Roll Call Vote Dimensionality Reduction for the European Parliament

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Abstract. Recorded votes in legislative bodies are an important source of data for political scientists. Voting records can be used to describe parliamentary processes, identify ideological divides between members and reveal the strength of party cohesion. Using popular dimensionality reduction techniques and cluster validation methods, we explore an alternative formulation of the problem of working with vote data. We present results of dimensionality reduction techniques applied to votes from the 6th and 7th European Parliaments, covering activity from 2004 to 2014.

1 Introduction

As a law making body, votes passed in the European Parliament (EP) can have significant influence on citizens across the European Union. Members of the European Parliament (MEPs) hold power over the majority of EU legislation, as well as decisions on budgets and spending. Analysis of votes is not only of interest to researchers, but many interest groups and industries operating within the EU. To produce insights into legislation and party politics computational approaches are highly dependant on latent variable models—using point estimates to make sense of and test theories using voting records[9], speeches[18], party manifestos[2], expert surveys[15], and more recently social media[1].

A common theme in these models is the low dimensional reconstruction of high-dimensional data. Roll call votes, where the vote of each member is recorded are typically represented as a matrix of legislators with *for* and *against* votes, treating abstentions as missing values. Legislators, in this case MEPs, are represented as vectors in d dimensions, where each dimension encodes a vote in some way. *Scaling* methods are then applied to recover point estimates or produce visualisations. Scaling methods essentially perform dimensionality reduction, transforming data in a high-dimensional space to a space with fewer dimensions—an n dimensional space $\mathbb{R}^n$ where $n << d$, typically 2 or 3 dimensions are used to produce interpretable visualisations.

While established methods for inductive scaling of roll call votes exist, there are many other potential alternatives that remain unexplored. We describe 4 such alternatives in Section 3 and formulate a cluster quality based evaluation approach, highlighting advantages and drawbacks of each.

2 Related Work

The NOMINATE [17] family of multidimensional scaling approaches are the most widely adopted methods for estimating ideal points from roll call data, and have been applied to European Parliament roll call vote data in [9] where the main policy dimensions based on this data reveal a dominant left-right dimension, as well as evidence of a pro-/anti-Europe dimension.

The results of scaling are often used as features for downstream tasks, such as [15] where ideal points are used as features in estimating party influence. In [7] roll call votes are compared to survey responses.

Scaling using text from speeches[18] can be related to the broader task of dimensionality reduction [14]. Popular scaling methods include Wordfish [13], and Wordscores [10]. The Wordfish model is applied to EP debates in [18]. While strong evidence for left-right ideology was not found in the speeches, the results suggest that legislators express ideology differently through speaking and voting.

What all these approaches share is a strong domain specific focus: scaling approaches like W-NOMINATE[16] are developed to deal with roll call votes and not any other kind of application. We propose adopting methods not commonly used with roll call data, but widely used in general in many different domains.

3 Methods

We cast the problem of roll call vote analysis as a dimensionality reduction problem, for which a wide range of methods exist. We apply 4 methods (PCA, NMF, t-SNE, SGNS with t-SNE) to roll call voting records from the 6th and 7th European Parliament, testing different ways of encoding the vote matrix, detailed with results in Section 4

3.1 Evaluating projections

In order to evaluate the quality of the low dimensional embeddings of MEPs, we adopt the Silhouette Score[19]. We define clusters as the parliamentary groups to which MEPs belong to. For each MEP i, the silhouette score is:

$$s(i) = \frac{b(i) - a(i)}{\max\{a(i), b(i)\}}$$

where $a(i)$ is the average distance from MEP i to all other MEPs in their group, and $b(i)$ is the lowest average distance to another group cluster of which the MEP is not a member of.

$s(i)$ scores close to 1 suggest that an MEP is appropriately clustered, while scores close to -1 suggest that the MEP would be more appropriately placed in a different, neighbouring group. The average $s(i)$ over all MEPs in a group is a measure of how tightly grouped MEPs are in the space, or rather, how strongly party discipline dictates vote behaviour[8]. The average $s(i)$ score across all MEPs for all groups provides a measure of quality of a method.

3.2 Encoding Vote Data

The EP plenary votes are publicly available and published regularly[1]. Before applying techniques to roll call votes, we construct the vote matrix X: the high-dimensional representation of votes—where vote outcomes are one-hot encoded. Every vote is 3 elements representing a binary value for *Yes*, *No*, and optionally *Abstain*.

Other potential encodings, given vote metadata and method choice are possible: instead of one-hot, a count matrix is produced by merging votes using title similarity, or policy area or committee. Detailed vote meta data is available for the 6th parliament[2] from [8], but is incomplete for the 7th parliament.

MEPs who switch groups[5] during the term present a data consistency challenge for roll call analysis using our proposed evaluation measure. MEPs who follow group voting procedure of one group for a period of the term, and then switch will be correctly clustered with the group most similar to them, but mislabelled during evaluation, as voting records remain, while group affiliation can change.

Every effort has been made to correct inconsistencies with data such as removing duplicate vote records and matching roll call records with MEP profiles to ensure MEPs represent the correct group at the time of the vote, but some inconsistencies may remain.

3.3 Dimensions in EU Votes:

Using the evaluation scores of projections built using different dimensions, we can try to investigate how many dimensions are optimal for each method. Figure 1 shows that dimensionality reduction approaches work best for 2 or 3 dimensions in most cases. In previous work[9], the main policy dimensions were a dominant left-right dimension, and a pro-/anti-Europe dimension. As we only use one kind of evaluation approach, there is not enough evidence to show that this 3rd dimension in the "vote space" is substantive.

4 Results

4.1 W-NOMINATE

The Weighted Nominal Three-step Estimation approach[16] is an inductive scaling technique specifically designed for ideal point estimation of legislators using roll call data.

While the method is ubiquitous, a number of drawbacks are highlighted in [3]. Specifically: excluding votes decided by less than 2.5% of legislators in the minority, which results in poorer discrimination among extremist MEPs, and excluding MEPs with short voting histories. In the 7th Parliament dataset 5 of 853 MEPs and 460 of 6961 votes are excluded with the recommended settings.

[1] `http://www.europarl.europa.eu/plenary/en/votes.html`
[2] `http://personal.lse.ac.uk/hix/HixNouryRolandEPdata.htm`

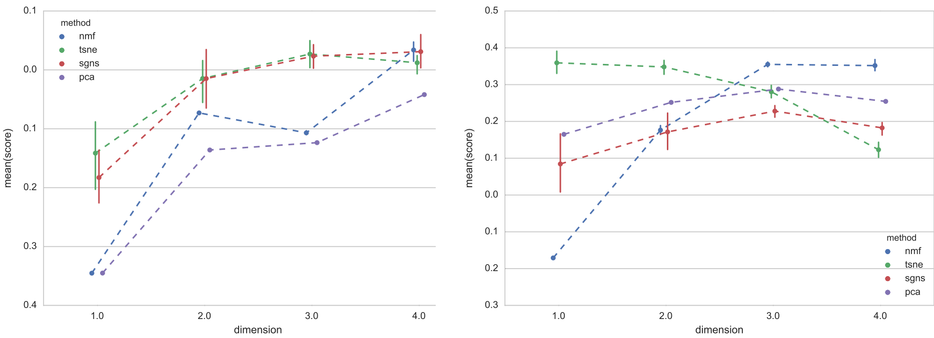

Fig. 1. Silhouette scores for techniques with different target dimensions for the 6th (left) and 7th (right) Parliaments.

The methods we propose do not exclude any MEPs or Votes, and do not require setting vote or MEP specific thresholds, however they do introduce their own method specific parameters and initialisation strategies that can affect results, and do not solve the problem of parameter tuning.

Figure 2 shows W-NOMINATE estimates that form our baseline: other approaches are compared to $s(i)$ scores derived from these results. Detailed scores by party group for the 7th parliament are shown in Table 1 below.

Group	W-NOMINATE	t-SNE (Counts)	t-SNE (SGNS)	NMF (Counts)
EPP	0.719	0.509	0.084	**0.766**
S&D	**0.504**	0.459	0.366	0.241
ALDE	**0.703**	0.555	0.457	0.438
G/EFA	**0.791**	0.612	0.505	0.351
ECR	0.417	**0.689**	0.559	0.538
EUL_NGL	0.532	0.533	**0.566**	0.374
EFD	-0.315	**-0.279**	-0.443	-0.349
NI	-0.407	-0.319	**-0.125**	-0.380
	0.549			

Table 1. 7th Parliament Silhouette Scores for each group (cluster) of MEPs, best scores highlighted.

While some groups are clustered more appropriately by the methods we explored, overall W-NOMINATE produces the best clustering of MEPs, using the Silhouette Index.

In Figure 2, the x axis is interpreted as the left/right dimension, with left wing groups such as the European United LeftNordic Green Left (EUL/NGL) placed on the left, and right wing groups such as Europe of Freedom and Democracy

(IND/DEM) on the right. The y axis is interpreted as capturing a pro/anti EU integration dimension, with pro-EU groups assigned estimates close to 1 and Eurosceptic or anti-EU MEPs assigned point estimates close to -1.

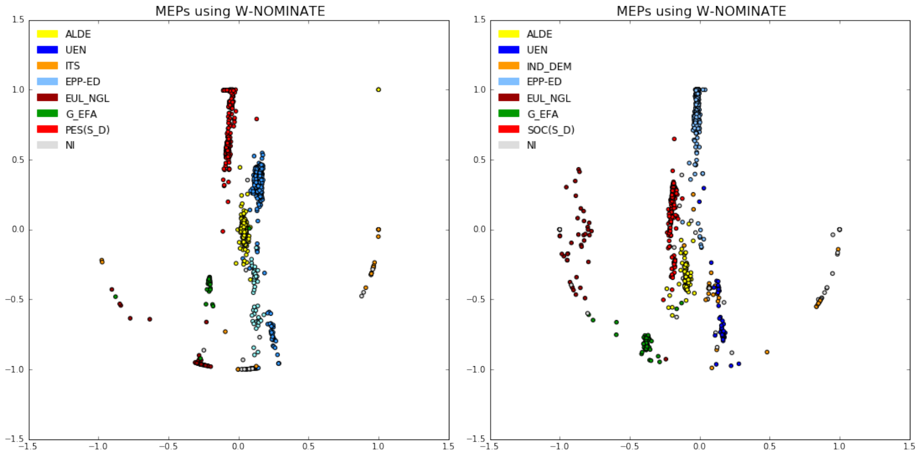

Fig. 2. W-NOMINATE scales for the 6th (left) and 7th (right) Parliaments.

4.2 PCA

Principle Component Analysis[6] is a commonly used linear dimension reduction technique. PCA is performed using Singular Value Decomposition on the vote data matrix. Figure 3 shows the resultant visualisations:

4.3 NMF

Given a non-negative matrix X, Non-negative Matrix factorization[12] approaches find two factor matrices W and H where the product of W and H approximates X. The dimensions of the factor matrices are significantly lower than the product. NMF is not commonly used for visualisation, but is a popular approach for clustering[4] and topic modelling.

4.4 t-SNE

t Stochastic Neighbourhood Embedding is a popular dimensionality reduction and visualisation technique. Data is usually embedded in 2 or 3 dimensions, creating interpretable visualisations of high dimensional spaces. The stochastic nature of the process can sometimes produce visualisations that are drastically different, or contain structure that could be over-interpreted. For example, in a $2d$ plot, the x and y coordinates are not reliable values to use as point estimates

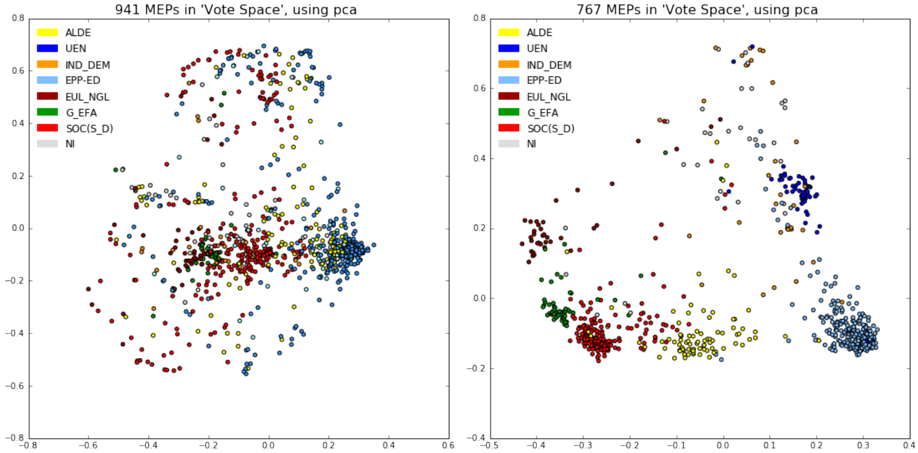

Fig. 3. PCA reduction for the 6th (left) and 7th (right) Parliaments.

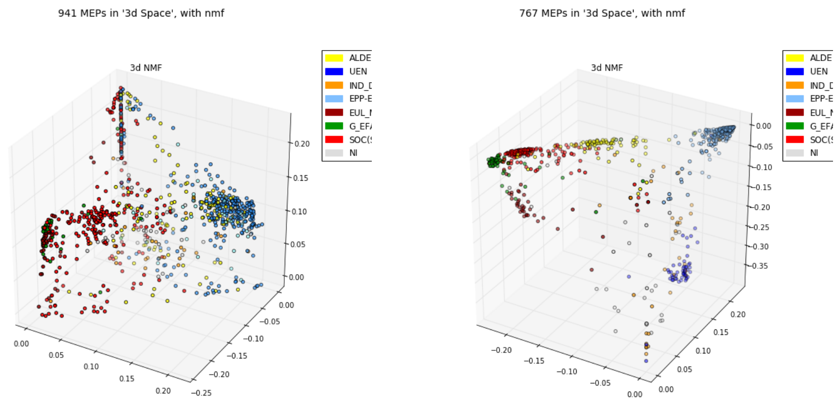

Fig. 4. NMF reduction for the 6th (left) and 7th (right) Parliaments in 3 dimentions.

in the same way as NOMINATE scores are—however, the clusters produced and relative positions of MEPs can be informative as MEPs with similar voting patterns will be clustered together. Figure **??** shows projections with t-SNE applied to the vote matrix X.

4.5 SGNS with t-SNE

We explore a two step process, where votes and MEPs are treated as co-occurrences—embedding votes and MEPs into a 200 dimensional space with Stochastic Gradient Descent with Negative Sampling[11] and then applying t-SNE to further reduce dimensionality down to 2 or 3 for visualisation. The two step process

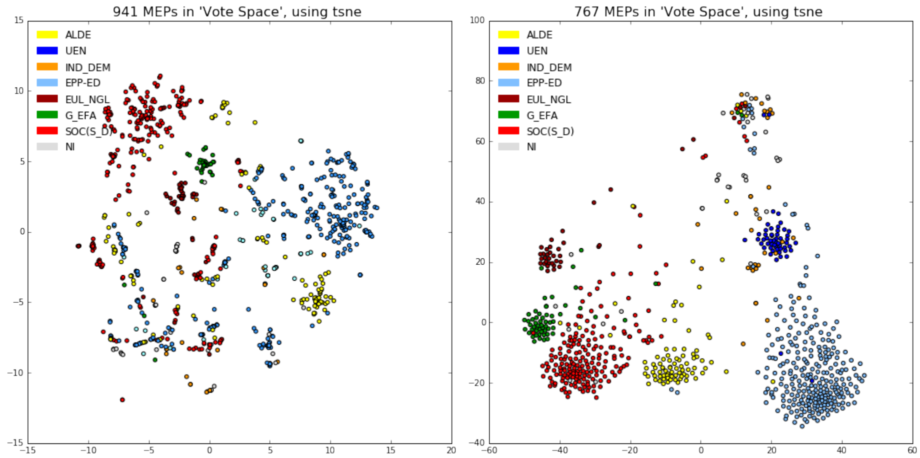

Fig. 5. t-SNE reduction for the 6th (left) and 7th (right) Parliaments.

tends to exaggerate distances between MEPs of the same group, however this method introduces more parameters and instability, making qualitative analysis difficult and prone to over interpretation—where visualisation artefacts can be interpreted as meaningful.

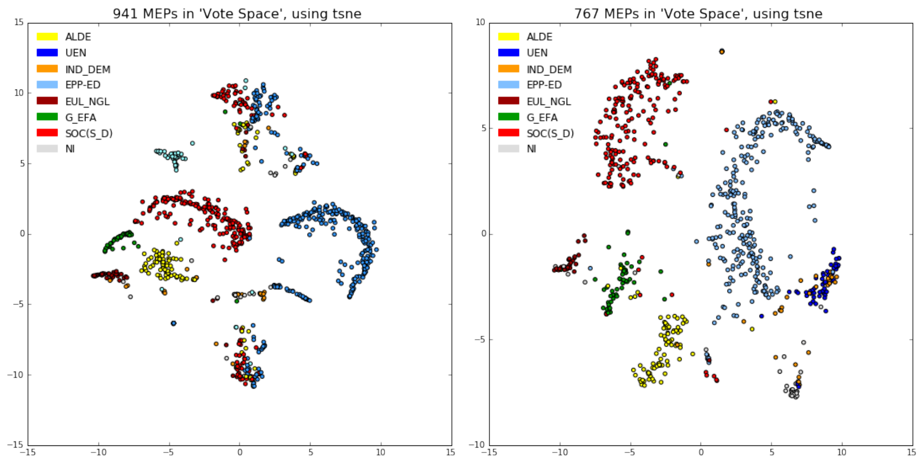

Fig. 6. t-SNE reduction for the 6th (left) and 7th (right) Parliaments.

In some cases, MEPs belonging to one group are considered more similar to another group, and are ostensibly misclassified. Closer inspection of the underlying voting records revealed the for

5 Conclusion

While the methods we explore do not out perform the well established and widely used NOMINATE approach using a cluster validation based evaluation, there are a number of useful recommendations we can make when using different methods: NNDSVD initialization strategy for NMF produces most stable results; PCA initialization for t-SNE can help with stability of results. Even so, there is still a risk of over interpreting the structure that t-SNE produces. Before drawing any conclusions from visualisations made with t-SNE, we recommend paying particular attention to the implementation and parameters, especially the learning rate used during optimization. The SGNS approach allows most flexibility with arbitrary contexts, but is the least stable method.

Many techniques are applicable if we treat roll call vote scaling as a dimensionality reduction problem. All methods that aim to project or embed high dimensional data in a low dimensional space introduce some uncertainty and instability. Uncertainty in point estimates can come from many sources: from data quality issues and encoding schemes, to parameter and initialization choices, to visualisation choices. Given these issues, one advantage that the alternative methods we explored have is their speed and efficiency: multiple runs under different settings can highlight errors in ideal point estimates more clearly.

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