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Center on Institutions and Governance Working Paper No. 1

Animation: A Tool for Understanding the Dynamics of Legislatures

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February 2005

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February 2, 2005

Introduction

Do the dynamics of behavior in a legislature indicate political stability or, on the contrary, portend instability, even armed conflict? Are the members of a legislature in fixed ideological positions, necessitating that political chance occur as a result of the *selection* of new representatives through the political process. Or do legislators *adapt* to the changing demands of their constituents? How do new legislatures, like the United States Congress in 1789, the United Nations General Assembly in 1946, and the European Parliament in 1979 organize themselves politically? How is a legislature affected by a massive change in membership, as has occurred with the recent enlargement of the EU? How does behavior of new legislators develop in an ongoing legislature? How do legislatures respond to increasing political tension on a variety of issues ranging from slavery to abortion? This essay focuses on the use of animation in addressing these and other questions.

[1] I would like to thank Keith T. Poole who took the conceptual model we developed jointly and did all the programming to make it operational. Although I programmed the original animation in FORTRAN at the Pittsburgh Supercomputer Center, the PC versions have been implemented by two very talented undergraduate assistants. Douglas Skiba did the original ANIMATE in QuickBasic for DOS at Carnegie Mellon University. Zelalem Aleghen, a Brown student, was the leader in the recent development of web-based Java animations for the United States Congress, the United Nations General Assembly, and the European Parliament. Aleghen's work was supported by the Student Technology Assistant program at Brown and the Institute for Governmental Studies VoteWorld project at UC Berkeley. My own work has benefited from a number of grants from the National Science Foundation.

A picture is worth 1000 words. A moving picture can be worth 1000 time series regressions. This paper is particularly concerned with moving pictures that are animations of time-series estimates of the dynamics of behavior in voting bodies. The empirical focus is the European Parliament, the United States Congress, and the United Nations General Assembly. Animations of these legislatures can be viewed at www.voteworld.berkeley.edu.

The Spatial Model of Voting

The animations I discuss are based on the estimation of a very, very simple voting model, known is the social sciences as "the spatial model of voting" (Enelow and Hinich, 1984). I am going to explain this model, summarize how we estimate the model, how we animate the model estimates, how the animation has a technical use in improving the estimation, and how the animations have improved our substantive understanding of politics. Before concluding, I will indicate how animation can, in the future, be more broadly used as a research tool.

The spatial model was originally proposed in a seminal paper by Hotelling (1929). We commonly use polar words such as liberal vs. conservative or left vs. right to describe politicians or political parties. Hotelling's insight was that political choices could also be described in these terms. Voting for more worker protection in Europe is left; voting against it is right. If being left or right can be represented as a matter of degree, that is, as a number on a continuum, we have a spatial representation of both the legislators and the choices. The Hotelling approach posits that if these representations were known, the legislator would vote for the choice whose position was closer to the legislator's own position. Hotelling's insight came from an analogy to consumer behavior. If the consumer wants a burger, the consumer will patronize, all other things being equal, the closer of two burger joints.

Hotelling's conceptual model can easily be extended to encompass more than one dimension. In addition to having a left-right stance, a member of the European Parliament (MEP) can have a stance on further integration of Europe. So Socialist members and Green MEPs might both support more worker protection, but only the Socialists might support strengthening the Commission's role in setting environmental standards.

A snapshot of estimated legislator estimation for the fifth European Parliament has been taken from the EP animation. It appears as figure 1. Token values indicate the parliamentary group of the legislator, with "S" for Socialist, "V" for Green, "COM" for Communist, etc. The labels assigned to the dimension are just reasonable interpretations. All scaling methods in contemporary use are blind to the content of the roll calls and to the parliamentary group alliance of the legislator. The picture shows us that legislators cluster by parliamentary group but that there is dispersion within each group. The groups are not perfectly disciplined. The picture shows that on the pro-anti integration dimension there is a continuum of ideal points, with moderates as well as extremists. In contrast on the main, left-right dimension, there are moderates (such as French Gaullists) only among the anti-Europeans. The main, pro-European parties are sharply polarized on left-right issues. There is a channel between the groups.

If we toggle the animation to present the deputies by nationality (B for Beligum, P for Portugal, F for France, U for UK, D for Germany, K for Denmark, etc.) rather than by parliamentary group, we find hardly any clustering. See figure 2. Ideological or partisan preferences over policy, not cohesive national interests, form the voting behavior of members of the EP (Hix, Noury, Roland, 2004).

Dimensionality

The number of dimensions might be expected to be quite low. The United Nations General Assembly makes very little policy and allocates very few resources. It is just a place for position-taking. These positions might well have fallen yesterday on a pole running across the West-East spectrum generated by the Cold War and today by a similar dimension separating the West from "rogue" states. After decolonization, another dimension might oppose rich nations in the "North" to poor ones in the "South". There might be not much left beyond the "ideologies" expressed in positions along these dimensions.

In legislatures that make policy, there might be many more dimensions. After all, each constituency is different and policies affect how money and other goodies flow to and are taken from the constituencies. Mathematically, if there are N legislators, we are guaranteed to be able to classify all the votes with N-1 dimensions. Perhaps we need 434 dimensions to capture the behavior of the 435 members of the House of Representatives.

What is surprising is that even in the United States, where, as former Speaker Tip O'Neill is said to have said, "All politics is local", on average the simple spatial model in one or two dimensions will allow us to correctly classify 85% or more of the individual votes. This is true even of close votes where the division is about 50-50. In the contemporary United States Senate for example, a one-dimensional liberal-conservative model will get about 90 of the 100 senators correct, even if the vote ended in a 50-50 tie. The 10 "errors" tell us that, as also happens with burger joints, other things aren't always equal. Some results from various legislatures around the world are shown in Table 1.

Comparative research suggests why the ideological model in one or two dimensions is so powerful. (People rarely, or should I say never, find a meaningful

second or third dimension. But in periods of great political instability, as in the 1850s United States, voting can become chaotic and indescribable by a spatial model.). The answer is not in the number of political parties—low dimensionality holds in the EP and in the Czech Republic, both of which have about 9 parties. It also holds in the United Nations General Assembly (UNGA) where there is no party structure. The answer is not in party discipline—low dimensionality holds in the low discipline United States. What all legislatures have in common, however, is that they use majority rule to make decisions. Obtaining majorities would seem to require forming coalitions that have coherent voting across issues. The extreme version of coherent voting would be represented by a classic Westminster system where the government and the opposition represent two blocs that produce the same voting split time and again. A Westminster legislature is trivially one-dimensional; just place the two parties anywhere and draw a line between them.

The finding of low dimensionality in voting is extremely important to the development of formal political theory and to formal political economy in economics. For tractability, the formal models are all based on low dimensional representations. (See Persson and Tabellini (2000) and Drazen(2000) for recent comprehensive statements of theoretical developments.) The finding of low dimensionality in legislative voting suggests that the theory has validity as a model of policy formation. But it is also important to ask if the dimensions are stable in time, particularly in terms of thinking of dynamic models of policies, as in inter-generational transfer payments such as old age pensions and health care.

Low dimensionality also means that we can use a simple two-dimensional scatterplot to capture how legislators vote. The moving pictures in the aforementioned animations flash by many frames of scatterplots. Each legislator is

represented by a token in the plot. The token is placed at the ideological position of the legislator at a given point in time.

Estimation

How do we find the legislator ideological positions that appear as tokens in the scatterplot? The only currently available procedure that can take dynamics into account is termed DW-NOMINATE (McCarty, Poole, and Rosenthal, 1997) that is the latest version of a scaling algorithm that Keith Poole and I began developing in 1982. It combines Hotelling's insight with the random utility model developed by Nobel laureate Daniel McFadden (1976). The random utilities represent those other things that aren't always equal. DW-NOMINATE is a procedure that chooses the legislator positions (aka ideal points), the roll call outcome positions, a signal-to-noise parameter, and dimensional weights. The parameter values are chosen to maximize the likelihood of observed choices, subject to some heuristic constraints. These constraints deal with some practical problems, such as not locating Tom DeLay in the deeper regions of extreme right-wing space just because he almost always votes on the conservative side of an issue. Similarly, we would not want to put Ted Kennedy in liberal heaven. Recently, Jeffrey Lewis and Poole (2004) have developed an appropriate procedure for estimating confidence intervals for the parameters. Their work tells us that the estimates are quite precise. The 95% intervals for tokens seen in the animations would typically be small ellipses around the points.

What makes DW-NOMINATE distinctive among scaling techniques is its ability to handle ideological positions in a dynamic setting. How can we determine that Newt Gingrich is more conservative than Henry Clay if Gingrich and Clay served more than a century apart? The answer is that legislatures consist of overlapping cohorts of members. So, for example, some members of the current, 107th House will

have served in the 97th and some members of the 97th will have served with members of the 87th, etc.

To take advantage of the leverage afforded by overlaps, we have to impose some structure on the permissible change in individual positions. The most straightforward assumption is to assume than a legislator never changes his or her position throughout his or her period of service. This "constant" model in fact appears to be a very good first approximation to the data not only in the United States but also for the French Fourth Republic (Rosenthal and Voeten, 2004).

More relaxed assumptions can be made to explore the stability of the positions of individual legislators. Poole and Rosenthal (1991a, 1997) allowed legislator positions to be linear, quadratic, and cubic functions of time. Time was represented by integers, with each Congress (roughly two years) being a period. They found that linear movement improved significantly on the constant model but that higher order polynomials had little bite. They also found that the linear movement was most important before 1900. For the past century, there is little movement—legislators enter and "die with their ideological boots on".

An important exception occurs when a legislator changes his or her party allegiance. In that case, there is typically a big jump in position. For example, after the 1994 election several Democratic members of the U.S. House of Representatives defected to the Republicans. These were southerners who had been moderates, in the center of the liberal-conservative split. They did not become, however, the most left-wing members of the Republican party. Instead, they jumped to very conservative positions, near other southern Republicans. The jump testifies that much of the previous position incorporated loyalty to the Democratic party while the current position may incorporate loyalty to other southern Republicans.

Once one accounts for party switchers, there is little for linear trend to explain. This point is clearly illustrated by the example of Strom Thurmond of South Carolina, the longest serving member in the history of the United States Senate. Thurmond served as a Democrat for the 10 years spanned by the 84th to 88th Congresses and then switched to the Republicans, serving through the 107th Congress. The US animation is based on DW-NOMINATE with linear trend within party and discrete changes after party switching. If in the animation one searches for Thurmond, then toggles "Search Results" and then "Selected Only", one will see that there is very little movement by Thurmond either as a Democrat or Republican but a big jump when he switches.

Rosenthal and Voeten (2004) found a similar result for the French Fourth Republic. Allowing for the numerous party switches in the Fourth Republic (1946-1958) improved substantially over a constant model for the three legislatures of the Republic. On the other hand, the party switching model did almost as well as separate scalings of the legislatures. The effect of party-switching shows one advantage of doing dynamic, as against static, estimation. The results clearly indicate that the ideological positions of members incorporate effects from party membership.

Overlap

The performance of DW-NOMINATE depends critically on two factors. First, the validity of the hypothesis used to impose enough structure to make the estimation possible. If legislators are not relatively stable in their positions, DW-NOMINATE will be misspecified. Second, the extent of the overlap. If there was ever an election where the entire membership of the House of Representatives changed, we could not place the history of the House in a common space. DW-NOMINATE would work but the ideological positions before the complete turnover would not be comparable to those after. The basic idea extends smoothly. Where

there is a lot of turnover, DW-NOMINATE estimates are on shakier grounds than where there is stable membership. (The degree of turnover is a matter of the absolute number of legislators serving in each of two successive legislatures, not the percentage. In a very large legislature, such as the EP, turnover can be quite high as long as the number of returning legislators is substantial. In some of the early United States Congresses, the small size of the legislature and substantial turnover weakens the precision of a dynamic analysis. The recent imposition of term limits in several state legislatures in the United States will create a similar problem.)

Fortunately, many voting bodies have institutional features that build in stability. The nation-state system since World War II has generally been very stable, with the exception of the collapse of the "evil empire". So DW-NOMINATE should work well for the UNGA, especially if one allows for regime changes such as Castro for Batista, PRC for Taiwan, black South Africa for apartheid. It will work well for the United States Senate since only one-third of the membership is elected every two years as members serve for staggered six-year terms. For other legislatures, such as the United States House of Representatives before incumbency bias set in and for the EP, a dynamic estimation should be viewed with more caution. It would be useful to improve our animations by including a bar that shows the degree of overlap.

One benefit of animation is that it can correct an estimation that has gone astray when the degree of overlap is small. Take the case where there is zero overlap. Than the computer, which is blind to the party affiliation of the legislators and to the content of the roll calls, might mistake our conventions about what is left and right. We can always rotate a space 180^{o} without changing the results. A world where Tom DeLay is left and Maxine Waters is right is the same, scaling wise, as one where DeLay and Waters look like we think they look. When there is little overlap, the

starting values for DW-NOMINATE might cause, on one or more dimensions, a flip of this kind. That is, the starting values can flip a dimension at a point in history and the optimization procedure can get stuck and fail to undo the flip. When Poole and I viewed the first animation, we saw a flip that had not been apparent when we just looked at goodness-of-fit measures. We multiplied some of the starting values by -1 and got more sensible results. This is but one example of how animation provides insights about data.

The Second Dimension Compared to the First

The animations are, as said before, two-dimensional scatterplots. This is a convenient way to make a graphical portrayal of the results. This does not mean the second dimension is very important, even if the legislator tokens are dispersed on the second dimension. By construction, the first dimension, portrayed horizontally, is at least as important as the second. In fact, it is typically far more important in accounting for the data. Throughout American history, for example, a second dimension has had real importance only when race generated a separate, active dimension. This occurred during the debate over slavery from roughly 1830 through 1850. (Between 1850 and 1860, there was a spatial realignment with slavery becoming the horizontal dimension.) It also happened from roughly 1937 through 1975 during the debate over civil rights for African-Americans. For the rest of American history, the cutting lines that divide Yeas and Nays on a given vote have been largely perpendicular to the horizontal axis, indicating that the second dimension is quite weak. While there are interesting second dimensions in the European Parliament (for or against further European integration) and the UNGA (First and Second worlds versus Third), the first dimension is still far more important. Our animations would be improved by showing measures of fit for the two dimensions.

Some Uses of Animation'

Animations can be useful both in carrying out a dynamic scaling and in interpreting the results. I previously indicated how viewing an animation can be used to see flips in alignments that occur when there are few legislators that serve in both of two successive legislatures. The more important use of the animation, however, comes in seeing important trends that generate testable hypotheses.

Spatial Stability of i\Individual Legislators

When Poole and I first estimated a dynamic model, we noticed a substantial increase in fit by allowing for a linear trend in legislator positions. We did not know that the linear trends did not have equal importance throughout the history of Congress. Nor did we think of testing for this. When we viewed an animation, however, it was immediately apparent that legislators were moving much more early on in the history of Congress than recently. We went back to the estimated terms and showed that the average linear trend in the early nineteenth century was about 2.5 times what it was in the late twentieth century (Poole and Rosenthal, 1997, p. 73). Since the current trends are so small—and even smaller when party-switching is taken into account—we can argue that legislators are more inclined to maintain personal ideologies or reputations rather than adapt to possible changes in constituent preferences. Or, more precisely, legislators do not relocate relative to one another. If there is adaptation to preferences, it is because the entire country has become more liberal or more conservative.

Realignment of the Southern Democrats

A standard story in U.S. Politics 101 is the "three-party system". During the civil rights conflict in the 1950s and 60s, Northern Democrats, Southern Democrats,

and Republicans represented three distinct groups. The Southern Democrats frequently voted with Republicans in a "conservative" coalition. The three-party system can be seen in any frame from the U.S. Congress animation for this period. What was less known was when and how this system was created. The animation clearly discloses that Southern Democrats constituted the left-wing of the Democratic party from the end of Reconstruction (1877) well into the New Deal of Franklin Roosevelt preferences. Southern Democrats often were Populists and generally had a concern with redistribution from a rich, white North to a poor, white South. In contrast, in the "three party system" the Southern Democrats had become moderates on the liberal-conservative dimension and occupied a distinct position on the second, civil rights/race dimension.

When did the evolution from the post-Civil War system to the three-party system occur? The animations make clear that the evolution started before World War II, during Roosevelt's second term. The roll calls that provoked the movement of southern Democrats had to do with such pre-war issues as lynching in the South and was continued during the war by roll calls on voting rights for African-American members of the armed forces.

Polarization

Perhaps the most striking and noted finding in my research with Poole has been the observation of the "Polarization of American Politics" (Poole and Rosenthal, 1984, Krugman, 2002a, 2002b). Polarization can be measured in a variety of ways, such as the difference between the party medians on the first dimension (see Schickler, 2000, or the average distance between member pairs across the two parties in two dimension (Poole and Rosenthal, 1997, p. 83). Both of these and a number of other sensible measures of "polarization" have been increasing since the mid to late

1970s. We in fact discovered this pheonemon at its onset, using data from interest group ratings (Poole and Rosenthal, 1984). The phenomenon now stands out much more clearly in the animation where one sees the clouds of scatterplot points for Democrats and Republicans separating on the liberal-conservative dimension and drawing further apart. One can also see that polarization decreased markedly over the first three-quarters of the twentieth century. The decrease started well before the realignment of the South. The evolution of polarization appears related to changes in income inequality and immigration (Rosenthal, 2004).

Issues, Not Institutions

Substantial insight can be produced by looking at animations of two legislatures simultaneously. The animation of Congress is setup this way, with the House and Senate appearing in two adjacent windows. Looking at the two animations together shows that the location of parties, polarization, and individual volatility of position are highly similar across the two chambers. Roll call voting alignments in the two chambers would thus seem to be dictated by the major issues that confront the nation, such as slavery, war, taxes, and economic crises. Although congressional scholars have drawn important distinctions about institutional differences between the two chambers (such as more open rules in the Senate, cloture in the Senate, etc.), these differences are for the most part swamped by the substantive agenda that confronts the two chambers. An important exception occurred in the interwar period when agrarian Republicans from the farm belt, such as LaFollette of Wisconsin and Norris of Nebraska, caused more disperson among Senate Republicans, with the agrarians taking moderate to liberal positions. This is likely to have been partly

institutional in difference, since the farm states are strongly overrepresented in the Senate. But on the whole, it is hard to see any institutional effects in the animations.

The House and Senate are not the only legislatures that could me matched. For example, the UNGA and the EP could be paired. Are differences between European countries found in the UNGA echoes in the EP. For example, the Nordic countries form a distinct bloc in the UNGA. Does this find an echo in the EP? Was there a change in the UN voting of the 10 countries that just joined the EP as their candidacies advanced?

The Future of the Study of the Dynamics of Legislatures

Animations will become more valuable as our theoretical models and estimation techniques for the dynamics of roll call voting advance. For totally anachronistic reasons, time has been crudely measured in applications of DW-NOMINATE to date. In fact, it is relatively easy to access the exact dates and sequencing of the votes that enter into DW-NOMINATE. Among the research topics that this suggests are:

1. Do legislators enter with pre-wired ideological positions or is there a period of learning, of deciding where the legislator will be placed? If there is learning, how fast does it take place?
2. Are there important events within the course of a legislature that disrupt the ideological placement of legislators or the mapping of issues. The types of events that I have in mind would include 9/11, the defection of James Jeffords of Vermont from the Republican party in the 106th Senate that resulted in Democratic control of the Senate, the scandals that led to the resignation of the European Commission headed by Jacques Santer.

3. How can we portray voting on a sequence of amendments on a particular bill. For example, in the 106th Senate, the Senate voted on over 20 amendments dealing with the bankruptcy bill (Nunez and Rosenthal, 2004). Clinton and Meirowtiz (2001) have developed a model where bill locations are constrained in that the winning outcome on the immediately previous amendment becomes the status quo (typically "Nay") outcome on the current vote. Animation would permit visualization of the path of voting on amendments.
4. How can we track the evolution of an issue over time. For example, there are long histories of voting on minimum wages in Congress (Poole and Rosenthal, 1991b) and the Arab-Israeli conflict in the UNGA. One could overlay the issue votes on the animated scatterplots by showing the succession of cutting lines for the designated issue.

Animation will also be more useful as our estimation techniques improve. One avenue is to exploit more of the agenda structure of the data, as in Clinton and Meirowitz (2001).

Another road is to abandon DW-NOMINATE for a technique that may be more suitable to most legislatures. DW-NOMINATE achieves identification of parameters by imposing a functional form to the utility function of the legislators and by assuming that "what is not equal" takes the form of errors drawn from a Normal distribution. In addition, it assumes that these errors are independently and identically distributed across all legislators and all votes, even for 214 years of voting in the United States. Fortuitously, this version of Occam's lawnmower was not too bad for Congress, where party discipline is relatively weak.

Beyond Congress, NOMINATE and other parametric techniques are likely to lack face validity. In examining scatterplots for the French Fourth Republic, Rosenthal and Voeten (2004) discovered that NOMINATE had two problems. First, the scaling put over a third of the deputies on the rim of the space, a reflection of the fact that the error rate was far lower in France than in the U.S. Second, the space was distorted by the fact that the left-wing parties, particularly the Communists, were highly disciplined while the right-wing parties were much, much less so. Similar problems seem to occur in applying NOMINATE to scaling the EP. For France, these problems did not arise when using the non-parametric optimal classification method of Poole (2000). Future progress in dynamic estimation would appear to require the development of non-parametric procedures that are robust to the process generating the data.

Conclusion

Animation is a powerful tool for quickly grasping the major results that arise from dynamic estimations of roll call voting behavior. While it is important to apply normal :professional standards, including statistical tests, to these findings, it is nonetheless striking to realize how much of the basic story will come out from watching a brief animation.

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Table 1[2]

W-NOMINATE Results For Selected Legislatures

Legislature	Number of Scalable Roll Calls[a]	Number Scalable Legislators[b]	Percent Correctly Classified	APRE
105th House 1997-98	946	443	One: 88.2 Two: 89.2	One: .644 Two: .674
85th House 1957-58	172	441	One: 79.0 Two: 84.8	One: .390 Two: .558
Third European Parliament: 1989-94[c]	2,283	589	One: 89.8 Two: 91.3	One: .543 Two: .610
Fourth European Parliament: 1995-97[c]	2,230	704	One: 89.4 Two: 91.4	One: .536 Two: .622
1841 British Parliament[d]	186	478	One: 89.7 Two: 92.5	One: .651 Two: .748
French National Assembly, 1951-56[e]	341	645	One: 93.3 Two: 96.0	One: .818 Two: .892

[2] This table appears in Poole and Rosenthal (2001). It is based on the static version of DW-NOMINATE.

(Table 1 continued)

34 Sessions of Czech Parliament 1993-97[f]	----	200	One: 94.2 Two: 95.7	One: .770 Two: .863
1995 Polish Parliament[g]	1791	464	One: 88.9 Two: 92.1	One: .485 Two: .630
U. N. General Assembly 1946-53[h]	383	60	One: 85.9 Two: 88.0	One: .481 Two: .558
U. N. General Assembly 1954-69[h]	662	126	One: 86.5 Two: 88.2	One: .555 Two: .614
U. N. General Assembly 1970-88[h]	2279	158	One: 90.3 Two: 91.8	One: .468 Two: .548
U. N. General Assembly 1991-96[h]	344	186	One: 91.8 Two: 93.0	One: .621 Two: .677

[a] All the analyses used our standard criterion of at least 2.5% minority voting for inclusion in the scaling

[b] All the analyses used our standard criterion of a minimum of 25 votes for a legislator (or nation) to be included in the scaling.

[c] Source: Noury (1999, Tables 1 and 2)

[d] Source: Scaling performed by authors. See Schonhardt-Bailey (1999) for an analysis.

[e] Source: Scaling performed by authors.

[f] Source: Mielcova and Noury (1997, Tables 1 and 2). The numbers given in the table are averages.

[g] Source: Scaling performed by authors. See Mercik and Mazurkiewicz (1997) for an analysis.

[h] Source: Voeten (2000, Table 2).

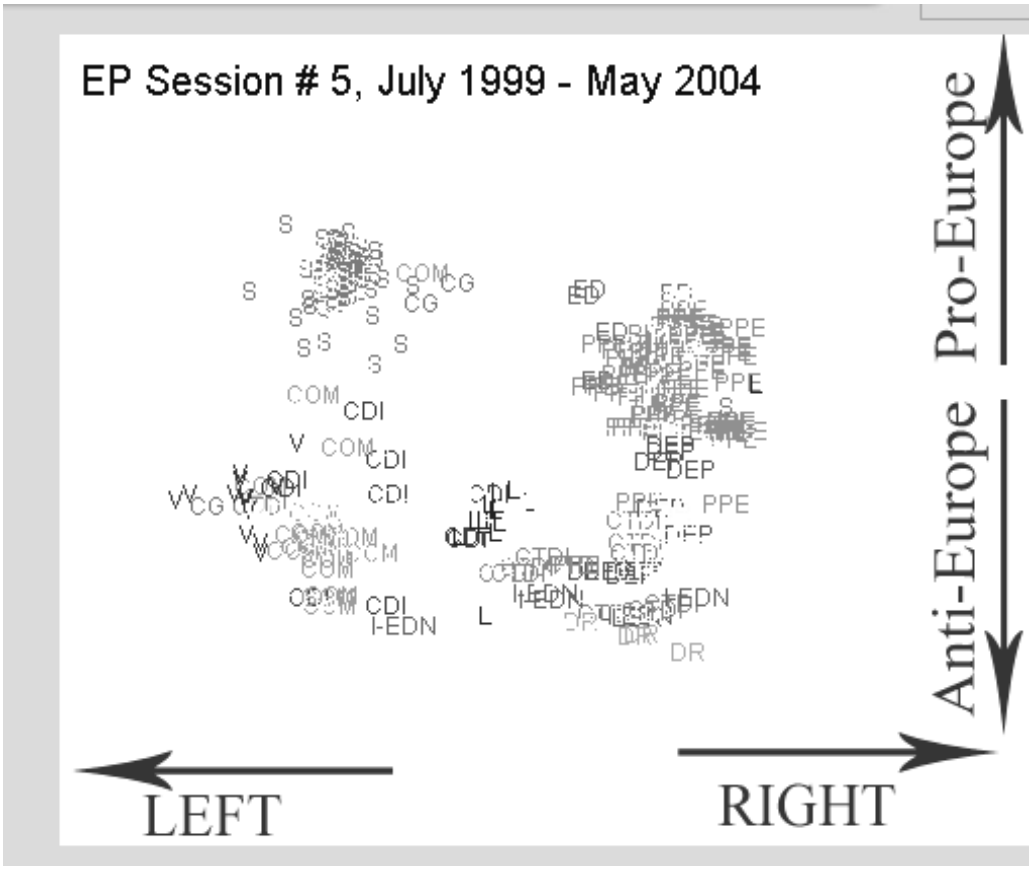

Figure 1. Ideal points in the European Parliament. Deputies identified by parliamentary group.

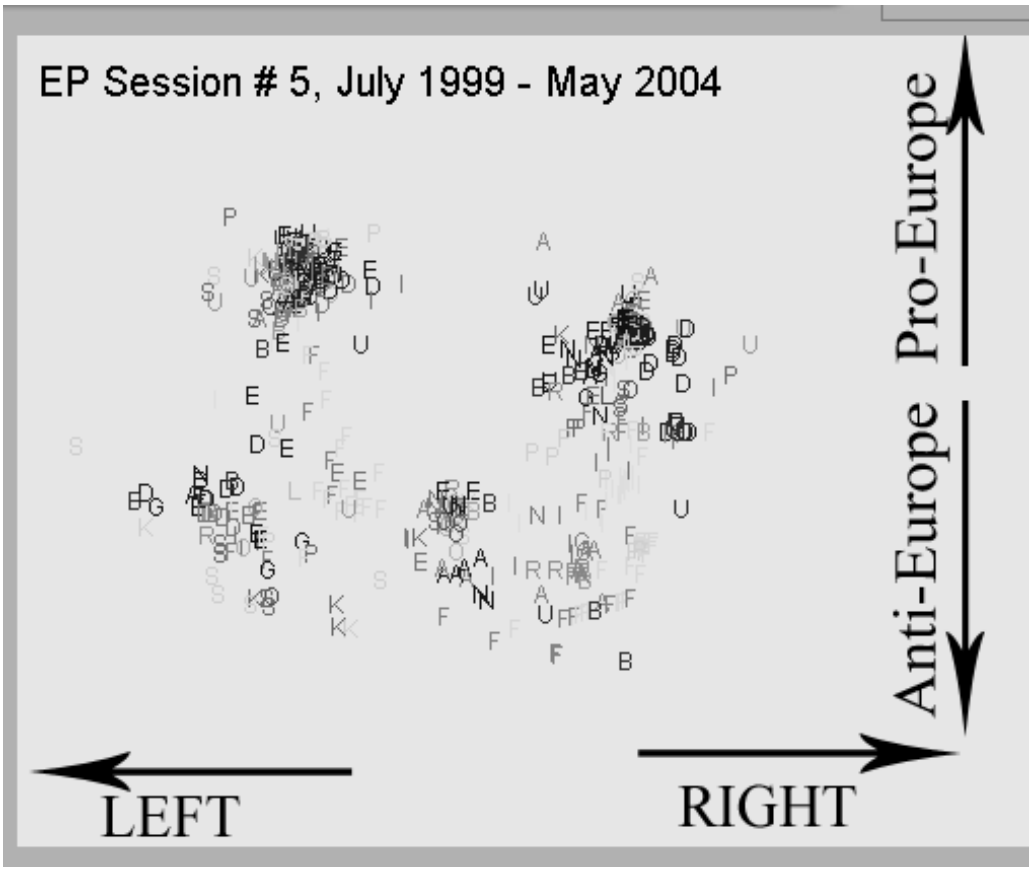

Figure 2. Ideal points in the European Parliament. Deputies identified by nationality.