The Electoral Geography of Weimar Germany:

Exploratory Spatial Data Analyses (ESDA) of Protestant Support for the Nazi Party[1]

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[1] The original data used in this paper are available from the Zentralarchiv für empirische Forschung of the Universität Köln. The specific variables and the GIS (Geographic Information System) data in the form of ArcView® 3.2 shapefiles and associated data files are available from the *Political Analysis* website.

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Abstract

For over half a century, social scientists have probed the aggregate correlates of the vote for the Nazi party (NSDAP) in Weimar Germany. Since individual-level data are not available for this time period, aggregate Census data for small geographic units have been heavily used to infer the support of the Nazi party by various compositional groups. Many of these studies hint at a complex geographic patterning that undermines any single predictive factor. Recent developments in geographic methodologies, based on GIS (Geographic Information Science) and spatial statistics, allow a deeper probing of these regional and local contextual elements. In this paper, a suite of geographic methods: global and local measures of spatial autocorrelation, variography, distance-based correlation, directional spatial correlograms, vector mapping and barrier definition (wombling) are used in an exploratory spatial data analysis of the NSDAP vote. Key indicators are examined: the NSDAP vote percentage in 1930 (and two sets of estimates from King's ecological inference method), the turnout of NSDAP voters in 1930, and the support for the NSDAP by Protestant voters. The results are consistent in showing a voting surface of great complexity with many local clusters that differ from the regional trend. The Weimar German electoral map does not show much evidence of a nationalized electorate but is better characterized as a mosaic of support for "milieu parties", mixed across class and other social lines and defined by a strong attachment to local traditions, beliefs and practices.

1 Introduction

Despite attempts to bridge the epistemological and methodological gaps between the disciplines of geography and political science recently, lack of awareness of developments in geographic techniques by political scientists is still evident.[2] Some reasons can be proffered for this neglect, not the least of which is the nature of the data deployed by political methodologists in their analyses. Over time, data collected from surveys of individuals have become the norm and, partly because of difficulties of inference across levels, political scientists have tended to eschew aggregate data collected for geographic units (King, 1997). The preponderance of individual-level data is of relatively recent vintage. A classic study of political behavior, V.O. Key's (1949) *Southern Politics in State and Nation,* used aggregate electoral data, while Pollock's (1944) study of Nazi party electoral success pointedly relied on a geographical analysis of the aggregate votes. King's (1997) ecological inference methodology was recently the subject of a forum in the leading US geography journal, *Annals of the Association of American Geographers* (Vol. 90, no. 3, 2000). The reviews were generally favorable regarding the attempt to bridge the aggregate-individual scale, though important issues concerning the role of spatial autocorrelation still await resolution (see also Cho and Anselin, 2000 and Davies-Withers, 2001). It seems fair to assert that given the propensity of political scientists to rely on survey data of individuals and of geographers to rely on aggregate, often Census, data for small areal units, the gap between the preferred methodologies will likely continue.

The purpose of this paper, using the example of voting for the Nazi party in Weimar Germany, is to help bridge the gap by linking the methodological advances in geography and related environmental sciences to research questions in political science. While much of spatial

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[2] Some key exceptions have been special issues of *Political Geography* devoted to contextual models of political behavior (Vol. 14, nos. 6/7, 1995) and to controversies in political redistricting (Vol. 19, no. 2, 2000). Both geographers and political scientists contributed to the volume edited by Ward (1992) on *The New Geopolitics.* Ongoing sponsorship of workshops by the National Center for Geographic Information and Analysis (www.ncgia.ucsb.edu) and the Center for Spatially Integrated Social Science (www.csiss.org) brings together practitioners from both disciplines. A special issue of *Political Geography,* complementing this special issue of *Political Analysis* titled "Developments and Applications of Spatial Analysis for Political Methodology", is published as Vol. 21, no. 2, 2002.

autocorrelation is extended to spatial econometric modeling in a regression framework (Anselin, 1988), I confine my attention in this paper to descriptive and exploratory methods of spatial analysis. Extensive use of spatial econometric modeling to political data can be seen in O'Loughlin, Flint and Anselin (1994) and O'Loughlin, Kolossov and Vendina (1997). This paper is an exercise in exploratory spatial data analysis and therefore no inferential models are employed. Instead, attention is given to methods developed in the environmental sciences, especially environmental biology and physical geography, for uncovering underlying structures.

In examining the nature of aggregate data distributions and possible causal relationships, it emphasizes methods of exploratory spatial data analysis (ESDA – see Anselin, 1995), most of which have been developed in the geographical sciences and are increasingly available in specialized mapping and analyses software for the environmental sciences. Despite the addition of geographic modules to statistical software (such as the S-Plus module for ArcView GIS®), most of the users of such software seem to be environmental scientists (geologists, physical geographers, biologists, ecologists, engineers) interested in statistical data properties rather than social scientists with a bent towards the examination of aggregate data. Though survey data suffice nicely for most political topics, some research questions force the use of aggregate data. These include analysis of historical political questions that predate the arrival of reliable survey data (including the forces behind the electoral success of the Nazi party in Weimar Germany), political behavior in countries without national-level survey data but with acceptable census data (much of the world falls into this category), and questions that focus on the context of political decisions, forcing a consideration from the individual to the neighborhood and larger scales. Events data in international relations, gathered for countries and sub-state units, can also be analyzed using the spatial methodology (Murray *et al;*, 2002)

Spatial autocorrelation is the most fundamental concept in geography and integrates the growing set of spatial statistical approaches with the key elements of the discipline. A geographic truism, often known as the First Law of Geography (Tobler 1970, 236), states that "everything is related to everything else but near things are more related than distant things." Across all specialized branches of geography and across all epistemological divides, spatial autocorrelation underpins geographic assumptions, methods and results. The (relative) order generated by spatial autocorrelative processes, the distribution of phenomena on the earth's surface has been well documented in thousands of studies and simple observation, we know that clustering of like objects, people and places is the norm.

Geostatistical methods are typically configured for large samples and are used widely by environmental scientists. In order to introduce these methods to human geography, we need both larger datasets (many aggregate geographic units, also called polygons) than those to which we are accustomed, and a point sampling strategy. At a fine scale of resolution, every spatial distribution is discontinuous. The main difference between geostatistics and spatial autocorrelation is that the former deals with point sampling, usually on a grid, of a continuously geographic phenomenon (like a forest), the latter deals with a division of a geographic surface, thus producing an aggregation of geographic phenomena (Griffith and Layne, 1999, 457). With a large number of polygons, say approaching 1000 units, a centroidal or some other point sampling strategy offers a reasonable approximation of a continuous surface that can be modeled using geostatistical methods, like kriging (a statistical interpolation method that predicts values for unsampled locations on a surface) and trend surface analysis (fitting a linear or polynomial trend to a latitude, longitude and height surface).

In this paper, geostatistical methods are heavily used. Mantel correlation analysis (correlating distance and difference vectors) and variography -the process of pattern description and modeling using the variance of the difference between the values at two locations- are used to help understand the distribution of the Nazi party votes. Vector mapping (identifying local directional trends) and directional spatial correlograms (summary measures of association by major angles and distances) are added to the usual tools of spatial autocorrelation analysis- Morans I and G^*_i, measures of global and local spatial association- and GIS mapping in this paper. Wombling analysis (identification of statistically significant boundaries on a surface) is applied for the first time to a political geographic problem.

2 Weimar German Data and the Nazi Vote

Because of the use of methods based on point sampling, a dataset with many cases is preferred for analysis, and ideally it should also retain substantive interest. I chose the example of voting in Weimar Germany for this study. The issue of how the NSDAP (*Nationalsozialistiche Deutsche Arbeiterpartei*) or Nazi party came to electoral prominence has spurred hundreds of local and national-level studies over the past six decades. A data set available for aggregate analysis of Nazi support (German Weimar Republic Data, 1919-1933, no. 0042) is available from the ICPSR (www.icpsr.umich.edu), but users are cautioned that this dataset is replete with errors (Falter and Gruner, 1981). A cleaned version is available from the *Zentralarchiv für empirische Forschung* of the *Universität Köln* (see Hänisch, 1989 for an account of the data and levels of aggregations). The raw dataset consists of electoral and census data for Weimar Germany from 1919 to 1934 for 6,000 spatial units. However, the data are sparse for many individual units and must be aggregated to the same geographic basis for matching of census and electoral data. Previous works (O'Loughlin, Flint and Anselin, 1994; O'Loughlin, Flint and Shin, 1995) have used a dataset of 921 units for study of the key breakthrough election, that of 1930 when the NSDAP increased their vote share to 18.3%. However, in this current study over a longer time span (1924 to 1933), the data are aggregated to 743 units, including both *Kreise* (counties) and cities of Germany.[3]

Much is known about the NSDAP vote from a variety of authors (Childers, 1983; Falter, 1986, 1991; Kater, 1983; Küchler, 1992). Highly relevant to this paper, researchers have generally concluded that the geographic pattern is highly complex, with both strong local and regional elements, and that the correlation between the vote and compositional factors (e.g. religion, class, occupation, gender) is relatively weak. Until 1928, the NSDAP aimed its platform at blue-collar

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[3] The data were collated by Colin Flint for his (1995) dissertation work that examined the diffusion of the NSDAP vote on a regional basis from 1924 to 1933. The number of cases varies from election to election because of boundary changes and aggregations.

workers, but it had unexpected success in rural areas. Thereafter, the NSDAP targeted farmers, skilled workers, shopkeepers and civil servants, following a lower-middle class strategy that was bolstered by strong support for private property. Rural areas of Germany became bifurcated along the lines of inheritance traditions. In the Catholic areas of the south and west, where partible inheritance was common, the NSDAP platform fell on deaf ears while in the northern and northeastern rural sections, where impartible inheritance was the norm, the party found much success (Brustein, 1996). The composition of the NSDAP electorate additionally varied from region to region as a result of local economic circumstances and external pressures. Combining a model of economic interest with "political confessionalism" -attachment to a party based on social networks and historical traditions, such as the attachment of the urban and industrial working-classes to the Communists- most researchers accept that no one factor accounts for the success of the Nazi party. In May 1924, the NSDAP received 6.5% of the vote, decreasing to 3.0% in December 1924 and to 2.6% in 1928. The electoral breakthrough to 18.3% in 1930 was doubled to 37.4% in July 1932 after the economic collapse in Germany. The vote dropped to 33.1% in November 1932 before peaking at 43.8% in the last Weimar election in 1933, with the NSDAP never having never reached a majority.

For purposes of our earlier work, we divide Weimar Germany into six regions based on historical and cultural attachments; these regions overlap to some extent with the post-World War II Federal *Länder* that also were predicated on the notion of regional attachments. The regional boundaries are shown in Figure 1. In this present paper, these regions are not used as predictors, but reference is made to them in describing the map patterns and in probing the map's spatial structure. The Nazi party took advantage of this regional mosaic by pushing a variegated appeal that was modified from locale to locale depending on local conditions (Heilbronner, 1998; Ault and Brustein, 1998; Brustein, 1990, 1996; Brustein and Falter, 1995; Kater, 1983; Stachura, 1980). The Weimar dataset is therefore satisfactory for detailed spatial analysis and offers a test of how far exploratory spatial data analysis can be carried to gain insights into a complex story that is still not fully understood, despite a massive effort by historians and social scientists. As shown by O'Loughlin, Flint and Anselin (1994), geographic-compositional models for the 1930 NSDAP vote need to take this spatial heterogeneity into account; the regression models with spatial autoregressive terms showed that different combinations of NSDAP supporters were distributed across the six regions.

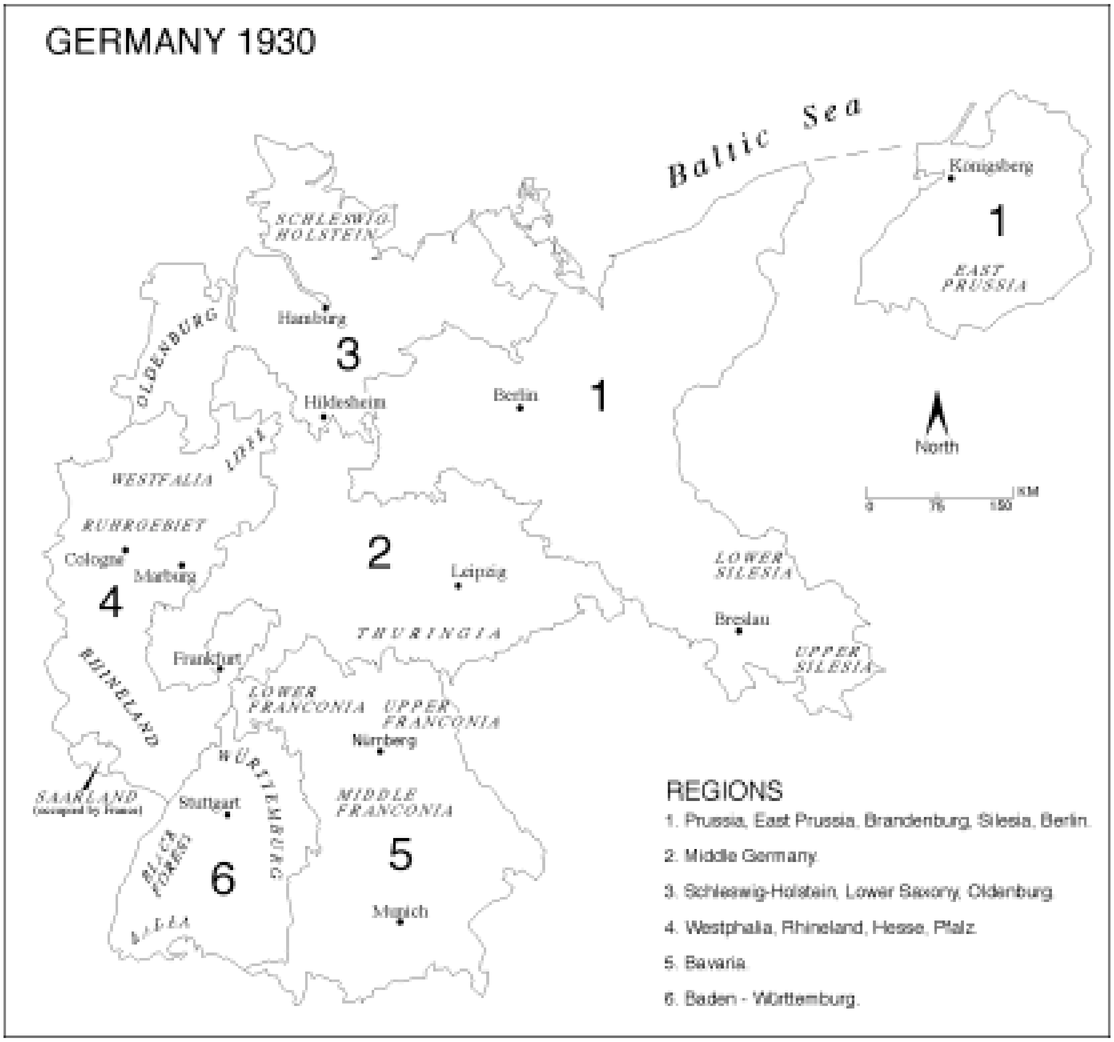

Figure 1: The Six Historical-Cultural Regions of Weimar Germany (with key locales).

Since the main purpose of this paper is to describe and highlight the geographic elements in the support for the NSDAP, I will analyze a series of votes between 1924 and 1933 but I center the analysis on the 1930 Weimar parliamentary election. From just 2.6% in 1928, the NSDAP vote rose dramatically in 1930 to reach 18.3% of the total, making it the second largest party in the *Reichstag* (parliament) after the SPD (*Sozialdemocratische Partei* – social democrats). Therefore, 1930 is generally considered the "breakthrough election" for a party that had existed on the fringes of the parliamentary scene for a decade and directional analysis of the changes between the years 1924-28, 1928-1930, and 1930-32 allow for a better understanding of the spread of the party support, and these changes will be introduced during the directional correlation analysis.

The key dependent variable for analysis is the percentage of the 1930 valid vote received by the NSDAP in each of the spatial units. The distribution of the Nazi ratio of the 1930 vote is shown in Figure 2. While the map makes regional and local clusterings evident, it is lacking in wide bands of similar values. In general, the distribution of strong Nazi party support corresponds to the Protestant regions of the country, with largest values in East Prussia, Schleswig-Holstein, Oldenburg and Saxony. The Catholic areas of the Rhineland, Bavaria, Upper Silesia, as well as big cities, and industrial areas (notably Berlin, the Ruhr and Thuringia) were centers of opposition to the Nazi party. (In 1924, the party had received their strongest support in Bavaria, their center of initial mobilization and organization). However, within the North-Northeast versus West-Southwest-South divide, there are numerous islands of support and opposition distinguishing Catholic and Protestant areas; see the contrast between Upper and Lower Silesia or the eastern and central parts of the East Prussia exclaves. It is this cartographic complexity that makes the electoral map of Weimar Germany both a social science puzzle and a candidate for detailed spatial analysis.

3 The NSDAP in Weimar Germany

In this study I examine NSDAP support in Germany using six analytical steps: a) global indicators of spatial autocorrelation, b) distance and variance patterns, c) local indicators of spatial association, d) directional spatial autocorrelation analysis, d) vector mapping, and e) wombling (barrier identification). The percentage of the vote for the NSDAP is used throughout this study since it allows comparison to previous works and, in many ways it is the easiest indicator to both visualize and comprehend in the spatial analysis. The general indicator of the NSDAP vote is a conglomerate of the support of various constituencies for the Nazi party. One of several key correlates of Nazi party support have been identified in previous studies, I also use the ecological estimates for NSDAP voter turnout and Protestant population support for the NSDAP. To estimate the ratio for the 743 geographic units, I used the EzI version of the King program that does not require the use of the Gauss program (EzI: A(n Easy) Program for Ecological Inference by Kenneth Benoit and Gary King) available from http://gking.harvard.edu/stats.shtml.

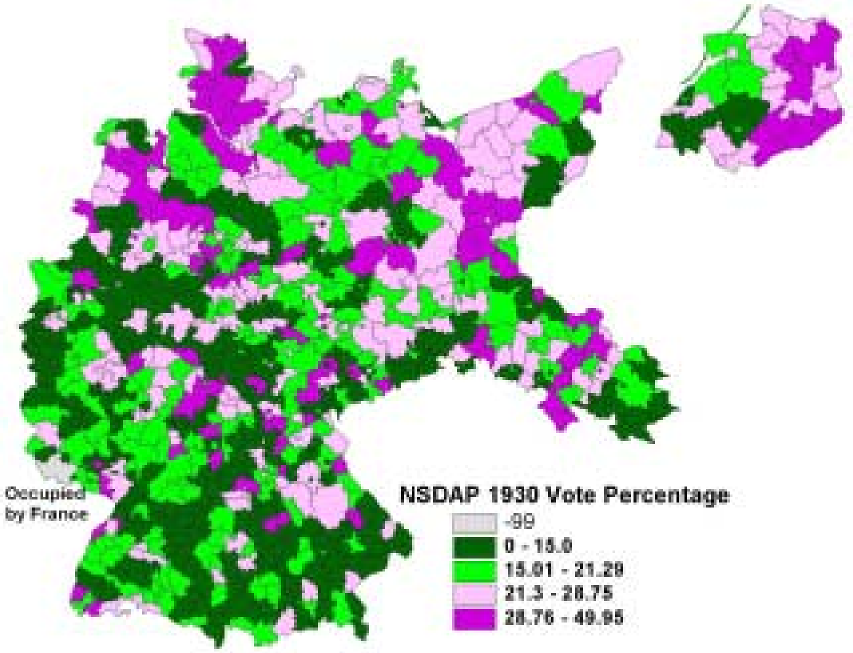

Figure 2: Distribution (Quartiles) of the NSDAP 1930 Vote in Percentages

The EI (Ecological Inference) method has gained a great deal of press and familiarity in political science since it was first introduced by Gary King (1997). King has promoted his ecological inference technique as a method that allows disaggregation of the global (whole study region) estimates to the individual units that comprise the aggregate.[4] These estimates can be mapped, as King (1997, 25) illustrates for the white turnout in the 1990 New Jersey elections, and can also be the subject of further "second-order analysis". In this study, the EI estimates are only considered in descriptive, exploratory spatial data analyses. King's EI method, though now well known to political scientists, has only recently been introduced to geography. Though its potential is recognized (Fotheringham, 2000; O'Loughlin, 2000; Davies-Withers, 2001), no application of it designed to tackle key human geographic questions, has yet been published.

Using the EI methodology, I am interested in whether the group of interest, the Nazi party, showed a significant gain over its opponents in turning out its voters. Knowing the marginals (votes for the NSDAP and non-NSDAP parties, the turnout and the eligible voters), we can use EzI to estimate the NSDAP voter turnout using the accounting identity (King's notation):

$$\mathbf{T_i = \beta_i^b X_i + \beta_i^w (1\text{-}X_i),} \tag{1}$$

where $\mathbf{T}_i$ is the proportion of NSDAP voters turning out to vote in each *Kreisunit*[5]; $\mathbf{X_i}$ is the proportion of the voters that picked the NSDAP; $\mathbf{1\text{-}X_i}$ is the proportion of the vote for all other parties; β_i^b is the proportion of the NSDAP supporters that came to the polls; and β_i^w is the proportion of non-NSDAP supporters who came to the polls. The purpose of the EzI modeling is to estimate β^b (the aggregate turnout rate for Nazi voters for the whole country); one can also get estimates for the individual counties and cities (*Kreisunits*), β_i^b . Both $\mathbf{T_i}$ and $\mathbf{X_i}$ are known values, and β_i^b and β_i^w are the unobservable parameters of interest to be estimated using King's ecological inference method. (Full details are available in King, 1997). Two key indicators -the estimated turnout of NSDAP voters and the estimated ratio of Protestants who voted for the NSDAP- are spatially examined in this study.

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[4] An alternative method of inferring sub-unit values published in this journal from Johnston and Pattie (2000) is not feasible since one of the key data requirements for its implementation, the national estimate of the ratios from survey data, is not available for the era of the Weimar republic.

[5] The number of Kreisunits varies from 883 to 940 in the Weimar data files due to changes in the form of amalgamations, border alignments and division of existing Kreisunits between the elections.

Table 1: EzI Estimates for Turnout of NSDAP Supporters in Reichstag Elections, 1924-1933

Election Date	No. of Cases	Ezi Estimate	Mean Turnout	+/- to NSDAP*
May 1924	930	.616	.743	-.127
December 1924	927	.899	.767	+.132
1928	940	.860	.759	+.101
1930	916	.809	.811	-.002
July 1932	924	.903	.818	+.085
November 1932	911	.882	.782	+.100
1933	883	.808	.870	-.062

* Gain and loss to the NSDAP calculated from the estimated NSDAP turnout compared to the mean turnout. The number of spatial units varies from election to election as a result of data availability in the Weimar German file.

The key comparative data for all Weimar Reichstag elections are shown in Table 1. The NSDAP voter turnout slipped below the national average in only the first and last elections (May 1924 and 1933). During the year of the rapid party growth and electoral surge, 1932, the turnout of NSDAP voters exceeded the national average by 8.5% and 10%, significantly boosting the party fortunes. The methods by which the NSDAP managed to activate its supporters are detailed in Brustein (1996), Grill (1983) and Hamilton (1982). In the turmoil of Weimar electoral politics, parties often matched an electoral strategy with promotion of street violence that targeted opponents' electioneering. After 1930, paramilitary Nazi groups targeted supporters of opposing parties and prevented many from voting.

From previous research, it is clear that the key compositional predictor of the NSDAP vote in Weimar Germany is the Protestant ratio of the local population. After 1928, the NSDAP gained a large proportion of the support of the DNVP (*Deutsche National Volkspartei* – German National Peoples Party), a largely Protestant party in the north and east of the country whose vote was collapsing. The Catholics also had their own conservative party, the *Zentrum* (Center) party whose core support was in Bavaria. One of the main explanations of the rise to prominence of the NSDAP focuses on political confessionalism and the role of the religious loyalties in local communities that existed before the rise of a national electorate after 1945 (Passchier, 1980; Grill, 1986). The argument states that the NSDAP was relatively weak in Catholic areas because of the special nature of agricultural relations (the nature of inheritance) and social-cultural conflict about Catholic schools in the southern and western regions of the country that tied voters to the *Zentrum* party (Brustein, 1996; Stone, 1982; Heilbronner, 1998). Since the earliest work by Pollack (1944), the correlation of the NSDAP vote and the Protestant ratio has colored all subsequent studies.

EzI estimates indicate a 3.6% gain to the NSDAP from protestant voters in 1930, the breakthrough election for the party. By the July 1932 election, the advantage had risen to 9.0%. The advantage is calculated as the difference between the overall NSDAP vote ratio of 18.3% and the EzI estimate of Protestants voting for the NSDAP of 21.9%. In 1932, the respective figures were 37.4% and 46.4%. Data presented in table 2, however, suggest that German voting patterns were in fact quite complicated and that strong regional attachments remained. The comparisons to the national and regional means for the NSDAP clearly indicate the variegated nature of the core relationship.

Table 2: Regional Pattern of EzI Estimates for Protestant Ratio and NSDAP Vote 1930*

Region	Number of Cases	EzI Estimate	Protestant Ratio	NSDAP 1930 Ratio	Regional Gain/Loss	National Gain/Loss
Prussia	193	.216	.786	.214	+.002	+.033
Central Germany	144	.203	.829	.199	+.004	+.020
NorthWest Germany	74	.271	.837	.243	+.028	+.088
Rhineland	124	.211	.458	.155	+.056	+.028
Bavaria	150	.289	.270	.167	+.122	+.106
Baden-Württemburg	58	.174	.549	.152	+.022	-.009

*****The mean national percentage for the NSDAP was 18.3% for a total number of cases of 743.

While caution is warranted for the estimates from Northwest Germany and Baden-Württemburg due to the small number of cases, the regional variation in the advantage to the NSDAP from the Protestant areas is large, from an advantage of only 0.2% in its core support region, Prussia, to 12.2% in Bavaria. In the two most Catholic regions (Bavaria and the Rhineland), Protestant support for the NSDAP was the strongest (regional advantage over the mean of 12.2% and 5.6% respectively). That the Protestant population's support of the NSDAP was not uniformly similar across the country is undoubtedly connected to the tensions between the populations in mixed areas. For example, Heilbronner (1998) shows this for the Black Forest region of south-west Germany and Stone (1982) illustrates the same for Franconia (the northern part of Bavaria). In these mixed regions, the religiously based political parties acted as proponents of the confessional economic interests and politics took on a decidedly local, village-level, focus. Though the parties were competing nationally, the election can also properly be seen of thousands of local and regional contests for control. The Nazi party recognized this phenomenon in their appointment of *Gauleiters* (regional leaders), who in turn appointed local party organizers for the culturally defined divisions of the state (Freeman, 1995). Hitler's speeches and the party flyers also tailored the Nazi party message to local circumstances (Brustein, 1996). As is evident from all the maps and statistics in this paper, the German electorate was highly disaggregated in a geographic manner, partly as a result of the splintered nature of the German Reich (only in existence for about 70 years), partly as a result of the strong culturally-defined effects that promoted distinct place-based uniqueness, and partly as a result of the electoral strategies of the parties.

The estimates for the 743 *Kreisunits* are derived from simulations, using a number of random samples from the distribution of values within the bounds of each *Kreisunit* that are set by the marginal totals of the cross-tabulations for each (King, 1997). The geographic distribution of these estimates for 1930 Weimar Germany are shown in Figure 3 (turnout of Nazi party voters in the 1930 election) and Figure 4 (support of Protestants for the NSDAP).

The comparative figure for the turnout of the Nazi party supporters is the estimated national mean of .811. Lowest values (below .75) are found in some of the regions of highest party support (eastern East Prussia, Oldenburg and Schleswig-Holstein) as well as in mostly Catholic or mixed religious regions in the West and South. Similarly, highest turnouts of Nazi party voters are in Lower Silesia (a Catholic coal-mining region), in Saxony and in Central Germany (Thuringia, Saxony). But, again the dominant feature of the map is its inchoate nature; Nazi party strength or weakness did not correspond to party turnout in any readily apparent way. The map of the estimates of the Protestant support for the NSDAP (Figure 4) is not cohesive; no macro-regional elements (and fewer localities) stand out in the map that highlights the extreme values. In the language of spatial analysis, this map has less spatial heterogeneity and more spatial dependence (O'Loughlin and Anselin, 1991). The mean value for Germany is .219; only scattered *Kreisunits* in northern Bavaria, East Prussia and Central Germany (mixed Protestant-Catholic regions) are evident as strongholds for Protestant support for the party. In contrast, in the Catholic areas of the Rhineland, Westphalia, and Württemburg, very low ratios of Protestants chose the NSDAP in the 1930 election.

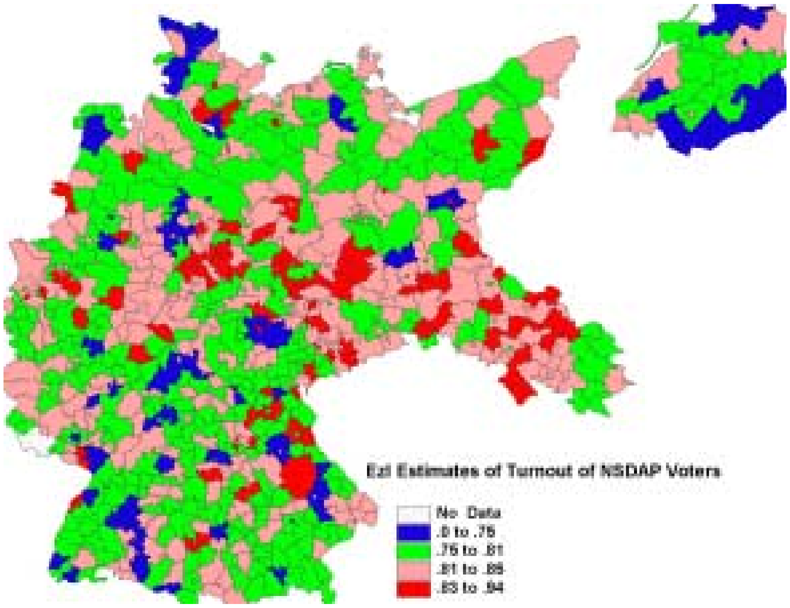

Figure 3: EzI Estimates of the Turnout of NSDAP Voters, 1930

4 Global Indicators of Spatial Association

In spatial analysis, global summary measures of distributions are now as common as statistical distribution measures that are typically presented in the social sciences (Rogerson, 2000). The limitations of the usual mean and variance statistics are evident when a simple choropleth map of the distribution of the NSDAP vote shows regional clustering. Towards the goal of summarizing a geographic distribution, the Morans I measure is now most commonly presented, though there are alternative measures of spatial patterns (see Cliff and Ord, 1981; Bailey and Gatrell, 1995).

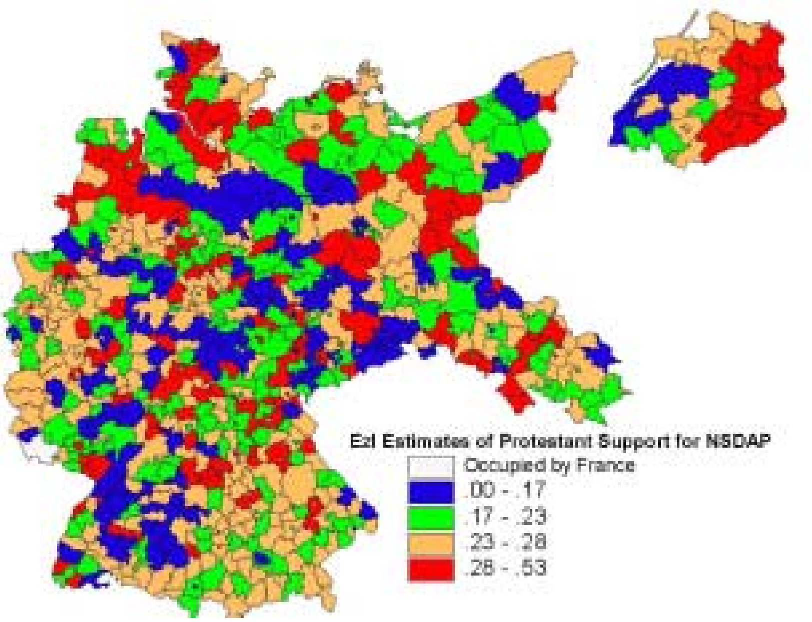

Figure 4: EzI Estimates of Protestant Support for the NSDAP, 1930

Morans I is derived from:

$$\mathbf{I = (N/S_o)\Sigma_i \Sigma_j w_{ij} x_i x_j / \Sigma_i x_i^2}, \qquad (2)$$

where $\mathbf{w_{ij}}$ is an element of a spatial weights matrix **W** that indicates whether or not **i** and **j** are contiguous; the spatial weights matrix is row-standardized such that its elements sum to 1; $\mathbf{x_i}$ is an observation at location **i** (expressed as the deviations from the observation mean); and $\mathbf{S_o}$ is a normalizing factor equal to the sum of all weights ($\mathbf{\Sigma_i \Sigma_j w_{ij}}$). The significance of the Morans I is assessed by a standardized z-score that follows a normal distribution and is computed by subtracting the theoretical mean from I and dividing the remainder by the standard deviation. *Spacestat* ™ version 1.90 was used for the calculation of the spatial statistics used (Anselin, 1998; Anselin and Bao, 1997).

While the Nazi map patterns are complex and apparently disorganized, calculation of the Morans I measure of spatial correlation suggests otherwise. The values for five spatial lags are presented in Table 2. Since contiguity is defined here as a shared *Kreisunit* boundary, a fifth order neighbor would be reached in five spatial steps across the separating geographic units. While the issue of the choice of contiguity metric is debated not only in geography (Harvey Starr and his colleagues have written widely on the subject of measuring contiguity in international relations – Siverson and Starr, 1991; Starr, 2002), it is generally agreed that the nature of the data should dictate the choice of metric. Thus, distance metrics are typically presented for indices of spatial autocorrelation for trade while border contiguity is more plausible for international conflict analyses (O'Loughlin, 1986; Griffith and Layne, 1999). In earlier work on Weimar Germany, O'Loughlin, Flint and Anselin (1994) used an inter-centroidal distance of 56 kilometers as the definition of *Kreisunit* contiguity.

Table 3: Morans I for Spatial Autocorrelation in District EzI Estimates of NSDAP Vote, 1930

Variables	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
NSDAP30	.260	.164	.112	.071	.062
Turnout	.203	.151	.131	.105	.092
(*Turnout_ezi*)	.156	.108	.079	.058	.038
Protestant	.566	.491	.409	.323	.239
(*Protestant_ezi)*	.120	.015*	.016*	.017	.011

* not significant at α = .05

The correlograms for five spatial lags (first-order neighbor, second-order neighbor, etc) of the five variables of interest follow the classic pattern in spatial analysis - decreasing positive values with increasing lags, with the greatest decline from the first to the second lag. Because the number of cases varies from lag to lag (some *Kreisunits* did not have higher order neighbors), comparison of the Morans I values requires caution. The population distribution variable (Protestant ratio) is clearly -and unsurprisingly- more geographically clustered than any of the other variables. Because of centuries of religious conflict and accommodation, political compromise and geographic allocation, the religious map of Germany in 1930 still reflected to a great extent the pre-industrial pattern. Only in the large metropolitan areas was a more recent mixing of the two predominant religious groups evident. A second comparison of the EzI estimates with the percentage figures shows the effect of variable controls on the distributions. Since the geographic patterning of Protestant supporters of the NSDAP and of NSDAP voter turnout are noticeably less clustered than the distribution of Protestants and of overall turnout, respectively, one way to press this comparison is to examine the level of clustering across the six cultural-historical regions of the country.

Table 4: Morans I Test for Spatial Correlation - Variables and District EzI Estimates, 1930

VARIABLE (EzI estimate)	Prussia	Central Germany	Northwest Germany	Rhineland	Bavaria	Baden-Württemburg
Number of Cases	193	144	74	124	150	58
NSDAP 1930	.349	-.060*	.106*	.204	.181	.286
Turnout	.335	.256	.159	.185	.116	.035*
(*Turnout_ezi*)	.285	.150	.166	-.113*	.046*	.169
Protestant	.541	.040	.348	.384	.521	.035
(*Protestant_ezi*)	.134	-.050*	-.078*	.211	.150	.154

* not significant at α= .05

The Morans I values for the first order lags of the six cultural-historical regions are presented in Table 4; again, caution in comparison is warranted because of the variable number of cases. The main contrast in this table is between the regions with significant positive spatial autocorrelation (Prussia and Bavaria) and the other four regions. Bavaria and Prussia were the most homogenous regions of Germany in religious, cultural and historical terms (most consistent boundaries) and are often considered as polar opposites within the country. In the mixed regions of the center of the country, the pattern of NSDAP support is random in Northwest and Central Germany, as can be seen in the map in Figure 2, due to local political-confessional loyalties. The pattern for turnout is also random in the southwest (Baden-Württemburg). Like the correlograms in Table 3, the autocorrelation for the EzI estimates of turnout of the NSDAP voters and of Protestant support for the NSDAP is less clustered than the raw data, except for Baden-Württemburg.

A consistent feature of Morans I values for political geographic data is one of positive and significant spatial autocorrelation. Clustering of geographically distributed phenomena is the norm and has been documented for many political variables across an array of contexts. Voting surfaces are especially marked by positive spatial autocorrelation especially for small-scale units like wards or precincts. As the size of the unit increases, it typically becomes more heterogenous and the Morans I values tend towards indications of less clustering. The Weimar case study is interesting not only for its historical significance but also because the base map (distribution of the NSDAP vote in 1930) shows regional heterogeneity, local dependence (spatial autocorrelation), national trends (northeast to southwest), and a complex association between the predictor and dependent variables. Partly because of these complications, most studies of the Nazi party have been case studies of one or a few localities (a small city or a rural area) using archival materials. While these studies offer a great deal of information about the mechanisms of the party's strategy and successes, they do not provide much help in understanding the national picture. Is it an amalgam of local stories with no common denominator or a macro-level process with local deviations? The methods of spatial analysis can help to determine the answer.

A final analysis of non-directional global statistics concerns the changing Morans I values over time. It is worth remembering that the NSDAP support ranged from 6.5% in their first national effort in 1924 to 43.8% at the last Reichstag election of 1933. Several trends are immediately apparent from the lagged Morans I values of Table 5. As expected, the values drop consistently with increasing lags and the values at the third lag for the early elections (before 1930) are negative and significant, indicating a chessboard-like pattern of high and low values. The most extreme Morans I value is that for the first election, May 1924, when the NSDAP was a small minority and had only scattered support throughout Germany, with a more concentrated nucleus of support in Bavaria (Freeman, 1995; Stögbauer, 2001). Similarly, the first lag value for the changes between the May 1924 and November 1928 elections as well as the 1932-33 elections are the largest, indicating a strong contagious diffusion effect as party support grew into adjoining districts at the beginning and the end of its rise to power. Since all of the values for the changes between elections are significant at the first and second order lags, the evidence is consistent with a model of geographic spreading from core *Kreise* that were scattered throughout Germany. Obviously, not all of Germany was equally susceptible to the NSDAP appeal. Strong resistance was particularly noticeable in the major cities, especially Berlin, and in the majority of Catholic regions, where political confessional loyalties were strongest between social-economic groups and the parties representing their interests. In order to discern these localities of resistance, it is necessary to disaggregate the global indicator into its local components, using local indicators of spatial autocorrelation.

Table 5: Distribution of Morans I Values for the NSDAP Vote in all Elections

Elections and Changes between Elections	Lag 1	Lag 2	Lag 3	Mantel Test	
				coefficient	Z-score
May 1924	.313	.058	-.065	-.032	-1.59
December 1924	.175	.028	-.043	.010	0.46
1928	.210	.013	-.025	-.014	-0.07
1930	.161	.025	.012	.082	4.94*
July 1932	.202	.057	.037	.070	4.89*
November 1932	.176	.023	.010	.042	2.82*
1933	.113	.027	.019	.072	4.68*
Change 5/24 – 12/24	.272	.056	-.029	-.022	-1.06
Change 12/24 – 1928	.128	.046	.025	.052	2.45*
Change 1928 – 1930	.219	.128	.096	.202	13.17*
Change 1930 – 7/32	.157	.027	.017	.013	0.85
Change 7/32 – 11/32	.139	.084	.072	.042	2.09*
Change 11/32 – 1933	.301	.100	.054	.058	2.92*

* Z-score significant at .05 level.

5 Global Analysis of the Voting Surfaces – Mantel Analysis and Variograms

Geography has been often and crudely described as a "discipline in distance." Two specific tests for this general proposition are used here. Global spatial association is measured by a widely used test (Mantel, 1967) that examines the relationship between two square matrices, typically distance matrix (in this study, the distances between the centroids of the *Kreise*) and some other measure of (dis)similarity between the points (here, the difference in their NSDAP % values). The analytical question is whether the value of the index indicates that the distance similarity is significantly related to the compositional similarity. A permutation procedure is used to estimate if the test statistic is significant by resorting the rows and columns of one of the matrices at random and comparing the resulting values. A variogram is a display of the spatial properties of the data, and a general upward curve with increasing distance to a threshold (or sill) is expected for spatial data, with increasing distance (Bailey and Gatrell, 1995).

The basic Mantel statistic is the sum of the products of the corresponding elements of the matrices

$$\mathbf{Z} = \mathbf{\Sigma}_{\mathbf{ij}}\ \mathbf{X}_{\mathbf{ij}}\, \mathbf{Y}_{\mathbf{ij},} \qquad (3)$$

where $\mathbf{\Sigma}_{\mathbf{ij}}$ is the double sum over all **i** and all **j**, **j** $\neq$ **i.** $\mathbf{X}_{\mathbf{ij}}$ is the matrix of inter-centroidal distances and $\mathbf{Y}_{\mathbf{ij}}$ is the difference in the NSDAP percentages between the respective geographic units. Like any product-moment coefficient, it ranges from -1 to +1 and its significance can be tested through a t-test after randomly permuting the order of the elements of one of the matrices (Dutilleul *et al.*, 2000). Illustrating the Mantel test using the same sequence of elections and between change elections as the Morans lagged values, shown in Table 5, one can see the same general results between the two tests. This is expected since both are product-moment coefficients, but in this instance, they use different measures of distance (border contiguity for the Morans I values; inter-centroidal distance for the Mantel tests). Election patterns after 1930 and inter-electoral change after 1924 especially 1928-1930, is strongly related to distance between the spatial units, further evidence of the contagious spatial diffusion inherent in the growth of the Nazi party.

Variogram analysis is often referred to as geostatistical analysis because of the central role that this methodology plays in physical and environmental geography. The focus is on the graph of the empirical semivariogram computed from half of the average of $\mathbf{(i-j)^2}$ for all pairs of locations separated by distance $\boldsymbol{h}$. Rather than plotting all pairs, making it impossible to distinguish the graphs in a large data set- the data are grouped by distance bands and the empirical semi-variogram is the graph of the averaged values. Every spatial statistical package includes a module for the calculation and display of variograms (Kaluzny *et al*, 1998; Bailey and Gatrell, 1995; Johnston *et al*, 2001; Griffith and Layne, 1999) and variography has been widely disseminated through the work of Cressie (1991) and Diggle (2002). Variogram computation and display is the first step in developing predictive models of spatial surfaces and for interpolating data locations, such as with kriging. The analysis here was completed using Surfer®7 (Golden Software, 1999). Variograms are often computed for different directions if there is a suspicion of anisotropy (directional biases and trends in the data); the models plotted here are omnidirectionally calculated and are the simplest models with no assumptions of directionality.

The plot for the NSDAP vote in 1930 (Figure 5a) shows a classic variograph pattern, indicating the presence of a large-scale trend or non-stationary stochastic process in the data. In contrast, the plots of the EzI estimates for the turnout of the NSDAP voters (Figure 5b) and the Protestant support for the NSDAP (Figure 5c) show no distinct trend with distance, and these surfaces can be considered as stationary. In a stationary process, the variogram is expected to rise to an upper-bound, called the sill and the distance at which the sill is reached is the range. Centroids that are separated by less than the value of the range are spatially autocorrelated, while those with inter-centroidal distances beyond the value of the range are uncorrelated.

A comparison of the ranges of the three graphs shows that the range (lag distance) is reached at a value between 2 and 4 for the EzI estimate graphs; thereafter, the variogram is flat, oscillatory or decreasing. By contrast, the graph of the NSDAP vote percentages (Figure 5a) continues to increase at a range of 13-14, a clear indication of a large-scale spatial autocorrelation. King (1997) has considered how spatial autocorrelation affects the ecological inference estimates; it is clear from these variographs and from the spatial measures (Morans I and local indicators explained below) that the EzI estimates of NSDAP turnout and of the Protestant support for the Nazi party are much less spatially autocorrelated than the dependent variable and the individual predictors. This conclusion does not preclude the possibility of local anomalies or some regional trends; it simply accounts for the fact that a control in the form of the EzI predictor removes much of the geographic patterning. King (1996), in a debate with political geographers, argued that similar socio-economic factors account for what underlies the geographic pattern of political phenomena and that identifying and removing these trends should be the aim of the geographic discipline.

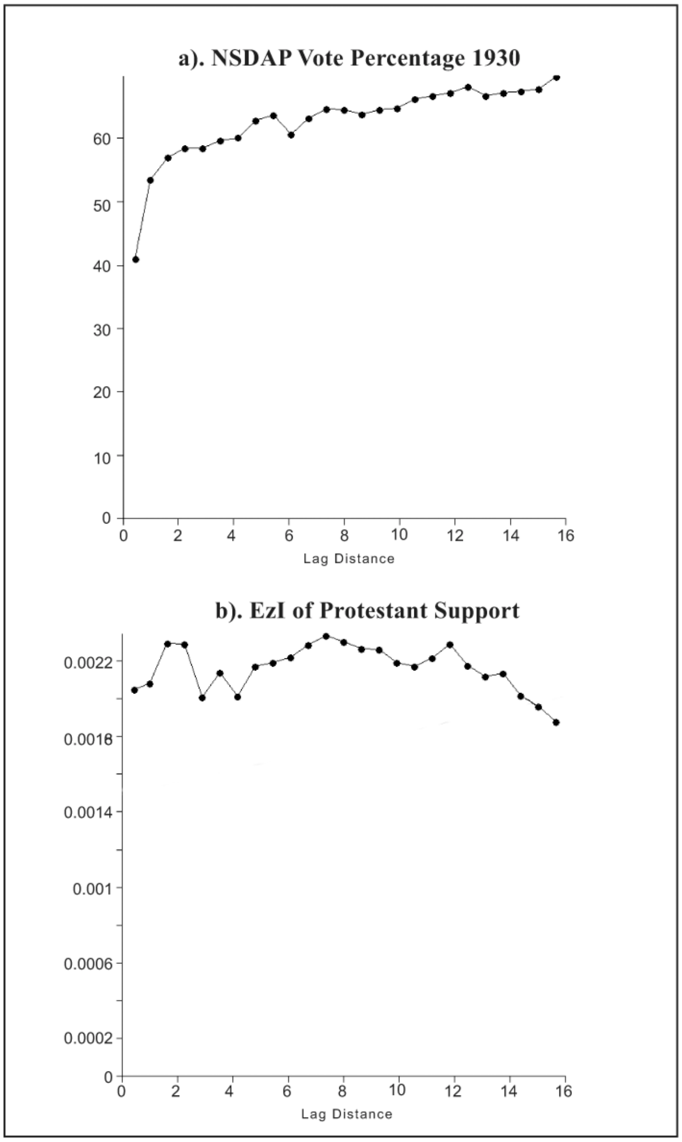

Figure 5: Variographs of NSDAP and Protestant Distributions

6 Local measures of spatial association

A recent trend in spatial analysis has been to disaggregate global statistics in order to uncover local clusters or "hot spots." If there is significant, positive spatial autocorrelation evident in the Moran I values (significant, negative autocorrelation would indicate a checkerboard pattern of alternating high and low values), local measures are used to identify the exact location of clusters of unexpectedly high or low values that contribute to the size and direction of the global statistic (Ord and Getis, 1995; Anselin, 1995; Fotheringham, 1997; Rogerson, 2000). Two other developments are pushing more use of LISAs (local indicators of spatial association). As more data for smaller geographic units have become available and manageable in GIS databases, it is common to generate highly significant global measures of spatial autocorrelation, like Morans I or Mantel coefficients, in situations with hundreds of data units. But whether these statistics are substantively interesting is hard to say without recourse to other, more disaggregated analyses. Secondly, the modified areal unit problem (MAUP) - a function of the essentially arbitrary nature of geographic boundaries in dividing up a surface into sub-units - means that global statistics remain somewhat arbitrary. Consider that a different spatial arrangement and the re-aggregation of the geographic sub-units would produce a different Morans I, since the contiguity matrix and the number of cases would be altered. A focus on local statistics helps to highlight and clarify these dilemmas of geographic data.

A common tactic to identify these local outliers prior to the development of the LISAs was to map and inspect large residuals from regression, frequently by adding spatial autoregressive terms to the equations (Anselin, 1988; Cliff and Ord, 1981). The most commonly-used LISA is the G^*_i (Ord and Getis, 1995), which is defined by:

$$G_i^* = \mathbf{\Sigma_i\, w_{ij}(d)\; y_j \;/\; \Sigma_j\; y_{j,,}} \qquad (4)$$

where $\mathbf{w_{ij}(d)}$ is an element in a binary contiguity matrix (not row-standardized) and $\mathbf{y_j}$ is an observation at location **j**. The G_i^* statistics should be interpreted as a measure of like values around a particular observation. The significance of the index can be assessed by standard Z-scores. A positive z-value for the G_i^* statistic at a particular location implies spatial clustering of high values around that location; a negative value indicates a spatial grouping of low values. The values can then be mapped as I have done in Figures 6-8, with extreme values that can be seen as the "hot spots".

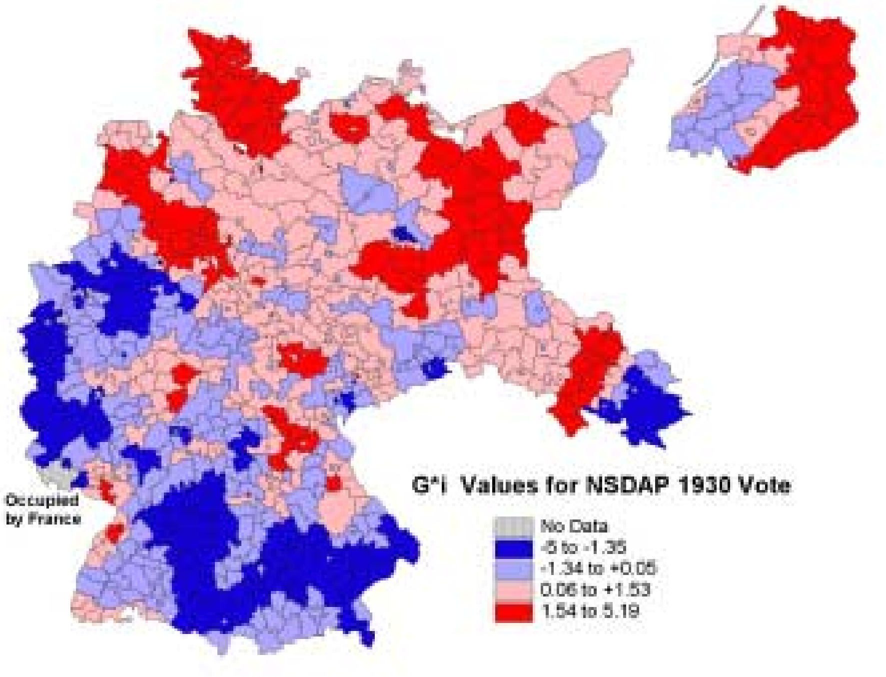

Fig. 6: Distribution of Local Indicators of Spatial Association for the NSDAP 1930 Vote

The attraction of the LISA method as tools to identify the clusters of low-low and high-high values in a geographic distribution is immediately obvious from the map in Figure 6. The northeast-southwest division of the country in the support for the Nazi party is readily visible. Within the two broad regions of support, regional anomalies are evident in the west-central part of East Prussia, in Upper Silesia, in Berlin and its environs, in Thuringia, and in the industrial areas around Dresden-Chemnitz of Saxony, and in the Ruhr valley. Within the zone of low NSDAP support to the south and west, Franconia (northern Bavaria), northern Baden, and the Palatinate (Pfalz) area bordering France stand out as regional anomalies. LISA use is part of a general trend in statistical geography away from the general pattern to the specific unit value distributions, since it allows a clear focus on spatial dependence. The method is thus essential to the ESDA strategy of calculation, visualization and mapping, and is part of a growing trend towards integration of spatial analysis and GIS (Anselin and Getis, 1992; Fotheringham, 1997).

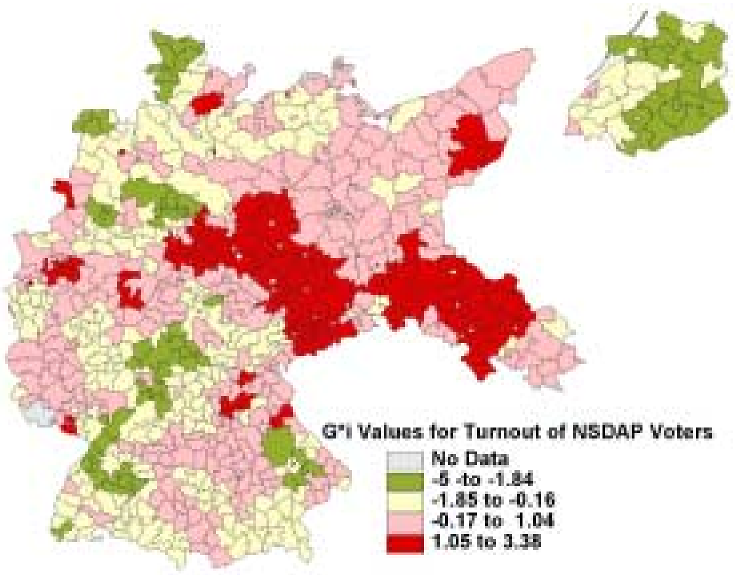

Fig. 7: Distribution of Local Indicators of Spatial Association for EzI Estimates of Turnout of NSDAP Voters, 1930

In contrast to the G^*_i map of the NSDAP votes distribution, the two maps of the EzI estimates of the NDSP turnout and the NSDAP protestant voters show less clustering (Figures 7 and 8). More values are non-significantly associated with neighboring *Kreisunits* in high-high or low-low zones, and the patches of neighboring high-high and low-low values are typically small, scattered around the country and not clearly associated with any underlying cultural-historical feature. Instead they appear to be associated with local phenomena. Of the 60 G^*_i values greater than +1.5, 27 are in Prussia and another 27 are in central Germany. Some clusters on the map demand attention. The high turnout of NSDAP voters in Protestant Lower Silesia (near a disputed zone of national conflict of Poles and Germans) is clearly visible, as is the high turnout in Thuringia, Franconia, central Germany, the north Rhine region, and the industrial region of Upper Saxony. Low turnout is marked in the NSDAP heartlands of East Prussia, Schleswig-Holstein, Hesse, and Oldenburg but not in the regions where the party was small and unimportant (in the Catholic south and south-west). It appears that turnout was highest in the mixed religious zones and in some border regions where cultural-religious and national conflicts held great prominence. Of course, the NSDAP leadership stressed the defensive role that the party played in protecting German values and interests, and appealed to certain economic groups with "rational economic" interest arguments (Brustein, 1996).

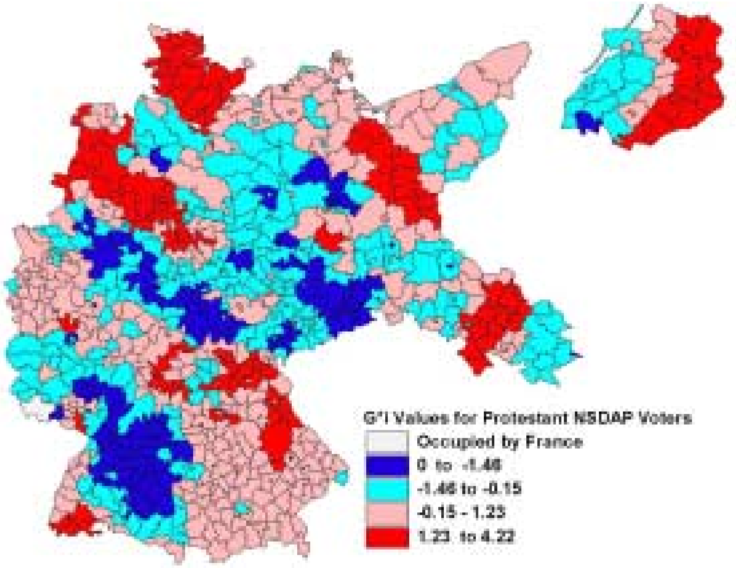

Fig. 8: Distribution of Local Measures of Spatial Association for EzI Estimates of Protestant NSDAP Voters 1930

The map of the EzI estimates of the Protestant support for the NSDAP is more clustered. Numerous groups of high and low Z-scores are evident in Figure 8. Of the 70 G^*_i values less than –1.5 for the EzI estimates of Protestant support for the NSDAP, 33 are found in the Rhineland (western border of the country) and another 14 are in Baden-Württemburg (using the regional boundaries in Figure 1). Of the 50 regions with G^*_i values greater than +1.5, 21 are in Bavaria and another 12 in are central Germany, a mixed religious zone. Traditionally high Protestant support regions show clustering of high voter turnout (Franconia, Silesia, east Prussia, Brandenburg, Schleswig-Holstein, Oldenburg) and are undoubtedly related to local tensions and political-confessional competition. Larger areas of low Protestant support for the NSDAP are found in the mostly Catholic regions of industrial Westphalia and Württemburg, and in Berlin. Why these regions should exhibit such clustering and other Catholic regions have no significant clustering is not immediately evident.

Use of the most common measures of spatial analysis indicate a pattern of NSDAP support that is both highly localized and weakly regionalized, except for a general NE-SW trend. Unlike many contemporary electoral geography maps, the NSDAP distribution (and its correlates) is more localized and not as regionalized. There are two possible explanations for this difference. First, the elections in Weimar Germany were the first set of relatively free and open contests, and as such, electoral preferences and trends had not stabilized. Over time, according to the nationalization thesis, minor parties are marginalized and disappear or are absorbed by larger parties, while the big parties campaign nationally and typically do not write off any locality. The result is that local and regional nuances are eroded and often disappear. Agnew (1988) has criticized this interpretation and has shown that in many European countries, local attachments and regional protest parties survive and prosper even in a time of national campaigning. The second interpretation is that Weimar Germany was simply a complex mosaic of culturally identifiable micro-regions, a product of a long history of local principalities, weak central authority and intense political-confessional competition. Fewer than seven decades of the Second German Empire after unification in 1871 had not yet dispersed these attachments. In this environment, parties (with the notable exception of the Communists) did not generally have a strong class base, but instead should be viewed as "complex constellations of social, religious and regional factors that had emerged into comparatively stable socio-cultural milieus" (Rohe, 1990, 1). These "*milieuparteien*" had a strong cultural association, and this nexus was assisted by the omnipresence of "*heimatbezogene Gemeinschaften*" (locally-based associations) that helped to develop a local consciousness in the Weimar period, continuing a pre-unification tradition. Further spatial analysis can unravel and clarify these regional and local idiosyncrasies.

7 Directional spatial autocorrelation

To this point, I have used global and local measures of spatial association. These measures do not consider the possibility of any directional trend in the pattern. To analyze geographic trends, trend-surface analysis is often employed, where the independent predictors are the locational coordinates (east-west and north-south). Furthermore, by making the surface more complex by adding terms (e.g. quadratic, cubic, etc), surface models can often be developed that fit the pattern well. If the surface is more complex with many ridges, valleys and depressions, one quickly reaches the point of diminishing returns in adding terms. Recent developments in spatial analysis have blended locational and structural indicators (the socio-economic attributes of the geographic units) as independent predictors in regression models.[6]

Prominent among these new spatial methods has been a search for measures of spatial association that also take direction into account. In many environmental geographies, such as climatology (e.g. wind direction) or biogeography (e.g. diffusion of a tree infestation or the spread of a noxious plant), directionality is a crucial factor in anticipating future developments and in generating strategies to ameliorate the impending trends. In these circumstances, the global spatial association measures are disaggregated by direction so that it is possible to determine predominant modes and routes of change. In this way, spatial association is not only a factor of contiguity but also of the angle of direction between the spatial units. The locational coordinates of the geographic centroids of the spatial units are the key controls, and contiguity is measured by circular bands of increasing distance (called annuli) around the centroids.

To this point, we have assumed isotropy in the global models of spatial autocorrelation, that interaction is equally possible and predictable in all directions with no evidence of directional bias. In the case of the NSDAP votes, this assumption is questionable since the maps show some north-east

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[6] See Jones and Cassetti, 1991 for the spatial expansion model; Brunsdon *et al.*, 1998; Fotheringham and Brunsdon, 1997; and Fotheringham *et al* , 2000 explain geographically-weighted regression.

to south-west trends. One method to determine whether this trend is significant -whether these angular directions are more prominent than others- is to model autocorrelation using a bearing autocorrelogram. This method is one of a family of disaggregated autocorrelation measures that help to determine anisotropic spatial patterns (variable directional bias in the spatial pattern) (Rosenberg, 2000). Bearing analysis is the term given by Falsetti and Sokal (1993) to the related methods that determine the direction of greatest correlation between data distance and geographic distance. The data distance matrix **V** is usually the difference between the values of two cells (in this case in their percentage of voters who chose the NSDAP). The usual geographic distance matrix (inter-centroidal distance) **D** is transformed into a new matrix $\mathbf{G}_\theta$ by multiplying each entry of **D** by the squared cosine of the angle between the fixed bearing (θ) and that of each pair of points

$$\mathbf{G}_{ij} = \mathbf{D}_{ij} \cos^2 (\theta - \alpha_{ij}), \tag{5}$$

where $\mathbf{G}_{ij}$ is the $\mathbf{ij}^{th}$ of matrix **G**, $\mathbf{D}_{ij}$ is the $\mathbf{ij}^{th}$ element of matrix **D**, and α_{ij} is the angular bearing of points **i** and **j**. If the two bearings point in the same direction $(\theta - \alpha_{ij} = 0)$, the function of $\cos^2$ will equal one; if the bearings are at right angles to one another, the function of $\cos^2$ will equal zero (Rosenberg, 2002). Typically, the reference angle θ is due East and the correlation between **V** and $\mathbf{G}_\theta$ is calculated via a Morans I test and repeated for a set of θ. Rather than calculating the bearing correlogram for all angles between 0 and 180^0, the values are calculated for a set of standard values (10, 20, 30 etc degree angles from θ). Other directional methods use wind-rose correlograms (Oden and Sokal, 1986; Rosenberg *et al.*, 1999) where the classes are based on both distance and direction.

In the bearing spatial correlogram, the weight variable incorporates not only the distance or contiguity between points (centroids or capital coordinates of a country) but also the degree of alignment between the bearing of the two points and a fixed bearing; in this paper, the fixed bearing is the east direction. All analyses were completed using *PASSAGE* (Pattern Analysis, Spatial

Statistics, and Geographic Exegesis), a program by Michael Rosenberg.[7] Use of these methodologies has proven useful in tracking genetic drift in Japan and in identifying prostate cancer clusters and trends in Europe (Sokal and Thompson, 1998; Rosenberg, 2000.)

A bearing correlogram can be calculated in the same way as the usual correlogram for spatial autocorrelation, except that the distance is weighted by direction. Distance bands are used to assign weights – each distance class has an associated weights matrix W that indicates whether the distance between a pair of centroids falls into that class. The weight matrix is converted into a new matrix W' by multiplying each entry by the squared cosine of the difference between the fixed bearing and that of a pair of points, as in equation (5) above. Pairs of points that do not fall into the distance class have an initial weight of zero and are unaffected by the transformation. Pairs that fall into the distance class are down-weighted according to their lack of association with the fixed bearing, $\boldsymbol{\theta}$. In the bearing correlogram, rather than simply presenting the coefficients in a table (as in Table 5), the bearing coefficients are plotted against the angle. Each distance class (annulus) is represented by a concentric circle -or semi-circle since the other half is redundant in a symmetric plot- and each coefficient is plotted above or below the annulus ring. The distance from the ring represents the size of the coefficient, while a shading or symbolic scheme can indicate its level of statistical significance (see Rosenberg, 2000 and Rosenberg, 2002 for more detailed descriptions).

Six bearing correlograms are presented in Figures 9-11. On each of the semi-circular diagrams, the coefficient is plotted every 18 degrees (10 per 180 degree arc), while the annuli lines plot out the values for each distance band. Since autocorrelation is typically larger at smaller spatial distances, a greater density of annuli is shown for small distances in the plots. The plots demonstrate the geographic diffusion of the NSDAP in the early elections, 1928-1930, the period of electoral breakthrough. In the 1928 election in which the Nazi party received 2.6% of the vote, there is no clear distance (spatially lagged) or directional trends in the pattern of support. The pattern is significantly and positively autocorrelated in all directions at the first ring (inter-centroidal distances

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[7] Available from www.public.asu.edu/-mrosenb/Passage/

of 23 km) but only in a northerly direction at the second lag (35 km). By the third annulus (45 km), fewer significant values are noted – again in a northerly direction. In contrast, values to the east and to the east-northeast as well as to the northwest are almost negatively autocorrelated at all distance bands. At higher distances, the pattern of coefficients is haphazard with non-significant values prominent throughout the display. The display is typical of a spatially unordered process with some local clustering. However, in this case, the clustering is not equally prominent in all directions. The clines are evident to the east and to the west -change from positive to negative autocorrelations is more evident in these directions. Clines can be visualized as slopes in a topographic contour map and their presence indicates a steep slope or change of values.

By 1930, the pattern starts to become more regularized. In this year, when the NSDAP vote reached 18.3%, the clustering is evident in all directions to the second annulus (34 km) and significant coefficients are found to the northwest in the 3rd ring. The negative coefficients are still prominent to the east and northeast at the 4th and higher annuli, but the significant positive coefficients to the north are visible to the 7th annulus. Again, the prominent clines are to the east and northeast, indicating the most prominent directional trend on the map. Thus, it is clear that the significant trend in the Nazi party vote by 1930 had become a NE-SW one (the SW direction is not plotted due to symmetry).

A diffusion study is a study of change between time periods or, in this case, one of the changes in the NSDAP vote percentages over time. Figure 10 presents two bearing correlograms for the vote changes, December 1924-1928 and 1928-30. As might be expected, these correlograms show less randomness in the angular/distance distribution of the Morans I coefficients. In the period 1924-1928, when the NSDAP vote decreased by 0.4% (from 3.0% to 2.6%), there is strong evidence of localized spreading for the first two annuli (to 35 km) and to the north-northwest for the 3rd ring (45 km). As is typical of spatial patterns, high and significant negative coefficients are seen in all directions for the longer inter-centroidal distances.

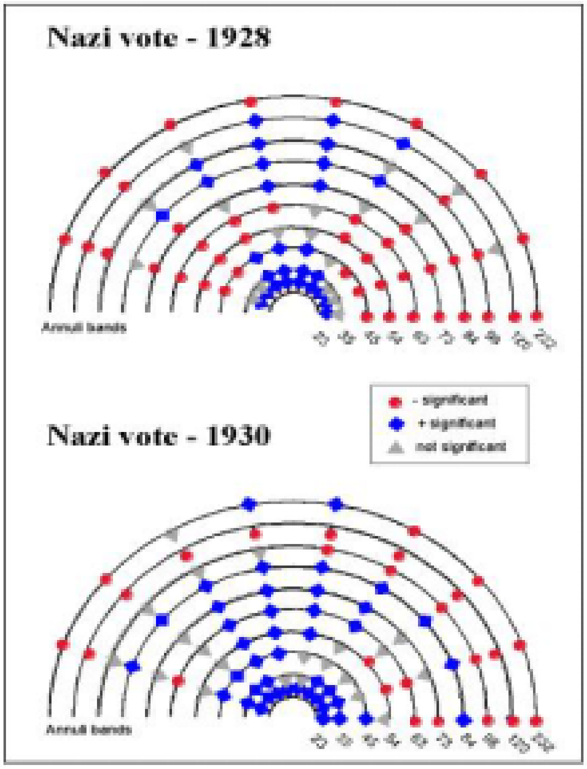

Figure 9: Bearing Correlogram of NSDAP Vote Percentages, 1928 and 1930

The clustering of growth in the NSDAP vote continued between 1928 and 1930 (rise in the vote from 2.6% to 18.3%). The first four annuli (up to 54 km) show significant positive spatial autocorrelation in all directions and to the northwest for the 5th, 6th and 7th bands (up to 84 km). The cline is most evident in this direction (NW-SE) and the diffusion of the NSDAP support demonstrates a trend along this axis. Party gains in the northern and northwestern regions (Schleswig, Holstein, Lower Saxony, Oldenburg) contributed to this diffusion. By 1932 (not shown here), change is more localized in all directions and no further regional trends are evident.

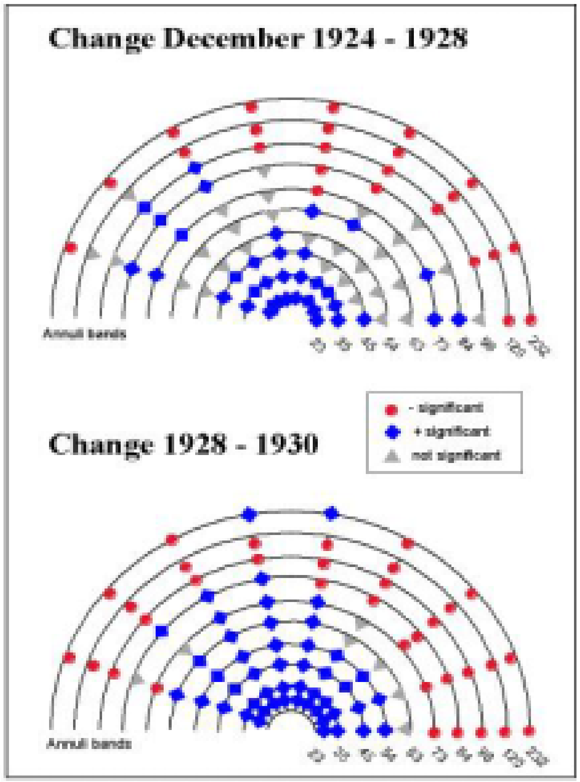

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Figure 10: Bearing Correlograms of Change in the Distribution of the NSDAP Votes

Two further bearing correlograms for the EzI estimates of the NSDAP voter turnout for 1928 and 1930, are presented for comparison. From these diagrams (Figure 11), we can conclude that the patterns are also highly localized with significant positive values seen in all directions for the first two annuli in both elections. The trend continues to the northeast in 1928 for two further annuli (up to 54 km) but disappears by 1930. This NE-SW trend replicates the pattern for the 1928 vote distribution but no cline is evident in the 1930 map of the EzI estimates; instead, small local disconnected clusters scattered around Weimar Germany can be seen in Figure 7. The biggest changes occurred between 1924 and 1928, when the Nazi party was organizing itself and developing its electoral tactics, its regional and local profiles, and its national platforms. In many ways, 1928 was a classic mobilizing election; after that date, the electoral patterns stabilized and concentrated existing trends. Compared to other parties, the Nazi party was a "catch-all" national party and did not have either an intensive regional core of support (like the *Zentrum* party in Bavaria) or a strong class association (like the Communist or the Social Democratic parties) (Stögbauer, 2001).

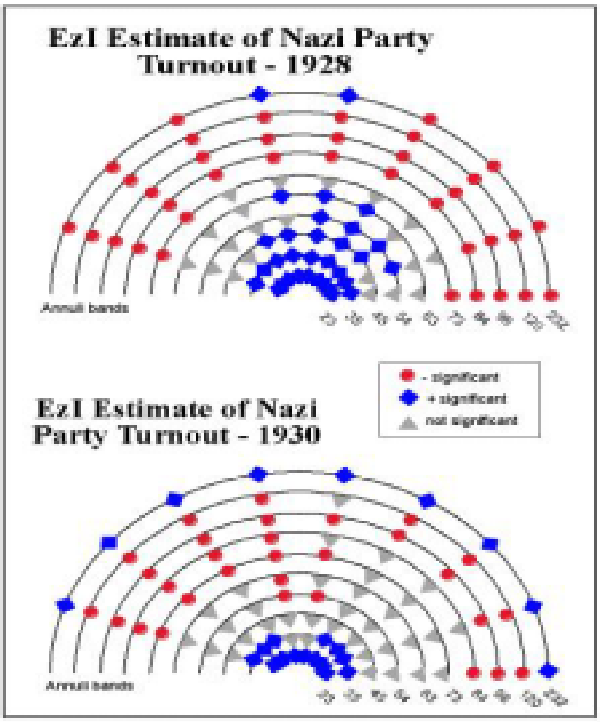

Figure 11: Bearing Correlograms of the EzI Estimates of the Turnout of NSDAP Voters, 1928 and 1930

Bearing correlograms are useful devices for disaggregating global autocorrelation measures like Morans I. In many spatial applications, association will vary not only by distance, but also by direction. Bearing correlograms can help to determine if trend surfaces are significant, but they also suffer from the fact that, as a general measure, the local components that constitute or bias the trends cannot be determined from the general measure. Just as the Morans I (global) statistic can be deconstructed and local indicators of spatial association (LISAs) can be mapped, we now turn to vector fields as a way of examining the local trends that cumulatively constitute the national directional autocorrelations.

8 Vector Mapping:[8]

In spatial interaction analysis, use of vector mapping is helpful to visualize the directions of flows. Akin to maps showing dominant wind direction and using the same symbolization (arrows of various widths and lengths pointing in the direction of dominant flow), vector maps have been widely used for portraying trade and migration flows, as well as other interact ional data such as telephone calls, mail flows and international cooperation-conflict -see the examples in Bailey and Gatrell, 1995, Chapter 9. Tobler (1976) pioneered this methodology in human geography and developed the concept of "vector fields." Vectors, shown by arrows of variable width and length, link origins and destinations by indicating the direction of net flows. Repeating this for all flows shows the "wind of influence" at each origin – a vector showing the sum of all flows and directions. If there are enough data points, an interpolation can be made to a regular spatial grid of locations.

In the example of NSDAP voting in this paper, we are not using interaction data, though the analogy to interactional data is useful. Instead, a vector map will contain two components, direction and magnitude, calculated from computing the gradient of the surface grid. Perhaps the best analogy is a contour map where arrows point in the direction of steepest descent (downhill) and the direction of the arrows change from grid to grid depending on the topography surrounding the grid node. The magnitude of the arrow changes depending on the steepness of the slope, where longer vectors indicate steeper slopes (Golden Software, 1999, 243). In a highly patterned map with a large-scale and even change of gradients from a few prominent nodes, the direction and magnitudes of the vectors will be consistent and dramatic[9]. By contrast, a vector map of slope gradients in a complex contour surface, such as cancer distribution in a metropolitan area, will show a random pattern of small arrows pointing in multiple directions, reflecting the lack of a dominant angular bias. The

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[8] Thanks are due to Ron Johnston and Mike Ward for suggesting that the directional biases underlying the bearing correlograms should be examined.

[9] An example is inter-censal elderly population flows in the US with Arizona and Florida acting as powerful magnets

surface vector mapping of the NSDAP vote and the EzI estimates for the NSDAP voter turnout and the Protestant supporters of the NSDAP were completed using Surfer7©.

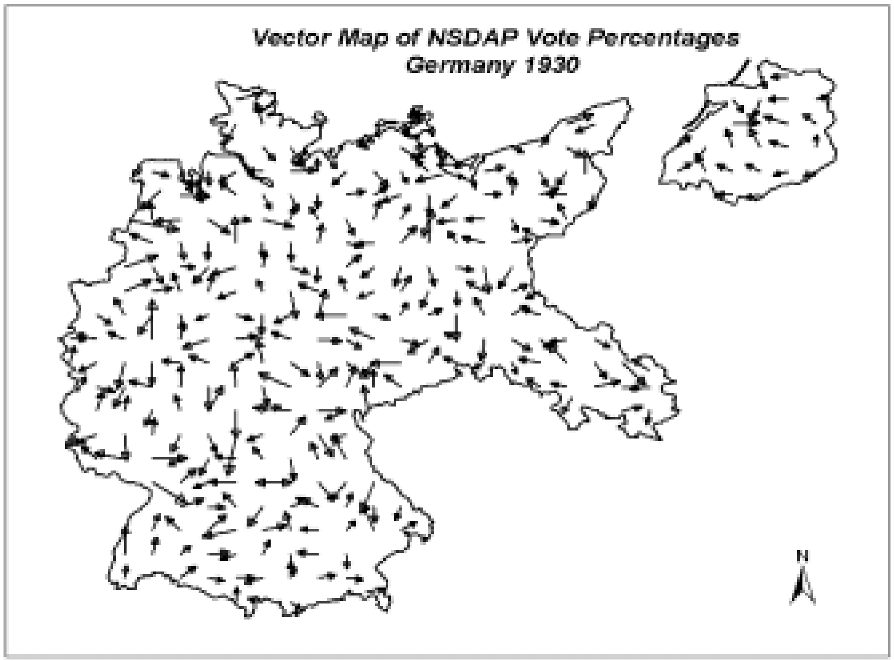

Figure 12: Vector Map of the NSDAP Vote Percentage, 1930

The directional correlograms had shown some general large-scale (across multiple spatial lags) autocorrelation in certain directions, depending on the variable under analysis. What is clear from Figures 12-14 is that the pattern is highly complex with multiple "sinks" and "ridges" in the surfaces. In Figure 12 (vector fields for the surface of the percentage of the vote for the NSDAP in 1930), "sinks" (places to which the arrows are directed) correspond to major cities (Berlin, Leipzig, Dresden, the Ruhr cities, and Allenstein) and regions (Upper Silesia, and parts of Brandenburg and of Pomerania), where the support was lower than in the surrounding *Kreise*. "Ridges", or places where the Nazi party support was locally and regionally-prominent, can be seen in the Munich area, Württemberg, Westfalia, Oldenburg, Holstein, and the eastern part of East Prussia. No long-distance directional vectors are visible since the pattern is highly localized. The vector pattern confirms previous statements about the local and small-scale autocorrelative nature of the NSDAP vote.

Strong regional or national trends would be translated into long arrows with a strong directional bias. In the directional correlograms above, significant values beyond the third-order lag (less than 50 km) were rare.

Similar localized vector maps can be seen in the EzI estimates for the turnout of the NSDAP voters and for the support of the Protestant voters for the NSDAP (Figures 13 and 14). In each case, there are more evident “ridges” than “sinks”. On the EzI turnout vector map, sinks are identifiable in the eastern edge of East Prussia, in the Berlin region, and in the Frankfurt region of Hesse. Ridges of estimated high turnout are more numerous and are generally associated with traditional regions of NSDAP strength – in Lower Silesia, Franconia, Thuringia, Oldenburg, Holstein and Württemberg. Other ridges do not mark high values as much as they indicate higher values than surrounding lower turnout rates –as in central Bavaria, Saxony, and Westphalia. However, the dominant map feature is the short arrow length and multiple directional orientations.

The variation of support of the Protestant population for the NSDAP is highly localized as indicated in the vector map of Figure 14. While it is well known that the aggregate correlation of the NSDAP vote and the Protestant population distribution is significant, the EzI estimates do not show dramatic variations in the ratio of Protestants who voted for the NSDAP (Figures 4 and 14). The maps are highly localized and only small pockets of higher and lower support than the national average are visible. Lower values (sinks in the vector map) are seen in Upper Silesia, Württemberg, the industrial Ruhr cities, and central Bavaria. Ridges of higher support are visible in the Rhineland (a Catholic region), northern Baden, Franconia, and the northern tier of regions (Oldenburg, Holstein, and the Mecklenburg region east of Hamburg). The complexity of the cultural-economic map of Weimar Germany reflects a mosaic of historical traditions and an un-nationalized electorate in the 1920s. Such traditions are frequently identified in electoral geographic studies of contemporary Western Europe, such as Shin (2001) for central Italy and Agnew (1987) for Scotland and Italy.

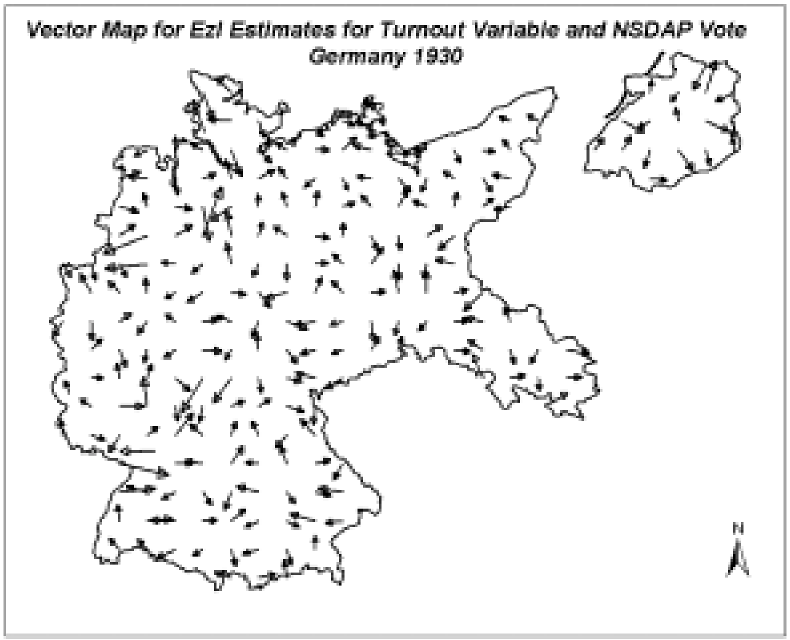

Figure 13: Vector Map of the EzI Estimates of the Turnout of NSDAP Voters, 1930.

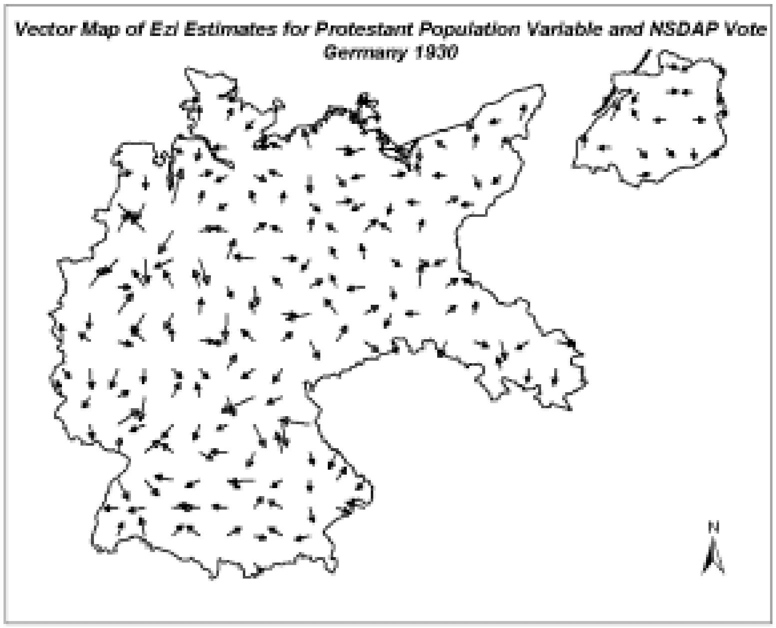

Figure 14: Vector Map of EzI Estimates of Protestant Support of the NSDAP.

9 Wombling (Barrier Analysis)

A final spatial analytical method that focuses on the regional differences across shared boundaries to identify significant "barriers" (major differences across the line) can help to determine the geographic extent and influence of these barriers. If the voting surface barriers correspond to other regional lines (e.g., cultural regions), then we can attribute significance to these historical bounds.[10] Methods of detecting difference boundaries are called wombling techniques, since they were first quantified by Womble (1951). Wombling methods vary. The magnitudes of the derivatives of the surfaces can be added together to get a composite picture of the barriers (if one has more than one measure, such as alleles) (Sokal and Thompson, 1998). In this study, a simpler measure of difference uses a distance metric to measure the difference between the values at the polygon centroids; only adjacent polygons (sharing a boundary) are used in the dissimilarity calculations. Because the locations of the polygon (*Kreise*) boundaries are known, so-called "crisp boundaries" can be delineated.[11] Barriers mark the edge of a homogenous area, demarcating it from different regions.

In order to link sub-boundaries using BoundarySeer (available from www.terraseer.com), certain criteria must be met if a polygon boundary element qualifies as part of a defined barrier. Boundary Likelihood Values (BLVs) are spatial rate of change indicators derived from gradient magnitudes; in this case, the gradient is the difference in the value of the variable under consideration (e.g., NSDAP percentage in 1930) between the centroids representing the polygons. By introducing a percentage threshold (e.g., top 5% of values represent a significant barrier and top 20% represent a modest barrier), a consideration of significance can be introduced (Barbujani and Sokal, 1990, 1991). There is debate in the literature on the benefits of *a priori* determination of the cut-off values, with

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[10] In landscape topographies, steep gradients (indicated by closely-spaced contour lines) are the zones of greatest surface changes. In genetic study, such as those of allele (a genetic marker) frequencies, barriers are important to identify since they show the areas over which genetic flow (population movement) is reduced or stopped (Sokal and Thompson, 1998).

[11] Fuzzy boundaries are appropriate when only point data are available and inter-point boundary interpolation is used

some preferring to use the historgram of values to find the thresholds. Since I am interested in comparing the barriers across the different wombling maps, I opted for consistent percentage cutoffs.

A second criterion in marking a barrier is a consideration of the angular alignment of the sub-boundary units. Gradient angles are the direction of the maximum change in the BLV at a specific centroid. The angle is calculated relative to a horizontal vector pointing east from the candidate centroid. The calculation is repeated for the second candidate centroid. If the angular threshold for the maximum angle between gradient vectors is more than 90 degrees, the boundary joining the centroids is no longer considered as part of a defined barrier. A second angular calculation is similar to the bearing correlogram procedure above and calculates the angle of the vector connecting the two centroids and due east. Two adjacent boundary elements are connected to form a sub-boundary if the average differences in their gradient angles and their connection angle with the sub-boundary are within thresholds set by the user. In this study, 30 degrees is the maximum angle threshold for the connecting centroidal vector and due east. Especially useful in diffusion studies, where the concept of barriers assumes central importance, the wombling technique allows a spatial comparison of different types of barriers (e.g., linguistic, cultural, religious, genetic, political or topographic) so that a correlation of boundary effects can be made and hypotheses about the effects of biological or physical features on socio-demographic characteristics can be tested (Bocquet-Appel and Bacro, 1994). In this study, the barriers were identified only for the univariate case.

The barrier identification method allows sub-boundaries to join across the *Kreise*. A distinct line of high values separated from a region of low values would be identified as a significant barrier across many *Kreise*. By setting the thresholds at 5% and 20% (of the boundary likelihood values), barriers at two levels can be identified in Figures 15-17. All of the 5% barriers are included within the 20% set of barriers. Like the previous displays, the dominant feature of the maps is the specificity of the locations and the lack of extended barriers across multiple *Kreise*. In Figure 15, the original NSDAP voting surface, the barriers mostly separate urban from rural *Kreise* or are aligned along regions. This wombling map has more consistent boundaries than the other two. Examples of these localized barrier expressions are seen in the lines separating Upper and Lower Silesia, the city of Berlin from its rural *umland*, Württemburg from Bavaria, Franconia from the rest of Bavaria, the Ruhr from the rest of Westphalia, eastern East Prussia from the rest of the province, and so forth. Barriers sometimes correspond to political boundaries (relics of earlier kingdoms incorporated into the Reich), physiographic divisions and to obvious cultural lines. Islands of higher values are clearly marked but the lack of conjoined, extensive lines is still noticeable.

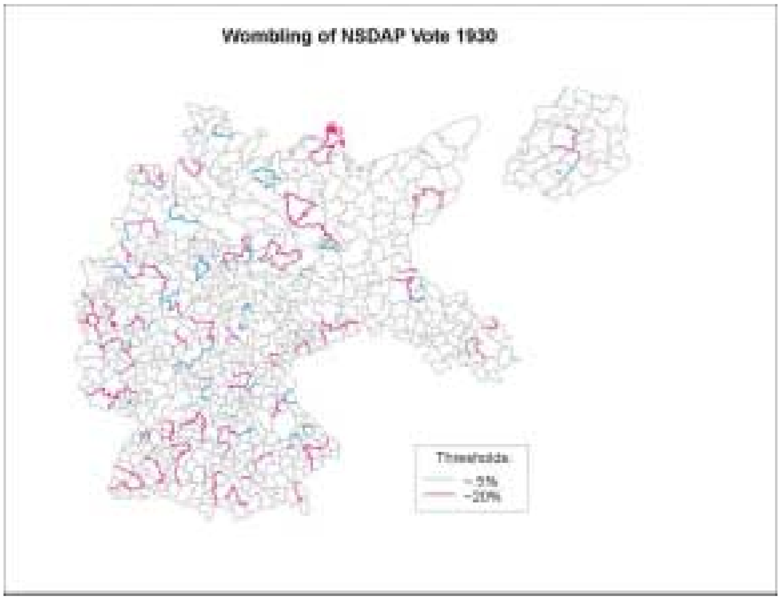

Figure 15: Significant Barriers in the NSDAP Voting Surface, 1930

The barrier map of the EzI estimates for the Nazi voter turnout (Figure 16) shows fewer extensive boundaries than the overall NSDAP surface. While not particularly continuous across multiple *Kreise*, significant barriers demarcate weak regional characteristics. In north-central Germany (south-west of Hildesheim), there is a barrier separating higher values (larger turnout of NSDAP voters) to the east from lower values to the south-west in Westphalia. Similarly, a region of high values north of Hamburg is distinguished from its neighbors and a region of high values in Franconia from lower values to the south and to the north-west in the rest of Bavaria. Part of Württemburg is separated from the rest of south-west Germany by its low values and the distinctive regions of NSDAP strength in Oldenburg (north-west corner of Germany) and eastern East Prussia are again distinguished on the barrier map.

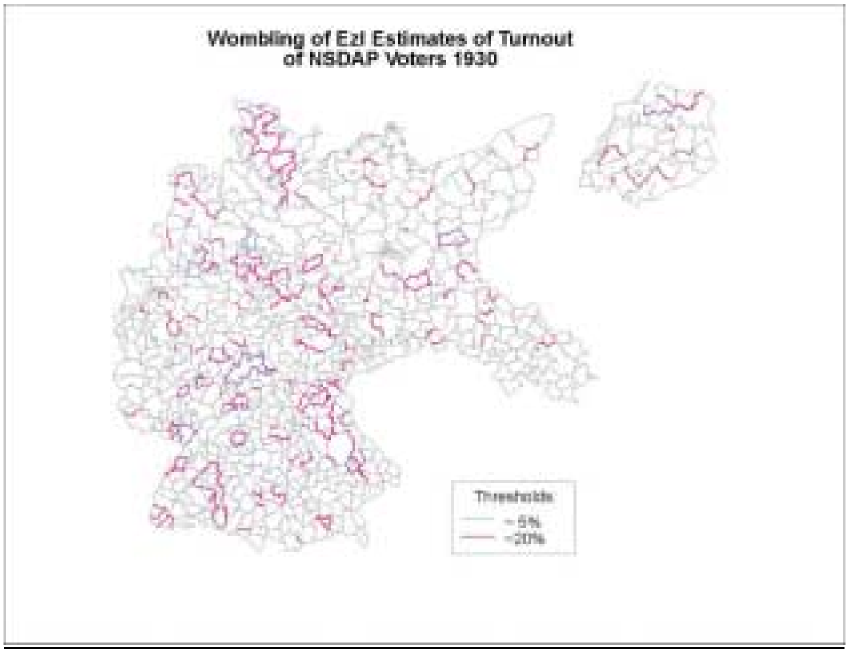

Figure 16: Significant Barriers in the Surface of EzI Estimates of NSDAP Voter Turnout

The final map (Figure 17) also displays barriers that divide culturally distinctive regions, where support of Protestants for the NSDAP was higher (or lower) than neighboring regions. This map is less "orderly" than the NSDAP EzI turnout map but certain regions are again identifiable by scattered barriers. High regions of Protestant support for the NSDAP in Upper Franconia and the adjoining region of Thuringia are visible. Similarly, low values concentrate in the Ruhr region, in northern Württemberg, and in Upper Silesia. The rest of the barriers isolate individual *Kreise* from their surroundings.

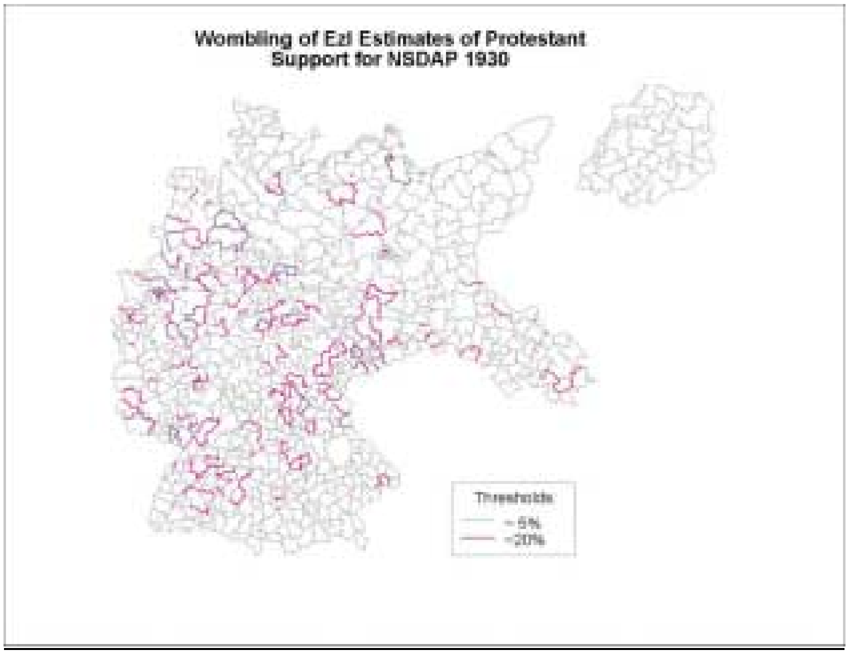

Figure 17: Significant Barriers in the Surface for EzI Estimates of Protestant NSDAP Support

The wombling analysis confirms previous exploratory spatial data analysis conclusions about the lack of geographic pattern in the Weimar Germany voting surfaces. Numerous islands that are distinctive from surrounding regions, urban-rural differences, weak relationships between voting and socio-demographic characteristics, and lack of countrywide trends are consistent across the maps of this paper. While most analysts use multiple measures to define barriers, I opted for the univariate modeling since the multivariate barriers are often hard to explain and correlate with other map features. Wombling offers much more potential use than has been the case in social science, perhaps hampered by the lack of accessible software. With the growing use of exploratory spatial data methods that include recognition of clusters ("hotspots") and barriers, especially in epidemiological study (Bailey and Gatrell, 1995; Griffith *et al*, 1998), diffusion of these methodologies into the rest of human geography is expected.

10 Conclusion

In this paper, I have stressed the benefits of exploratory spatial data analysis (ESDA) methods for examining a puzzle of long standing in the social sciences: Who voted for the Nazi party in Weimar Germany? In many ways, the Weimar German dataset, consisting of both census and electoral data at the level of *Kreise*, provides as complete of an aggregate account of the phenomenon as might be expected, and in some ways it exceeds the data files for contemporary societies in its geographic coverage, small scale, and temporal match between census and electoral data. Previous studies of the Nazi party phenomenon were motivated by the concern to check hypotheses about the propensity for different groups (e.g., religious, socio-demographic, age, occupational) to vote for the Nazis, but the conclusions to date have only been partial. Problems such as multicollinearity, scale of analysis, spatial autocorrelation, and accurate census measures of the predictive factors continue to plague the quantitative historical studies of Weimar Germany. This study has shown that the country did not have a nationalized electorate and that a very complex cultural-historical mosaic underlies the electoral map. Clearly, any modeling of the NSDAP vote has to take this mosaic into account. Searching for a single explanation (a univariate model) of the Nazi phenomenon is likely to prove to be a futile endeavor.

Traditionally, the geographic factor (spatial autocorrelation) is modeled out of the regression equations, though geographers have been arguing for over 30 years that these practices -"a throwing out of the baby and keeping the bath-water" – Gould, (1970, 444) - miss the point that human societies are not arranged in a statistically independent manner. Indeed, contra King (1996), geographers argue that the dynamics of human interaction in communities of kindred individuals, driven by needs of security and familiarity and/or by fears of the dissimilar, give rise to a "contextual" element that is more than simply the sum of the effects of the community composition. Examples of these contextual effects abound and the recent application of multi-level modeling of survey data of political attitudes has shown that typically 10-20% of the variance in the responses is attributed to contextual effects (Jones and Duncan, 1998; O'Loughlin, 2002).

Typically, the first step in any geographic analysis is mapping - using a variety of techniques to explore the structure of the spatially distributed data. The methods used in this paper rank among the most common, though the use of point-based (centroidal) data is still relatively uncommon in human geography because most census data are collected for polygons (spatial entities). In the past two decades or so, there has been a retreat in geographic analysis from complex multivariate modeling (factor analysis and canonical correlation enjoyed their heyday in the 1970s) to a more focused attempt to understand basic distributive properties of the key variables (Fotheringham *et al.*, 2000). It seems fair to conclude, though, that the trend has been to build models with more geographic terms and fewer compositional (socio-demographic) ones, partly as a result of a recognition of collinearity and the emphasis on parsimony, but also because the geographic models are complex and include multiple terms (see Griffith *et al.*, 1998 for an example).

Over two decade ago, Jean Laponce (1980) pointed out that geography was a net importer from political science (in turn, a net importer from economics). My guess is that this net flow is still the same. What has changed is the revolution in geographic methodologies of aggregate data analysis -some of which are used in this paper- the integration of statistical and GIS methodologies, and the theoretical conceptualization of context. Unfortunately, many political scientists continue to adhere to an out-moded conceptualization of space, place and region. Over time, as political scientists have moved more and more to survey-based data analysis, the advantages of aggregate data in certain circumstances have not been noticed. Previous dismissal of these data due to perceived problems of ecological fallacy, inadequate methods for handling spatial autocorrelation, and insufficient experience in mapping geographic data are increasingly unwarranted. Further rapprochement of geographers and political scientists in tackling issues of mutual interest is to be welcomed.

References

Agnew, J. A. 1987. *Place and Politics: The Geographical Mediation of State and Society.* Boston: Allen and Unwin.

Agnew, J.A. 1988."'Better Thieves than Reds'? The Nationalization Thesis and the Possibility of a Geography of Italian Politics." *Political Geography Quarterly*, 7: 307-21.

Anselin, L. 1988. *Spatial Econometrics: Methods and Models.* Dordrecht, Netherlands: Kluwer Academic Publishers.

Anselin, L. 1995. "Local Indicators of Spatial Association – LISA." *Geographical Analysis* 27: 93-115.

Anselin, L. 1998. *Spacestat Tutorial: A Workbook for Using Spacestat in the Analysis of Spatial Data.* Morgantown, WV: Regional Research Institute.

Anselin, L. 2000. "The Alchemy of Statistics, or Creating Data Where No Data Exist." *Annals, Association of American Geographers* 90: 586-92.

Anselin, L. and S. Bao. 1997. "Exploratory Spatial Data Analysis Linking SpaceStat and ArcView." In *Recent Developments in Spatial Analysis*, eds. M. Fischer and A. Getis. Berlin: Springer-Verlag, pp. 35–59.

Anselin, L. and A. Getis. 1992. "Spatial Statistical Analysis and Geographic Information Systems." *Annals of Regional Science* 26: 19-33.

Ault, B. and W. Brustein. 1998. "Joining the Nazi Party." *American Behavioral Scientist* 41: 1304-1323.

Bailey, T. and A. Gatrell. 1995. *Interactive Spatial Data Analysis.* Harlow, Essex: Longman.

Barbujani, G. and R.R. Sokal. 1990. "Zones of Sharp Genetic Change in Europe are also Linguistic Boundaries." *Proceedings of the National Academy of Sciences* 87: 1816-1819.

Barbujani, G. and R.R. Sokal. 1991. "Geographic Population Structure of Italy. II – Physical and Cultural Barriers to Gene Flow." *American Journal of Human Genetics* 48: 398-411.

Bocquet-Appel, J. P. and Bacro, J. N. 1994. "Generalized Wombling." *Systematic Zoology* 43: 442-448.

Brunsdon, C., A. S. Fotheringham, and M. E. Charlton. 1998. "Geographically Weighted Regression - Modelling Spatial Nonstationarity." *The Statistician*, 47, Part 3: 431-443.

Brustein, W. 1990. "The Political Geography of Fascist Party Membership in Italy and Germany, 1918-1933." In *Social Institutions: Their Emergence, Maintenance and Effects*, eds. M. Hechter, K-D. Opp, R. Wippler. New York: Aldine, pp. 245-264.

Brustein, W. 1996. *The Logic of Evil: The Social Origins of the Nazi Party, 1925-1933.* New Haven, CT: Yale University Press.

Brustein, W. and J. Falter. 1995 "Who Joined the Nazi Party?: Assessing Theories of the Social Origins of Nazism." *Zeitgeschichte* 22: 83-108

Childers, T. 1983. *The Nazi Voter: The Social Foundations of Fascism in Germany, 1919-1933.* Chapel Hill, NC: University of North Carolina Press.

Cho, W. Tam and Anselin, L. 2000. "Spatial Autocorrelation and EI: Some Further Results." Paper presented at the conference on "New Methodologies for the Social Sciences: The Development and Application of Spatial Analysis for Political Methodology", University of Colorado at Boulder, March 10-12, 2000.

Cliff, A.D. and J. K. Ord. 1981. *Spatial Processes: Models and Applications.* London: Pion.

Cressie, N. 1991. *Statistics for Spatial Data.* New York: John Wiley and Sons.

Davies-Withers, S. 2001. "Quantitative Methods: Advancement in Ecological Inference." *Progress in Human Geography* 25: 87-96.

Diggle, P. 2002. *Statistical Analysis of Spatial Point Patterns.* New York: Oxford University Press.

Dutilleul, P., J.D. Stockwell, D. Frigon and P. Legendre. 2000. "The Mantel Test versus Pearson's Correlation Analysis: Assessment of the Differences for Biological and Environmental Studies." *Journal of Agricultural, Biological and Environmental Statistics* 5: 131-150.

Falsetti, A.B. and R.R. Sokal. 1993. "Genetic Structure of Human Populations in the British Isles." *Annals of Human Biology* 20: 215-229.

Falter, J. 1986. *Wahlen und Abstimmungen in der Weimarer Republik*. Munich: C.H. Beck.

Falter, J. 1991. *Hitlers Wähler.* Munich: C.H. Beck.

Falter, J. and W. Gruner. 1981. Minor and Major Flaws of a Widely-Used Data Set; The ICPSR "German Weimar Republic Data 1919-1933" Under Scrutiny." *Historical Social Research* 6: 4-16.

Flint, C. 1995. *The Political Geography of Nazism: The Spatial Diffusion of the Nazi Party Vote in Germany.* Ph.D. dissertation, Department of Geography, University of Colorado-Boulder.

Flint, C. 2001. "A TimeSpace for Electoral Geography: Economic Restructuring, Political Agency and the Rise of the Nazi Party." *Political Geography* 20: 301-330.

Fotheringham, A. S. 1997 "Trends in Quantitative Methods, I: Stressing the Local." *Progress in Human Geography* 21: 88-96.

Fotheringham, A. S. 2000. "A Bluffer's Guide to "A Solution to the Ecological Inference Problem'." *Annals, Association of the Association of American Geographers* 90, 582-86.

Fotheringham, A.S. and C. Brunsdon. 1999 "Local Forms of Spatial Analysis." *Geographical Analysis* 31: 340-358.

Fotheringham, A.S., C. Brunsdon and M. Charlton. 2000. *Quantitative Geography: Perspectives on Spatial Analysis.* London: Sage.

Freeman, M. 1995. *Atlas of Nazi Germany: A Political, Economic and Social Anatomy of the Third Reich.* 2nd Ed. New York: Longman.

Golden Software. 1999. *Surfer 7.0 Users Guide: Contouring and 3-D – Surface Mapping for Scientists and Engineers.* Golden, CO: Golden Software.

Gould, P. 1970. "Is *statistix inferens* the Geographical Name for a Wild Goose." *Economic Geography* 46, no. 2 (Supplement), 439-448.

Griffith, D.A., P.G. Doyle, D.C. Wheeler and D.L. Johnson. 1998. "A Tale of Two Swaths: Urban Childhood Blood-Levels across Syracuse, New York." *Annals, Association of American Geographers* 88: 640-665.

Griffith, D.A. and LJ. Layne. 1999. *A Casebook for Spatial Statistical Data Analysis: A Compilation of Analyses of Different Thematic Data Sets.* New York: Oxford University Press.

Grill, J.P. 1983. *The Nazi Movement in Baden, 1920-1945*. Chapel Hill, NC: University of North Carolina Press.

Grill, J.P. 1986. "Local and Regional Studies on National Socialism." *Journal of Contemporary History* 21: 253-294.

Hamilton, R. 1982. *Who Voted for Hitler?* Princeton, NJ: Princeton University Press.

Hänisch, D. 1989. "Inhalt und Struktur der Datenbank 'Wahl- und Sozialdaten der Kreise und Gemeinden des Deutschen Reiches von 1920 bis 1933'." *Historical Social Research* 14: 39-67.

Heilbronner, O. 1998. *Catholicism, Political Culture, and the Countryside: A Social History of the Nazi Party in South Germany*. Ann Arbor, MI: University of Michigan Press.

Johnston, K., J.M. ver Hoef, K. Krivoruchko and N. Lucas. 2001. *Using ArcGis™ Geostatistical Analyst.* Redlands, CA: ESRI.

Johnston, R. and C. Pattie. 2000. "Ecological Inference and Entropy-Maximizing: An Alternative Estimation Procedure for Split-Ticket Voting." *Political Analysis* 8: 333-345.

Jones, J.P. and E. Casetti, eds. *Applications of the Expansion Method.* New York: Routledge.

Jones, K. and C. Duncan. 1998. "Modelling Context and Heterogeneity: Applying Multilevel Models." In *Research Strategies in the Social Sciences.* ed. E. Scarbrough and E. Tanenbaum. Oxford: Oxford University Press, pp. 95-123.

Kaluzny, S.P., S.C. Vega, T.P. Cardoso and A.A. Shelly. 1998. *S+ Spatial Stats: User's Manual for Windows® and Unix®*. New York: Springer-Verlag.

Kater, M.H. (1983) *The Nazi Party: A Social Profile of Members and Leaders, 1919-1945.* Cambridge, MA: Harvard University Press.

Key, V.O. 1949. *Southern Politics in State and Nation.* New York: Vintage Books.

King, G. 1996. "Why Context Should Not Count." *Political Geography* 15: 159-164.

King, G. 1997. *A Solution to the Ecological Inference Problem: Reconstructing Individual Behavior from Aggregate Data.* Princeton, NJ: Princeton University Press.

Küchler, M. 1992. "The NSDAP Vote in the Weimar Republic: An Assessment of the State-of-the-Art in View of Modern Electoral Research." *Historical Social Research* 17: 22-51.

Laponce, J. A. 1980. "Political Science: An Import-Export Analysis of Journals and Footnotes." *Political Studies* 28: 410-19.

Mantel, N. 1967. "The Detection of Disease Clustering and a Generalized Regression Approach." *Cancer Research* 27: 209-220.

Murray, C.J.L., G. King, A.D. Lopez, N. Tomijima and E.G. Krug. 2002. "Armed conflict as a public health problem." BMJ Journal324, 9 February, 346-349.

Oden, N..L and R.R. Sokal. 1986."Directional Autocorrelation: An Extension of Spatial Correlograms in Two Dimensions." *Systematic Zoology* 35, 608-617.

O'Loughlin, J. 1986. "Spatial Models of International Conflict: Extending Theories of War Behavior." *Annals, Association of American Geography* 76, 63-80.

O'Loughlin, J. 2000a. "Can King's Ecological Inference Method Answer a Social Scientific Puzzle: Who Voted for the Nazi Party in Weimar Germany?" *Annals, Association of American Geographers* 90: 592-601.

O'Loughlin, J. 2002. "Democratic Values, Trust, and Geographic Context: A Multi-Level Analysis of the World Values Survey Data, 1990-97." In *Interrogating the Globalization Project*. ed. R. Honey. Iowa City, IA: University of Iowa Press, forthcoming.

O'Loughlin, J. and L. Anselin. 1991. "Bringing Geography Back to the Study of International Relations: Spatial Dependence and Regional Contexts in Africa, 1966-1978." *International Interactions* 17: 29-61.

O'Loughlin, J., C. Flint and L. Anselin. 1994. "The Geography of the Nazi Vote: Context, Confession and Class in the Reichstag Election of 1930." *Annals, Association of American Geographers* 84: 351-380.

O'Loughlin, J., C. Flint and M. Shin. 1995. "Regions and Milieux in Weimar Germany: The Nazi Party Vote of 1930 in Geographic Perspective." *Erdkunde* 49: 305-314 (and 4 map supplements).

O'Loughlin, J., V. Kolossov and O. Vendina. 1997. "The Electoral Geographies of a Polarizing City: Moscow, 1993-1996." *Post-Soviet Geography and Economics* 38: 567-600.

Ord, J.K and A. Getis. 1995. "Local Spatial Autocorrelation Statistics: Distributional Issues and an Application." *Geographical Analysis* 27: 286-296.

Passchier, N. 1980. "The Electoral Geography of the Nazi Landslide." In *Who Were the Fascists?* , eds. S.U. Larsen, B. Hagtvet and J.P. Myklebust. Bergen: Universitetsforlaget., pp. 283-300.

Pollock, J. 1944. "An Areal Study of the German Electorate, 1930-1933." *American Political Science Review* 38: 89-95.

Rogerson, P.A. 2000. *Statistical Methods for Geography*. Thousand Oaks, CA: Sage.

Rohe, K. 1990. "German Elections and Party Systems in Historical and Regional Perspective: An Introduction." In *Elections, Parties and Political Traditions: Social Foundations of German Parties and Political Traditions, 1867-1987,* ed. K. Rohe. New York: Berg, pp. 1-25.

Rosenberg, M.S. 2000 "The Bearing Correlogram: A New Method of Analyzing Directional Spatial Autocorrelation." *Geographical Analysis* 32, 267-278.

Rosenberg, M.S. 2002. *PASSAGE*: Pattern Analysis, Spatial Statistics, and Geographic Exegesis. Version 1.0. Tempe, AZ: Department of Biology, Arizona State University. (available from www.public.asu.edu/~mrosenb/PASSAGE/).

Rosenberg, M.S., R.R. Sokal, N.L. Oden and D. DiGiovanni. 1999. "Spatial Autocorrelation of Cancer in Western Europe." *European Journal of Epidemiology* 15: 15-22.

Siverson, R. M. and H. Starr. 1991. *The Diffusion of War: A Study of Opportunity and Willingness.* Ann Arbor, MI: University of Michigan Press.

Shin, M. 2001. "The Politicization of Place in Italy." *Political Geography* 20: 331-353.

Sokal, R.R. and B.A. Thompson. 1998. "Spatial Genetic Structure of Human Populations in Japan." *Human Biology* 70, 1-22

Stachura, P.D. 1980. "The Political Strategy of the Nazi Party, 1919-1933." *German Studies Review* 3: 261-288.

Starr, H. 2002. "Opportunity, Willingness and Geographic Information Systems (GIS): Reconceptualizing Borders in International Relations." *Political Geography* 21: 243-261.

Stögbauer, C. 2001. *Wählerverhalten und nationalsozialistische Machtergreifung: Ökonomische, soziostrukturelle, räumliche Determinanten sowie kontrafaktische Politiksimulation.* St. Katherinen: Scripta Mercaturae Verlag.

Stone, N. 1982. "Pillars of the Third Reich." *New York Review of Books* 29: 24-26.

Tobler, W. 1970. "A Computer Movie Simulating Urban Growth in the Detroit Region." *Economic Geography* 46: 234-240

Tobler, W. 1976. "Spatial Interaction Patterns." *Journal of Environmental Systems* VI: 271-301.

Ward, M. D., ed. 1992. *The New Geopolitics.* New York: Gordon and Breach.

Womble, W.H. 1951. "Differential Systematics." *Science* 114: 315-322.