr and Most 1983a). Houweling and Siccama (1983) adopted a "diffusion theory of war" and used an epidemiologic model to show that wars are not independent events but contiguous in space and time. Placing the geography of war firmly in the quantitative empirical approach to the study of international conflicts represents an important departure from conventional studies of the causes of war in both political science and political geography. Along with the use of relative distance to analyze interstate relations (Rummel 1979), the role of geo-

graphic distance and location has been resurrected from its neglected position in quantitative international relations (QIR) research.

With the renewed emphasis on geographic explanations in the field of international relations, we need a detailed consideration of the geography of war, highlighting the effects of different definitions of geographic contiguity and the potential contribution of spatial variables relative to the usual structural explanations that are based on economic, social, and political trends. Thanks to recent technical advances in defining and measuring spatial or contextual effects (Cliff and Ord 1981), geographers can examine the geographic causes of war and weigh this explanation against structural (social, economic, and political) explanations of international conflicts. The purposes of this paper are therefore (1) to examine and redevelop existing spatial models of international conflicts by extending the notion of distance and location effects beyond first-order contiguity measurements and (2) to

develop a multivariate model of conflict that incorporates both spatial (endogenous) and structural (exogenous) elements.

The Geography of International Conflicts

Analysts often invoke terms like diffusion, contamination, spread, contagion, the border or neighboring effect, and the epidemiology of violence to reflect an infectious disease analogy that may be used in the spatial analysis of war. Despite the well-known positive correlation between number of neighbors and war behavior among states, borders are not a direct cause of war.¹ Instead, the border/war relation is explained by the concept of potential interaction. Models of international relations suggest that similarities between states reduce tension and generally lead to agreement on matters of mutual interest and to cooperation on the global scene, whereas differences are expected to produce tension and, in some cases, conflict (Rummel 1979). Nations located in proximity to each other are more likely to go to war than nations located far apart. We also know that similar states tend to cluster in distinctive regions of the world. (A glance at the maps in the *New State of the World Atlas* (Kidron and Segal 1984) confirms this.) We then have a basic contradiction: states sharing similar social, economic, and political characteristics are, on the one hand, expected to cooperate and to remain at peace with each other, but their proximity increases the chance of war. Although research on the relationships between the domestic attributes of states and their international behavior (including "prone to conflict") have produced conflicting results, consistent and positive relationships have been found between military expenditures (a domestic attribute) and the likelihood of war. For both sets of relationships, it would appear that geographic contiguity is the key to explanation. "Borders are an attribute, borders produce contact, contact generates conflict, conflict leads to international violence" (Zinnes 1980, 328).

Starr and Most's work (1978, 1983a, 1983b) indicates that borders create opportunities for both cooperation and conflict. As the number of borders increases, so does the probability of being attacked, which leads to a rise in uncer-

tainty. If nations are vulnerable or feel themselves to be vulnerable, they have a high likelihood of increasing military expenditures, becoming involved in arms races, and going to war. Moreover, having a neighbor at war with a third party increases the odds that a nation will become involved in war (Most and Starr 1980). In effect, feelings of uncertainty and vulnerability that result from contiguity are more important than the feelings of cooperation that are expected to result from nation similarity. One way to reduce vulnerability is to form alliances, but this can increase the probability of confrontation, arms races, and conflict (Siverson and King 1979, 47). Also, adjoining states are likely to have border disputes over resources, territory, or ethnic differences; these disputes constitute the single most common type of international conflict since World War II (Mandel 1980).

One disturbing characteristic of both the Starr/Most and the Houweling/Siccama (1983) work on conflicts is that their explanation focuses entirely on one set of factors. They see war behavior as a function of the number of borders, and other nongeographic explanations such as national attributes are ignored. The use of univariate explanations is not unique to these studies. The frequency of war has been related separately to military expenditures, type of government (libertarian or not), number of neighbors, economic bases, and major power competition. The prototype of a complex integrated model offered by Choucri and North (1975) to explain the conflict between the great powers leading to World War I has not spurred the development of similar models. Yet location and national attributes should not be examined separately for their individual effects on conflict behavior. They undoubtedly have interactive effects, as noted by Zinnes (1980). Clearly the study of war demands a multivariate approach, incorporating both geographic and structural (social, economic, and political) elements. One method that may help to resolve part of this problem (or, at least, may clarify the extent to which geographic and nongeographic effects are important in explaining war) is a mixed spatial autoregressive-regressive model or, in our terms, a spatial-structural model. Before we can accept Most and Starr's (1983) verdict that relating a nation's attributes to its international behavior is a research cul-de-sac, we must broaden the research path to examine the attrib-

ute-war relationship in its proper spatial contexts.

Spatial Location and International Conflicts

Some confusion has arisen in conflict studies over the measurement of contagion. Although the studies by Most and Starr (1980) and Houweling and Siccama (1983) correctly incorporate both space and time elements in their discussions of war contagion, their definitions are confined to first-order, or immediate, neighbors. Immediate neighbors may be of greatest concern to a state, but spatial effects may also extend to second-, third- or higher-order neighbors. The problem is well known in time-series analysis where autoregressive models frequently have components measuring the lag effects of two or more previous time periods. In epidemiology the rate of disease in a county is strongly related to the rate in adjoining counties and also to the rates in noncontiguous but nearby counties. The distribution of conflict is highly variable across the world's regions (Fig. 1). It is therefore

important not only to measure the clustering of war by different contiguity measures but also to clarify the extent of the spatial lag effect in international conflicts.

Spatial considerations in the form of regional location may be significant in modifying the expected attribute-war linkages. A more accurate view of the variable definition of "location" can be derived from the traditional geopolitical approach to world affairs. Cohen (1982) has advocated a more detailed consideration of "shatterbelt" regions, which because of their complex national, religious, political, ideological, economic, and physical composition, are intrinsically areas of local and global tension. He identified three such shatterbelts—sub-Saharan Africa, the Middle East, and Southeast Asia—and advocated a geostrategy for the United States. This "regional or geopolitical" view is useful because it highlights the complexity of the world's regions, the divergent interests of local states, the relationship between local and global confrontations, alliance behavior, and the often-neglected fact that boundary disputes in these shatterbelts have often been a cause of war over the past 30 years.

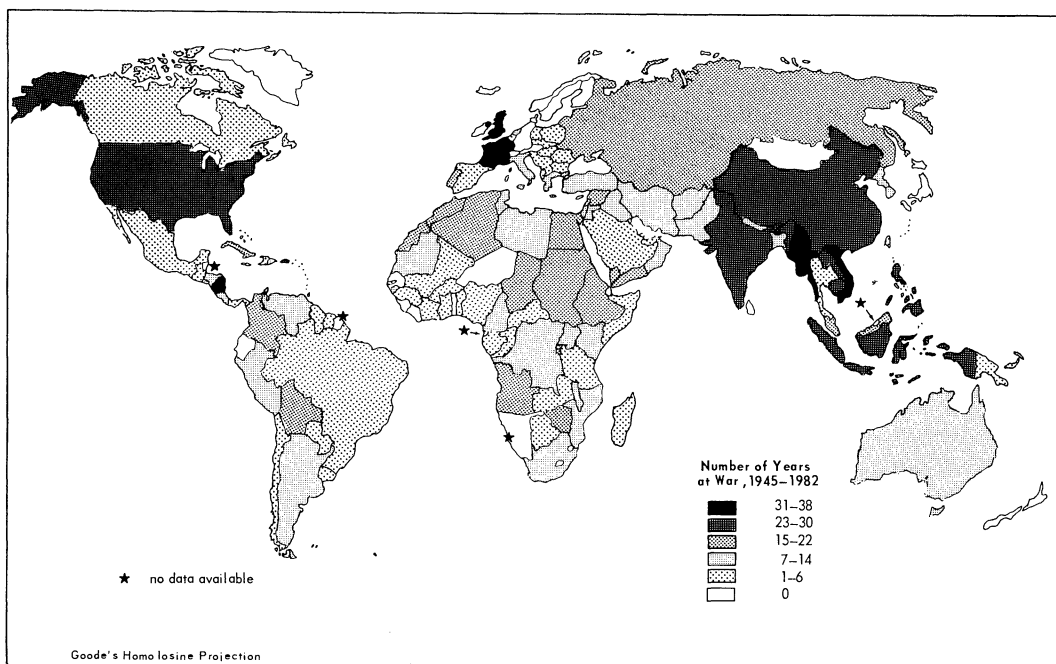


Figure 1. The global distribution of conflict 1945-1982. Source: Stockholm International Peace Research Institute (SIPRI) 1983.

Measuring the Spatial Effect in International Conflicts

Recently researchers in international relations have expanded distance or location indices beyond the early measures. Starr and Most (1976, 1983a) considered six "mutually exclusive and symmetric" types of borders, arranged in two political categories, noncolony and colony borders. For each category, land, sea, and proximate-zone (the few borders that "just miss" the criteria of land or water contiguity) borders are measured. Because borders continually change as a result of decolonization and war, Starr and Most remeasured the borders for four post-war periods in their African analysis (1983a). They have, therefore, provided a careful and longitudinal analysis of the relationship between *first-order* contiguous borders and war. Houweling and Siccama (1983) use linear distance based on the latitude and longitude of the battlefield locations to express the spatial element in their time-space diffusion study of war between 1816 and 1980. When battlefield locations were unknown or confused, they used the coordinates of capitals instead. On the face of it, linear distance would appear to be a logical distance metric, but because the costs of overcoming distance have changed dramatically over the past 170 years, the use of an absolute distance metric from 1816 to 1980 is suspect.

A clear need exists for further extension of the distance metrics used in international relations. Three different paths can be followed to develop better measures. First, as discussed above, higher-order contiguity matrices can be constructed and examined in the context of war behavior. It is easy to visualize situations where a nation at war with a neighbor entices, perhaps through alliance, another state bordering its enemy to attack their mutual adversary. In this case, a first-order lag would view these connected conflicts as separate events whereas a second-order lag (assuming the allies in this case are noncontiguous but are spatially joined through their adversary) would correctly specify the distance-war relationship. It is easy to extend this notion to third, fourth, and higher orders. The construction of a spatial correlogram (plotting the spatial autocorrelation function with increasing lags) will indicate the trend of wars with increasing lags. We would expect, from Richardson and Starr/Most, a declining value in the spatial autocorrelation score so that

first-order lag values are highest, followed by a sharp decline to the second order and a continuing decline with higher lags. Deviations from this expected relationship should lead to a rethinking of border measures and a new definition of the geographic effect in international conflict studies.

A second possible extension to existing contiguity definitions is specifying a double criterion for a contiguous link. An expected conflict between neighbors will not occur unless both nations are willing and able to engage in conflict (Most and Starr 1983). Large states can exercise power over small neighbors through nonmilitary means and achieve their objectives without going to war. In this view war is more likely between neighbors if they are of approximately equal strength, assuming that a large difference in power status and no protection from allies will lead the smaller state to recognize the inevitable outcome. As discussed earlier, bordering states with similar attributes are expected to resolve differences through negotiation more readily than are contiguous states of different political or ideological persuasion. In both instances, we would measure contiguity in two steps. If states share a common boundary *and* are of approximate equal size (e.g., in military personnel) or if they touch *and* are of different character, they are considered neighbors. Unless a double criterion is met, the states are not considered neighbors for testing the specific border war hypothesis.

A third possible extension is a refinement of the concept of contiguity. In most instances, states are contiguous as long as they touch *somewhere* along their boundary. Thus, for state C sharing 98 percent of its border with state B and 2 percent with state A, both A and B are considered contiguous. We would generally expect that the greater the shared boundary (as a proportion of total length of the state's border), the more frequent will be problems of mutual concern. We would expect, other attributes being held constant, that events in state B will be more important to state C than those in state A. It might therefore make sense to code states as neighbors only if their shared boundary is greater than some threshold. The specific threshold used is somewhat arbitrary, but 20 percent seems reasonable as most states have from three to five neighbors. The percentage could vary from region to region and from large to small states to reflect regional conditions.

In this study, eight types of neighbors are defined in a preliminary attempt to address some of these issues related to contiguity in international relations (Table 1). The first three measures replicate the border definitions used by Starr and Most (1976, 1983a). Measure 4 attempts to isolate important neighbors by identifying as neighbors only those adjoining states with more than 20 percent of a state's total border. Measures 5 and 6 are relative definitions of neighboring, in this instance the top ten trading partners in exports in 1958 and 1978. (Import neighbors were also defined, but because the results were so similar, only export neighbors are used.) Most major trading partners are either contiguous or located in the same region. The major exceptions to this are large industrial states, particularly the U.S., Japan, West Germany, and states producing raw materials of high demand, such as Saudi Arabia. Measure 7 uses Pythagorean distances between capitals of nations, with a distance exponent of 2.0 to reflect the expected drop in interaction with increasing linear distance.² Finally, Measure 8 is an attempt to consider Most and Starr's (1983) distinction between states capable and incapable of waging war. To be chosen as a neighbor, a state had to share a land or sea border with the

state under consideration *and* be of approximately equal strength, measured in this instance by size of military personnel. The 135 states in the sample were accorded standard scores on this dimension, and a neighboring state had to be within 0.5 standard deviation on this dimension of the state under consideration.

Measures of Spatial Clustering in Interstate Conflicts

Having described some of the conceptual and measurement issues plaguing research on the geography of warfare, we turn now to the specific research steps in this study. The study has two main aims, to describe the geography of war using descriptive spatial autocorrelation methods and to construct an explanatory model of war using both geographic and structural variables. Each of these tasks requires consideration of the theoretical and operational questions faced in each analysis.

Spatial autocorrelation methods have been widely used for analogous social and economic geographic problems. Since only the most important points can be treated in this section, the interested reader is urged to consult Cliff and Ord's (1981) technical monograph. Unlike temporal autocorrelation, spatial autocorrelation has measurement problems because lagging is multi- not unidirectional and spatial weights are difficult to define theoretically. Generally, spatial autocorrelation studies have tested whether the spatial arrangement of values is random or whether there is a significant pattern in the data. Significant positive autocorrelation scores indicate clustering of similar values, and negative autocorrelation values indicate a chessboard arrangement of different values.

Both dichotomous and ratio-level data can be examined for significant spatial autocorrelation using Moran's *I* coefficient, the most widely used index. War data are binary (war or no war) or ratio-scaled (the number of war months or the number of battle deaths) for each nation. For the ratio-level data used in this study, Moran's *I* is computed by

$$I = \frac{n}{W} \left(\sum_i \sum_j w_{ij} z_i z_j / \sum z_i^2 \right) \quad (1)$$

where w_{ij} is a weight denoting the influence of the j^{th} neighbor on the i^{th} nation (for the conti-

Table 1. Definition of the Contiguity/Autocorrelation Measures in Tables 3 and 4

Contiguity measure	Definition
1	Neighbor if share land border or sea border within 200 miles of country or its possessions
2	Neighbor if share land border or sea border within 200 miles of motherland only
3	Neighbor if share land border or sea border within 200 miles or if separated by third state by less than 200 land miles
4	Neighbor if land or sea border share is greater than 20 percent
5	Neighbor if among top ten states in exports 1958
6	Neighbor if among top ten states in exports 1978
7	Morans <i>I</i> value computed on basis of the square of the distance between capitals (see text)
8	Neighbors if share land border or sea border within 200 miles and if the military personnel is of approximately equal size (see text)

guity measures $w_{ij} = 1$ if contiguous, $0 =$ if not); x_i is the war index for state i ; $z_i = x_i - \bar{x}$, or deviations from the mean; W is the weights matrix; z_j is the value of the contiguous nation, and n is the number of observations. This autocorrelation coefficient, I , can be converted into a test statistic, the standard normal deviate Z , using

$$Z = \frac{I - E_I}{\sigma_I} \quad (2)$$

where E_I is the expected value of I and σ_I is the standard deviation and $E_I = -1/n-1$. The computation of the standard deviation of I varies according to whether the researcher is interested in testing a null hypothesis of randomization (the probability that the observed values are arranged in a random manner given all possible arrangements) or of normality (that the values of x_i are the result of taking n values at random from a normally distributed population of values). Generally, the randomization hypothesis is tested in geographic studies, and it would seem to be most appropriate in this study of international conflicts. The significance of the test statistic Z can be found by reference to a table of critical values. With a hypothesis of positive spatial autocorrelation in war outbreaks, based on the previously reported work of Richardson and Starr/Most, the one-tailed critical value for Z at the $\alpha = .05$ level is 1.645. Z -values greater than this support previous results. A correlogram of the Moran's I values can be constructed based on different lags so as to examine the relationship between increasing inter-nation distance and conflict. Finally, it should be noted that in testing regression residuals for independence, the residual values can be used in the Morans I formula, (Cliff and Ord 1981, 67).

As discussed earlier, previous researchers have confined their attention to first-order contiguity when examining clustering of war behavior. Their expectation that lags beyond the first order are unimportant can be checked by computing the autocorrelation coefficient for higher-order lags. Because of the computational difficulties involved in using the global sample of 135 states, a smaller file was needed. Africa has been the study area for previous research (Starr and Most 1983a) and was a logical choice for a compact and well-defined region. For the spatial correlogram analysis, a separate file was created for 43 African states. Each African state's first to fifth order neighbors were defined using the

most common criterion of contiguity—states sharing a land or sea border. Comparing the standard normal deviate values of the world ($n = 135$) with the African ($n = 43$) case indicates the extent to which wars in Africa are more or less clustered than they are in the world.

Constructing Mixed Geographic-Structural Models of War

In modeling international conflicts, one should view conflict as a function of both structural (national economic, political, and social attributes) and spatial variables. In first building a purely structural regression model, I related the war index to social, economic, and political variables. Collinearity was reduced by careful variable selection; the final eight variables are representative of the range of structural attributes used in previous studies. When the residuals from the structural regression model were tested for spatial autocorrelation, significant positive autocorrelation indicated that the model might have been misspecified. Because of the documented importance of location in international conflicts, a mixed model incorporating both structural and spatial autoregressive components was tested. The mixed structural-spatial model was

$$y_i = a_i + b_1x_1 + b_2x_2 + \dots + b_nx_n + b_{n+1} \sum_{j=1}^m w_{ij}y_j + \epsilon_i \quad (3)$$

where y_i is the war index of nation i (e.g., battle deaths in a specified time period); a_i is the intercept value; b_1 - b_n are the regression coefficients for the n structural variables; and b_{n+1} is the autoregressive coefficient for the term $\sum_{j=1}^m w_{ij} y_j$, the influence of wars in neighboring state j on nation i through the use of the w_{ij} metric, either distance or contiguity as described earlier. The model can be fitted using OLS for large samples (Cliff and Ord 1981). The residuals e_i were tested once again for spatial autocorrelation; an absence of significant trend in the residuals is taken to mean that the model has been properly specified. These models have been applied in other contexts, including the Huk rebellion in the Phillipines (Cliff and Ord 1981, Ch. 9). Because of the preliminary nature of the present study, only a temporally static mixed regressive-autoregressive model was calibrated.

Data

There are only about six data archives available for studies of international conflicts, and they differ in their coding of the relative importance of events and conflicts (Starr and Most 1983a). At least two sets of conflict data should be used so that selection bias is minimized. The Correlates of War (COW) file (Small and Singer 1982) is probably the most widely analyzed source of conflict data. Using the revised and complete file from 1816 to 1980, I selected six conflict measures for each of three time periods: 1816–1918, 1919–1945, and 1946–1980. The limits of each time period were set according to the accepted practice of defining nineteenth-century, early- and late-twentieth century conflicts by the sequence of major diplomatic and hegemonic shifts in international affairs. For each of 135 nations, six conflict indices were chosen: (1) number of systemic wars, (2) number of war months in systemic wars, (3) number of battle deaths in systemic wars, (4) number of civil wars (I combined Small and Singer's extrasystemic (or colonial) wars with civil wars because extrasystemic wars occur infrequently and I believe that both types of conflict represent internal strife), (5) number of war months in civil wars, and (6) number of battle deaths in civil wars. Small and Singer (1982) defined systemic wars as conflict between member states of the international system, and extrasystemic wars as those between states and nonmembers (e.g., colonies) of the international system or between two nonmembers. In general, this COW file measures large-scale organized warfare. As a check on the COW results, the SIPRI (Stockholm International Peace Research Institute) data on conflict were also analyzed. Summary SIPRI measures (number of wars between 1945 and 1982, number of years at war from 1945 to 1982, and war status in 1982 (at war or not at war)) are given in Kidron and Smith (1983). Severity indices were provided for the COW data by dividing the battle deaths by the number of war months for both the systemic and civil war indices (Table 2).

The data on the independent variables for the regression models were selected from a variety of sources. Using Wallensteen's (1981) division of world politics into four components (geography, ideology, economy, and power), I chose 15 variables as structural predictors (O'Loughlin 1984). Military expenditures as a proportion of

total government spending, size of military personnel, arms imports and exports, military expenditures per capita, and military expenditure per area were used as indices of power; government type, cold war ideology, and the reliability of the military were selected as ideological measures; regional location, number of neighbors, and war behavior of neighbors were selected to represent the geographic factor; and imports (millions of U.S. dollars) per capita, exports per capita, and import/export ratio are measures of economic power. A final data coding difficulty should be noted. Conflicts in states that have disappeared from the world map (e.g., Baden-Wurttemberg, Tuscany, Sicily) were coded according to the state of present location (e.g., West Germany, Italy). This coding procedure does not pose major difficulties for the post-World War II period and, consequently, emphasis is placed on the interpretation of the results for the 1945–80 data subsets.

Spatial Autocorrelation in International Conflicts

The global distribution of international conflicts is clearly not random (Fig. 1). The country-by-country pattern of post-World War II conflict indicates that a few states have been involved frequently in war, a result of their colonial or hegemonic status. As this map provides only a summary view of the conflict pattern, other indices of conflict must be computed and analyzed. Using the eight different definitions of neighbor shown in Table 1, I computed the spatial autocorrelation of conflicts for different war indices. Tables 3 and 4 list the clustering scores for the individual conflict indicators. Comparing the effect of variation in contiguity definition on the clustering score of international conflicts is an important methodological issue. Comparison across rows in Tables 3 and 4 indicates the effect of the definition of neighbor on the autocorrelation coefficient.³ Wide fluctuations in the value of the coefficient would indicate unstable results stemming from the definition of contiguity, and previous work that used only one kind of distance metric such as first-order contiguous neighbors would be called into question. Comparison down columns checks for instability in the clustering coefficient as a function of the use of different war and conflict indices. This com-

Table 2. Definition of the Structural and War Indices

Variable	Definition	Source
Structural indices		
<i>MCGE</i>	Average defense expenditures as % of central govt. expenditures, 1971–80	ACDA Yearbook
<i>MILEXP</i>	Average military expenditures 1971–80 (000's of U.S. dollars)	ACDA Yearbook
<i>MILREL</i>	Reliability of military (1 = reliable; 2 = barely reliable; 3 = unreliable; 4 = utterly unreliable)	Kidron and Smith 1983
<i>GOVTYPE</i>	Type of government (1 = multiparty; 2 = restricted parl.; 3 = one party parl.; 4 = military and despotic)	Kidron and Smith 1983
<i>NAYBORS</i>	Number of land borders or sea borders within 200 mile limit	Author
<i>IDEOLO</i>	Ideology in 1980 (1 = core East; 2 = pro-East; 3 = non-aligned; 4 = core West; 5 = pro-West)	Kidron and Smith 1983
<i>IMEXRAT</i>	Ratio of imports to exports in 1978	IMF Yearbook
<i>IMPCAP</i>	Ratio of arms imports to population	SIPRI Yearbook
<i>EXPCAP</i>	Ratio of arms exports to population	SIPRI Yearbook
<i>SHATTER</i>	Location in a shatterbelt (1 = yes; 0 = no)	Cohen 1982
<i>ARMSIM</i>	Arms imports in 1980	SIPRI Yearbook
<i>ARMSEX</i>	Arms exports in 1980	SIPRI Yearbook
<i>MILSIZE</i>	Size of military personnel	SIPRI Yearbook
<i>MILEXCA</i>	Military (arms) exports in \$ per capita, 1971–80	ACDA Yearbook
<i>SPENDA</i>	Military expenditures in \$ per sq. mile of area	SIPRI Yearbook
War indices		
<i>YRSWAR</i>	Number of years at war 1945–80	Kidron and Smith 1983
<i>SYSNO</i>	Number of systemic wars	Small and Singer 1982
<i>SYSWM</i>	Number of war months in systemic wars (1945–80 for regression equation)	Small and Singer 1982
<i>SYSBD</i>	Number of battle deaths (in 000's) in systemic wars (1945–80 for regression equation)	Small and Singer 1982
<i>NAYWAR</i>	Number of years at war of bordering states (1945–80 for regression equation)	Author from <i>YRSWAR</i>
<i>NAYWM</i>	Number of war months in systemic wars of bordering states 1945–80	Author from <i>SYSWM</i>
<i>NAYBD</i>	Number of battle deaths (in 000's) in systemic wars of bordering states 1945–80	Author from <i>SYSBD</i>
<i>CWNO</i>	Number of civil and extrasystemic wars	Small and Singer 1982
<i>CWWM</i>	Number of war months of civil and extrasystemic wars	Small and Singer 1982
<i>CWBD</i>	Number of civil and extrasystemic wars battle deaths	Small and Singer 1982
<i>SYSEV</i>	Severity of systemic war (battle deaths per month)	Author
<i>SWSEV</i>	Severity of civil and extrasystemic war (battle deaths per month)	Author
<i>NUMWAR</i>	Number of wars 1945–1982	Kidron and Smith 1983
<i>YRSWAR</i>	Number of years at war 1945–1982	Kidron and Smith 1983
<i>ATWAR82</i>	Nation coded 1 (at war) or 0 (not at war) in 1982	Kidron and Smith 1983

parison is likely to show considerable variation between the systemic and civil war indices. Within each of these categories, some variation is expected as some wars are more severe than their time length would suggest.

War Clusters and Contiguity Measures

Contiguity Measures 1–4, (absolute defini-

tions of contiguity) in Table 3 can be considered together, with the definition of neighbor becoming more stringent from 1 to 4. In general, the standard normal deviates (z-scores) indicate strong and significant positive spatial autocorrelation. Only the clustering scores of some civil war indices fall below a z-value of +1.65 (the .05 significance level for a one-tailed test) especially in the two more recent periods, 1919–45 and 1946–80. Because the civil war category

also contains extrasystemic or colonial wars, the switch from significant clustering in the nineteenth century to nonsignificance since 1919 should not be too surprising. Most extrasystemic wars in the nineteenth century were located in South Asia and Africa and involved only a handful of European states and their col-

onies. The systemic indices are consistent across the rows, showing that a changing contiguity definition from Measures 1 to 4 has no appreciable effect.

An important trend that has implications for the choice of border measures is the decline in the size of autocorrelation coefficient and z -

Table 3. Spatial Autocorrelation of Conflict and Structural Indicators Using Absolute Measures of Contiguity

Indicators ^b	Contiguity Measures ^a							
	1		2		3		4	
	<i>I</i>	<i>z</i> ^c	<i>I</i>	<i>z</i>	<i>I</i>	<i>z</i>	<i>I</i>	<i>z</i>
War indicators								
1816–1918–COW								
<i>SYSNO</i>	1.57	11.09	1.37	10.47	1.58	11.07	.74	8.78
<i>SYSWM</i>	1.20	8.51	1.41	10.70	1.55	10.81	.69	8.14
<i>SYSBD</i>	1.19	8.51	1.18	8.90	1.32	9.27	.78	9.14
<i>CWNO</i>	1.11	7.88	0.93	7.11	0.96	6.80	.62	7.33
<i>CWWM</i>	1.47	10.41	0.72	5.56	0.82	5.81	.40	4.82
<i>CWBD</i>	0.75	5.35	0.42	3.31	0.43	3.10	.36	4.28
<i>SYSSEV</i>	1.25	8.89	1.20	9.13	1.38	9.69	.79	9.31
<i>CWSEV</i>	0.62	4.43	0.44	3.46	0.45	3.30	.22	2.68
1919–1945–COW								
<i>SYSNO</i>	1.85	13.04	1.58	12.01	2.59	18.06	.80	9.40
<i>SYSWM</i>	1.21	8.56	0.81	6.22	1.01	7.12	.36	4.33
<i>SYSBD</i>	0.51	3.68	0.46	3.58	0.48	3.47	.25	3.00
<i>CWNO</i>	0.48	3.63	0.50	3.88	0.54	3.87	.10	1.30
<i>CWWM</i>	0.00	0.13	0.06	0.22	0.01	0.13	.01	0.13
<i>CWBD</i>	0.56	4.04	0.48	3.77	0.48	3.49	.41	3.70
<i>SYSSEV</i>	0.56	4.02	0.53	4.11	0.71	5.07	.26	3.17
<i>CWSEV</i>	0.01	0.13	0.14	1.30	0.00	0.13	.01	0.08
1946–1982–COW								
<i>SYSNO</i>	1.76	12.43	1.55	11.79	1.90	13.26	.69	8.13
<i>SYSWM</i>	0.94	6.71	0.58	4.46	0.76	5.36	.37	4.37
<i>SYSBD</i>	0.83	5.94	0.83	6.28	0.83	5.86	.38	4.54
<i>CWNO</i>	0.69	5.00	0.68	5.22	0.75	5.31	.32	3.82
<i>CWWM</i>	0.52	3.80	0.46	3.61	0.40	2.93	.36	4.25
<i>CWBD</i>	0.09	0.76	0.08	0.72	0.08	0.69	.02	0.35
<i>SYSSEV</i>	0.99	7.07	0.98	7.48	0.82	5.81	.43	5.14
<i>CWSEV</i>	0.01	0.13	0.01	0.13	0.01	0.13	.01	0.08
Other war indicators—SIPRI								
<i>NUMWAR</i>	1.19	8.47	0.73	5.60	0.80	5.68	.14	1.76
<i>YRSWAR</i>	2.35	16.55	1.64	12.42	1.94	13.53	.72	8.46
<i>ATWAR82</i>	2.08	14.71	1.92	14.52	2.24	15.58	.84	9.89
Structural indicators								
<i>MILEXP</i>	0.61	4.37	0.34	2.70	0.38	2.77	.14	1.73
<i>GOVTYPE</i>	1.64	11.63	1.44	10.95	1.59	11.14	.58	6.89
<i>MCGE</i>	2.19	15.43	1.97	14.92	2.34	16.29	.94	11.11
<i>MILSIZE</i>	1.60	11.32	1.20	9.62	1.46	10.25	.58	6.81
<i>MILREL</i>	1.86	13.15	1.63	12.38	1.92	13.45	.84	9.83
<i>IDEOLO</i>	2.04	14.41	1.80	13.64	1.04	14.26	.81	9.55
<i>ARMSEX</i>	0.57	4.15	0.51	3.96	0.52	3.73	.04	0.58
<i>ARMSIM</i>	1.71	12.09	1.63	12.42	1.99	13.85	.68	7.98
<i>MILEXCA</i>	1.20	8.50	1.17	8.90	1.25	8.78	.48	5.69
<i>IMPCAP</i>	1.09	7.78	1.08	8.24	1.21	8.47	.56	6.59
<i>EXPCAP</i>	0.60	4.32	0.56	4.32	0.57	4.10	.06	0.73
<i>SPENDA</i>	0.16	1.28	0.16	1.34	0.18	1.36	.07	0.85

^a For definitions, see Table 1.

^b For definitions, see Table 2.

^c *I* is Moran's *I* coefficient for spatial autocorrelation and *z* is the associated standard normal deviate. For $\alpha = .05$, *z* is significant when greater than 1.96 for a two-tailed test and 1.645 for a one-tailed test.

Table 4. Spatial Autocorrelation of Conflict and Structural Indicators, 1945–1982, Using Relative Measures of Contiguity and Distance

Indicators ^a	Contiguity Measures							
	5		6		7		8	
	<i>I</i>	<i>z</i>	<i>I</i>	<i>z</i>	<i>I</i>	<i>z</i>	<i>I</i>	<i>z</i>
1946–1982–COW								
<i>SYSNO</i>	1.93	10.84	1.83	9.24	0.87	11.46	1.37	12.23
<i>SYSWM</i>	1.58	8.88	1.27	6.46	0.62	8.28	0.50	4.53
<i>SYSBD</i>	0.23	1.42	0.14	0.84	0.97	13.08	0.82	7.38
<i>CWNO</i>	0.31	1.90	0.66	3.44	0.35	4.14	0.46	4.21
<i>CWWM</i>	0.32	1.90	0.20	1.15	1.00	8.21	0.95	8.54
<i>CWBD</i>	0.09	0.68	0.12	0.75	-.01	0.19	0.31	2.86
<i>SYSSEV</i>	0.23	1.42	0.16	0.98	0.98	12.87	0.08	0.81
<i>CWSEV</i>	0.01	0.15	0.02	0.17	1.00	6.24	0.00	0.11
Other war indicators—SIPRI								
<i>NUMWAR</i>	2.16	12.09	2.30	11.53	.06	1.42	0.56	5.03
<i>YRSWAR</i>	3.22	17.94	3.01	15.11	.25	6.96	1.34	11.94
<i>ATWAR82</i>	3.13	17.44	4.27	21.26	.03	1.13	1.42	12.67
Structural indicators								
<i>MILEXP</i>	1.29	7.30	1.62	8.20	.01	0.57	0.26	2.38
<i>GOVTYPE</i>	2.85	15.87	3.33	16.61	.27	7.24	0.94	8.43
<i>MCGE</i>	2.63	14.67	2.86	14.29	.27	8.67	1.44	12.85
<i>MILSIZE</i>	1.50	8.45	1.49	7.55	.08	2.60	1.11	9.94
<i>MILREL</i>	2.97	16.53	3.52	17.55	.03	1.00	1.27	11.30
<i>IDEOL</i>	3.11	17.32	4.27	21.26	.20	5.96	1.32	11.79
<i>ARMSEX</i>	0.43	2.50	0.53	2.81	.01	0.38	0.48	4.35
<i>ARMSM</i>	2.29	12.85	3.03	15.16	.14	4.25	1.46	12.88
<i>MILEXCA</i>	0.70	4.03	1.12	5.70	.24	7.28	0.44	4.02
<i>IMPCAP</i>	0.49	2.87	0.90	4.60	.97	13.02	0.77	6.88
<i>EXPCAP</i>	0.48	2.81	0.55	2.90	.95	6.43	0.22	2.06
<i>SPENDA</i>	0.53	3.08	0.68	3.52	.30	9.24	0.08	0.80

^a For definitions, see Table 2.

scores with the more stringent contiguity measures 2, 4, and 8 (Tables 3 and 4). There are both technical and theoretical causes for this trend. Clearly the fewer neighbors a state possesses (some states have no neighbors), the lower the values of $\sum w_{ij}z_i z_j$ in the computation of Moran's *I* and, consequently, the lower the coefficient. The weighted neighboring effect is computed only when *i* and *j* are neighbors. In a theoretical sense, we would expect states with a large number of neighbors to become involved in more conflicts, so changing the contiguity values to exclude neighbors of a state's colonies and possessions changes the picture considerably. The figures in Tables 3 and 4 replicate the results of Starr and Most (1976, 1983a) who found weaker correlations between spatial location and war as the definition of neighbor was tightened. It is worthwhile to emphasize that all indices in this study remained significantly positively autocorrelated, with general support for the border/war hypothesis. These results, together with those of earlier studies, suggest

that care should be taken in selecting contiguity indices and that several border measures are preferable to a single one. The largest autocorrelation coefficients were registered by the structural economic, social, and political variables, indicating that wars cluster less than would be expected if there were a one-to-one relationship between war and the structural predictors. As portrayed in the *War Atlas* (Kidron and Smith 1983), the values for the power, political, and economic variables are highly clustered geographically.

A comparison of the autocorrelation scores in Tables 3 and 4 down the columns reveals the consistently lower scores attained by the severity of war indices (battle deaths and battle deaths per war month). Why this should be so is not immediately evident, but it may reflect a tendency of low-intensity wars to involve a larger number of mutually contiguous states whereas high-severity conflicts involve only a few more scattered states. Regardless of the cause, the difference is consistent for all three time periods

and for both systemic and civil wars. The largest range in the Moran's *I* spatial autocorrelation coefficients appears for the SIPRI data. For the SIPRI indicator *NUMWAR* (number of wars), the difference in Moran's *I* for Measure 4 (nations are coded as neighbors only if they share more than 20 percent of the total boundary) from those of Measures 1–3 is noteworthy. The difference between the contiguity measures is much less for *YRSWAR* (the number of years of war). The values of the COW indicators are lower for relative distance measures (5 and 6) than for absolute measures (1–4), as expected, because the spatial contagion explanation of conflict has always focused on absolute contiguity. A focus on Measure 8 supports Most and Starr's (1983) argument that border states are more likely to go to war if both states feel they have something to gain from the enterprise and both feel they have some capability to wage war. A comparison of the COW indices for Measures 2 and 8 (the latter differs from the former only in the added criterion of approximately equal power) indicates the slightly larger values for Measure 8. Although the differences are not great, they lend tentative support to Most and Starr's argument about the additional role of power equality in modifying the border/war relationship.

Use of a distance metric (Measure 7) rather than contiguity measures raises the values of Moran's *I* and its associated standard normal deviate for the COW data. For the SIPRI war measures and the predictor data set, however, the changes produced by using linear distance are inconsistent and fluctuate widely from large increases to large decreases (Table 4). These shifts raise the question of the choice of weights in clustering indices. The debate is not settled in the spatial analysis literature, and some researchers have urged using a combination of the contiguity-distance metric as a compromise. Careful consideration of the notion of neighbors and of the theoretical issues pertinent to the particular research context is essential. In the case of conflict between states, many of the conflicts that arise have clear "border causes" such as disputes over resources, territory, or population. In these cases a contiguity metric modified to take the size of states into account seems most appropriate.

In summary, this spatial autocorrelation analysis shows general support for the original Richardson hypothesis that links war and geographic

location. Although there is some (expected) variation in the Moran's *I* value as the weights change, the differences are not large enough to promote any single measure over others. The civil war indices are most unstable, but this may be purely a function of the relatively small sample of civil and extrasystemic wars tallied by the COW project. Preliminary work by geographers on the diffusion of coup d'états in Africa (Huff and Lutz 1974) needs to be brought up to date with better data and analytic techniques. Tentative support for the hypothesis that border states are more likely to go to war if they are approximately equal in size suggests the need to weight absolute contiguity measures by relative power indices, such as military strength, political ideology, alliance membership, leadership character, and war history. In this regard, we are limited only by theoretical constraints; the technical measures can be adapted easily to accommodate proposed changes. Finally, it should be noted that distance-based neighbor measures, such as Measure 7, should probably be avoided because of our inability to specify theoretically the value of the distance exponent. In a general sense, we know that the "tyranny of distance" has been lessening so that an exponent of 3.0 might be appropriate for nineteenth-century transport and communication technology, 2.0 for early twentieth-century conflicts, and 1.5 for the post-1945 period. Beyond such rough estimates, however, we have no basis for assessing whether particular exponents are meaningful for the comparative analysis of the different types of war.

Spatial Correlograms of Conflict in Africa

Constructing correlograms that plot the autocorrelation function (ACF) by increasing lags is often the first step in a time-series analysis. By careful examination of the correlogram, the analyst can identify the process producing the observed patterns, model the process, estimate its parameters, and forecast future developments. In geography correlograms are often constructed for each of the cardinal directions (N,S,E,W) and for increasing spatial lags on a grid surface (Cliff et al. 1975). Africa was chosen as the region for the present correlogram analysis because of its use in previous spatial studies of war (Starr and Most 1983a), its compact and geographically connected arrangement of states, and the large number of international and civil/

extrasystemic wars that have occurred here since 1945. The ACF (autocorrelation function) using Morans *I* and contiguity Measure 2 (land and sea borders of motherland only) was computed for lags 1 to 5. The lag neighbors are exclusive so that a lower-order lag takes precedence. Twelve indicators, (8 conflict and 4 structural) were chosen for the analysis, and the cor-

relograms are displayed in Figure 2. Generally values of Morans *I* greater than 0.40 were significant. (Significance is determined partly by the standard deviation, which will vary by index.) Most of the lag values for the COW war indices did not reach this threshold, but the *YRSWAR* and *ATWAR82* indices of the SIPRI data were far in excess of the significance

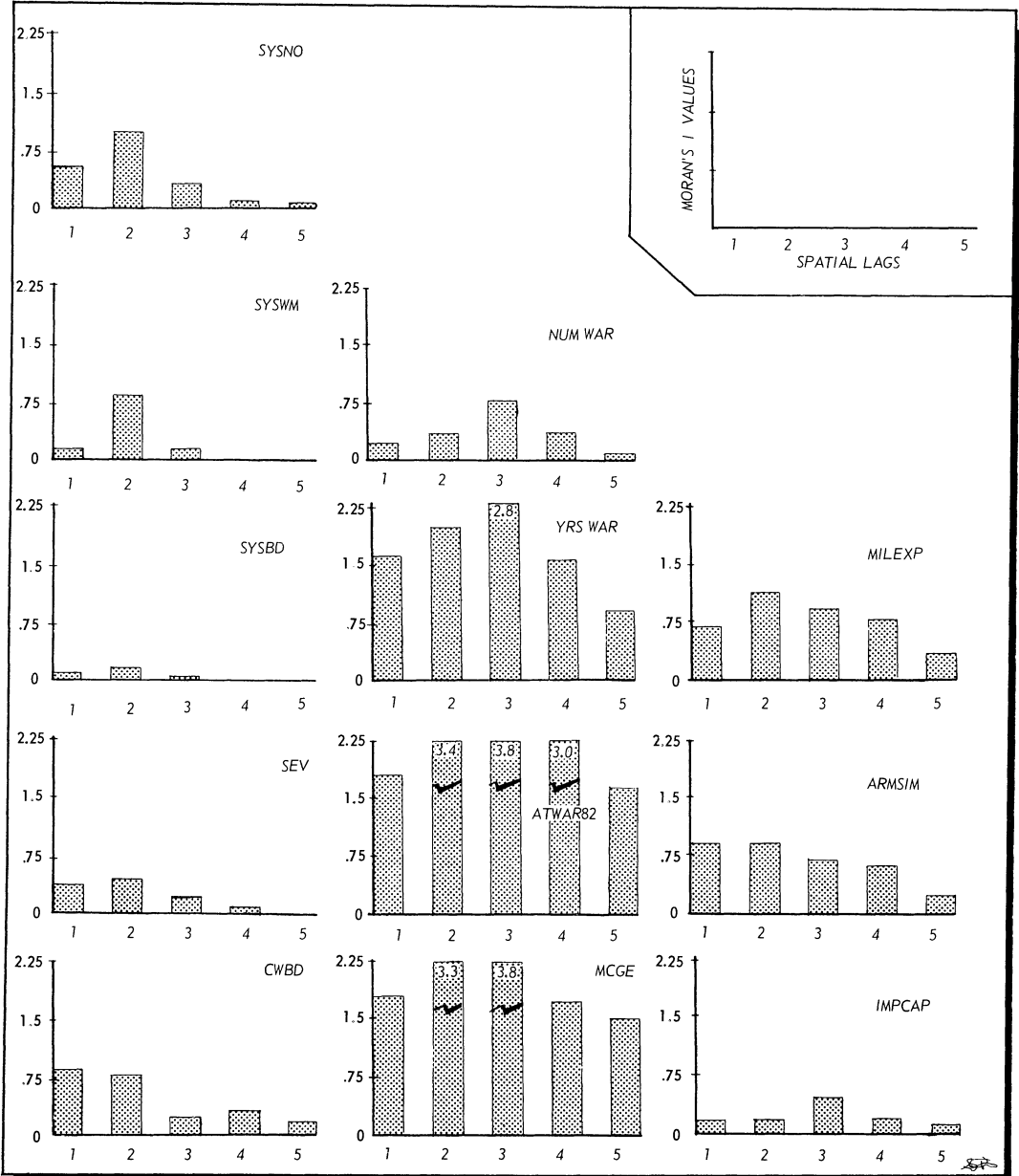


Figure 2. Spatial correlograms of war and structural indicators in Africa. Source: Correlates of War (COW) Small and Singer 1982 and Stockholm International Peace Research Institute (SIPRI) 1983.

threshold. Starr and Most (1983a) obtained a similar result for the COW data: the correlations in Africa between number of neighbors and war outbreak, though positive, were much lower than were correlations for the world sample, a factor attributed to the effects of the contradictory results of colony and noncolony border analysis. More borders lead to more war in Africa, as in the rest of the world, but less frequently than is the case in the rest of the world.

I noted earlier that a general trend of decreasing Morans I values with increasing lag should be expected. Previous researchers, in effect, have hypothesized that a spatial autoregressive process, indicated by a steep decline in the ACF from lag to lag, is most appropriate for the border/war relationship. In fact, none of the African correlograms show the expected spatial autoregressive pattern (Fig. 2). Not only do some Morans I values increase or remain stable with increasing lag, but the decline is gradual after lag 3 in all cases. From the graphs in Figure 2, it would appear that the moving-average (MA) process or random shock models should be fitted for the eight war indices. In a MA model, the pattern is the result of the random shocks and is not the result of a contagion or autoregressive process. In Figure 2, for the number of systemic wars (*SYSNO*), number of systemic war months (*SYSWM*), systemic war battle deaths (*SYSBD*), systemic war severity (*SEV*), and civil war battle deaths (*CWBD*), the most likely model representation is that of a MA process model that captures random shocks at the first and second lags. For the other indices and after the differencing that is probably required in all cases, the most appropriate, parsimonious, and interpretable choice is also likely to be a low-order MA model. In no case is a purely spatial autoregressive model indicated.⁴

Further development of the univariate (in this case, purely geographic) modeling of international conflicts is a lengthy and complicated procedure with a shaky premise that *only* geography causes war, or at least, that only geographic causes should be examined. A look at the spatial correlograms here has been sufficient to shake previous beliefs about the nature of the geographic factor in international conflicts. Contrary to expectations, the observed pattern of conflict is not first order autoregressive, the assumption implicit in the work of Starr and Most and of Richardson. Not only are higher-order influences present but also a moving aver-

age (random shock) model may be more appropriate than an autoregressive model. The documented inconsistency of previous results may be due to the use of a simplistic first-order autoregressive model instead of a more complex process model, such as a moving-average model. Before the simple spatial autoregressive view gains complete acceptance in the literature, there is a clear need for a more thorough examination of other, more complex, geographic measures.

A Mixed Spatial-Structural Model of War

A mixed spatial-structural regression model was used in a preliminary test of the relative importance of geographic and structural variables in determining the incidence and severity of war outbreaks. The pattern of conflicts in Figure 1 is the pattern to be explained by the use of both spatial autoregressive and structural predictors. Despite the caveat that first-order autoregressive processes may not be appropriate for all geographic analyses, a simple spatial process model was used. The purpose of the analysis was to assess the feasibility of such approaches to modeling war behavior. Eight structural variables were chosen to minimize collinearity and to represent all four elements (geography, ideology, power, and economy) of Wallensteen's (1981) world politics (Table 5). To reduce the problems associated with having many zero entries, three 1945–80 conflict indicators (systemic war months (*SYSWM*), systemic war battle deaths (*SYSBD*), and years at war 1945–82 (*YRSWAR*)) were chosen as the dependent variables. The results of the purely structural (nonspatial) model are in Table 5, and those of the mixed spatial-structural model are in Table 6.

As expected from previous studies (e.g., Zinnes 1980), military expenditures provided the highest zero-order correlations with the war indices (Table 5). Total military expenditures had the highest correlation with *SYSWM* (systemic war months), and military expenditures as a proportion of total government expenditure (*MCGE*) showed the highest correlations with *SYSBD* (systemic battle deaths) and *YRSWAR* (years at war 1945–82). Of the remaining predictors only *SHATTER* (a dummy variable mea-

Table 5. Multiple Regression Analysis—Structural (Nonspatial) Model

Dependent variable	Coefficients	Independent Variables ^b								R ²
		<i>MILEXP</i>	<i>MCGE</i>	<i>NAYBORS</i>	<i>SHATTER</i>	<i>IMPCAP</i>	<i>GOVTYPE</i>	<i>IMEXRAT</i>	<i>MILREL</i>	
<i>SYSWM</i> (Systemic war months) (Resid. $z = 2.14^a$)	<i>b</i>	.819	.641	-1.681	.760	-9.732	1.339	-.079	-1.890	
	St. error	.159	.146	.887	4.215	9.658	1.493	.123	2.001	
	beta	.393	.341	-.151	.014	-.077	.071	-.048	-.072	
	Simple <i>r</i>	.432	.350	-.006	-.056	-.023	.057	-.029	-.084	.319
<i>SYSBD</i> (Systemic battle deaths) (Resid. $z = 1.62$)	<i>b</i>	1.823	2.999	6.212	-11.687	-62.629	12.737	-.182	-12.718	
	St. error	.936	.858	5.203	24.792	56.958	8.724	.718	11.792	
	beta	.164	.297	.104	-.042	-.093	.126	-.021	-.090	
	Simple <i>r</i>	.184	.311	.127	-.035	-.043	-.022	.003	-.069	.153
<i>YRSWAR</i> (Years at war 1945-82) (Resid. $z = 3.44^a$)	<i>b</i>	.113	.272	.305	.815	-5.412	1.308	.031	1.350	
	St. error	.059	.054	.328	1.567	3.591	.555	.046	.743	
	beta	.151	.402	.076	.043	-.119	.190	.053	.142	
	Simple <i>r</i>	.232	.423	.159	.001	-.048	.037	.071	.150	.273

^a Spatial autocorrelation in residuals significant at .05 level for one-tail test.

^b Variables defined in Table 2.

asuring location in one of the three global shatterbelts) had a consistently significant relationship with all of the war indicators. The correlation of number of neighbors (*NAYBORS*) was zero for *SYSWM* and slightly positive for the other indices. The economic and ideological variables of *GOVTYPE* (type of government), *MILREL* (reliability of the military), *IMEXRAT* (import-export ratio), and *IMPCAP* (imports per capita) were not significantly correlated with the war indices, but the signs were in the expected directions. The *R*² values are modest and vary from .170 to .342; the lower values reflect the weaker relationships between the military

expenditure variables and battle deaths. In a stepwise format, only two or three structural predictors would have been entered into the equation (*MILEXP*, *MCGE*, and *SHATTER*), but for comparison purposes, all eight predictors were forced into the multiple regression equation and the overall *F*-ratio remained well within the significance range. *T*-tests indicate that only the two military expenditure variables are significant in all three equations.

These results are not surprising given the highly complex and unpredictable nature of war outbreaks. The relationship between war occurrence and military expenditure is clearly rein-

Table 6. Multiple Regression Analysis—Mixed Structural/Spatial Model

Dependent variables	Coefficients	Independent Variables ^c								R ²	
		<i>AUTOREG</i> ^b	<i>MILEXP</i>	<i>MCGE</i>	<i>NAYBORS</i>	<i>SHATTER</i>	<i>IMPCAP</i>	<i>GOVTYPE</i>	<i>IMEXRAT</i>		<i>MILREL</i>
<i>SYSWM</i> (Systemic war months) (Resids. $z = .416^a$)	<i>b</i>	.052	.798	.519	-1.856	1.284	-8.744	1.036	-.074	-1.710	
	St. error	.035	.159	.166	.891	4.210	9.637	1.501	.122	1.995	
	beta	.129	.383	.277	-.166	.024	-.069	.054	-.045	-.064	
	Simple <i>r</i>	.316									.328
<i>SYSBD</i> (Systemic war battle deaths) (Resids. $z = 1.49$)	<i>b</i>	.101	1.417	2.540	7.022	-7.019	-55.922	13.155	.116	-12.152	
	St. error	.053	.933	.880	5.166	24.659	56.484	8.637	.725	11.675	
	beta	.161	.128	.253	.118	-.025	-.083	.130	-.013	-.084	
	Simple <i>r</i>	.217									.176
<i>YRSWAR</i> (Years at war 1945-82) (Resids. $z = -1.02$)	<i>b</i>	.103	.091	.195	-.347	1.034	-6.510	.904	.031	1.157	
	St. error	.026	.055	.054	.346	.572	3.326	.524	.043	.696	
	beta	.366	.121	.288	-.088	.055	-.143	.131	.052	.121	
	Simple <i>r</i>	.471									.356

^a Spatial autocorrelation in residuals significant at .05 level for one-tail test.

^b *AUTOREG* is autoregressive component in model; it is represented by *NAYWM*, *NAYBD*, and *NAYWAR*, respectively.

^c Variables defined in Table 2.

forcing, but the direction of the relationship is hard to define and support. The occurrence of war seems to be independent of the type of government and economic composition of a country. The results in Table 5 suggest five possible strategies for further analysis. One would be to discard all regression and correlation approaches to the study of war; as Most and Starr (1983) have pointed out, general patterns may not exist and therefore techniques designed to tease out such patterns are inappropriate. A move to simple contingency analysis, as illustrated in Starr and Most (1983a, 1983b), is then indicated. Second, future analysis should recognize that the relationships between war and national attributes might be contradictory or nonlinear. It may be that war outbreaks and severity increase with military expenditures to an inflection point and then level off. In some regions, military expenditures may show no relationship with war indices (e.g., Western Europe), but the relationship may be significant in other regions (e.g., Africa). The linear relationship for the world system is then an amalgamation of these results and should be disaggregated by region. Third, the choice of structural predictors may be too limited. Rummel's (1979) field theory has shown the importance of the behavioral element in international relationships. Such indicators as the role and perceptions of national elites and leaders might be incorporated into an extended (nonmajor powers) version of his model. Fourth, as discussed throughout this paper, a geographic element may be needed. Whatever its specific expression, geographic position does appear to play an important role in interstate war behavior. A specific component measuring this interaction might be a useful addition to the purely structural model in Table 5. Finally, some combination of the second, third, or fourth model extensions might be appropriate, such as a disaggregation of the linear relationship of military expenditures and war behavior by region, nonlinear expression of some other predictors, new structural predictors, and a spatial autoregressive element. Before we can accept the suggestion to abandon regression analysis in the study of war (Most and Starr 1983), attention should be directed to some of these possible extensions to existing relationships.

As a first attempt to tackle some of these improvements on the multiple regression model, a spatial autoregressive component was added to

the eight structural predictors. The residuals of the structural regression equations (Table 5) are all positively and significantly autocorrelated, thereby violating one of the assumptions of regression. Such positive autocorrelation is the result of the misspecification of the form of the relationship, the absence of a significant predictor, or the absence of a geographic element (Cliff and Ord 1981). The addition of a spatial autoregressive component will frequently solve the problem of autocorrelation in the error terms and sometimes will add significantly to the level of explanation. An equation with nonautocorrelated error terms is considered superior to one having a higher R^2 value but significant autocorrelation in the residuals. In the absence of detailed knowledge of the form of the most appropriate geographic component, I used a first-order autoregressive component in this first attempt as a mixed structural-spatial model (Table 6).

The spatial autoregressive element was defined as the average of the war indices of the first-order neighbors using the most common contiguity measure (land and sea borders of the motherland). For each of the three war indices, the average incidence of war months, battle deaths, and years at war of the neighbors was computed and added as a ninth predictor to the multiple regression equation. Comparison of Tables 5 and 6 shows some important changes. For each of the three equations there was a modest rise in the R^2 value, but more important is the fact that the z -value of the autocorrelation coefficient for the residuals drops below 1.64, the .05 significance level for a one-tail test.⁵ The high, though insignificant value of z for the *YSBD* (systemic war battle deaths) equation residuals (Table 6), indicates that some additional predictor or changed specification of this model is needed. The addition of the autoregressive element for the *YRSWAR* (years at war 1945–82) equation produced a slight overcorrection, with the z -score for the residuals showing a value of -1.11 . As a result of the autoregressive component, the regional predictor (*SHATTER*) declines in importance from the structural model, but the military expenditures variables remain unaffected in their positions of primary importance. The governmental and economic variables continue to demonstrate a weak relationship with war behavior (Table 6).

The spatial autoregressive component (*AUTOREG*) is ranked first in the *YRSWAR*

equation, third in the *SYSWM* equation, and fourth in the *SYSBD* equation in terms of the strength of the zero-order correlations and beta coefficients. It appears, therefore, that spatial factors are as important as military expenditures and are more important than the commonly used political and economic predictors in explaining war behavior. Because the autoregressive components show intercorrelation only with the number of neighbors (*NAYBORS*) and shatterbelt location (*SHATTER*), using only the structural political, economic, and social predictors would not adequately capture the geographic factor.

This attempt to include a geographic element in war studies is modest, but the results are positive enough to encourage further work on the "geopolitical element" in war behavior. There are three avenues that should prove fruitful. First, the nature and form of the geographic process—autoregressive or moving average—must be identified, measured, and incorporated into the structural analysis of war. Correlogram analysis, though tedious, is essential in this process. The spatial ACF should be computed for different regions and time periods to check for stability and to examine the temporal and spatial processes responsible for the pattern of war. Second, further refinement and consideration of the weights used in spatial autocorrelation is clearly warranted. Contiguity matrices seem most appropriate in war studies, but the choice of neighbor definition needs careful consideration. The more restrictive the definition of contiguity, the more important the geographic element will appear. Third, researchers should consider weighting each of the geographic or structural predictors; for example, military expenditures could be weighted by regional location. In examining the causes of the Huk rebellion in the Philippines, Doreian and Hummon (1976) found a significant increase in explanation when they weighted the original cultural and economic variables by geographic location. It is evident that detailed consideration of the "geography of war" is a promising field despite the technical and theoretical problems associated with this approach.

Conclusions

My purpose in this paper has been to promote debate and research on the geography of war by

examining geographic influences on war behavior and by showing the complex nature of the spatial component. Five conclusions seem warranted as a result of this work. First, the paper gives general support to the border/war hypothesis stemming from the pioneering work of Richardson (1960) and elaborated by Starr and Most (1976, 1983a). In particular, this study agrees with Starr and Most on three important issues: (1) a precise and theoretically defensible definition of neighbor is required, (2) bordering states are more likely to go to war if their power statuses are approximately equal, and (3) though African results generally replicate those of the world system, the level of war clustering seems to be lower than it is in the larger sample. In essence, a different methodological route has led to the same general conclusions on the border/war hypothesis. Second, much more work is needed on the problem of weights in spatial autocorrelation. As mentioned earlier, the issue is far from resolved in the geographic and regional science literature. Though most practitioners agree that a priori definition of the weights is to be preferred, most reluctantly continue to use weights determined by trial and error judgments. An all-inclusive weight matrix, applicable in all global regions and time periods, is clearly not appropriate, but different weight matrices could be justified for large Western nations and small African countries. The best approach in the short term is to work within one continental data set and sort out the technical and methodological problems before extending the study to the world system.

A third conclusion relates to the data sets. Despite the general consistency of results from the two different data sets (COW and SIPRI), Morans I is susceptible to fluctuations in data bases. Consequently, greater attention must be given to the choice of wars and predictors than is normally the case with geographic data. The detailed international data available in Conflict and Peace Data Bank (COPDAB) file (Azar 1980), with both cooperation and conflict interaction coded, would seem particularly suited for geographic analysis. A fourth conclusion is suggested by the work of Houweling and Siccama (1983). They have shown, that wars are clustered both in space and time. The next stage is to model the space-time processes through construction of space-time correlograms, identification of the process model, estimation of the parameters, and integration of the results with

structural predictors. Examples of these complex models for other research contexts are available in Haggett, Cliff, and Frey (1977).

Finally, the study of war must fit into a larger theoretical context. In this paper, the theory of war has a distinct behavioral flavor. But, in a broader space and time framework, models are being developed to explain the general timing and location of international conflicts as a result of changes in the world system (Wallerstein 1984; Modelski 1983). That certain world regions or shatterbelts are more prone to violence and periodicity in warfare has been established: what is needed now is a two-scale model that would predict the general location of wars in time and space and, within these space-time constraints, would predict the specific occurrence of war. An integration of world systems theory and time-space clustering models looks promising in this regard.

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Notes

1. The zero-order correlation coefficients between the number of neighbors and war behavior, as measured by deaths, occurrences, and length of conflicts, vary. A coefficient of 0.77 was reported by Richardson (1960), 0.84 by Midlarsky (1975), and between 0.52 and 0.79 by Starr and Most (1976).
2. The distance exponent of 2.0 is common in geographic distance decay models applied to interactions such as migrations, communications, travel behavior, and trade flows (Taylor 1971).
3. Using relative measures of contiguity, such as neighbors defined by trade relationships, requires comparative war and structural data. Since relative data were available only for the contemporary period (post-World War II), the war and structural indices were necessarily confined to this time period. Table 3 gives the results for absolute contiguity measures, and Table 4 provides results for relative contiguity measures.
4. Given the limited information and lack of theory in war research, it would not be appropriate to fit autoregressive or moving average models to the data. The technical problems are modest by comparison to the conceptual ones. As discussed ear-

lier, examination of war using only a univariate model is inappropriate.

5. I recognize that the usual tests for autocorrelation are invalid for an equation with autoregressive terms. No appropriate method has been developed yet to estimate serial correlation in equations with spatial autoregressive terms (Cliff and Ord 1981, 240). I provide the estimates of spatial autocorrelation in the residuals of the mixed structural-spatial autoregressive model in Table 6 for comparison with the values in Table 5. Mapping the residuals from the mixed structural-spatial model showed a random global distribution. The Moran's *I* values for the residuals and the maps of the residuals from both equations indicate the switch from serial correlation to non-correlated values, and the discussion reflects this switch.

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