

STOCHASTIC BLOCK MODELS FOR MODELLING POLITICAL ENGAGEMENT

by

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Abstract

This is my abstract.

Acknowledgments

Blah blah blah.

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Introduction

1.1 Background

The advent of social media has enabled political parties to engage with the broader populous in new and unforeseen ways. The ability to bypass the traditional mediating forces of mass media allows for an unfiltered promotion of policy, ideology and party stances. This is specifically interesting in Canada's political system which has historically been defined by large brokerage parties. In order to win a diverse range of electoral districts across Canada, these "big tent" parties try to appeal to various political persuasions. Political adverts, and policy have traditionally been the conduits through which brokerage parties attempt to accommodate different ideologies, but social media allows for a direct, granular approach to political messaging which is completely novel. Social networks, formed through new media like Twitter, are inherently relational and thus lend themselves well to being represented as graphs. Therefore, as political strategy becomes increasingly digital, the use of graph theory can potentially illustrate how large brokerage parties organize and along what axes Canadians engage with political parties.

1.2 Motivation

The way information is distributed and received has changed significantly over the past decade. Cogburn and Espinoza-Vasquez argue that Barack Obama’s 2008 presidential campaign was a watershed moment in social media campaigning – and in the subsequent decade, from Macron to Brexit to the Five Star Movement, social media has played an increasing role in how politics is conducted [3]. Between 2013 and 2018, the share of Canadian federal media expenditure spent on digital advertising rose from 27% to 65%, a 140% increase, making the study of new media critical from a social science perspective [1]. Additionally, rises in political polarization, populism and a decline in trust in political institutions in the 21st century has been a topic of popular debate. Ezra Klein argues in his 2019 book, *Why We’re Polarized*, that this due to a shift in preferences for parties over policies [6]. If this is the case, then this preference to engage along party lines rather than choosing to engage with specific issues should pattern engagement. An empirical analysis of how users behave and engage with political parties online should privilege the relational aspect of social media. Social network analysis helps avoid the pitfalls of survey data, famously described by Allen Barton as “a sociological meat grinder, tearing the individual from [their] social context” [4].

Graph theory’s use in social network analysis, also called network science, has already been applied to explore problems in marketing, sociology and epidemiology – but there is a gap in analysis of political engagement online. Therefore, the contribution of this thesis is a novel, robust mathematical process for analyzing different axes of political engagement online in a purely relational manner. A secondary outcome of making relationships a “first-class citizen” in this work will be an organic

analysis of what issues produce the most engagement. This deviates from traditional survey data that ask test subjects which issues concern them – and instead uses observations of past behaviour to model variations in local connectivity to answer the question: “what do people actually care about?” All of this will be done in the context of the 2019 Canadian federal election and the tweets of Canada’s five major, english speaking party leaders: Andrew Scheer, Elizabeth May, Jagmeet Singh, Justin Trudeau, and Maxime Bernier.

1.3 Research Question

The primary question concerning this project is: in the lead up to the 2019 Canadian federal election, did politically active users on Twitter engage with political elites along the axis of issues (also referred to as topics or policies) or parties? If Ezra Klein is correct, then *who* produces the message will pattern engagement more than *what* the message is; this will act as the initial null hypothesis, with the alternate hypothesis being that who produces the message is equally to or less important than what the message is.

The secondary question to be explored is: during this period, what topics produced the highest level of engagement? And, what topics were important to the broader populous versus a party leader’s base?

Social Media and Politics

2.1 Political Communication in the Digital Era

Technological innovation often precedes political disruption; Martin Luther's 95 theses could only be spread at scale by virtue of Gutenberg inventing his printing press first [5]. This example had obvious political ramifications and is a testament to the impact of the means of communication on the political sphere. McNair defines political communication as:

1. All forms of communication undertaken by politicians and other political actors for the purpose of achieving specific objectives.
2. Communication addressed to these actors by non-politicians such as voters and newspaper columnists.
3. Communication about these actors and their activities, as contained in news reports, editorials, and other forms of media discussion of politics. [7]

This is a broad, outward focused definition that includes most public, political discourse – verbal or otherwise. However, social media has changed all three aspects of this definition in novel ways. Most notably, the rate at which politicians can

communicate information to achieve “specific objectives” has increased as a result of rapid nature of social media, and the granularity at which actors can target the these messages has gotten smaller due to the massive swaths of user data available [10]. Therefore, the value of using computational methods to study political communication in the 21st century is a natural fit.

2.1.1 Technology’s Implications for Democratization

While fully exploring the impact of social media on democracy is out of the scope of this project, it is an important justification for why research in this area needs to be conducted. The traditional model of the media being a mediating force through their reporting, commentary and analysis is no longer valid. Previously, political actors needed to use the media to broadcast their messages to their desired audiences [7]. Social networking sites allow these same actors to reach audiences in the millions without having to gain access to the media first; in this effect, the second and third elements of McNair’s definition are also being transformed. Yascha Mounk argues that this has given voice to political outsiders who would be shut out from mainstream platforms. Thus, social media may not be inherently democratic or undemocratic, as it has contributed to democratic backsliding and overturning authoritarian governments, but it can certainly have a destabilizing affect [8]. Therefore, a better understanding of new media’s ramifications is critical, and empirical modeling can aide in this understanding.

2.2 Canadian Brokerage Politics

While it is clear that technology is changing how information is received, and thus must also be changing how politics is conducted, it may not be clear the role of Canadian politics in this research. However, Canada's political system is the perfect environment to test the importance of political messaging, because relative to most liberal democracies, the system is dominated by party politicians. As Carty put it:

No obvious simple geographic reality, no common linguistic or religious homogeneity, no common revolutionary experience or unique historical moment animated [Canada] or gave it life. Canada was created when a coalition of party politicians deemed it to be in their interest to do so, and it has been continuously grown, reshaped and defended by its politicians.
[2]

Thus, it is not surprising that Canada's electoral system encourages electoral pragmatism – and developed large, “big tent” parties that are among the most organizationally weak and decentralized of established democracies [2]. This system defines political parties as brokers of the often conflicting, weakly integrated electorate – as opposed to mobilizers of distinct communities, articulating claims rooted in their pre-existing interests. In this way, parties act as the principal instruments of national accommodation, rather than democratic division [2].

Rationale

The dominance of parties in Canadian politics, their amorphous ideological stances, and the many intersectional geographic, linguistic and religious cleavages have given

birth to what's been coined the brokerage party system. [2]. The need to capture pluralities in a diverse range of electoral districts gives Canada a unique set of dynamics - making it an interesting case to explore.

Modelling Unstructured Text Data

3.1 Background

Blah blah blah

3.2 Latent Dirichlet Allocation

Blah blah blah

Graph Theory and Computational Social Science

Graph theory is the study of mathematical structures, called graphs, which are used to model pairwise relations between entities. Graphs consist of a finite set of vertices, V , and a set of ordered pairs of vertices, E , called edges. A graph can be defined by the tuple, $G = (V, E)$. The graphs built in this project have added constraints and is defined as below:

- *Vertices:*
- The text in the entries may be of any length.

4.0.1 Spectral Graph Theory

An excerpt from an Alloy

Network Laplacian Spectral Descriptor

4.1 Random Graphs

Where the graphs at...

4.1.1 Background

4.1.2 Stochastic Block Models

Stochastic block models Statistical methods for block modeling have been proposed as stochastic block models. Here the positions are taken to be latent classes for the nodes, referred to as the colors of the nodes. The conditional distribution of dyads is assumed to be independent conditional on the node colorings and the goal is to determine the latent classes, and thereby to define the block model. This approach was first proposed by Holland, Laskey, and Leinhardt (1983) and further developed by Nowicki and Snijders (2001) who presented an algorithm for node classification. Airoldi, Blei, Feinberg, and Xing (2008) extended this approach to mixed membership models. [11]

4.2 Measures of Centrality

Centrality is a measure of prominence for vertices within a graph. For the purpose of this thesis, it will be used to measure the relative importance of different topics tweeted about in the lead up to Canada's 2019 federal election.

4.2.1 Background

There are various different ways of measuring vertex centrality that have successfully been applied to problems in marketing, economics and epidemiology; Stephenson and Zelen explored the utility of centrality measures in studying the social dynamics of Gelada baboons. [12]. Common centrality measures include measures of degree and

betweenness. This thesis will focus on the notion that central vertices are close to other central vertices, which is one of the founding intuitions behind Google’s “page-rank” algorithm and eigenvector centrality.

4.2.2 Eigenvector Centrality

As Newman lays out in his 2016, *Mathematics of Networks*: “the eigenvector centrality [...] accords each vertex a centrality that depends both on the number and the quality of its connections: having a large number of connections still counts for something, but a vertex with a smaller number of high-quality contacts may outrank one with a larger number of mediocre contacts.” [9]

If we define the eigencentality of vertex x as $C_E(x)$, where $C_E(x)$ is proportional to the average eigenvector centrality of x ’s neighbours, multiplied by some constant λ :

$$C_E(x) = \frac{1}{\lambda} \sum_{j=1}^n A_{xj} C_E(x) \quad (4.1)$$

By defining the vector of centralities as $C_E(X) = (C_E(x_1), C_E(x_2), \dots)$ this equation can be rewritten as $\lambda C_E(X) = \lambda A$, and it is evident that $CE(V)$ is an eigenvector of the adjacency matrix with eigenvalue, λ [9]. By Perron-Frobenius theorem, picking the largest eigenvalue of A will result in all elements of $C_E(X)$ being non-negative [9].

Thesis Contribution

Here we go This is the big one

5.1 Topic Modelling

Model topics?

5.1.1 Hyper-Parameter Tuning

5.1.2 Results

5.2 Topic Centrality

5.2.1 Total Network Topic Centrality

Define what it is, show the full graph again.

5.2.2 Party Leader Topic Centrality

Now, consider a fact stating that relation r is total, i.e.,

5.2.3 Results

...upper bound on Embee's performance:

$$\text{upper bound is } \begin{cases} O(bN^2) & \text{if } scope \leq 16 \\ O(bF) & \text{if } scope > 16 \end{cases}$$

5.3 Stochastic Block Models

Describe generic algorithm without specifying if its the party/topic model

5.3.1 Artificial Neural Network Adaptation

Stochastic Party Leader Block Model

The stochastic party leader model generates user behaviour only taking into account the previous party leaders each user had engaged with prior. For each user, when deciding which tweet they are to retweet, their retweet history is converted into a probability distribution (ex. *history* = [*JT* = 0, *AS* = 1, *JS* = 3, *EM* = 2, *MB* = 0] generates *probs* = [0.09, 0.19, *JS* = 0.36, *EM* = 0.27, *MB* = 0.09]). In this sense, it models a world in which politically engaged Twitter users only engage along the axis of party leaders, with a complete disregard for the topics tweeted about.

Stochastic Topic Block Model

Conversely, the stochastic topic block model models a world in which politically engaged Twitter users only engage along the axis of topics. Here, the topic history of a user is converted into a probability distribution, and with a probability of ϵ , that user will retweet the topic with the highest activation – regardless of which party leader tweeted it.

Stochastic Hybrid Block Model

The final model developed is a hybrid of the stochastic party leader block model, and the stochastic topic block model. Here, two history vectors for each user are captured – the n dimensional party leader history vector, and the k dimensional topic history vector. After each respective vector is converted into a probability distribution, the weight of a retweet of topic i by party leader j is determined by the function:

$$weight(partyleader = i, topic = j) = \alpha P(i) + (1 - \alpha)P(j) \quad (5.1)$$

Where $P(i)$ is index i of that user’s *party leader* probability distribution, $P(j)$ is index j of that user’s *topic* probability distribution, and α is some constant that determines the relative weighting of the two. As α approaches 1, the hybrid model becomes equivalent to the stochastic party leader block model – and as α approaches 0 the model approaches the stochastic topic block model. This model then generates different “worlds” in which users’ political engagement falls on the spectrum from only caring about *party leaders* to only caring about *topics*.

5.3.2 NetLSD for Describing Political Engagement

The final objective of comparing the relative importance of topics and party leaders in driving political engagement requires comparing the structure of target graph shown in ??, and various hybrid models generated with different values of α . Using the Network Laplacian Spectral Descriptor described in section 4.0.1 by Tsitsulin et al. the optimal alpha value can be determined in a scale-adaptive, size-invariant, and permutation-invariant manner [13].

5.3.3 Results

Summary and Conclusions

6.1 Summary

6.2 Other Work

As dictated by the Queen's School of Computing, 25% of the evaluation for CISC 500 is left to be arranged between the student and their supervisor. Given the nature of this research, lab work or developing software appeared out of scope. I believe that one of the benefits of applied research is its ability to take abstract concepts and frameworks and show their utility in solving complicated problems. This took the form of performing a lecture on the project's research and the application of graphs in Dr. Robin Dawes' CISC 235: Data Structures course.

6.2.1 International Network for Social Network Analysis

The findings and methodologies proposed in this thesis will be presented at the International Network for Social Network Analysis' annual Sunbelt conference in Paris, France.

6.3 Future Work

* better ANNs * different contexts (UK, US, Chile, France) * more variables? * more efficient way of fitting the model

6.4 Conclusion

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