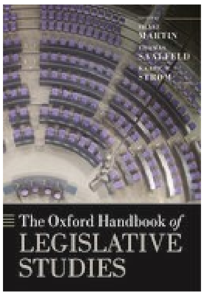

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CHAPTER

5 Roll-Call Analysis and the Study of Legislatures

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Abstract

Scalingmethods to evaluate the latent dimensions of political behavior and choice have had a substantial impact on our understanding of the properties of legislative roll-call voting. As interest in spatial models of legislatures has grown, these methods have been employed to operationalize theories of the role of preferences and ideology in legislative politics. Scaling procedures and ideal point estimation have enabled the evaluation of the spatial properties of voting and numerous empirical investigations of spatial theories of politics. With the advent of new techniques and more computational power, such methods have become even more widespread in comparative politics. We provide an overview of these methods and applications with a discussion of several challenges and recent developments in the field.

Keywords: roll-call voting, parliaments, scaling methods, factor analysis, spatial methods, legislatures, US Congress, economic models, multidimensional scaling method, unfolding method

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5.1 Introduction

THE application of spatial models of choice and judgment to measure the behaviour of legislators is built upon applying statistical procedures that analyse observed data and extract latent (i.e. abstract) dimensions upon which the objects or subjects can be placed. In political science, scholars are generally interested in policy or ideological scales using individuals' judgments or observed voting behaviour. The results of these scales, usually called "ideal point estimates," uncover the basic dimensionality of choice behaviour and have the potential to reveal the underlying latent preferences behind that behaviour. In political contexts, these might be basic differences such as left-right, liberal-conservative, secular-religious, or regional cleavages that provide a common thread across numerous policy choices. For legislative scholars, these tools can provide an invaluable means for testing hypotheses relating to legislators' preferences or for exploring the basic patterns behind otherwise complex data. With numerous arguments in the study of legislatures relying on spatial analogies of the policy distances between political actors, the empirical methods of quantifying distance in legislative behaviour have provided enormous utility to the field. These methods have become central to the study of the US Congress and as scholars adapt these methods for comparative purposes they are increasingly important for studies of other legislatures as well.

5.2 The Evolution of Scaling Techniques and Spatial Analysis

The scaling methods used to analyse roll-call voting mostly originate from research in psychology that was generally interested in deriving latent properties such as intelligence from patterns of data. The foundational work in this area was conducted by Charles Spearman (1904) in the form of factor analysis and by Karl Pearson (1901) in the form of Principle Component Analysis (or eigenvector-eigenvalue decomposition). These techniques were advanced by L. L. Thurstone who succeeded in developing a method for extracting multiple factors from a correlation matrix (1931; 1947).[1]

Parallel to these innovations in statistics were developments in economic models. Hotelling, who also gave principal components a solid statistical foundation (Hotelling 1933), produced the seminal theoretical work on the stability of competition, which is now generally recognized as the beginnings of the spatial (geometric) model of voting (1929). This work later led to the development of the median voter theorem by Black (1948; 1958) and the influential exploration of its implications for political competition by Downs (1957).

In 1936 the work of Eckart and Young (1936) along with Young and Householder (1938) provided the foundations for classical multidimensional scaling (MDS), which was developed by Torgerson (1952; 1958). MDS methods are applied to relational data, such as similarities and preferential choice data that can be regarded as distances.Multidimensional scaling methods represent measurements of similarity between pairs of stimuli as distances between points in a low-dimensional (usually Euclidean) space. The methods locate the points in such a way that points corresponding to very similar stimuli are located close together while those corresponding to very dissimilar stimuli are located further apart.[2] Shepard (1962a; 1962b) developed *nonmetric* multidimensional scaling (NMDS) in which distances are estimated that reproduce a weak monotone transformation (or rank ordering) of the observed dissimilarities.[3] Kruskal's (1964a; 1964b; 1965) monotone regression procedure led to the development of a powerful and practical nonmetric MDS computer program (Kruskal, Young, and Seery 1973).[4]

At the same time Guttman (1944; 1950) developed scalogram analysis (Guttman Scaling),whichformsthe basis of modern Item Response Theory,[5] while Clyde Coombs developed unfolding analysis (Coombs 1950; 1952; 1958; 1964) for ranked preference data. In this work, Coombs introduced the idea of an ideal point and a single-peaked preference function; the purpose of an unfolding analysis was to arrange the individuals' ideal points and points representing the stimuli along a scale so that the distances between the ideal points and the stimuli points reproduced the observed rank orderings.[6]

By the mid-1950s these techniques began to appear in the work of political scientists interested in
p. 105 legislative voting. Duncan MacRae's pathbreaking work on voting in ↳ the US Congress (MacRae 1958; 1970) utilized both factor analysis and scaling methods to analyse correlation matrices computed between roll calls and between legislators to uncover the dimensional structure of roll-call voting.[7] In the 1980s Poole and Rosenthal combined the random utility model developed by economists (McFadden 1976), the spatial model of voting, and alternating estimation methods developed in psychometrics (Chang and Carroll 1969; Carroll and Chang 1970; Young, de Leeuw, and Takane 1976; Takane, Young, and de Leeuw 1977) to develop NOMINATE, an unfolding method for parliamentary roll-call data (Poole and Rosenthal 1985, 1991; 1997; Poole 2005).

The NOMINATE model is based on the spatial theory of voting.[8] Legislators have ideal points in an abstract policy space and vote for the policy alternative closest to their ideal point. Each roll-call vote has two policy points—one corresponding to "yea" and one to "nay." Consistent with the random utility model, each legislator's utility function consists of (1) a deterministic component that is a function of the distance between the legislator and a roll-call outcome; and (2) a stochastic component that represents the idiosyncratic component of utility, which captures the aspects of voting behaviour that are not explained by the spatial dimension. The deterministic portion of the utility function is assumed to have a normal distribution and voting is probabilistic. An alternating method is used to estimate the parameters, meaning that an iterative process alternates between estimation of the ideal points and the roll-call parameters. Given starting estimates of the legislator ideal points, the roll-call parameters are estimated. Given these roll-call parameters, new legislator ideal points are estimated, and so on. Classical methods of optimization are used to estimate the parameters.

As advances in computing power have popularized simulation methods for the estimation of complex multivariate models, these methods were fused with long-standing psychometric methods. Specifically, Markov Chain Monte Carlo (MCMC) simulation (Metropolis and Ulam 1949; Hastings 1970; Geman and Geman 1984; Gelfand and Smith 1990; Gelman 1992) within a Bayesian framework (Gelman, Carlin, Stern, and Rubin 2000; Gill 2002) have been increasingly used to perform an unfolding analysis of parliamentary roll-call data in legislatures and courts, especially due to the influential work of Martin and Quinn (2002) and Clinton, Jackman and Rivers (2004). The difference is that estimations are based on sampling from conditional distributions for the legislator and roll-call parameters using the Gibbs sampler (Geman and Geman 1984; Gelfand and Smith 1990), especially the implementations by Jackman (2008) and Martin and Quinn (2009). Although not intrinsic to the estimation method, Bayesian MCMC applications usually use a quadratic deterministic utility function.[9]

5.3 Spatial Models of Voting

The common thread of all spatial (geometric) models of voting is the notion that a vote is based on the
p. 106 distance between a respondent's or legislator's ideal point and a policy ↳ proposal. We focus on the legislative voting model of binary choice (roll-call voting) because it is the most widely used, but our development below can be easily extended to mass survey data (ratio scale, rank orders, and nominal data).

An important concept here is the notion of spatial "error." By error, we simply mean instances of voting that are not in line with spatial preferences. For instance, if a legislator encounters a proposal that provides disutility relative to the alternative (the status quo), that voter should vote "nay," while a legislator should vote "yea" if that proposal is closer to his or her ideal point. In short, if there were no error of this sort, the legislator would always vote for the closest alternative in the policy space on every roll call. This results from the fact that the utility function is symmetric. Let the two policy outcomes corresponding to yea and nay on the jth (j=1,...,q) roll call be represented by O_{jy} and O_{jn} respectively. In most cases it is more convenient to work with the midpoint of the two outcomes:

$$Z_j = \frac{O_{jy} + O_{jn}}{2}$$

In one dimension Z_j is known as a cutting point that divides the yeas from the nays. With perfect spatial voting, all the legislators to the left of Z_j vote for one outcome and all the legislators to the right of Z_j vote for the opposite outcome. In two dimensions, a *cutting line* will divide the yeas and nays.

In one-dimensional perfect roll-call voting both the legislators and the roll-call midpoints are represented by points—X_i and Z_j respectively—and a joint rank ordering of the legislators and roll-call midpoints can be found that exactly reproduces the roll-call votes (Poole 2005). The process of eigenvector decomposition (described in fn.1) of the voting pattern in Fig. 5.1, for example, will produce a rank order (from X_1 to X_6) that corresponds to the ideal points depicted for the legislators.

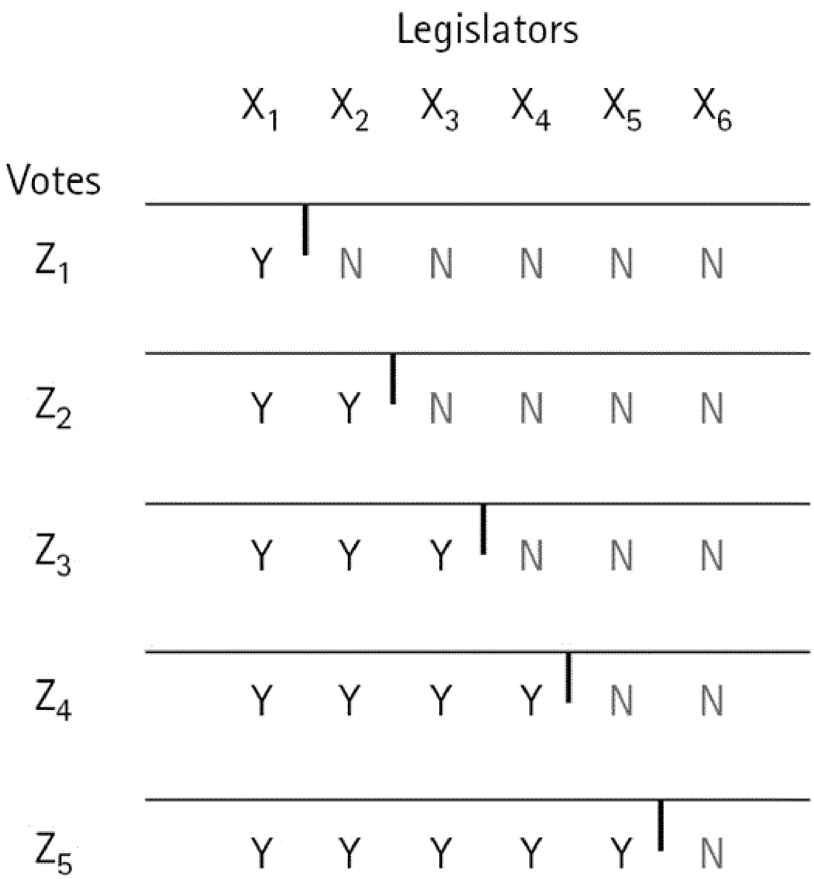

Fig. 5.1 Perfect spatial voting in one dimension

p. 107 In two or more dimensional perfect voting a legislator is still represented by a point—the s by 1 vector X_i where s is the number of dimensions—but a roll call is now represented by a plane that is perpendicular to a line joining the yea and nay policy points—the s by 1 vectors O_{jy} and O_{jn}—and passes through the midpoint, the s by 1 vector Z_j. The normal vector to this cutting plane is parallel to the line joining the yea and nay policy points. Fig. 5.2 shows a simple example of 12 legislators in two dimensions, where the cutting line is shown that separates the yea (Y) and nay (N) voters on a particular proposal with outcomes of O_y if passed and O_n if defeated. Because each voter can be separated by this cutting line, this two-dimensional example produces no errors.

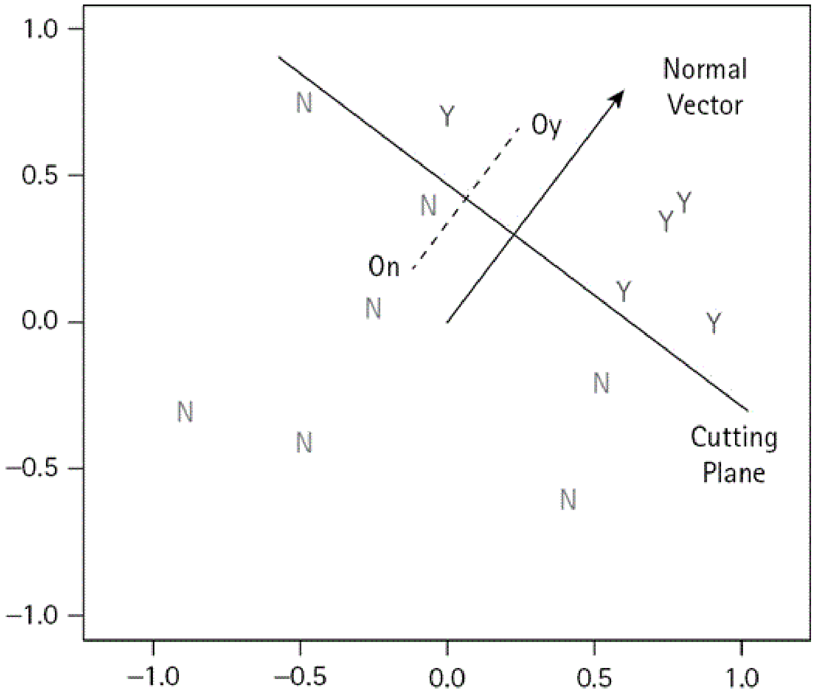

Fig. 5.2 Example of a cutting line in two dimensions

In two dimensions, if a variety of voting coalitions form amongst the legislators, then the q cutting lines will criss-cross one another in a myriad of directions creating a very large number of what are called "polytopes." With perfect voting a legislator is only defined up to a polytope. That is, each legislator could be anywhere in the polytope that corresponds to his or her roll-call choices (Poole 2005). A non-parametric method of unfolding binary choice data is Optimal Classification (Poole 2000; Poole et al. 2012b), which optimizes cutting-line locations in order to minimize the number of incorrectly predicted votes (errors). In this method, the coordinates are obtained by finding their optimal location among the cutting lines that minimizes the number of errors. Fig. 5.3 presents an example of the process of locating members in two dimensions using this method, and employing data from the sixth EU Parliament (Hix, Noury, and Roland 2009), with the MEP coordinates and a sample of 100 cutting lines plotted.[10]

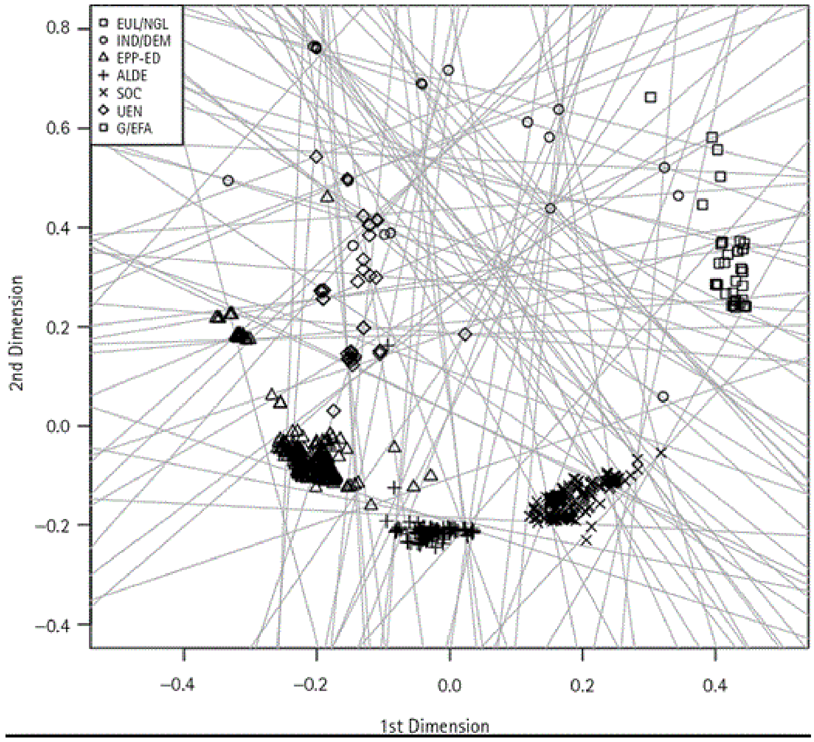

Fig. 5.3 Optimal classification coordinates and cutting lines for the sixth EU parliament

If error is present, then the problem of estimating cutting planes is equivalent to a probit or logit analysis depending upon the assumptions made about the error. The parametric methods of roll-call analysis make use of some form of assumption about error in order to obtain interval information. As an illustration, Fig. 5.4 presents a spatial map of the final passage vote of the landmark 1964 Civil Rights Act in the US Senate
p. 108 using ↳ DW-NOMINATE. The left panel shows all the senators and the right panel shows just the five senators who were errors in the DW-NOMINATE analysis. Each senator's location in the map is a function of all the roll-calls the senator participated in during his/her career. The cutting line is specific to the roll-call and divides those senators who are predicted to vote yea from those who are predicted to vote nay. Those senators who are incorrectly predicted—the "errors"—are indicated in the right side plot.

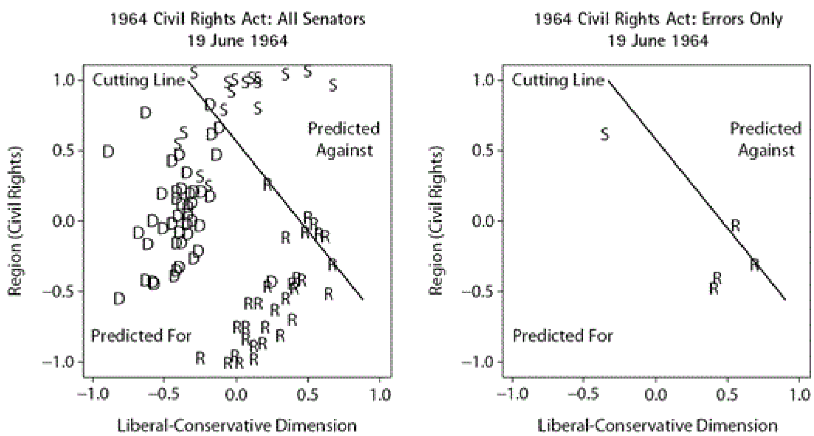

Fig. 5.4 Cutting line and errors on 1964 Civil Rights Act in the US Senate

The descriptive labels and the relative positions of the party tokens in the map show that a coalition of Republicans and Northern Democrats voted for the act and a coalition of Southern Democrats and a few Republicans voted against the act.

The major probabilistic models of parliamentary voting, such as DW-NOMINATE in this example, are based on the random utility model described above. To recap, in the random utility model a legislator's overall utility for voting year is the sum of a deterministic utility and a random error. Drawing on the description in Poole (2005), suppose there are p legislators, q roll calls, and s dimensions indexed by i=1,...,p, j=1,...,q, and k=1,...,s, respectively. Legislator i's utility for the yea outcome on roll call j is:

$$U_{ijy} = u_{ijy} + \varepsilon_{ijy}$$

p. 109 where u_{ijy} is the deterministic portion of the utility function and ε_{ijy} is the stochastic portion of the utility function. If there is no error, then the legislator votes yea if $U_{ijy} > U_{ijn}$. Equivalently, if the difference, $U_{ijy} - U_{ijn}$, is positive, the legislator votes yea. With random error the utility difference is:

$$U_{ijy} - U_{ijn} = u_{ijy} - u_{ijn} + \varepsilon_{ijy} - \varepsilon_{ijn}$$

So that the legislator votes yea if:

$$u_{ijy} - u_{ijn} > \varepsilon_{ijn} - \varepsilon_{ijy}$$

That is, the legislator votes yea if the difference in the deterministic utilities is greater than the difference between the two random errors. Since the errors are unobserved, we must make an assumption about the error distribution from which they are drawn. We can calculate the probability that the legislator will vote yea. That is:

$$P(\text{Legislator i votes yea}) = P(U_{ijy} - U_{ijn} > 0) = P(\varepsilon_{ijn} - \varepsilon_{ijy} < u_{ijy} - u_{ijn})$$

$$P(\text{Legislator i votes nay}) = P(U_{ijy} - U_{ijn} < 0) = P(\varepsilon_{ijn} - \varepsilon_{ijy} > u_{ijy} - u_{ijn})$$

So that P(yea)+P(nay) = 1.

p. 110 Poole and Rosenthal's NOMINATE (*Nomina*l *T*hree-Step *E*stimation) model is based on the normal distribution utility function. The normal distribution concentrates the utility near the individual's ideal point with tails that quickly approach zero as the choices become more and more distant.

With the normal distribution utility model, legislator i's utility for the yea outcome on roll call j is:

$$u_{ijy} = \beta e^{\left(-\frac{1}{2}\sum_{k=1}^{s} w_k d_{ijky}^2\right)}$$

where d_{ijky}^2 d_{ijky}^2 is the squared distance of the ith legislator to the yea outcome on the kth dimension:

$$d_{ijky}^2 = (X_{ik} - O_{jky})^2$$

the w_k are salience weights ($w_k > 0$); and because there is no natural metric β "adjusts" for the overall noise level and is proportional to the variance of the error distribution. The w_k allow the indifference curves of the utility function to be ellipses rather than circles.

The difference between the deterministic utilities is:

$$u_{ijy} - u_{ijn} = \beta \left\{ e^{\left(-\frac{1}{2}\sum_{k=1}^{s} w_k d_{ijky}^2\right)} - e^{\left(-\frac{1}{2}\sum_{k=1}^{s} w_k d_{ijky}^2\right)} \right\}$$

This equation cannot be further simplified. Despite this apparent complexity, it is not difficult to work with computationally.

With the quadratic distribution deterministic utility model, legislator i's utility for the yea outcome on roll call j is just:

$$u_{ijy}\ u_{ijy} = -d_{ijy}^2 \ = -\sum_{k=1}^{s} \left(X_{ik} - O_{jky}\right)^2$$

The difference between the deterministic quadratic utilities is:

$$\begin{aligned} u_{ijy} - u_{ijn} &= -\sum_{k=1}^{s} \left(X_{ik} - O_{jky}\right)^2 + \sum_{k=1}^{s} \left(X_{ik} - O_{jkn}\right)^2 \\ &= -2\sum_{k=1}^{s} X_{ik}(O_{jkn} - O_{jky}) + \sum_{k=1}^{s}(O_{jkn} - O_{jky})(O_{jkn} + O_{jky}) \end{aligned}$$

p. 111 This is isomorphic with the two parameter Item Response Model by setting:

$$\alpha = \sum\nolimits_{k=1}^{s}(O_{jkn} - O_{jky})(O_{jkn} + O_{jky}) \ \text{ and } \ \beta_j = \begin{bmatrix} -2(O_{j1n} - O_{j1y}) \\ -2(O_{j2n} - O_{j2y}) \\ \vdots \\ -2(O_{jsn} - O_{jsy}) \end{bmatrix}$$

where β_j is an s by 1 vector. This allows the difference between the latent utilities for yea and nay to be written in the same form as the item response model; namely:

$$y_{ij}^{*} = U_{ijy} = U_{ijn} = \alpha_j + X_i' \beta_j + \varepsilon_{ij}$$

where y_{ij}^{*} is the difference between the latent utilities and

$$\varepsilon_{ij} = \varepsilon_{ijn} - \varepsilon_{ijy} \sim N(0,\ 1)$$

This is known as the *Quadratic-Normal Model* (Poole 2001; 2005). Both the NOMINATE model and the Quadratic-Normal can be estimated with maximum likelihood (Poole 2005; Poole et al. 2012a).

An alternative to maximum likelihood estimators for spatial voting models is Monte Carlo simulation (Metropolis and Ulam 1949; Hastings 1970; Geman and Geman 1984; Gelfand and Smith 1990; Gelman 1992), which makes use of a "random tour" of the parameter space in a Bayesian framework (Jackman 2000a). The random tour involves recording the probability function at hundreds of thousands or millions of points in the parameter space. From this process, the shape of the distribution over the parameter space is known with some degree of certainty at the end of the tour. The means and standard errors of the parameters are calculated based on this information. The Markov-chain Monte Carlo (MCMC) method used to generate the random tour is computationally intensive, but produces both estimates of the legislator ideal points and roll-call parameters and measures of uncertainty for those estimates.

The intuition behind the Bayesian simulation approach can be seen by looking at the simple formulas for conditional probability. Let θ and Y be two events, then in classical probability theory:

$$P(\theta\Big| Y) = \frac{P(\theta \cap Y)}{P(Y)} \text{ and } P(Y\Big| \theta) = \frac{P(\theta \cap Y)}{P(\theta)}$$

hence

$$P(\theta \cap Y) = P(\theta| Y)P(Y) = P(Y| \theta)P(\theta)$$

p. 112 And

$$P(\theta\Big| Y) = \frac{P(Y|\theta)P(\theta)}{P(Y)}$$

In the Bayesian framework, Y is the observed data, the θ are the parameters, $P(Y|\theta)$ is the likelihood function of the sample, $P(\theta)$ is the prior distribution of the parameters, P(Y) is the marginal distribution of the sample, and $P(\theta | Y)$ is theposterior distribution. Because P(Y) is a constant, the posterior distribution is proportional to the product of the likelihood function and the prior distribution; that is:

$$P(\theta| Y) \infty (Y |\theta)P(\theta)$$

The researcher specifies the prior distribution of the parameters, $P(\theta)$. When this framework is applied to roll call data, Y is the p by q matrix of choices and θ is the vector of legislator ideal points and roll call parameters.

In the Bayesian NOMINATE model (Carroll et al. 2013) the Likelihood function is:

$$L\left(O_{jy}, O_{jn}, X|Y\right)$$

where X is the p by s matrix of legislator coordinates, and O_{jy} and O_{jn} are q by s matrices. The prior distributions are all normal distributions so the posterior distribution is:

$$\xi(O_{jy}, O_{jn}, X|Y) = L(O_{jy}, O_{jn}, X|Y)\xi(O_{1y})\xi(O_{1n}) \ \ldots \ \xi(X_p)$$

Similarly, the Posterior distribution for the Bayesian Quadratic Normal (IRT) model is:

$$\xi(\alpha_j, \beta_j, X | Y)$$

Each of these models can be estimated using standard MCMC methods (Clinton, Jackman, and Rivers 2004; Carroll et al. 2009a; Carroll et al. 2013). For the same models, Bayesian estimation generally provides similar estimates to those of MLE approaches (Carroll et al. 2009a) but the former allows greater flexibility in the use of exogenous information and a measure of uncertainty obtained via simulations, at the expense of requiring greater computational resources. In addition, many recent efforts to tailor models to specific
p. 113 problems have made use of the BUGS language[11] for statistical ↳ programming which enables the flexible use of Bayesian MCMC methods (e.g. Clinton and Jackman 2009; Zucco and Lauderdale 2011).

5.4 Seminal Applications of Scaling Methodology in Legislative Studies

As noted earlier, the initial substantive applications of early scaling techniques were applied to the US Congress (e.g. Clausen and Cheney 1970; Clausen 1973; see Collie 1984 for review). As spatial techniques were developed, several waves of research emerged employing NOMINATE, notably Poole and Rosenthal's work identifying the growing ideological polarization in Congress (1984; recently extended by McCarty, Poole, and Rosenthal 2006) and the debate surrounding the dimensionality of Congress (Poole 1984; Poole and Rosenthal 1985; Koford 1989; Wilcox and Clausen 1991). Using the measures made possibly by the DW-NOMINATE dynamic scaling technique, Poole and Rosenthal (1997) completed a landmark study of the evolution of the American Congressional party system. This work provided a new understanding of the shifts between the major eras of political, economic, and social conflict—through the lens of the latent patterns of legislative voting behaviour.

Much of the subsequent development of the method itself has been driven by the desire to derive preference measures for Congress to operationalize important theories in the field, especially those employing formal spatial models. Among these questions one of the most prominent has been the relative importance of party, preferences, and constituency on voting (Levitt 1996; Snyder and Groseclose 2000; Ansolabehere, Snyder, and Stewart 2001; McCarty, Poole, and Rosenthal 2001; Cox and Poole 2002). Many theorists examining influential Congressional organization theories have also made use of these preferences measures, including informational and distributive theories of committees (Londregan and Snyder 1994), "conditional party government" theory (Aldrich and Rhode 1998; Forgette and Sala 1999), "party cartel" theory (Cox and McCubbins 2005), and "pivotal politics" theory (Krehbeil 1998; Chiou and Rothenberg 2003). Numerous studies have also attempted to distinguish between partisan and "floor median" control of Congress using scaling techniques (Krehbiel et al. 2005; Clinton 2007; 2011; Stiglitz and Weingast 2010). Much of this work on parties has extended to applications in the American state legislatures (Aldrich and Battista 2002; Wright and Shaffner 2003; S. Jenkins 2006; Shor et al. 2010; Carroll and Eichorst 2013) and historical contexts (J. Jenkins 1999).

With the solidification of scaling methods as a standard tool in the study of Congress, there has been a dramatic increase in the use of such methods in comparative contexts. Again, many applications have been
p. 114 focused on identifying the ↳ dimensional basis of voting divisions. Hix (2001) and Hix, Noury, and Roland (2006), provided early and important applications of ideal point estimation to identify the origins for voting cleavages in the EU Parliament. Similar analyses have examined the key dimensions of voting behaviour in the UN (Voeten 2000; 2004), Korea (Hix and Jun 2009), Ireland (Hansen 2009), the Weimar Republic (Hansen and Debus 2011), Canada (Godbout and Hoyland 2011), Switzerland (Hug and Schulz 2007), and the Czech Republic (Lyons and Lacina 2009). Rosenthal and Voeten (2004), focusing on the French Fourth

Republic, employ Optimal Classification to exploit its appropriateness for situations of "perfect" spatial voting (that is, low rates of spatial voting "error") which is especially common in chambers with high levels of party unity. Others have employed some form of spatial analysis method to assess the basis of voting blocs in legislative data in cases such as Argentina (Jones, Hwang, and Micozzi 2009), Chile (Morgenstern 2004; Alemán and Saiegh 2007), Brazil and Uruguay (Morgenstern 2004), France (Sauger 2009), Hungary (Ágh 1999), Denmark (Hansen 2008), Russia (Bagashka 2008), and the EU Council (Hagemann 2007; Hagemann and Hoyland 2008).

Parallel to the studies of Congress built around testing formal and informal spatial and ideological arguments, numerous recent comparative studies have used ideal point estimates to measure policy preferences of individual legislators to allow testing of hypotheses requiring a proxy measure for ideological preference information. These applications have been employed to examine questions such as the reasons for switching parties in Brazil (Desposato 2006), legislative organization theory in Russia (Myagkov and Kiewiet 1996) and Italy (Curini and Zucchini 2010), and the role of ideology in legislative voting in Brazil (Zucco 2009) and the UK (Kam 2001; Schonhardt-Bailey 2003). Jones and Hwang (2005) use ideal point estimation as part of their extension of Cox and McCubbins' (1993) cartel theory to the Argentine Congress.

5.5 Trends, Extensions, and Improvements

Among the most important extensions to empirical spatial models are those addressing the issue of comparability across time. One such challenge is to make ideal points comparable across time by constraining them to a common scale. The most well-known approach of this sort is the DW-NOMINATE model (Poole and Rosenthal 1997) which constrains ideal points to be a polynomial function of time. An alternative approach has made use of "bridge" observations across time (Bailey 2007), such that voters in different time periods are treated as having voted on the same issues.

A second major concern of researchers, so far mainly in the US context but relevant elsewhere, has been establishing comparability between legislators in different chambers. One approach to this is to make use of the common members between two or more p. 115 ↳ chambers to unify the roll-call data, an approach taken by Poole (1998), Bailey (2007), and Battista et al. (2013). Another approach in the same vein is to rescale coordinates based on a common metric, an approach taken by Shor, Berry, and McCarty (2010) in their work designed to place US State legislators on a common scale. Bridging techniques also allow other institutions and actors to be considered on the same scale as legislators, as has been done in the case of US presidents (e.g. McCarty and Poole 1995; Bailey and Chang 2001; Bailey 2007; Treier 2011).

Another issue of particular concern for comparative applications is the matterof abstentions. Since abstentions are numerous in many chambers outside Congress, questions of how abstentions should be treated have led to the application of multichotomous choice models (e.g. Rosas and Shomer 2008).

Finally, a major source of innovation recently in the broader genre of preference measures has been the application of these methods to data sources other than roll-call votes. These range from analogous alternatives such as early day motions in the UK (Kellermann 2012) to data with very different properties such as legislative co-sponsorship (Talbert and Potoski 2003; Alemán et al. 2009; Desposato, Kearney, and Crisp 2011; Calvo and Sagarzazu 2011; Barnes 2012), speech (Proksch and Slapin 2008; Bernauer and Bräuninger 2009), and other sources of data with valuable choice information (e.g. Hix and Crombez 2005). Co-sponsorship, in particular, has been a source of interest for the closely related method of network analysis (Fowler 2006; Alemán 2009).

5.6 Problems and Issues with Scaling Techniques

Although it is a widespread practice to use ideal point estimates as a form of raw data processed through subsequent statistical analysis, both as independent and dependent variables, it is important to note that underlying each estimate is a stochastic process that ideally should be taken into account for many applications. One initial limitation of estimation via the NOMINATE model on this front, and an attraction of Bayesian estimators, was the lack of reliable measures of uncertainty for the ideal point estimates (see Poole and Rosenthal 1997). Such uncertainty estimates are often important in establishing the statistical meaning in the difference between the ideal points of different voters or between those of the same voter across time. This was addressed in the NOMINATE framework through use of the parametric bootstrap (Lewis and Poole 2004; Carroll et al. 2009b; Poole et al. 2011), providing standard errors to enable statistical tests of the difference between legislator points.

For all parametric methods, a significant issue persists in obtaining reliable interval information for ideal points—that is, a meaningful basis for cardinal distances between legislators' ideal points. Although the recovery of rank orders has proven extremely p. 116 ↳ robust via numerous methods, the meaning of the distance between points remains an area of substantial concern. In particular, with low levels of error, there is no basis for the recovery of interval-level parameter estimates in spatial (geometric) models of parliamentary voting. This problem is especially severe for the legislators that would be interpreted as "extreme." An inherent problem of probabilistic estimators is the issue of "errorless" voting by a legislator at the exterior of the preference dimension—those at the exterior of the policy space—which is particularly problematic in smaller chambers (such as committees or courts) where these constitute a larger proportion of the membership. Errorless voting is often better assessed through the non-parametric method of Optimal Classification (Rosenthal and Voeten 2004), although this method lacks the uncertainty measures available in other methods (Poole 2005).

Perhaps the greatest limitation for the spatial analysis of roll-call data is simply the degree to which the data fit the assumptions of the model. For researchers aiming to obtain a measure of preferences, roll-call votes are only as useful as the underlying process by which they are generated. Despite the wide acceptance of the face validity of data generated from US Congressional voting, in some cases roll calls simply do not contain information on the sincere preferences of individual legislators and are not useful for such applications. Thus, scholars can fruitfully apply these methods only with deep knowledge of the meaning behind the input data. While scaling methods can always identify latent dimensions of difference among legislators, what these differences represent may vary dramatically from case to case. Hence one cannot assume comparability between the type of information uncovered in any two legislative environments.

In situations where strategic voting is widespread—where voting is motivated by factors unrelated to one's preferences regarding the content of the policies under consideration—one cannot assume that the variation in the data can be reasonably interpreted as reflecting the preferences of individual legislators. For instance, in systems with very high party discipline, defections may not be directly a function of preferences and therefore will not provide reliable preference information on the individuals within the party (Spirling and McLean 2007; Spirling 2010). Of course, behaviour in such cases may nevertheless provide meaningful information on group-level preferences or on the position-taking strategies involved with these voting decisions.

Another widespread challenge for interpreting the meaning of ideal point estimates occurs when there is a biased selection mechanism for determining which votes occur (e.g. Carrubba et al. 2006; Carrubba, Gabel, and Hug 2008; Hug 2010; see also Clinton and Lapinski 2008). Without choice data that provides information distinguishing legislators on issues where they disagree, no technique can uncover differences in underlying preferences—even if the voting itself reflects those preferences.

Perhaps the broadest and most obvious limitation on further expanding the traditional application of spatial models of choice is the lack of recorded voting data. Many countries do not record roll-call votes in significant numbers at the individual level (Carey 2009). As a result, there has been a growing interest in
p. 117 alternative inputs that meet the needs of researchers looking for measures of policy preferences (e.g. Saiegh ↳ 2009). Hence, the family of scaling methods discussed will continue to be applied to legislative environments far beyond the existence and reliability of roll-call data. Of course, for studies intending to explain voting behaviour itself, issues regarding limitations in the selection of recorded votes must be addressed directly.

5.7 Conclusion

Spatial methods of analysing choice data have made an enormous contribution to our understanding of legislatures. Beyond the countless studies dealing with the US Congress, numerous quantitative analyses of state legislatures and assemblies outside the US have been enabled by applying spatial methods to roll-call data. However, substantial limitations exist in our ability to export standard interpretations of ideal point estimates derived from the work on the US Congress. This does not mean spatial roll-call analysis cannot provide useful information in most contexts, but each application must fundamentally reassess the meaning of these measures. Doing so requires a thorough evaluation of the numerous variables leading up to the choice in question before one chooses to interpret the data through a spatial model. That, in turn, means acquiring deep knowledge of the processes and norms of the legislatures we study.

Notes

1. See Poole (2008), on which this section draws, for a thorough review of this work.

2. The method is as follows. First, transform the observed similarities/dissimilarities into squared distances. (For example, if the matrix is a Pearson correlation matrix subtract all the entries from 1 and square the result.) Next, *double-centre* the matrix of squared distances by subtracting from each entry in the matrix the mean of the row, the mean of the column, adding the mean of the matrix, and then dividing by -2. This has the effect of removing the squared terms from the matrix leaving just the cross-product matrix (see Gower 1966). Finally, perform an eigenvalue-eigenvector decomposition to solve for the coordinates.

3. Graphing the "true" (that is, the estimated or reproduced) distances—the d's—versus the observed dissimilarities—the δ's—revealed the relationship between them. This became known as the "Shepard diagram."

4. This became known as KYST. Later de Leeuw (1977; 1988) and de Leeuw and Heiser (1977) modernized KYST with the SMACOF algorithm.

5. It is a set of items (questions, problems, etc.) that is ranked in order of difficulty so that those who answer correctly (agree) on a more difficult (or extreme) item will also answer correctly (agree) will all less difficult (extreme) items that preceded it.

6. Both unfolding analysis and scalogram analysis deal with individuals' responses to a setof stimuli. But whereas unfolding analysis assumes a single-peaked (usually symmetric) utility function, Guttman scaling and IRT models are based on a
p. 118 utility function that is always monotonically increasing or decreasing over the relevant dimension or space. Yet, these ↳ models are observationally equivalent in the binary choice context typical of parliamentary voting (Weisberg 1968; Poole 2005).

7. See Cromwell (1982; 1985) for similar applications on divisions in the UK parliament, Best (1982; 1995) for applications to parliaments in Europe. See Broach (1972) and Harmel and Hamm (1986) for early applications to US state legislatures and Collie (1984) for a broad review of later work.

8. See Poole (2005), on which this section draws for a more extensive discussion of these models.

9. With a quadratic deterministic utility function the simple item response model (Rasch 1961) is mathematically equivalent to the basic spatial model if legislators have quadratic utility functions with additive random error (Ladha 1991; Londregan 2000; Clinton, Jackman, and Rivers 2004). This has the effect of making the estimation quite straightforward as it boils down to a series of linear regressions.

10. Shapes vary by party group as follows, European People's Party–European Democrats (EPP–ED), Party of European Socialists (SOC). Alliance of Liberals and Democrats for Europe (ALDE), Union for Europe of the Nations (UEN), the Greens–European Free Alliance (G/EFA), European United Left–Nordic Green Left (EUL/NGL), Independence/Democracy (IND/DEM).

11. See Lunn et al. (2000). See Armstrong et al. (2014) for an overview of these and other software implementations.

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