AGENT-BASED AND COMMUNITY MODELING, NETLOGO, AND THE 2012 PRESIDENTIAL ELECTION

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In the Spring and Fall of 2012 the authors used the 2012 election as a rich and engaging modeling topic in our Mathematical Modeling courses. This paper talks about our work modeling the general election in the Fall semester. The class developed an agent-based, community model with each student contributing several parts of the model. Our goal was not prediction but rather the development of a model. This paper does not talk about other work on the primaries and congressional districting. A longer and more complete version of this paper including those topics is available from either of the two authors. We used NetLogo with mixed results. It would be better to use a general-purpose, object-oriented language but, alas, fewer students seem to be learning such languages these days.

1 The Voters

In theory an agent-based model could have one agent for each voter. In practice, however, this is impractical and a good modeling compromise is to use several different groups of voters. We built our model on work done by the Pew Research Center for the People and the Press.[1] See Table 1. Before reading on we recommend that you

- Take the quiz at http://www.people-press.org/typology/quiz/ to see to which of the Pew groups you might belong.

- When you complete the quiz you will be taken to a page that describes the group in the Pew typology that appears to best describe you. See Figure 1. Read the description. Do you think it does a good job of describing you as a voter.

- Explore the links to descriptions of the other types in the Pew voter typology.

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[1] http://www.people-press.org/typology/

Group	Percent of the Public
Staunch Conservatives	9%
Main Street Republicans	11%
Libertarians	9%
Disaffected	11%
Post-Moderns	13%
New Coalition Democrats	10%
Hard-Pressed Democrats	13%
Solid Liberals	14%
Bystanders	10%

Table 1: Pew Typology

Figure 1: Pew Typology

[337] www.ictcm.com

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2   The Issues

We focused on how voters base their presidential votes on the issues. This is a simplification. Many other factors enter into voters' choices. We begin by looking at two examples.

2.1   Immigration

First we discuss illegal or undocumented **immigrants**.[2] Issues related to undocumented immigrants have been in the news for many years. As one example, the DREAM[3] Act was originally introduced in the Senate by Democrat Richard Durbin of Illinois and Republican Orrin Hatch of Utah in 2001 and more recently reintroduced in 2011. The DREAM Act if enacted would have offered permanent residency and a path to citizenship for qualifying illegal immigrants. Under the 2009 version, qualifying individuals would – have proof that they arrived in the United States before age 16; have proof that they resided in the United States for at least five consecutive years since their date of arrival; if male, have registered with the Selective Service; be between the ages of 12 and 35 at the time the bill was enacted (it wasn't); have graduated from an American high school, obtained a GED, or been admitted to an institution of higher learning; and be of "good moral character."

In 2010 Arizona enacted a controversial law, the Support Our Law Enforcement and Safe Neighborhoods Act, that was widely regarded as the most far-reaching anti-illegal immigration measure in recent U.S. history. The U.S. Supreme Court in a split decision sustained parts of the act and blocked implementation of others.[4]

2.2   Tax Policy

Next we examine tax policy. This issue includes both the distribution and the level of taxes. During the primary season the news focused on the percentage rate paid by the wealthiest individuals. In August 2012, the focus turned to the Governor Romney's income taxes – in 2010 he reported a total tax (line 60 form 1040) of $3,009,766 on an adjusted gross income (line 37) of $21,646,507, or 13.90%[5]. He also reported almost $3,000,000 in charitable contributions. For comparison, here are some paragraphs from whitehouse.gov.[6]

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[2]The choice of words makes a big difference – words like "alien," "illegal," and "undocumented" carry different connotations.

[3]Development, Relief, and Education for Alien Minors

[4]http://www.nytimes.com/interactive/2012/06/26/us/scotus-immigrationlaw-analysis.html   Accessed 13 August 2012.

[5]http://www.mittromney.com/learn/mitt/tax-return/2010/wmr-adr-return

[6]http://www.whitehouse.gov/blog/2012/04/13/president-obama-and-vice-president-biden-s-2011-tax-returns Accessed 12 August 2012.

[338]   www.ictcm.com

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Rate	Single Bracket	Joint Bracket
10%	$0 - $8,500	$0 - $17,000
15%	$8,500 - $34,500	$17,000 - $69,000
25%	$34,500 - $83,600	$69,000 - 139,350
28%	$83,600 - $174,400	$139,350 - $212,300
33%	$174,400 - $379,150	$212,300 - $379,150
35%	$379,150+	$379,150+

Table 2: United States Income Tax Brackets and Rates (2011)

Today, the President released his 2011 federal income and gift tax returns. He and the First Lady filed their income tax returns jointly and reported adjusted gross income of $789,674. About half of the first family's income is the President's salary; the other half is from sales proceeds of the President's books. The Obamas paid $162,074 in total tax.

The President and First Lady also reported donating $172,130 – or about 22% of their adjusted gross income – to 39 different charities. The largest reported gift to charity was a $117,130 contribution to the Fisher House Foundation. The President is donating the after-tax proceeds from his children's book to Fisher House, a scholarship fund for children of fallen and disabled soldiers.

The President's effective federal income tax rate is 20.5%. ...

President Obama's 2011 tax return is also available.[7]

We focus, in large part, on the distinction between regressive and progressive taxes. A regressive income tax takes a higher percentage from individuals whose income is lower than from those whose income is higher. A progressive tax takes a higher percentage from those whose income is higher than from those whose income is lower. If you look just at earned income then the United States Income tax is progressive. See Table 2. However, because of various provisions, especially the preferential treatment of capital gains, the United States Income tax is actually regressive. Most famously, Warren Buffett, President Obama (20.5%), and Mitt Romney (13.9%) "pay a lower tax rate than their secretaries.[8]"

With his choice of Congressman Paul Ryan as his vice presidential running mate, Governor Romney aligned himself with those who favor very regressive tax policies. In contrast to

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[7]http://www.whitehouse.gov/sites/default/files/president_obama_complete_return_2011.pdf

[8]Google "Buffet Brokaw" for Tom Brokaw's interview of Warren Buffett. In the interview Buffett says he paid 17.7% and that he did an informal survey to which 15 of the 18 people in his office responded. All of their rates were higher than his.
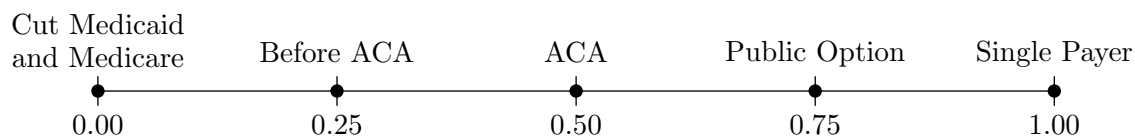
[339]   www.ictcm.com

1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

Figure 2: An Issue Spectrum for our Health System

Governor Romney, Congressman Ryan had laid out a very detailed program[9] "A Roadmap for America's Future." Among other things, this program eliminates taxes on interest, capital gains, and dividends. Because wealthier people tend to derive a large part of their income from interest, capital gains, and dividends this effectively shifts more of the tax burden from the wealthy to the middle class.

3 Issue Spectrums

Our first impulse is to represent possible positions on an issue by real numbers but there are other possibilities – for example, we might simply look at an unstructured set of possible positions. Representing positions by real numbers is attractive for several reasons – for example, positions are often naturally ordered – but representing positions by real numbers also has some disadvantages. Issues and positions are more nuanced.[10]

Nonetheless we modeled possible positions on each issue by an *issue spectrum* like the one shown in Figure 2 for our health system. Think of these options not as numbers that have numerical meaning but rather as ordered possibilities along a range or spectrum of possibilities. In Figure 2 the point 1.00 is the far blue end. The point 0.50 is the legislation signed into law by President Obama on 23 March 2010. The key vote was a straight party line vote in the Senate on 24 December 2009. The key to the usefulness of an issue spectrum is marking specific points on the spectrum with prose describing specific positions. In Figure 2 we have marked five points that have been clearly articulated in the public debate about health care.

- 0.00 – Cut Medicaid and Medicare below the levels in 2008 before the Affordable Care Act (ACA).

- 0.25 – The status quo in 2008 before the Affordable Care Act.

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[9]http://roadmap.republicans.budget.house.gov Accessed 14 August 2012.

[10]As an example, look at the very different positions taken on issues like the mandate that is part of the Affordable Care Act and cap-and-trade taken by groups like the Cato Institute and American Enterprise Institute that are firmly associated with the conservative side of the spectrum.

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- 0.50 – The status after the Affordable Health Care Act is fully implemented.

- 0.75 – A Public Option added to the Affordable Health Care Act. This possibility was debated during the conversation leading up to the Affordable Care. Like the Affordable Health Care Act itself, it leaves all the mechanisms of the health care system of 2008 largely in place, including the role of private insurance companies. It adds a public option that could compete against private insurance companies.

- 1.00 – Single Payer. This possibility would be a variant of the systems in place in most of the world, including Canada and Europe. It would sever or limit the connection between employment and medical insurance. In Canada, for example, most of the funding is provided by provincial and national governments. This covers medically necessary expenses. Many Canadian citizens have additional insurance for non-medically necessary expenses through their employers. The term "single-payer" refers to the financing of the health care system. The provision (distinct from the financing) of health care can come from a variety of possibilities – typically a mix of public and private with fees set by negotiations.

Our model focused on voters and candidates that had a position on each of the issues under consideration. Students answered questions like those below.

Question 1 *Draw an issue spectrum for three issues of your choice like Figure 2 with specific positions (with explanatory prose) at specific appropriate points.*

Question 2 *Pick five specific people and indicate their position on each of your three issue spectrums. You may pick members of your family, friends, or well-known people. Include both likely candidates for president and at least one newsperson.*

We modeled each voter's opinion on each issue with an *agreement curve* like the one shown in Figure 3. The x-axis represents the spectrum of possible positions. The curve will have values between zero and one, with one representing complete agreement with a position and zero representing complete disagreement. Later on we introduce weights that represent how important each issue is to each voter. Typically a voter has one position that they favor and the value of the agreement curve will be one at that point. As you move away from that point, the values of the agreement curve decrease. The curve will often be asymmetric and some voters may have flatter curves than others. Figure 3 shows one person's agreement curve for the health system. This person favored a public option but was willing to settle for the Affordable Care Act. The principle driving this person's opinion was the principle of increased coverage and this person was willing to sacrifice the ideal to pass legislation that would significantly expand coverage. Students developed agreement curves for several different issues and several different voters in the Pew typology.
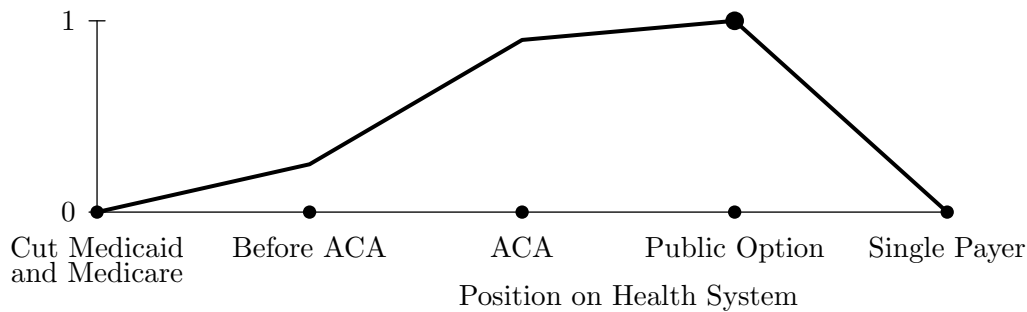
[341] www.ictcm.com

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Figure 3: Agreement Curve

4   The Message, the Media, and the Mindset

Voters decide for whom to vote in part on their perceptions of the candidates' positions on the issues. Figure 4 shows the model that the class developed of how voters perceived the candidates' positions on the issues.

- The candidates and their surrogates or spokespeople send out lots of messages. These messages are picked up by the media, both traditional and social media.

- Different media filter and emphasize the different messages in various ways and send them out to the voters.

- The voters interpret the messages in the context of their own background.

Campaigns have always had many ways of affecting voters' perceptions by targeting their messages to different audiences but modern campaigns have huge new opportunities for targeting messages based on data mining and social media. When you, for example, respond to a solicitation from a campaign organization for donations, you are not only sending money, you are sending information – did you, for example, donate money when the solicitation emphasized the economy, emphasized the deficit, promised to lower taxes, or to preserve Medicare, when its tone was positive, or when its tone was negative. Future solicitations will emphasize the same things that resulted in previous donations and at the same time paint a picture of a candidate and his or her opponent that is tailored to you.

Although the groups in the Pew typology are detailed and useful, they are not homogeneous. Different voters in the same group may perceive the same candidate's positions differently. For this reason, for each of the eight[11] groups of voters in the Pew Research

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[11] The Pew typology has nine groups but one of them does not vote and, hence, is not included in this model.

[342]   www.ictcm.com

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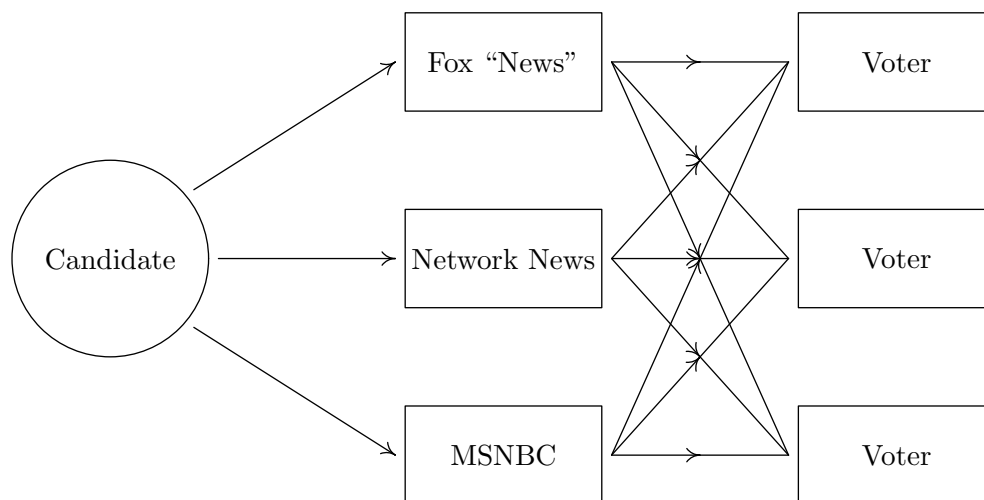
Figure 4: The Message, the Media, and the Mindset

Center typology the perception of a candidate's position on an issue will be a random variable – that is, if we pick a random voter from the group then that voter's perception of the candidate's position will depend on which voter we picked. We describe this randomness by a *perception random variable* like the one in the top graph in Figure 5. We think of the voters as being lined up on the x-axis and the perception that a particular voter, x, has is indicated by the corresponding y-value of the perception RV. The middle graph in Figure 5 shows an example perception RV for a group in which half of the voters believe the candidate's position is 0.75 and the other half believe the candidate's position is 0.25.

Operationally, we simulate choosing a random voter by choosing a random number, x, in $[0, 1]$. Then that voter's perception of the candidate's position on each issue is determined by evaluating $f(x)$ where the function f is the voter's group's perception random variable for that candidate and issue. The NetLogo code below illustrates a possible raw perception RV (bottom graph, Figure 5) for voters in the Solid Liberal group for President Obama's position on the size and role of government. They believe the candidate's position is between 0.50 and 0.75 and within this range the position is uniformly distributed.

```
to-report solid-obama-size-raw [voter]
  report line-segment 0 0.50 1 0.75 voter
end
```
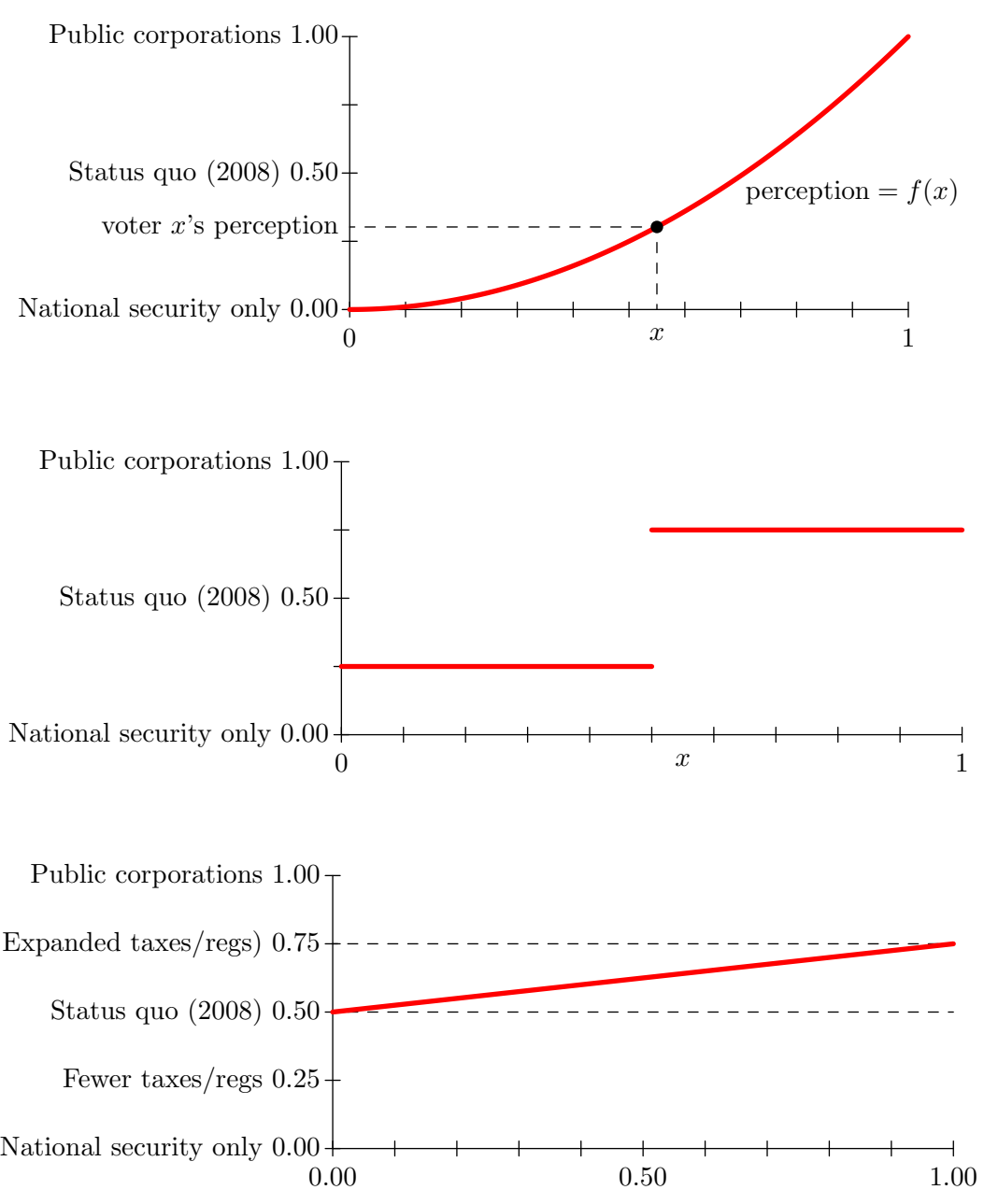
Figure 5: Perception Random Variables for a Candidate's Position on a Particular Issue

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Wide Variance in Typology Groups' News Choices

% who regularly read, watch or listen to…	Total	Solid Liberals	Hard-Pressed Dems	New Coalition Dems	Post-Moderns	Disaf-fecteds	Liber-tarians	Main Street Reps	Staunch Cons	By-standers
	%	%	%	%	%	%	%	%	%	%
Network news	43	38	**61**	47	38	**52**	35	**51**	30	35
Fox News	30	11	35	31	20	**40**	**38**	**37**	**54**	17
CNN	24	27	**44**	28	27	29	15	21	8	16
MSNBC	16	19	**23**	20	15	19	13	18	6	10
NPR	16	**34**	6	**25**	20	10	17	11	8	6
Daily newspaper	46	51	**57**	34	47	49	50	**55**	44	24
The NY Times	6	**18**	3	8	10	3	1	4	1	4
The Daily Show	8	**21**	8	3	14	3	3	3	1	6
Glenn Beck	6	1	5	6	1	5	9	8	**23**	1
Rush Limbaugh	5	2	1	4	1	4	9	7	**21**	1

PEW RESEARCH CENTER 2011 Political Typology. QA18. **Bold** figures are significantly higher than the national average.

Table 3: Pew Data on News Sources

Different groups in the Pew typology have different perception RVs because a voter's perception of a candidate's position depends on the voter's experience, background, and values. Different voters are alert to different words or read different meanings into the same word. For example, in some contexts the phrase "special interest groups" means unions to conservative voters but may be missed by other voters. Candidates are adept at using words like this to convey different meanings to different voters, a practice known as "dog whistling."

A voter's perception can also be influenced by his or her regular news sources. Table 3 paints a stark picture of the relationship between a voter's choice of news sources and place in the Pew typology. For example, 54% of Staunch Conservatives regularly watch Fox News while only 11% of Solid Liberals regularly watch Fox News. Interestingly Bystanders pay less attention to every news source than the average person.

According to the Pew Research Center data on news sources, 38% of Solid Liberals regularly listen to network news; 11% to Fox News; 27% to CNN; and 19% to MSNBC. Notice the sum of these numbers is 95%, so that at least 5% do not regularly watch any of these television sources. Of course, some may regularly watch two different television news sources. By contrast, the sum of the entries for Hard-Pressed Democrats for the same four sources is 163% – many Hard-Pressed Democrats regularly watch two or more television news sources. In addition to television news, 18% of Solid Liberals regularly read the New York Times, the national average is only 6%.

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We considered three news sources – Fox News, which has a consistent red bias, MSNBC, which has a consistent blue bias and other sources that are less biased (for example, ABC, CBS, and NBC network news). The model takes news sources into account by applying a filtering function to each voter's perception of each candidate's **raw** position on each issue, based the voter's regular news source. The result will be the voter's **filtered** perception of each candidate's position on each issue. Figure 6 illustrates two possible filtering functions – one that Fox News might apply and one that MSNBC might apply to candidates' positions on the size and role of government. The Fox News filtering function is

$$f(x) = \begin{cases} 1.2x & \text{if } 0 \leq x \leq 0.50; \\ 0.60 + 0.8(x - 0.50) & \text{if } 0.50 \leq x \leq 1. \end{cases}$$
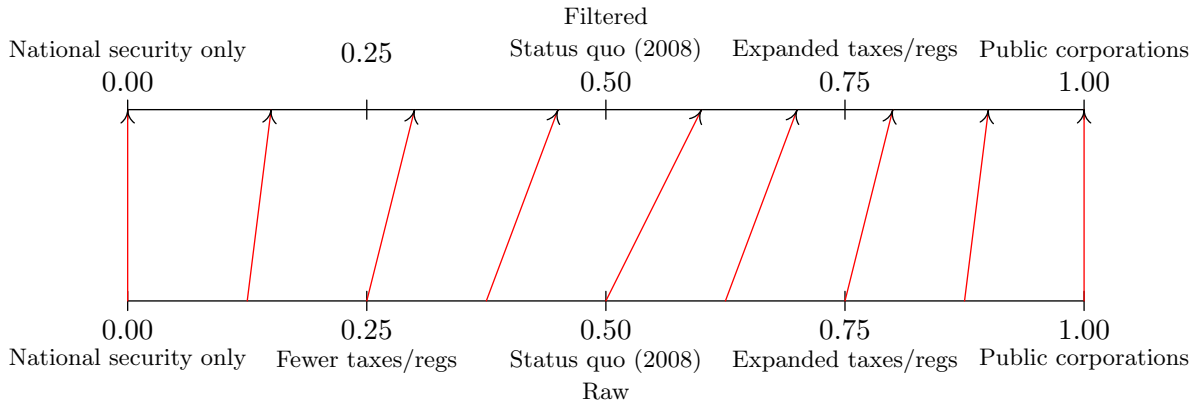
Notice that if the raw perceived position of a candidate on this particular issue was 0.50 then after the Fox filtration function it would be 0.60. The Fox filtration function shifts every position away from the most extreme red position – any compromise is exaggerated.

Figure 7 shows six sample agreement curves for different groups in the Pew typology on this issues. Note, for example, that the agreement curve for Solid Liberals is a piecewise linear curve made up of two segments – from $(0,0)$ to $(0.75, 1)$ and from $(0.75, 1)$ to $(1, 0.4)$. For each voter chosen at random we compute the extent to which that voter agrees with his or her perception of each candidate's position on each issue. This gives us numbers $a_1, a_2, \ldots a_n$. The numbers a_i are computed in three steps.
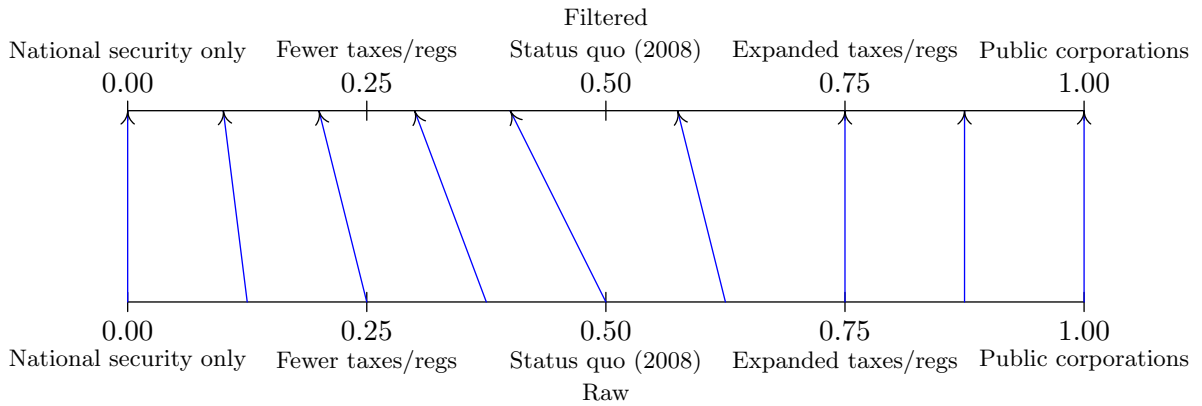
- First, we find a random variable x and compute the raw voter's perception of the candidate's position using a raw perception random variable.

- The next step is to simulate the filtering done by the news media. We model three possibilities – neutral filtering, red filtering, and blue filtering. For each group in the Pew typology we use the fraction, r, of that group that regularly watches Fox News and the fraction, b, of that group that regularly watches MSNBC. We choose a second random number y. If $y < r$ we apply the Fox filtering function to the raw perception. If $y > 1 - b$ then we apply the MSNBC filtering function. This gives us the filtered perception.

- Finally, we apply the group's agreement function to the filtered perception. This gives us the numbers $a_1, a_2, \ldots a_n$

The extent to which that voter agrees with the candidate is a weighted average

$$\left(\sum_{i=1}^{n} w_i a_i \right) \Big/ \left(\sum_{i=1}^{n} w_i \right).$$

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Filtered

National security only   0.25   Status quo (2008)   Expanded taxes/regs   Public corporations
0.00   0.50   0.75   1.00

0.00   0.25   0.50   0.75   1.00
National security only   Fewer taxes/regs   Status quo (2008)   Expanded taxes/regs   Public corporations
Raw

Fox "News" Filtering

Filtered

National security only   Fewer taxes/regs   Status quo (2008)   Expanded taxes/regs   Public corporations
0.00   0.25   0.50   0.75   1.00

0.00   0.25   0.50   0.75   1.00
National security only   Fewer taxes/regs   Status quo (2008)   Expanded taxes/regs   Public corporations
Raw

MSNBC Filtering

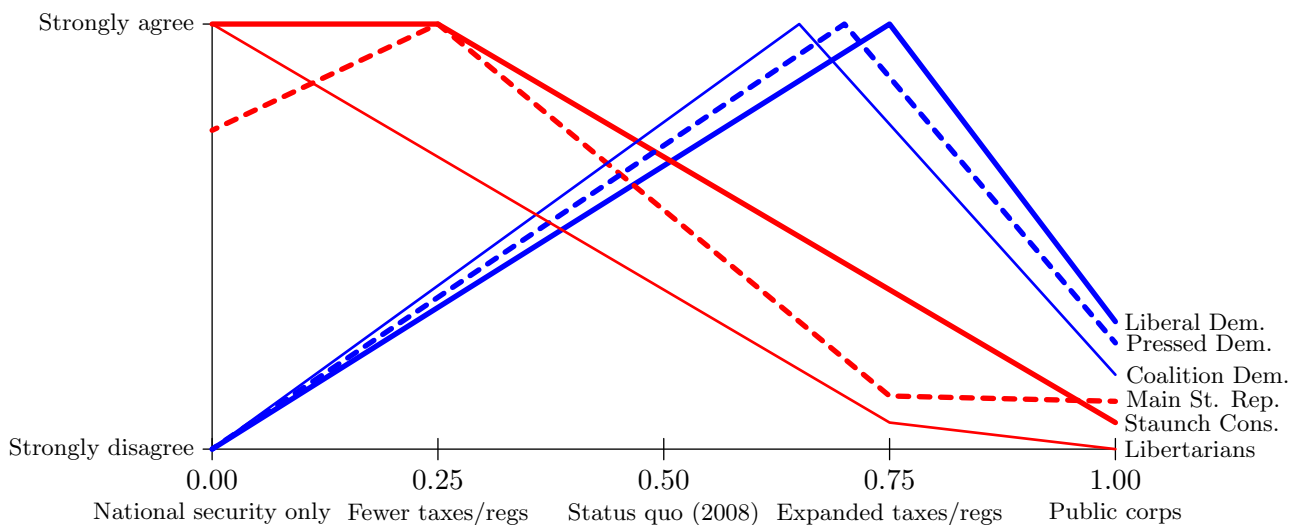Figure 6: Two Possible Filtering Functions
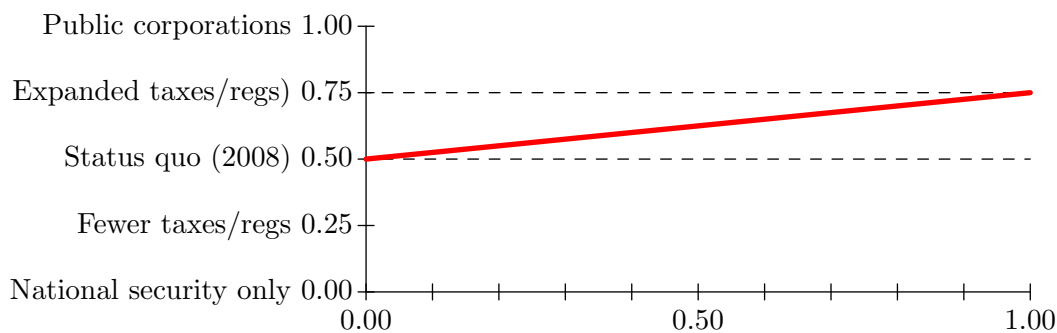
Figure 7: Six Example Agreement Curves

Figure 8: An Example Raw Perception Random Variable

where the weights $w_1, w_2, \ldots w_n$ depend on the Pew group. If a voter thinks issue i is more important than issue j then $w_i > w_j$. The weights $w_1, w_2, \ldots w_n$ for a group effectively represent the importance a voter in that group assigns to the issues.

4.1   A NetLogo Simulation

For each group in the Pew Typology students supplied NetLogo code for – issue weights; n agreement curves, one for each issue; and $2n$ raw perception random variables, one for each candidate for each of the ten issues.

Voters can vote for President Obama, vote for Governor Romney or decide not to vote in the presidential election. This decision is based on the weighted sums described above that represent a voter's overall agreement with a particular candidate's position.

$$A_O = \text{Obama Agreement} = \left(\sum_{i=1}^{8} w_i a_{i,obama} \right) \bigg/ \left(\sum_{i=1}^{8} w_i \right).$$

and

$$A_R = \text{Romney Agreement} = \left(\sum_{i=1}^{8} w_i a_{i,romney} \right) \bigg/ \left(\sum_{i=1}^{8} w_i \right).$$

If $A_O - A_R$ is bigger than some cutoff then the voter votes for President Obama. If $A_R - A_O$ is bigger than the same cutoff then the voter votes for Governor Romney. The value of the cutoff is set in the NetLogo code and determines how many voters decide not to vote.

Figure 9 (top left) shows one NetLogo simulation. This particular simulation shows the total vote – Obama 508, Romney 428, No vote 64 – for a rough base model. To see the total vote the user clicks the `vote all` button. Because this is a Monte Carlo simulation results will vary. To see just one Pew group the user clicks the appropriate button below the `vote all` button. The other screenshots show other aspects of this NetLogo program

This simulation is based on the national fractions for the groups in the Pew typology. By using state–by–state fractions the same model could be adapted to the realities of the electoral college. Although this would be a better model, it is still far from perfect or even a model that could be used for prediction. This model is, however, a good step in understanding presidential elections. A longer and more complete version of this paper is available from either of the two authors.

[349]   www.ictcm.com

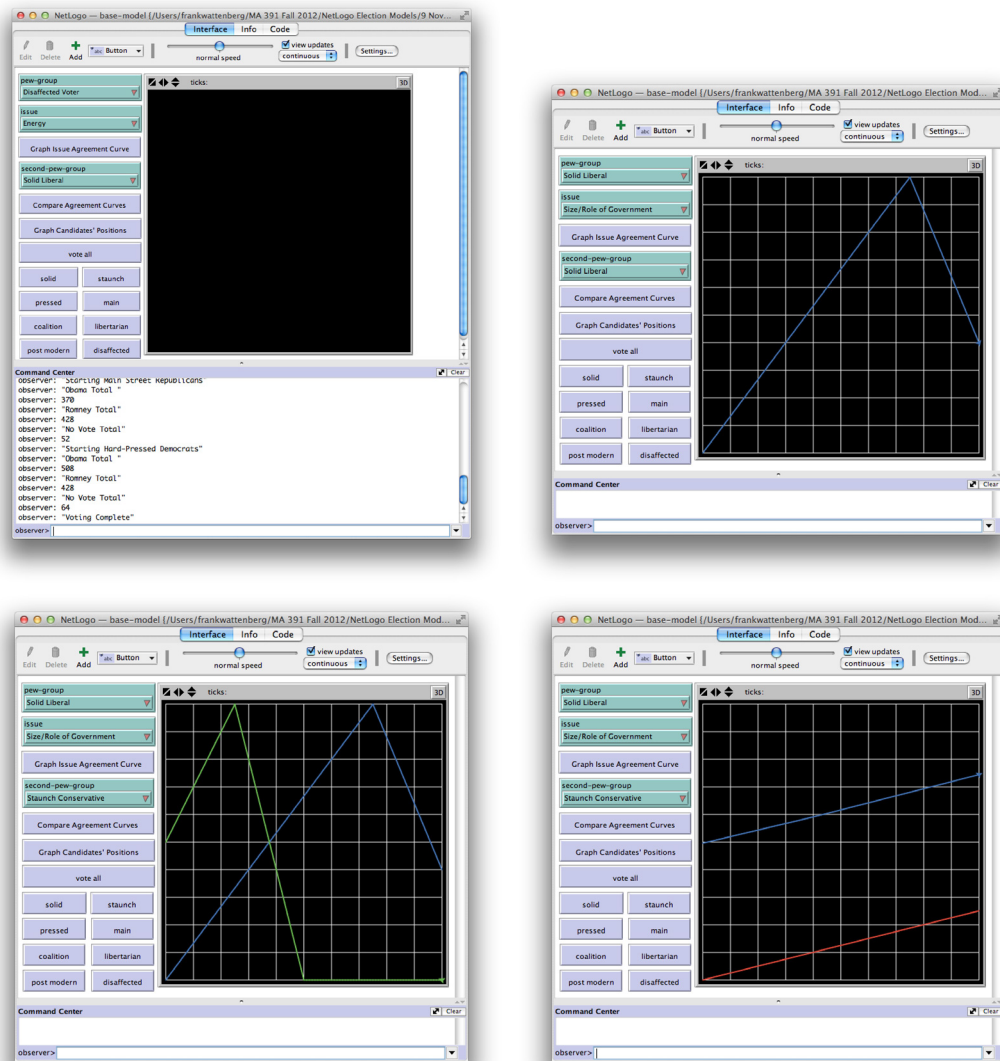1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

Figure 9: NetLogo Simulation Screenshots

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1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013