Comparative Analysis of Legislative Complex Networks

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https://github.com/jowch/CSE-416-Final-Project

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Abstract

Given the complex nature of today's political climate, we were interested in analyzing and quantifying various legislative bodies in select first-world countries. To do so, we performed complex network analysis on seven North Amerian and European countries (Austria, Denmark, France, Sweden, Switerland, UK, and US) to understand how a wide variety political parties interacted amongst each other with respect to cosponsorship. We found and plotted summary statistics and centrality measures to make comparisons possible.

1 Introduction

In the United States, politics has increasingly become a point of conversation due to change in presidency and new, controversial bills being signed into law. Cosponsorship provides a rich network between legislators that can be used to explain the political effects and efficiency of legislative processes. We propose to analyze the networks of different legislative bodies in select North American and European countries to determine how legislators interact amongst each other to cosponsor bills. We aim to answer questions such as which countries' legislators are most connected, how legislative parties and other attributes play into cosponsorship data, and what that means in terms of government performance and productivity. To perform our research, we will use cosponsorship data from different countries followed by analysis and comparison of statistics and centrality measures.

According to a study conducted by James Folwer from the Department of Political Science at the University of California, Davis, there are several trends that have been observed among legislators. In the United States, biennial elections cause members of the U.S. House and Senate to change every two years, but the trends remain stable. Firstly, party affiliation and similar values and ideals often lead to increased possibility of cosponsorship. Second, average number of cosponsors per legislator reflects the degree that the individual is integrated into their political network [3]. Because these studies were performed solely within U.S. Congression, we propose to analyze legislators from different first-world countries to determine if these trends would be observed in other political environments as well.

2 Materials and Methods

2.1 Data Collection and Pre-Processing

We first obtained cosponsorship data for the countries: Austria, Denmark, France, Sweden, Switzerland, United Kingdom, and the United States. The European networks were produced by a French researcher's website [1]. The United Kingdom Parliament was scraped from Early Day Motions [6], a web portal listing bills discussed. The United States

Congress data was scraped using a public domain tool [7]. The raw data was parsed and saved as `graphml` files. The data is stored in `CSE-416-Final-Project/data/` and the preprocessing was performed in the `Analysis` file in the root directory within our repository.

2.2 Data Analysis

Our analysis was performed using a library called graph-tool, which provides Python bindings to powerful abstractions and parallel algorithms for processing graphs. In addition, we used `numpy`, `scipy`, `pandas`, `seaborn`, and `matplotlib` to perform the comparative analysis.

We wrote a summary function that returns a summary of graph statistics with a given graph. These statistics include: number of edges, number of vertices, average clustering coefficient, average degree, average excess degree, average path length, size of largest connected component, and number of connected components. We then wrote a script that produces a summary output in a csv file for every country for every year.

An important attribute of our generated networks that we needed to measure was assortativity. Each graph had various vertex properties to perform assortativity measures on, but we decided to use 'party' to determine whether governments cooporate on a partison or bipartison basis. We mapped each 'party' to a unique ID, and joined this party enumeration property map with the original vertex properties. We then produced graphs for every country across each year, with nodes colored based off their respective enumerated 'party' property map.

Betweenness, closeness, and eigenvector centrality measures were also performed on our data to identify influential legislators. The graphed vertices and edges were scaled and colored with respect to its corresponding centrality measure. Vertices and edges that are yellow and larger in size reflect greater importance, whilst those that are blue and smaller in size reflect lesser importance. For the generated betweenness graphs, the top 3 percent of legislators with the highest betweenness centralities were colored yellow and enlarged.

3 Results and Discussion

3.1 Country-level Results

We will now go through the summary results for each country observed. It is important to note that every country we collected data on had temporal data except for Denmark and the UK, which was due to the structure of the resource from which we obtained the data. However, we still produced the same summary statistics and produced graphs whenever possible.

For Austria, the number of vertices and edges did not fluctuate between the years, maintaining average values of 63.1 and 63.0, respectively. As expected from this result, average degree has also been relatively stable. Excess degree decreased dramatically from 1995 to 1999, dropping from 4.5 to 2, which is similar to the average degree. This happens to coincide with Austria joining the European Union in 1995. Although it is unclear whether there is a correlation between these two events, it can be noted that the drop in excess degree close to average degree means that the degree of individuals are roughly the same as their neighbors. This means that there was, on average, a sharp decrease in hub behavior to nearly none at all.

The France legislative bodies have had a steady increase of vertices, starting with less than 300 vertices in 1986 to 500 today. The number of edges peaked during 2002-2007 when it was 16,000. The average distance has not decreased by much, which is surprising given the amount of increase in vertices.

There exists few changes in Switzerland's graph statistics over the years observed. The country's clustering coefficient remains consistently around 0.5, its number of vertices around 130, and its number of edges around 1750. According to BBC, Switzerland's neutrality and political stability has allowed it to become one of

the world's wealthiest countries [5]. This knowledge helps explain why Switzerland's legislative data has barely changed over the last decade.

There is an interesting change in the number of cosponsorships across Swedish parties between the years 2014-2018. The number of vertices across years consistently hover around 350, whereas the number of edges dropped from 4000 in 1988-1991 to 2000 in 2014-2018. This result happens to coincide with an event during the 2014 Swedish general election, in which the Social Democrats declared that they would not work with the Swedish Democrats. This decrease in edges across parties is evidently seen when comparing the assortativity graphs from the years 1988-1991 and 2014-2018, seen in Figures 1 and 2

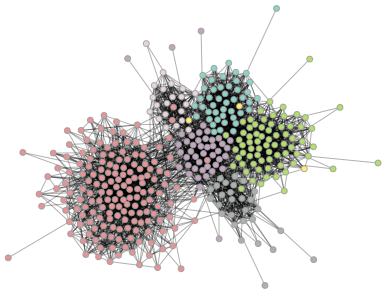


Figure 1. Sweden Assortativity 1988-1991

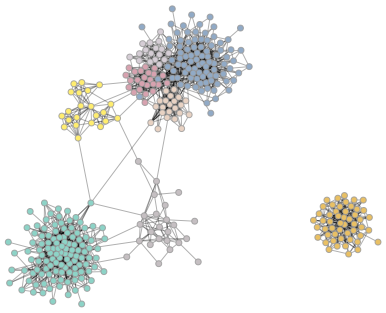


Figure 2. Sweden Assortativity 2014-2018

The US has an extremely consistent number of edges (around 100,000), vertices (a little over 500), clustering coefficient (almost 1.0), average degree (around 350), and average excess degree (roughly 400). This shows that although members change every 2 years, the legislators and their interactions are relatively stable. Most notably, the United States legislative bodies have highest completeness (67%; Figure 3) amongst the examined graphs, where completeness is the ratio between the number of edges in a graph and the number of edges in a complete graph with the same number of vertices.

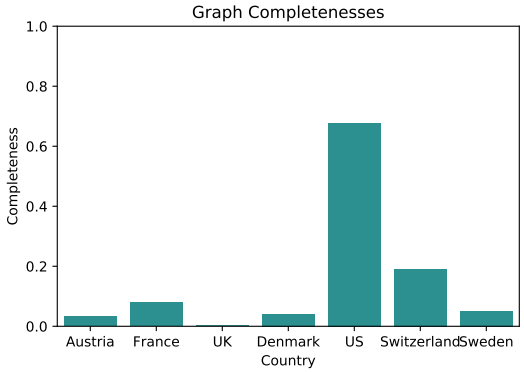


Figure 3. Graph Completeness

For the UK data, the average vertices is around 675, which is greater than the average number of edges (663). This means that generally, each node has slightly less than one edge. The average excess degree is greater than 200, which is more than 100 times the average degree. This can also be explained when observing a subset of the betweenness graph, as seen in Figure 4. The majority of the UK betweenness graph has a single node that is connected to many other nodes that only has one edge.

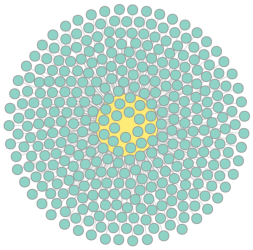


Figure 4. Subset of UK Betweenness Graph

In Denmark, there are two categories that have the highest number of vertices: Economy

and Justice. According to Forbes in December 2017, Denmark is known for its extremely efficient economy and equitable distribution of income. It is also currently undergoing an economic expansion. Denmark is rated #1 for least corruption [2]. Given this information, it is not surprising that Denmark would have the most legislators assigned to Economy and Justice.

3.2 Across-Country Results

We seek now to compare our results between countries. We see that, when comparing the number of edges and number of vertices, the UK has the largest number of vertices but the fewest number of edges, which means that the country has a very low average degree since there are many people with few connections when compared to that of other countries. This can be observed in Figure 5.

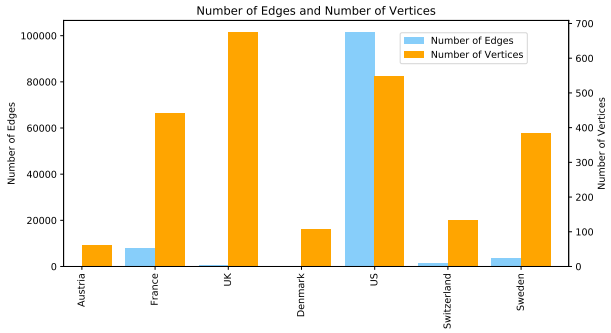


Figure 5. Number of Edges and Vertices

However, the UK has the second largest average excess degree, which means that although each legislator is not connected to many others, they are on average connected to other relatively important individuals. On the other hand, the US has an average degree that is much higher than that of other countries. This can be seen in the Figure 6

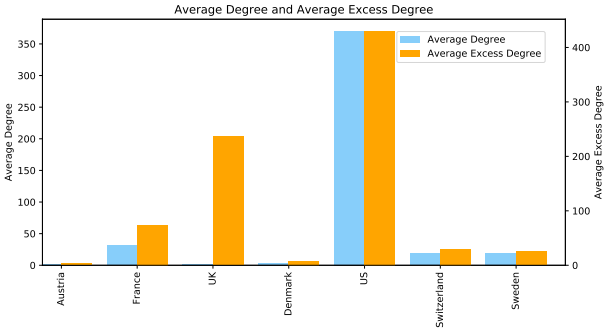
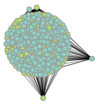


Figure 6. Average Degree and Excess Degree

We notice that the graph structure of the US - much like that of the UK - is separated into clumps. But unlike the UK, the US depicts an extreme partisonship structure in Figure 7.



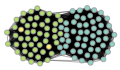


Figure 7. US Assortativity 115

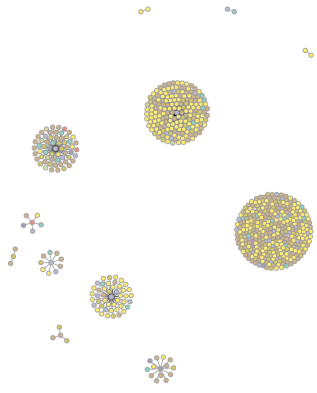


Figure 8. UK Assortativity

When compared to other countries, the US has a much larger average number of edges, and has the second smallest average distance. These

results are not surprising, since legislators in the US are highly connected, so the distances between any random two people in the same clumps are much less compared to that of other country. We also observe that the generated graphs reflect the underlying structure of governance. For example, from the France graph in Figure 9 we notice that the pink component has a single central actor, and one can thus make an educated guess that the cluster represents the French Socialist Party.

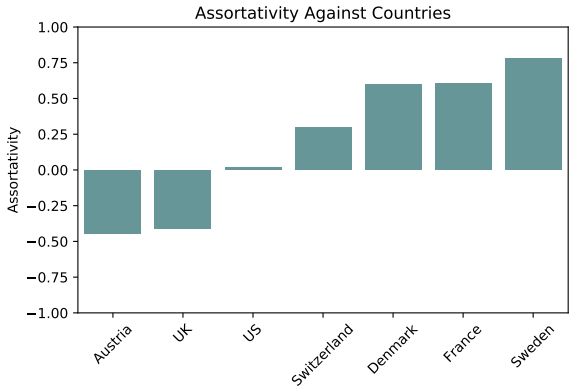


Figure 10. All-Country Assortativity Measures

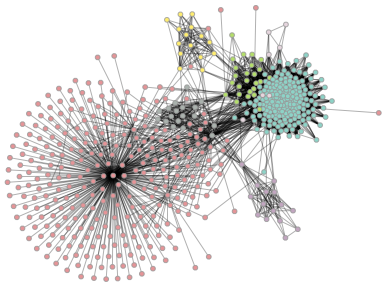


Figure 9. France Assortativity 2012-2017

We also expect that each country should exhibit power-law distributions, as there should exist hubs of legislative members with very high degree centralities. This turns out to be the case for smaller less densley connected graphs such as Sweden in Figure 11. However, this does not hold true for largely connected graphs such as the US, as seen in Figure 12. The US graph is almost a completely connected graph; Fully connected graphs have $n(n-1)/2$ edges. There are roughly 100,000 edges and 552 vertices in our US graph. In this case a complete graph would have 152,076, so the US is about 67% of a fully connected graph.

Assortativity measures can be seen in Figure 10. Assortativity values are most positive for Sweden (around 0.8) and most negative for Austria (around -0.45). Positive assortativity measures means that nodes tend to associate more with nodes with similar attributes, while negative assortativity means that nodes associate with nodes with different attributes. The US assortativity value is very close to 0, which indicates that there is no preference in either direction.

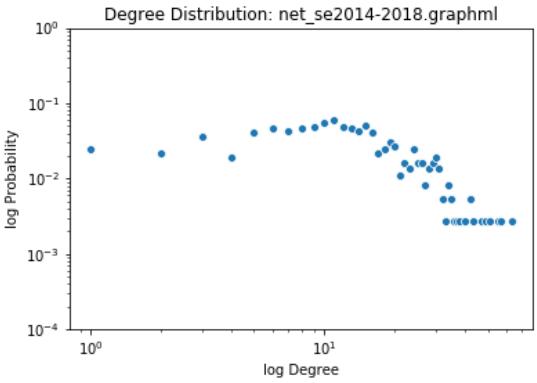


Figure 11. Sweden Degree Distribution 2014-2018

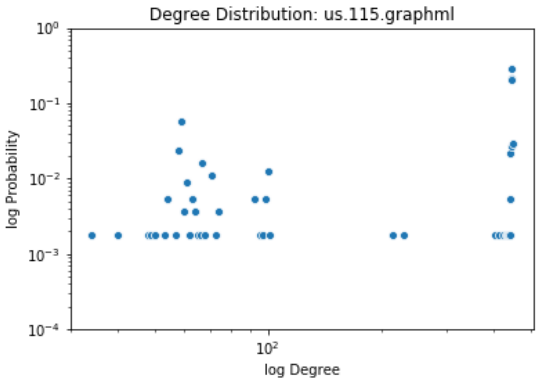


Figure 12. US Degree Distribution 115

4 Discussion

- Stability over time: US and France, something about democracy
- US - Has very consistent statistics. While the number of vertices do not change every two years during the turnaround, the number of edges do not necessarily need to be the same. However, the trend that the number of edges does not fluctuate widely across the years suggests that it is possible that the process that the legislators undergo is very stable and potentially inflexible. This is not innately a negative or positive trait of the United States legislative system
- France - steady increase in vertices but average distance does not change. This could imply that new members when they join the Parliament are joining existing neighborhoods rather than building new bridges. This could suggest that there is a strong party identity in France.

For our project, we use legislative cosponsorship networks across the US and selected European countries to try to infer social relationships in government that may influence legislative behavior. How well officials work together has a direct impact on the efficiency and productivity of government. The dynamic social relationships between legislators - of forging new relationships and maintaining older established relationships - matter. Moreover, our generated outputs hints at past and ongoing events that impact legislative cosponsorships. For example, the drop in number of cosponsorships across different parties in 2014-2018 in Sweden reflects the events that unfolded during the 2014 general elections. We have uncovered some intriguing results. First, we notice that the average distance tends to increase as the world gets smaller. One interpretation of this result is that members tend to be more isolated and fewer are willing to cooporate outside of their local network. As the world gets larger, the friendship circles that define and maintain social relationships grow. As communication between legislators improves, links become increasingly more interconnected, and the relative distance between any two given legislators decreases. This underlying phenomenom is reflected in the comparison of clustering coefficients across countries. For example, small countries like Austria or Denmark have low clustering coefficients of 0 and 0.2 respectively, whereas a large country like the US has a clustering coefficient of nearly 1. We also notice extreme partisanship in the US senate, which is expected given the party division and clashes between the Republicans and Democrats. The two components of the graph also represent the house and the senate. The house and the senate differ from an institutional design and have contrasting social structures, and so we would expect the behaviour in these two components to exhibit unique characteristics as well. Although we did not conduct any direct tests, the house and senate should differ in quantities such as clustering coefficient and average path length. Lastly, we examined the degree distributions of every graph, and expected that they follow power-law distributions. As it turns out, this does not hold true for large densley connected graphs.

References

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