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CONSTRAINED OPINION LEADER INFLUENCE IN AN ELECTORAL CAMPAIGN SEASON: REVISITING THE TWO-STEP FLOW THEORY WITH MULTI-AGENT SIMULATION

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The conventional wisdom derived from the two-step flow theory suggests that opinion leaders have great influence on their followers. However, it has been difficult for social scientists to measure and describe the extent to which political opinion leaders influence voters, especially when voters today access multiple information sources like communication networks and self-selected news media. This paper fills this gap by using agent-based modeling to represent what the two-step flow theory describes about opinion leader influence and refines the theory based on the findings. First, opinion leader influence does not diffuse to the public without homogeneous communication networks. Second, opinion leader influence usually does not diffuse widely to the public because it inevitably faces resistance from self-strengthening communication networks.

Keywords: Opinion leader influence; two-step flow theory; communication networks; media influence; agent-based modeling.

1. Introduction

Half a century ago, Paul F. Lazarsfeld and his colleagues provided a two-step flow theory of communication to explain how voters make up their minds during an election campaign season. Based on the data collected during the campaign season of the 1940 presidential election, this classic theory suggests that influence about vote choice flows from the news media to opinion leaders (the first step) and then from opinion leaders to the public (the second step) [17]. In 1955, Elihu Katz and Lazarsfeld studied more empirical cases on four aspects of the public's daily life: marketing, fashion, movie-going, and public affairs [15]. Their findings confirm the theory and highlight interpersonal networks of communication. Their work afterwards gained great attention from business and academia. In business, marketing professions started to pay greater attention to the need of opinion leaders. They commonly expect that opinion leaders in fashion who accept an image of a product

will persuade or influence their peers to purchase the same product. Ultimately, the market share will increase (see, for example, Ref. 27). In academia, a number of scholars in the social sciences, such as political science, sociology, and communication studies, have built on the idea of the two-step flow of communication and developed new research topics and concepts like the diffusion of innovation and the survival of disagreement (see, for example, Refs. 13 and 24). Although this theory has not been rigorously updated since its publication, the idea it suggests is still inspiring. This theory sees a society itself as a complex adaptive system of communication; within this system, citizens form their preferences about voting through continuous interactions with other people and the news media (see Ref. 16, p. xxii).

The goal of this paper is to apply multi-agent simulation or agent-based modeling (ABM) on the basis of the assumptions posited by Katz and Lazarsfeld to explore the extent to which opinion leaders influence voter preferences at the aggregated level. Opinion leaders in this paper refer to political experts, people in whom one has confidence and whose opinions about the campaign are held in high regard during the course of an election campaign. It is important to narrow the focus from opinion leaders in a general sense to political experts, because people who are influential in one field like public affairs are not likely to be opinion leaders in other fields, such as marketing and movies. Moreover, factors determining opinion leaders of one field usually differ from those in other fields. Social economic status, for example, is an important determinant of influence in pubic affairs, but not in fashion and marketing [15]. Therefore, it is important to see if the two-step flow theory applies to opinion leaders in voter preference as well as opinion leaders in fashion and marketing.

ABM has been increasingly widely used in the social sciences [14]. The advantage of using ABM to study opinion leader influence is that it facilitates the observations of the dynamics of communication between multiple actors — ordinary or non-elite citizens, opinion leaders, and the news media — over time, while the conventional method of survey data analysis falls short. As Katz reflects on the development of the theory over the past decades,

> "By now, we *know* that the media have only limited effects, as far as short-run persuasion is concerned. Even (well-hidden) advertising research will confirm this. We know, since Plato, that personal influence is persuasive. We also have learned that there is little use in asking which medium is more important because each may serve different functions — at different times — both in decision-making and in diffusion. The question to ask [today] is how do mass media and interpersonal influence interact at the individual level of decision-making and at the collective level of diffusion." (Ref. 16, p. xxiv)

The goal of the simulation of this paper is to represent Katz and Lazarsfeld's two-step flow theory with ABM and to find patterns that they did not identify. Are locally influential opinion leaders also influential nationally? What is the extent to

which opinion leaders influence the public as a whole, given that today's media environment is different from four decades ago (e.g. the prevalence of television and the growing use of the Internet)? What are the conditions in which opinion leaders are influential? This paper will show the patterns about constrained opinion leader influence on aggregated voter preferences during a campaign season and will discuss why it is the case. This attempt to combine theory and ABM turns out to refine the theory.

The next section will overview the two-step flow theory and its critiques. The focus of this section is on drawing correct assumptions from the theory and incorporating them into the model design. In the section on model design, attention is paid to (i) the difference between the two types of voters — opinion leaders and ordinary voters — and (ii) how agents process political information, including accessing the news media. This section will serve to provide internal validity of the model design. The fourth section will describe how the series of experiments were done, while the fifth section will report simulation results. The last section will discuss the findings and provide suggestions for future research.

2. The Theory and Critiques

The two-step flow theory of communication is basically a theory about opinion leaders and how opinion leaders influence the society. It describes how opinion leaders are influential more than it predicts the extent to which they are influential. According to the theory, opinion leaders tend to be more highly exposed to the news media content associated with their leadership than are non-leaders and are more likely to access national level news sources. They have higher social-economic status and more social contacts (friends and organizations, etc.). "Presumably this increased exposure [to the news media] then becomes a component — witting or unwitting — of the influence which such influentials transmit to others. As a result of these findings [about opinion leadership and exposure to the news media], the idea of the "two-step flow of communication" gains credence" (Ref. 16, p. 316).

Later empirical findings confirm these characteristics of political opinion leaders. For example, opinion leaders have a "large storage of political lore" and will be more stable in their vote preferences than ordinary voters. Because of their interest in political issues, they process political information more efficiently than general voters; these pieces of accumulated information in turn mobilize themselves to obtain more political information, or at least to maintain the level of interest [3, 4]. Consequently, they are more likely to be biased, partisan, and selective in consuming news messages [20] and polarized in political issues than ordinal voters [7].

The idea the theory conveys is clear: because opinion leaders are interested in public affairs and better informed than non-leaders, they are the primary source of influence over the public. The major problem with this theory, however, remains unresolved over decades: it originally does not explain enough. It omits at least

five things. First, opinion leaders are not news stations. They also discuss politics and are influenced by their fellows. Second, this theory does not detail how opinion leaders differ from ordinary citizens; it is likely that they are similar in their exposure to relevant media content and in their information level on national news (see, for example, Refs. 22 and 26). Third, the theory neglects the fact that opinion leaders are not always active information seekers. Opinion leaders can be passive information receivers [23]. Hence, their influence should be conditional. The extent to which they frame their followers depends on whether or not the issue discussed is controversial [5]. Fourth, major news stories are spread directly by the news media to a greater extent than by personal sources. It is questionable that citizens completely trust opinion leaders and completely distrust news media [28]. Fifth, information flow is not necessarily two-step. The multiple-step flow model suggests that a piece of political information may pass through several political experts before a voter receives it [9]. All these critiques imply that the idea of two-step flow is over-simplified and that it omits the role of individual differences regarding information processing and media use.

The two-step flow theory, in the face of such challenges, has evolved gradually into a multistage flow model that is often used in diffusion research (i.e. the study of the social process of how innovations such as new ideas, practices, objects, etc., become known and are spread throughout a social system). The studies of the diffusion of innovation discuss, for example, the characteristics of innovations that affect the rate of adoption, the stages of innovation decision process, and the types of adopters. The general characteristics of opinion leaders that this framework describes are consistent with those in the two-step flow theory: opinion leaders (i) are more exposed to all forms of external communication and thus are somewhat more cosmopolitan, (ii) have somewhat higher socioeconomic status, (iii) are more innovative (although their degree of innovativeness depends, in part, on the system's norms), and (iv) are at the center of interpersonal communication networks [24]. This framework of innovation diffusion, however, still does not provide answers to the questions about whether or not opinion leaders influence the electorate. It is questionable that voter preference diffuses in the same fashion as new ideas or a new technology.

The above overview suggests two points. First, an agent-based model of opinion leader influence will require the operationalization and specification of the assumptions derived from the two-step flow theory. Second, the model will need other assumptions about how individuals process information. As shown in the next section, we employ the following theories and empirical findings to the model design described in the next section. First, John Zaller's Receive-Accept-Sample (RAS) model of information processing [30] suggests that people form opinions through subjective selection and by averaging past impressions stored in memory. Second, people like to talk to like-minded peers (i.e. with a similar partisan orientation) [6]. Third, when a news event occurs, individuals like to access the media for information

before discussing it with other people [19].[a] Fourth, people are more likely to discuss politics with those with greater political expertise [1, 12, 19, 21, 25, 29] and are more likely to be influenced by those who they judge as political experts or trustworthy sources of political information [2, 11, 18]. Fifth, the uses and gratifications theory suggests that individuals tend to selectively perceive information from the news media to satisfy their needs [20]. Last, the theory of autoregressive influence [13] suggests that a voter will change her voter preference when she perceives that the majority of voter preferences across all other individuals within the self-selected network opposes her preference.

Building an internally valid model (one with reasonable assumptions and behavioral rules) will pave the way to a reasonable interpretation of simulation results. If the model is constructed following the assumptions of the theory, it should not be a surprise to see a pattern representing what the theory describes: opinion leaders are the centers of their communication networks and influence those connecting to them.

3. Model Construction

The two-step flow theory sees a society as a complex system of communication. "Together with the concept of 'selectivity' in exposure, perception, and recall of media messages, the 'two step' hypothesis points to a shift in the balance of power between media and audience, at least as far as short-run persuasion is concerned." (Ref. 16, p. xv). But, it does not specify how these mechanisms function simultaneously and interactively. This section will describe how I operationalized these concepts and incorporate them in a multi-agent model. The toolkit for this model construction and simulation is Swarm (www.swarm.org).

The multi-agent model includes two kinds of objects: citizens and the news media. Citizen agents refer to voters that make decisions following a given rule of information processing. Citizen agents have two classes: opinion leaders and ordinary voters. In the model construction, these two classes are similar in their procedures for obtaining information and choosing partners for political discussion, but they are different from each other in five respect: the level of political expertise or political knowledge; and the propensities to access the news media, to discuss politics, to perform selective perception about campaign news, and to memorize past impressions about the candidate.

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[a]We assume that an agent's probability of accessing the media is independent of the probability of discussing politics, because there is not yet a conclusion about relationship between these two variables. Some scholars suggest a negative relationship. They think that individuals having weak party identification, a higher education level, or feeling comfortable discussing politics with other people are less likely to access news media (see, for example, Ref. 19). The others suggest a positive relationship: talking to like-minded people is associated with perceiving media bias (see, for example, Ref. 6).

A news media object is defined as any source of information other than dyadic interpersonal discussion. First, it hosts and broadcasts a consistent voter preference, either "YES" (1) or "NO" (0). Second, every citizen agent can access this type of information at any time. There are two media objects in the model that every citizens can access according their partisan preference: one consistently broadcast piece of information favoring "YES" and the other "NO."

It is important to note that the news media objects, although labeled "the news media" here, are not simply two TV stations or channels. They can be a TV channel, a newspaper, a radio program, a magazine, a news website on the Internet, or even a town hall meeting. Because the attention is put on what an individual agent actually receives — "YES" or "NO" about a candidate — every time it accesses a news media object, and because the second nature of the news media object, there is no need to create objects corresponding to every specific type of information sources. The following two subsections will further specify the commonalities of the two types of agents and their differences.

3.1. *Citizen agents*

Figure 1 shows how citizen agents form opinions. Citizen agents are concerned with one issue. The two values 1 and 0 represent "YES" and "NO" on a ballot or a choice between Bush and Kerry in the 2004 American presidential election. Every citizen agent has a party identification (1 or 0), a voter preference (a hidden discrete variable of either 1 or 0), an opinion (an observable continuous variable with values varying between 0.00 and 1.00; this indicates preference strength), a self-selected mass medium (one that broadcasts a voter preference consistent with the citizen agent's party identification), and eight members of political communication.

A citizen agent's current opinion is an average of voter preferences perceived from other agents in a communication network and the media. As the model runs, citizen agents perform different degrees of selective perception about media information (i.e. interpreting and reinterpreting information received from the news media to be consistent with existing voter preference), summarize recent impressions obtained from members of communication networks and from the news media, and then evaluate whether or not to convert current voter preference into that held by the perceived majority.

The system will randomly assign the eight members before a simulation starts. A communication network is composed of nine agents shown on a 3×3 grid. Citizen agents sort the given network members by, first, the degree of political expertise and, second, like-mindedness (i.e. whether or not they have the same party identification). Hence, the top of a citizen agent's list of political discussion partners will be those whose political expertise is higher than the citizen agent and those who favor
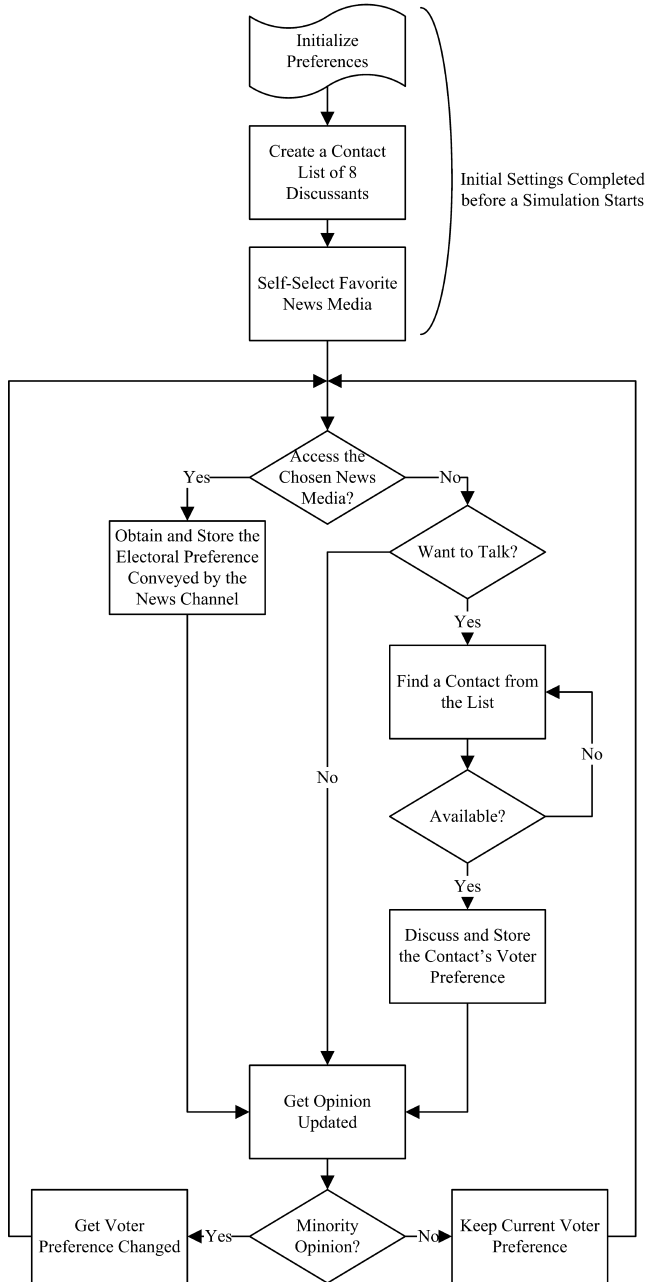
Fig. 1. Flow diagram of a citizen agent's information processing.

a party that the citizen agent favors; the least favorite discussants will be those who are lower in political expertise and who hold a different party identification.[b]

In each timestep during a simulation, every citizen agent will asynchronously take an action of either discussing politics, accessing the media, or doing something unrelated to obtaining voter preferences from political context. It will check what its favorite news medium is saying before having a discussion with its favorite network members. If the citizen agent "wants" to access the media (or, precisely, access any information source other than dyadic conversation), in that timestep it obtains and stores in memory a preference the medium conveys (1 or 0). If the citizen agent does not access the media but "wants" to discuss politics, it finds an agent on its list that is not occupied by any other citizen agent. Like the situation when two people finish a conversation or a chat about a campaign, both get an impression about each other's current voter preference, the two agents will stores each other's voter preference (1 or 0) in memory at that timestep. If the citizen agent does not feel like accessing anything related to the campaign, or decides to do nothing, its opinion at this timestep will remain the same as the previous one.

A citizen agent will change its voter preference (from 1 to 0, or from 0 to 1) when it perceives that 50% (or higher) of the impressions generated from its political context (including other people in its communication network and the news media) oppose its current voter preference. For example, suppose that the value of a citizen agent's current opinion is 0.44. This number can be interpreted in two ways. First, the agent's current voter preference is 0 or "NO," because 0.44 is less than the default threshold value 0.5. Second, the agent perceives that 44% of the information obtained from its political context favors "NO." Hence, if the value of the agent's opinion grows to 0.51 after several timesteps, it will flip over its voter preference from 0 to 1 and other agents that interact with it will start to obtain an impression that the agent favors "YES."

3.2. *Differences between ordinary citizens and opinion leaders*

How does a citizen agent "want" to discuss politics, access the media, or do nothing? This subsection continues to detail the differences between ordinary citizen agents and opinion leaders agents with respect to the propensities to take these actions.

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[b]Granovetter suggests two types of social networks: strong-tie social networks (family and close friends) and weak-tie social networks (coworkers or other friends) [8]. This categorization is perhaps straightforward but limited. In the new millennium, people can form their communication networks beyond the geographic boundary of family and neighborhood. Influential political discussants may come from weak-tie networks, such as friends met on the Internet.

Moreover, although the agents in this model are described as residing in a grid, we do not mean to say that social interaction is strictly based on geographical distance. Rather, these eight possible contacts might be located in a diverse set of geographical positions. In this model, if no contacts from one's party are available, agents prefer to interact with non-experts from the other party. The least favorite contacts are political experts supporting the opposite party. When an agent finds an available discussant, both agents will become unavailable to the other agents; see Ref. 10.

Table 1. The differences between ordinary citizens and opinion leaders.

	Ordinary citizens	Opinion leaders
Political expertise (a 10-point scale)	[1, 5]	[6, 10]
Propensity to access the news media	[0.1, 0.5]	[0.6, 0.9]
Propensity to discuss politics	[0.1, 0.5]	[0.6, 0.9]
Propensity to selective perception	[0.1, 0.5]	[0.6, 0.9]
Capacity to store messages	10	20

Based on the assumptions the two-step flow theory and related findings provide, opinion leader agents will have a higher level of political expertise and are more likely to access the news media, to interact with members of a communication network, to selectively perceive campaign news, and to memorize past impressions about the candidate.

Table 1 summarizes the operationalization of these assumptions. Given that every agent has different values for the five parameters, there are no two agents in the model that behave are exactly the same. Before simulation starts, the model will randomly give to every citizen agent a set of values of the five parameters. An ordinary citizen agent that has the set of values (1, 0.5, 0.1, 0.1, 10) for the five parameters, for example, will be more interested in accessing the news media than discussing politics, will be likely to receive inconsistent messages from the news media, and will not be frequently occupied by other agents to discuss politics.

First, opinion leader agents have higher levels of political expertise (6–10 on a 10-point scale) than ordinary citizen agents (1–5). The numbers in brackets indicate the range of the parameter. The political expertise level of ordinary citizen agents will not be lower than 1 or higher than 5.

Second, opinion leader agents are more likely to access a news media object (with probabilities of the variable *Propensity to Access the News Media* varying from 0.6–0.9) than ordinary citizen agents (with probabilities varying from 0.1–0.5). An opinion leader agent that has 0.7 for this parameter, for example, will contrast a random number (between 0 and 1, regenerated at every timestep) against 0.7. If the newly generated random number is lower than 0.7, it will access the news media. Therefore, the value 0.7 for this parameter indicates that the agent has a 70% chance of accessing the news media.

Third, opinion leader agents are more likely to discuss politics (with probabilities of the variable *Propensity to Discuss Politics* varying from 0.6–0.9) than ordinary citizen agents (with probabilities varying from 0.1–0.5). An opinion leader agent that has 0.8 for this parameter and does not like to access the news media at a run step (recall Fig. 1) will have an 80% chance of discussing politics.

Fourth, opinion agents tend to selectively perceive preferences (with probabilities of the variable *Propensity to Selective Perception* varying from 0.6–0.9) compared to ordinary citizens (with probabilities varying from 0.1–0.5). When an agent performs selective perception, no matter what the media object says, it reinterprets that message consistent with its partisanship. For example, suppose an ordinary

citizen agent likes to access the news media broadcasting "YES" and it has the parameter value 0.4. This means that in ten timesteps of accessing its favorite news media object, 40% of impressions it receives are "YES," while the other 60% are randomly either "YES" or "NO." Because opinion leaders, by design, are more likely to access self-selected news sources and selectively perceive media information, they are more likely to receive consistent 1s or 0s over time. Hence, their preferences will be more consistent than ordinary citizens. Ordinary citizens are less likely to differentiate media information, so they will be more likely to perceive random 1 or 0 when they access a media object.

Finally, opinion leader agents are able to store the most recent 20 pieces of perceived vote preferences (with the value of *Capacity to Store Messages* set to 20), while ordinary citizen agents recall the 10 most recent pieces of perceived voter preferences. Due to this design, opinion leader agents will be more stable in their voter preferences over time, while ordinary citizen agents are more easily influenced by their information context.

4. Experiment Design

4.1. *Default settings*

This section describes the use of the multi-agent model to examine the extent to which opinion leaders influence ordinary citizens' voter preferences.

First, each model will run 100 times. We observe the changes of the values of two variables: *OpinionYES* — the averaged percentage of ordinal citizen agents holding "YES" in 100 simulations — and *Diversity* — the averaged percentage of all citizen agents who perceive preference diversity in their communication network over the 100 simulations.

The change of values of *OpinionYES* will indicate the extent to which opinion leader agents reshape — either increase or decrease — the overall voters. If opinion leaders holding 1 are explicitly influential on aggregated voter preference, this number should increase over time. The change of values of *Diversity* will show if a virtual society of communication becomes heterogeneous during the simulation. A low percentage of this variable will mean that homogeneous clusters of opinion emerge, or a societal agreement about a candidate forms; a high number, instead, will indicate that most citizen agents perceive greater preference diversity during a campaign season.

Second, each run of the simulation will stop automatically if no agent changes its voting preferences for 20 timesteps, otherwise it will stop at the 901st timestep. Because this paper is about opinion leader influence during a campaign season, running a simulation for a reasonably short period makes more sense than running the model indefinitely. We assume that during a campaign season, a voter takes five actions a day, including accessing the media, discussing politics, or neither. The setting of 900 timesteps will approximate a six-month campaign season.

Table 2.   Model specification.

	Study 1				Study 2			
Models	1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4
% Ordinary Citizen YES	0	0	0	0	0.5	0.5	0.5	0.5
Accessing the News Media	F	T	T	T	F	T	T	T
Opinion Leader Preference	YES	YES	NO	—	YES	YES	NO	—

Third, each model will have 1,600 citizen agents, whose opinions are shown on a 40×40 raster. Opinion leader agents count for 10 percent of all citizen agents. A color scheme is used to help identify a pattern of voter preference. For ordinary citizen agents that strongly favor "YES," their opinions are set to be bright green on the raster. For opinion leader agents that strongly favor "YES," their opinions will be bright red. For both classes of citizens that favor "NO," their opinions are black. For ordinary citizen agents and opinion leader agents whose opinions varying between 1.00 and 0.00, their opinions are in different degrees of dark green and dark red, respectively.

4.2. *Model specification*

This subsection specifies the two studies and eight models, as Table 2 on the next page summarizes, derived from the default one described above. Study 1 focuses on the extent to which opinion leaders reshape voter preferences in a homogeneous society. All ordinary citizens by default favor "NO." Study 2 focuses on the role of opinion leaders in a polarized society where half of the ordinary citizen agents favor "NO" and the other half favor "YES."

Each study is composed of four models: (i) ordinary citizen agents that distrust the news media but like to access opinion leaders for political information, an important assumption described in the two-step flow theory of communication (Model 1-1 and Model 2-1), (ii) ordinary citizens obtaining information from the news media as well as opinion leaders favoring "YES" (Model 1-2 and Model 2-2), (iii) ordinary citizens obtaining information from the news media as well as opinion leaders favoring "NO" (Model 1-3 and Model 2-3), and (iv) there are no political experts (Model 1-4 and Model 2-4). Note that Model 1-1 should show the following two patterns because of the settings: (a) opinion leaders will be the hubs of information and the centers of opinion clusters, and (b) opinion leaders will homogenize voter preference of those within the communication network.

The rest of the models that go beyond the basic assumption of the two-step flow theory should help explore the influence of media use and opinion leader influence. The findings reported in the next section will go through three comparisons. First, contrasting the results derived from Model 1-1 with those from Model 1-2 (as well as contrasting Model 2-1 with Model 2-2) should show the influence of news media use. Second, contrasting the results derived from Model 1-3 with those from Model 1-2 (as well as contrasting Model 2-3 with Model 2-2) should show the magnitude of

opinion leader influence. Third, contrasting the results derived from Model 1-4 with those from Model 1-2 (as well as contrasting Model 2-4 with Model 2-2) should show the net influence of opinion leaders.

5. Simulation Results

Each of the eight models runs 100 times and each run uses a different random seed. For each run, the program records the summary statistics of the two key variables — *OpinionYES* and *Diversit*y. As a result, each model has 100 means of *OpinionYES* and 100 means of *Diversity.* Table 3 reports the means and standard deviations of the 100 runs for each model. The summary statistics provides robust and accurate information for cross-model comparisons detailed below.

Figure 2 shows the snapshots of the opinion rasters taken when a simulation ends. The visualization of voter preference patterns further helps the comparison across the models. To ensure the rasters in Fig. 2 are representative of the other 99 counterparts, we chose the model whose means of the two key variables fall within 1 standard error of the means of the 100 runs. For example, for Model 1-1, we chose the 13th run out of the 100 results because its mean of *OpinionYES* 0.61 and the mean of *Diversity* 0.29 fall within 1 standard error from the averaged means shown

Table 3.   Average proportions of the 100 simulations.

Models	Study 1				Study 2			
	1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4
OpinionYES	0.611	0.482	0.147	0.163	0.894	0.707	0.290	0.497
	(0.032)	(0.022)	(0.008)	(0.008)	(0.024)	(0.018)	(0.019)	(0.027)
Diversity	0.294	0.431	0.262	0.274	0.105	0.362	0.359	0.394
	(0.013)	(0.010	(0.012)	(0.012)	(0.019)	(0.008)	(0.013)	(0.010)

Note: Standard deviations are put in the parentheses.
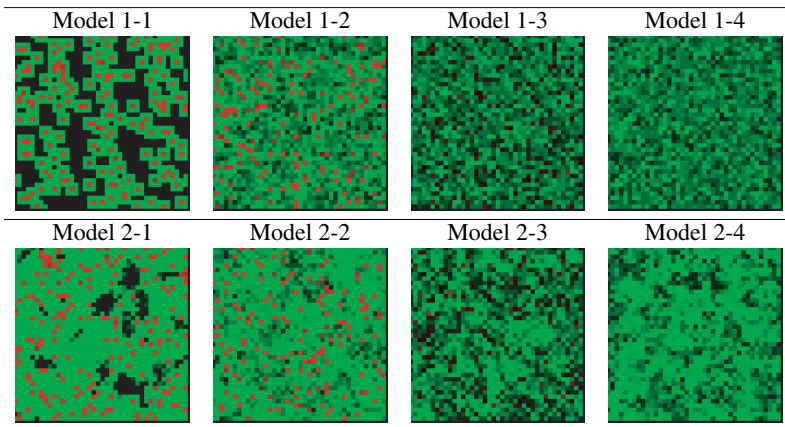

Fig. 2.   The opinion rasters of the simulation results.

in the second column of Table 3.[c] Except that the simulation of Model 1-1 stops at the 353rd timestep, all models run more than 900 time steps and, as discussed on page 16, stop at the 901st time step.

As expected, the pattern of Model 1-1 — clusters of bright green cells surrounding bright red cells — confirms what the two-step flow theory suggests: opinion leaders are the center of political influence. The finding that goes beyond the theory is the emergence of black clusters outside the green clusters. This pattern suggests that the influence of opinion leaders does not penetrate the black clusters. The preference "YES" does not cascade over "NO." This pattern is attributed to the model setting that ordinary citizen agents tend to discuss politics with other agents with greater political expertise, not with those perceived to have lower political expertise. As a result, citizen agents who do not have opinion leader agents in their communication networks (a) are not likely to receive any information about "YES," and (b) will consolidate their default voter preference through interaction with other agents who also hold "NO."

This finding holds in Model 1-2, where ordinal citizen agents access both self-selected news media and opinion leaders in their communication networks. Opinion leaders remain the centers of green clusters, but the brightness of the green cells decreases and the darkness of the black clusters also decreases. This new pattern suggests two things. First, it is more difficult for opinion leaders in Model 1-2 to influence their followers than those in Model 1-1. As shown in Table 3, the proportion of citizen agents supporting "YES" drops from 0.611 to 0.482. Second, opinion leaders encounter greater resistance within their networks. The proportion of agents perceiving preference diversity increases from 0.294 to 0.431. There are more citizens receiving what opinion leaders propose by accessing the news media.

The pattern shown in Model 1-3, where both ordinary citizen agents and opinion leader agents supporting "NO," remains consistent with the pattern of Model 1-2. If opinion leaders are influential and their influence penetrates the communication networks of an opposing preference, the simulation should have ended with a completely black raster. Interestingly, opinion leaders do not outweigh the news media in shaping voter preference. Model 1-3 shows that not all citizen agents remain favoring "NO"; instead, a great number of green cells emerges. The proportion of citizen agents favoring "YES" is not zero; 14.7% of agents do not conform to the majority preference. This pattern is attributed to the model design, setting that ordinary citizen agents tend to access the news media for political information before discussing politics with opinion leaders. As a result, some agents that access the opposite voter preference "YES" can be resistant to the influence from opinion leader and communication networks homogeneously favoring "NO."

The pattern of Model 1-4, where there is no opinion leader agents in the model, shows that the green clusters still emerge without the polling of opinion leaders.

[c]The runs chosen for Model 1-2 through Model 2-4 are the 18th, 20th, 24th, 46th, 21st, 36th, and 66th runs, respectively.

A comparison between Model 1-4 and Model 1-2 suggests that opinion leaders, if they are united in their voter preferences, are influential. Opinion leaders in Model 1-2, who are all favoring "YES," pull the proportion of support for "YES" from 0.163 to 0.482. However, opinion leaders have little leverage to remove political disagreement in a homogeneous society, given that citizen agents access alternative news sources. The proportion of citizen agents favoring "YES" in Model 1-4 (0.163) is about the same level as that of Model 1-3 (0.147).

Where Study 1 uses simpler models to examine opinion leader influence, Study 2 adds complexity to the simulation. In Study 2, ordinary citizen agents are not homogeneously favoring "NO," but are polarized in their voter preferences. Indeed, in a polarized society opinion leaders are very likely to be polarized in voter preference. Setting both types of citizen agents to be polarized in their voter preference, however, would blur the focus of this paper on predicting the influence of opinion leaders. Hence, in Study 2 while all ordinary citizens are polarized, opinion leader agents are united in favoring "YES."

Despite the difference between the two studie0s, the findings derived from Models 2-2 to 2-4 are consistent with those from Study 1. His worth noting that, due to the increase of ordinary citizens favoring "YES" in Study 2, social networks play a greater role outside opinion leader influence. Figure 2 shows a greater number of green clusters in Models 2-2 to 2-4 than in Models 1-2 to 1-4, while Table 3 shows that the proportion of citizens perceiving preference diversity is higher in Study 2 than in Study 1.

The most important finding of Study 2 is the pattern of Model 2-1. The opinion raster of Model 2-1 shown in Fig. 2 is a predicted pattern based on the two-step flow theory applied to a polarized society. Model 2-1 has a greater green area than Model 1-1, which seems to suggest that opinion leaders have a greater influence in Model 2-1 than in Model 1-1. In fact, however, opinion leader influence does not "diffuse" without the homogenization of social networks. In the clusters where opinion leader agents influence their close followers to support "YES" (recall the pattern of Model 1-1), the expansion of the green areas should be attributed to the greater number of ordinary citizens holding "YES" outside the rims of opinion leader influence. If the theory's assumption that individuals distrust the media and only trust opinion leaders is true, the patterns of Models 1-1 and 2-1 suggest a third step of information diffusion: the homogenization of social networks.

Note that, even though the green area expands, the influence of opinion leaders still does not penetrate all clusters in Model 2-1. In the area without opinion leaders, black clusters can emerge and continue throughout the simulation. As Table 3 shows, there are about one tenth of agents holding "NO" and perceiving preference diversity.

6. Conclusion and Discussion

The two-step flow theory of communication explains how citizens form voter preferences during a campaign season, but it does not clarify the extent to which

opinion leaders influence voters. This paper notes this gap, arms the theory with a theory-driven agent-based model, and shows how this model helps explore what Katz and Lazarsfeld did not identify. The model design of this paper incorporates three important assumptions drawn from the theory: (i) citizens do not trust the media as much as opinion leaders; (ii) the first step influence — information flows from the media to the experts; (iii) citizens prefer accessing opinion leaders for political information. By incorporating these assumptions into the model design, this paper identifies the patterns of information flows from experts to citizens.

The most important conclusion drawn from the simulation results is that the influence of opinion leaders does not cascade down to the mass public and reshape the aggregated preference. Unlike what the two-step flow theory leads us to expect, the findings show that opinion leader influence is not likely to diffuse beyond their closest followers, if the followers do not pass on the opinion leader preference to their network fellows. Simulation results also show that, even if the followers pass on their opinion leader preference to their fellows, it is not likely that those followers have the same strength of influence on other less politically interested people. The influence of an opinion leader favoring "YES" can be blocked by one or more citizens whose preferences are shaped by their fellow network members holding "NO."

The rejection of opinion leader influence has three causes. First, unlike the adoption of a new technology that requires no ideological root, a permanent change of voter preference requires overcoming ideological barriers rooted in an individual voter's belief system or partisanship [3]. A stable belief system guides a voter, especially opinion leaders, to selectively perceive information from the news media and filter incoming information that opposes current beliefs. This is evidenced by a sharp difference between black and green clusters in Models 1-1 and 2-1.

Second, citizens are subject to the influence of information sources other than opinion leaders. Even when citizens like to discuss politics with political experts, they do not talk to opinion leaders all the time everyday. As a result, it is very likely that social networks and the news media take over the role of opinion leaders. Even when voters like to access like-minded opinion leaders, opinion leaders have nothing to do with other information sources that can change their followers' preferences.

Third, any two opposing preferences have their supporters. In the 2004 American presidential election, many voters in swing states, such as Ohio, formed their voting preferences for George W. Bush through their daily access of chosen news media and their frequent discussion with friends from churches. It is difficult for opinion leaders favoring John Kerry to penetrate these clusters. The simulation results suggest that, when opinion leaders are united to support the same candidate, they are able to pull the public's preference in their direction. The influence of opinion leaders, however, is likely to be cancelled out by voters who have formed or reserved the opposite preference in their communication networks. Moreover, in the real world where opinion leaders are likely to be polarized in their voter preferences and where individuals access various types of news sources (e.g. the Internet and cable TV) more frequently than four decades ago, it is also likely that a voter experiences conflicting messages during the campaign season.

In conclusion, the path of influence regarding voter preference is better refined to be "media → opinion leaders → communication networks → the public." An opinion leader will be influential in a communication network with a high level of homogeneity in voter preference, but his influence will be constrained in a heterogeneous community.

The idea of a complex adaptive system is promising to untangle complex social phenomena. An ABM modeler, however, needs to pay attention to the issues regarding the internal validity and the external validity of a model. Hence, it will be important for future researchers who want to advance and apply this model for studying public opinion to address the following issues. First, in this paper the political expertise of individual citizen agents is a fixed value and does not increase over time. Future research needs to advance the model based on empirical findings about how and under what circumstances political expertise increases. Second, besides accessing opinion leaders, voters may weigh political experts' opinions. Future research needs to clarify if citizens selectively perceive what they obtain from their communication network peers. Third, in this paper an important assumption beyond the theory is that citizen agents tend to think about the news media before thinking about discussing politics with other people. Future studies may examine if this assumption is true, if there is any difference between ordinary citizens and opinion leaders in this respect, and if the findings of this paper hold after this assumption is relaxed. Fourth, further application of the findings of this paper to the real world requires external validation — matching the analysis based on the simulation data and the analysis based on empirical data. The findings drawn from the simulation results are theoretical; future research on opinion leader influence in a particular region or country needs to tune the parameters.

Acknowledgments

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