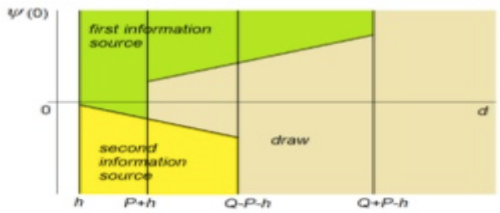

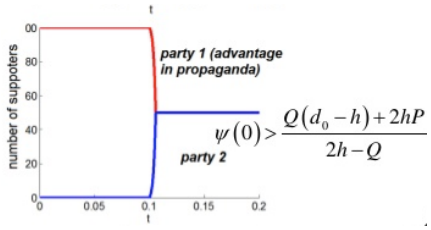

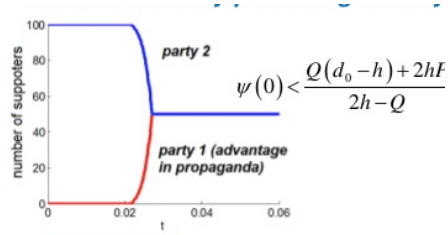

The Effect of Social Polarization on the Outcome of Information Battles

MATH MODELING MIDTERM REPORT

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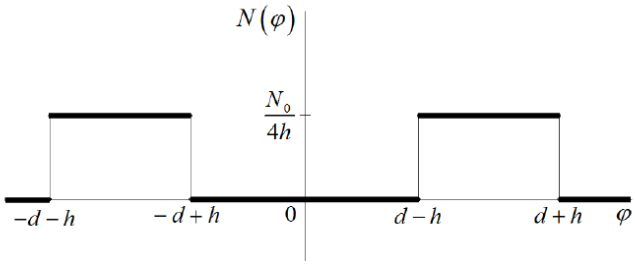
1. Abstract

With the development of the media and internet, the influence of the polarization on the outcome of the propaganda battles attracts more attention in all kinds of fields. This region draws in professionals and scientists from an assortment of fields, such as theory, social and political science, brain research. It likewise draws in IT analysts and mathematicians who create and examine models of purposeful publicity information wars. In this paper, we apply the numerical model of settling on decisions by people to the issue of how the degree of social polarization influences the result of the publicity information fight. We base on the Rashevsky's neurological scheme by focusing on position of individual in the confrontation. By finding out the equilibriums of the model and analyzing how this dynamic system behaves as time goes by based on different cases, we could get the final outcomes for the information battle. All the results come out should help people to prepare the information battle in different situations.

2. Introduction

Before starting to analyze the impact of polarization on the propaganda warfare, here are two necessary concepts need to be introduced. Firstly, "Propaganda wars", which means every individual from the general public is liable to two competing flows of propaganda warfare. These two flows are produced by two competing parties and each stream comprises of purposeful publicity, and there are two ways for each party to run propaganda wars. One way is media. People can get information by means of the media; the other ways is that people get data from media and transmit it further through interpersonal correspondences with different people. The sort of society is considered which contains two parties with oppositely inverse central demeanors. The scientific model has been researched logically and numerically.

Secondly, "A polarized society". Because the social media and internet develop rapidly, the issue of increasing polarization plays a vital role in the outcome of the propaganda battle. The impact of the polarization on political events causes widely concerns. During the detailed analysis of mathematical formalization process, we apply the concept "a polarized society" to present the main idea about the result of the propaganda warfare. "Polarized society" is depicted utilizing a dissemination bend with two high even levels. The separation between the gravity center is taken as a measure of polarization. Therefore, the way towards expanding polarization has the type of a common expulsion of the level from each other. Here is a simple graphic form of polarized society,



Graph #1

- d: Degree of polarization of society (How groups are distant from each other in attitudes)
- $\frac{1}{h}$: Measure of consolidation of individuals within each group

3. Model

In this paper, in order to figure out that how does the level of political polarization affect the result of the propaganda battle, we build up an approach that is centered around an alternate part of information fighting – that is, picking the position of the people in the confrontation. It depends on the Rashevsky's neurological scheme, which portrays the formation of the reaction of a person in response to the approaching stimulus, considering his attitude. With respect to the subject of purposeful publicity fighting between the two parties, the reaction is the position of the individual, i.e. his interest in the displacement of information in support of the particular party. The stimulus is the information that he gets both through interpersonal communication as well as the media. The model of the people in the propaganda battle in the society has the following assumptions:

- The society is a struggle between two parties X and Y
- Each party has its own media
- An individual belonging to this society has a position on the issue in question at any time

By referring the base model and the necessary assumptions, we could analyze the position of the individual. Here are two important factors which affect individual's reaction towards the propaganda battle:

- Permanent attitude $\boldsymbol{\varphi}$
- Dynamic component $\boldsymbol{\psi(t)}$

Attitude $\boldsymbol{\varphi}$ is a fundamental tendency to support one party or another, which is individual for every individual from the general public. It is shaped by the past social experience of an individual and mulls over social circumstance. Additionally, it is thought to be unaltered for this confrontation. Dynamic segment $\boldsymbol{\psi(t)}$ has a significantly controlled by the social condition of the shift towards the support of party X, which portrays the data field of society as a whole. It is influenced by the purposeful publicity of the two parties through the media and interpersonal communication, i.e., information shared by different individuals from the general public through relational correspondence.

Until now, we know that the position of the individual is: $\boldsymbol{\varphi + \psi(t)}$. If the result is positive, then the individual manifest position is to support party X. On the other side, the negative outcome of the position means the person is the supporter of the party Y. Introduce the new donate $N(\boldsymbol{\varphi})$ to describe the distribution of individuals. The number of the supporters who stand by their respective parties are given by:

$$\boldsymbol{X}(t) = \int_{-\boldsymbol{\psi}(\boldsymbol{t})}^{\infty} N(\boldsymbol{\varphi}) d\,\boldsymbol{\varphi} \qquad \textbf{(1)}$$

$$\boldsymbol{Y}(t) = \int_{-\infty}^{-\boldsymbol{\psi}(\boldsymbol{t})} N(\boldsymbol{\varphi}) d\,\boldsymbol{\varphi} \qquad \textbf{(2)}$$

total number is given by: $\int_{-\infty}^{\infty} N(\boldsymbol{\varphi}) d\,\boldsymbol{\varphi} = N_0$

As observed, we are supposed to get the $\boldsymbol{\psi(t)}$ to find the total number of the supporters standing for the particular party. Roughly, the $\boldsymbol{\psi(t)}$ can be portrayed as follows. Assume some time or another the individual got stimulus from three supporters of gathering X and a supporter of party Y, read one daily paper article for party X and two for the party Y. Having measured these stimuli in a specific way, we get a change of his position for a specific party (the weighting factors are set in this model exogenously). For instance, considering his attitude, he could turn out to be progressively or less radical supporter of his own party or change to the opposite side. The model has the form:

$$\frac{d\boldsymbol{\psi}}{\boldsymbol{dt}} = \boldsymbol{A\alpha}\left[\boldsymbol{C}(2\int_{-\boldsymbol{\psi}(\boldsymbol{t})}^{\infty} \boldsymbol{N}(\boldsymbol{\varphi})\boldsymbol{d\varphi} - \boldsymbol{N_0}) + \boldsymbol{b_1} - \boldsymbol{b_2}\right] - \boldsymbol{a\psi} \qquad \textbf{(3)}$$

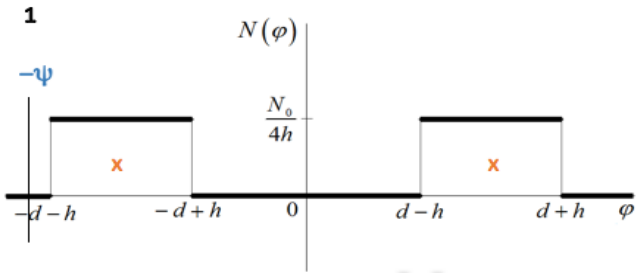
With the initial situation: $\boldsymbol{X}(\mathbf{0}) = \int_{-\boldsymbol{\psi}(\mathbf{0})}^{\infty} \boldsymbol{N}(\boldsymbol{\varphi})\boldsymbol{d}\,\boldsymbol{\varphi}$

The parameters $\boldsymbol{b_1} and\ \boldsymbol{b_2}$ portray the intensity of the media of the particular party. In this case, it is assumed that $\boldsymbol{b_1} > \boldsymbol{b_2}$. The positive constants $\boldsymbol{\alpha}$, **a, A, C** are presented in the neurological model, which gives neurological sense to these parameters. We can likewise propose some sociological elucidation. Therefore, the parameter **a** portrays the decay rate of the dynamic term of the inward position of a person. In this way, the interior position of every person is endeavoring to the position without propaganda fighting. This parameter is the rate of this "relaxation". The steady **C** describes the significance of relational correspondence contrasted with propaganda. Finally, the constant $\boldsymbol{A\alpha}$ depicts the general susceptibility of people to stimuli, showing how much does individual get affected by the stimulus of the propaganda warfare.

4. Analysis of Model

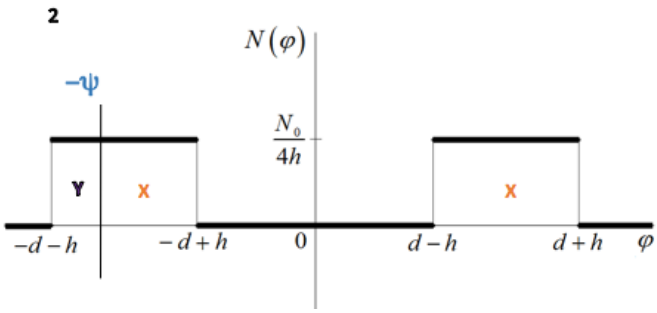
Now, it is very important to find out the equilibriums in this system. This is because equilibriums can represent how the whole dynamic system would behave under different cases. Since the distribution of individual attitude in this propaganda battle is already known, a notation ψ which means the shift of stimuli towards the support of the party X is introduced to analyze the model. As mentioned before, the range of the number of people who support the

party X is from $-\psi(t)$ to ∞ and the range of the number of people who support the party Y is from $-\infty$ to $-\psi(t)$. Thus, on the right side of the line $-\psi(t)$ represents the distribution of people who support party X; on the left side of the line $-\psi(t)$ represents the distribution of people who support party Y. Then, different cases of this model are analyzed separately.



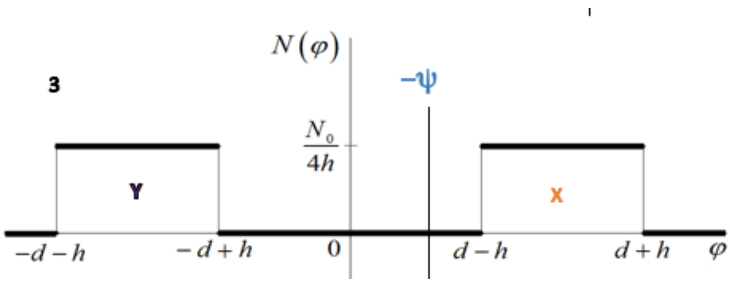
Graph #2

According to graph #2, $-\psi(t)$ is on the most left of the whole graph which is far beyond $-d-h$. Based on the content mentioned before, the right side of $-\psi(t)$ means the distribution of people who support party X and the left side of $-\psi(t)$ means the distribution of people who support party Y. Obviously, all the people in this model support party X. In other word, nobody in this model support party Y and party X wins the battle completely.



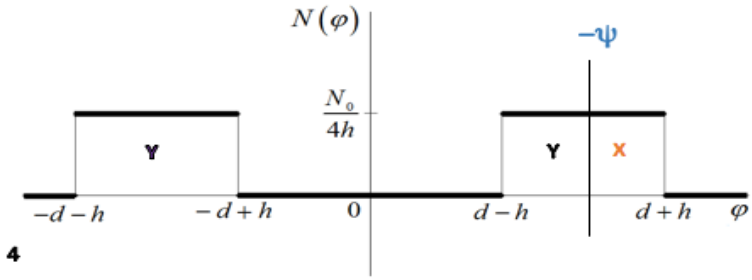
Graph #3

In graph #3, $-\psi(t)$ is between $-d-h$ and $-d+h$ which means there is still some people support party Y. On the other hand, most of the people still support party X. Thus, X wins the battle incompletely.



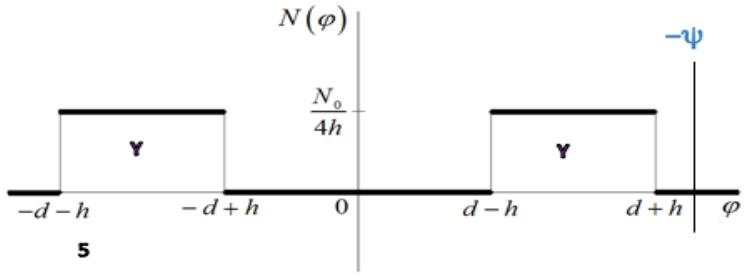
Graph #4

In graph #4, $-\psi(t)$ is between $-d+h$ and $d-h$ which does not influence the distribution of people who support party X and who support party Y. As a result, half of the people in the population support the party X and another half of the people support the party Y. The outcome of this battle will depend on other factors.



Graph #5

In graph #5, $-\psi(t)$ is between $d-h$ and $d+h$. From the graph, it is very clear that most of the people support the party Y and a small proportion of the people support the party X. Thus, the party Y wins the battle incompletely.



Graph #6

In the last graph #6, $-\psi(t)$ is on the most right of the graph which is far beyond the $d+h$. Thus, the party Y wins the battle completely. These are the five different cases in this model.

The form of the model is,

$$\frac{d\psi}{dt} = A\alpha\left[C(2\int_{-\psi(t)}^{\infty} N(\varphi)d\varphi - N_0) + b_1 - b_2\right] - a\psi \qquad (2)$$

In order to find out the equilibriums numerically, the left side of the equation is assumed as 0. Then we introduce the notation,

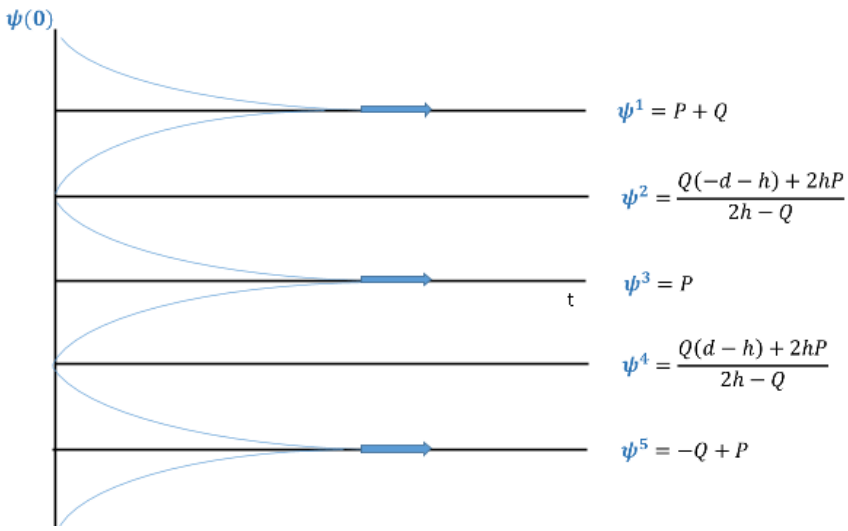
$$P = A\alpha(b_1 - b_2)/a \qquad (4) \qquad\qquad Q = A\alpha C N_0/a \qquad (5)$$

For P, we will need $2\int_{-\psi(t)}^{\infty} N(\varphi)d\varphi - N_0 = 0$ which means half of the people support the party X and half of the people support the party Y. Then, we move $a\psi$ to the right side of the equation to get the equilibrium $\psi^3 = P$. Based on the previous five different cases we

discussed, the first equilibrium represents the party X wins the battle completely which means all the people support the party X. Thus $2\int_{-\psi(t)}^{\infty} N(\varphi)d\varphi = 2N_0$. When we add P and Q together, we will get the corresponding result based on this case. Thus, $\psi^1 = P + Q$ which is the first equilibrium.

For case 5, the party Y wins the battle completely, we have $2\int_{-\psi(t)}^{\infty} N(\varphi)d\varphi = 0$. The result will be $\psi^5 = \frac{A\alpha(b_1-b_2-CN_0)}{a}$ which is exactly the answer when we use P subtract Q. Thus $\psi^5 = P - Q$. For case 2 and case 4 which is X wins the battle incompletely and Y wins the battle incompletely, we will use the knowledge from Calculus. In order to find out X(t) which means how many people support the party X in case 2 and case 4, we should calculate the area on the right side of the line $-\psi(t)$. Since we know $\int_{-\psi(t)}^{\infty} N(\varphi)d\varphi$ means the number of supporters of the party X, so, we plug X(t) into the equation **(3)** to get the second equilibrium and the fourth equilibrium where $\psi^2 = \frac{Q(-d-h)+2hP}{2h-Q}$ and $\psi^4 = \frac{Q(d-h)+2hP}{2h-Q}$.

After we find all the equilibrium points, the next step is getting a conclusion from those points to help us get a conclusion which part will win. When we are solving the equations for equilibrium points, we can also get the convergence for those points. And we get ψ^1, ψ^3, ψ^5 are converge and ψ^2, ψ^4 are diverge, which give us the graph # 7. In this case, ψ^1 means X totally wins, ψ^2 means X partial wins, ψ^3 means draw, ψ^4 means Y partial wins and ψ^5 means Y totally wins.



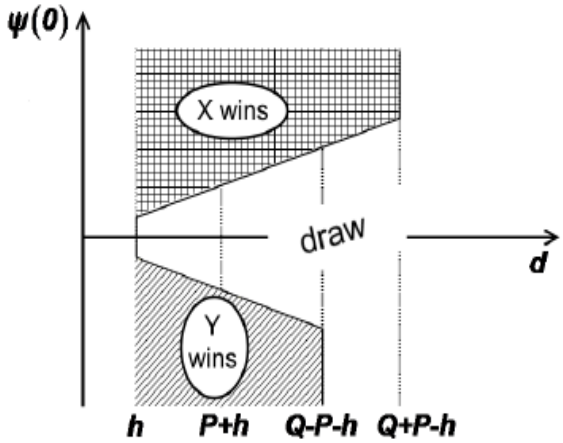
Graph #7

The horizontal axis means time, and the vertical axis means the value for $\psi(0)$. So, what we can get from this graph? As we start from a point $\psi(0)$, we will follow the tendency for each area. If, $\psi(0)$ is above ψ^1, then it will converge to ψ^1 as time goes by which means X will totally win. For $\psi(0)$ between ψ^1 and ψ^2, it will still go to ψ^1 as time goes by and it means X

will totally win. For $\psi(0)$ between ψ^2 and ψ^4, it will go to ψ^3 which means draw. For $\psi(0)$ below ψ^4, it will go to ψ^5, which means Y will totally win.

5. Conclusions and Future Perspectives

The graph #7 gives us an idea how we will get a final answer for which party will win. However, this is from a sociological; interpretation for the results which only shows only X wins, Y wins or draw. From statistical point of view, we are trying to get the percentage of chance to win for each case. In order to show the result more directly, we will get a graph for the percentage of chance to win for each part, graph #8.



Graph #8

The way to get the percentage of chance to win for each part from this graph is setting up a constant value d which is the horizontal axis. After decide d, we will measure the length for each part in vertically, the length for each part will standard for the percentage of chance to win. There are four different cases we can get from this part:

- Case 1 ($\boldsymbol{h < d < Q - P - h}$): X and Y have the same percentages of chance to win, but it also could be draw which is a small part.
- Case 2 ($\boldsymbol{Q - P - h < d < Q + P - h}$): Y will lose all the chance to win. The result will either be X win or draw.
- Case 3 ($\boldsymbol{Q + P - h < d}$): The final result will only be draw.
- Case 4 ($\boldsymbol{d < h}$): Overlaps

For case 1, if everything for both party is same, then the chance for them to win will be the same, but it will also could be possible to become draw. For case 3, if we are assuming that the distance between two party is really far away, then it will be really hard for people to change their side. Since the supporters for two parties are the same at beginning, then it will always become draw for the final answer. For case 4, we can think about this case as for the same thing and same reason, people will choose different sides as their final decision which will be really hard to collect the final result. So, why there is a part which Y lose all the chance to win which

is case 2? The reason is when we first assuming the media support for both part, we assume that the media support for party X is larger then party Y, so it will more likely that X will win in case 3.

What we did so far are really basic things for this model, we will try to set up different values for each variable in the model and the equation. So, we can get the idea about what the final results will be in various initial conditions, which means we may need some coding in this part. Those are also the most challenge parts we have now. For example, what the final result will be if we set up the initial conditions that all the people support the party X when all the media support party Y? How will the number of supporters for both party change as time goes by? How long will it take for people to choose which party they choose? Also, which party will win at last? The final answer we get in this case will totally different from the result we get so far. Also, the initial values we assume now are all constants, what will happen if we get linear functions for those values? So, we should consider more things about those. There must be different results coming out after we finish doing all of those things.

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