Governance in Social Media: A case study of the Wikipedia promotion process

Jure Leskovec
Stanford University
jure@cs.stanford.edu

Daniel Huttenlocher
Cornell University
dph@cs.cornell.edu

Jon Kleinberg
Cornell University
kleinber@cs.cornell.edu

Abstract

Social media sites are often guided by a core group of committed users engaged in various forms of *governance*. A crucial aspect of this type of governance is *deliberation*, in which such a group reaches decisions on issues of importance to the site. Despite its crucial — though subtle — role in how a number of prominent social media sites function, there has been relatively little investigation of the deliberative aspects of social media governance.

Here we explore this issue, investigating a particular deliberative process that is extensive, public, and recorded: the promotion of Wikipedia admins, which is determined by elections that engage committed members of the Wikipedia community. We find that the group decision-making at the heart of this process exhibits several fundamental forms of *relative assessment*. First we observe that the chance that a voter will support a candidate is strongly dependent on the relationship between characteristics of the voter and the candidate. Second we investigate how both individual voter decisions and overall election outcomes can be based on models that take into account the sequential, public nature of the voting.

Introduction

The overall behavior of a social media site is generally driven by the collective activity of a large population, but in many cases these sites are also guided by a much smaller group of core participants who are strongly committed to the success of the site. The guidance provided by such a core group can take many forms, ranging from assignment of tasks in massive open-source and crowdsourcing projects, to enforcement of explicitly articulated norms and rules on a site like Wikipedia, to much more informal types of on-line organizing, question-answering, and expertise location.

We think of all of these mechanisms as forms of *governance*, a process that plays an important role in social media, despite the fact that it is generally much more subtle — and maintains a much lower profile — than the forms of political, legal, and corporate governance that we are familiar with in the off-line world. Governance in social media involves both deliberation (the reaching of decisions by a core group) and also enforcement (the carrying-out of these decisions). There has been interesting recent work on governance in social media (see e.g. Beschastnikh et al. (2008)), but it remains a topic where there is much still to be understood — particularly on the issue of deliberation, since it can be difficult to find records of the process by which decisions were actually reached.

Work supported in part by NSF grant IIS-0705774.

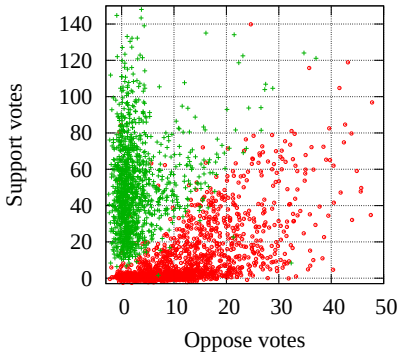


Figure 1: A scatter plot of the number of supporting and opposing votes, and the outcome of each election. Elections leading to promotion to adminship are shown in green; elections that did not lead to promotion are shown in red.

The Present Work: Group Decision-Making and Wikipedia Promotion. In this paper we consider the deliberative aspects of social media governance, by focusing on a setting where detailed traces of group decision-making by a site's elite can be studied.

Our setting is the Wikipedia promotion process, in which users of Wikipedia can be nominated to become *admins* — a category of highly trusted user to whom special administrative privileges are granted. The promotion process has a clearly defined formal structure: the candidate for adminship submits a case for promotion; there is then a period of discussion and deliberation by the community; and this is followed by a vote. There are two important features of this process that are worth noting. First, any Wikipedia user is allowed to vote, not just users who have achieved admin status (although the contents and results of the voting are interpreted by a special class of admins called *bureaucrats* in order to reach a final decision). Second, and crucial for our research purposes, the discussion and voting is carried out

completely in public, and is recorded as part of Wikipedia, so that a transcript is subsequently available. As a very simple illustration to give a sense for the dataset, Figure 1 shows a scatter-plot of the number of positive and negative votes in each Wikipedia promotion election. We describe the dataset in much more detail in a subsequent section.

The Wikipedia promotion process thus has the key ingredients we need: it is a deliberative process carried out by core, committed members of a social-media community; it has the goal of producing a single group decision; and it is publicly recorded, making the analysis possible. It also serves as an instance of a broad type of decision-making, familiar from the off-line world as well as the on-line world, in which people are asked to offer evaluations of other people.

Wikipedia promotion was studied recently by Burke and Kraut (2008); their focus was on considering the process from the perspective of candidates for adminship, using properties of the candidates to develop statistical models capturing their likelihoods of promotion. In contrast, because of our interest in the issue of deliberation, we study the process from the perspective of the voters: we ask how voters evaluate candidates, how a single voter behaves across many different elections, and how voting unfolds over time as an election of a single candidate is carried out in public.

The Present Work: Main Results. Our main findings can be viewed as identifying ways in which a voter's evaluation of an admin candidate reflects different types of *relative assessments* — based on the relation of the voter to the candidate, and to the (public) decisions of other voters.

We begin by analyzing how the relationship between characteristics of a voter V and a candidate C affect V's decision to vote positively or negatively. We find that the probability V will vote positively on C is strongly dependent on the relative values of several basic "figures of merit" for C and V; these include which of C or V has a greater number of edits, and which has a greater number of *barnstars*, awards given by other members of Wikipedia (Kriplean et al. 2008).[1] The extent to which C and V have interacted in the past also has a significant effect on the likelihood that V will vote positively on C. Overall, this analysis suggests that one should think of the likelihood of a positive vote on a candidate not as a function of just the candidate alone, but as a function of both the candidate and the voter.

We then consider the relationship between a voter V's decision and the public decisions of other voters expressed earlier in the election. To make this precise, we show how to compute a *response function* for V, giving the probability that V will vote positively as a function of the fraction of preceding votes that were positive. A non-trivial number of Wikipedia editors have each voted in several hundred elections, making reliable estimates of their individual response functions possible. We find a striking level of diversity in the response functions of these very frequent voters: some of them are very stingy with their positive votes, while others are much freer. These findings raise an intriguing possibility that transcends the particular definition of response functions and addresses the broader issue of aggregation in social data; it suggests that when we observe cumulative curves showing how members of a population respond *in aggregate* to the behavior of others (e.g. the types of social influence analyses found in Backstrom et al. (2006), Kossinets and Watts (2006), and Leskovec et al. (2006)), it may be that these aggregate functions are not typical of any particular individual, but instead represent averages over populations that are highly heterogeneous.

Understanding the relationship among different voters' decisions involves the consideration of how a single election's dynamics play out over time, as votes are cast publicly in sequence. We explore this issue further, asking how these dynamics affect the overall outcome of the election — i.e., whether the group decision is positive or negative. This is the setting of fundamental models for information cascades in economic theory (Banerjee 1992; Bikhchandani et al. 1992), and as such it is interesting to see how the dynamics reflected in the real data compare to the predictions of these models. We find that the probability of an election's success depends heavily on the outcomes of the first few votes — primarily, one expects, because these first few votes provide powerful evidence for the strength of the promotion case. However, with a few structured exceptions that we identify, we do not find strong evidence that the *order* in which a given set of initial positive and negative votes are interleaved has a significant effect on the outcome. This forms an interesting contrast with predictions of "herding" behavior, in which it is argued that a few concurring votes at the outset of a sequential voting process can induce subsequent conformity.

Related Work

As discussed in the introduction, governance in social media includes both deliberation and enforcement. The issue of enforcement, which is distinct from our investigation here, has been the focus of a line of work in human-computer interaction, addressing issues such as how the development and application of norms can help control deviant behavior in on-line communities (see e.g. Cosley et al. (2005) and the references therein).

In the study of deliberation, there have been recent investigations of on-line settings in which public opinions are expressed sequentially, as they are in Wikipedia promotion as well. Wu and Huberman (2008) study the sequences of reviews for a product on Amazon, and Danescu-Niculescu-Mizil et al. (2009) study the question of how the helpfulness of such reviews are evaluated by Amazon's user community. In a related vein, Lerman (2008) studies the patterns of voting for news stories on Digg, identifying patterns that help predict whether a story will become highly popular.

Finally, as noted in the introduction, Burke and Kraut

[1] Here is the definition of a barnstar from Wikipedia: *It is the custom to reward Wikipedia contributors for hard work and due diligence by awarding them a barnstar. To give the award to someone, just place the image on their talk page (or their awards page), and say why you have given it to them. Wiki barnstars were introduced to Wikipedia in December 2003. Since then, the concept has become ingrained in the Wikipedia culture. These awards are part of the Kindness Campaign and are meant to promote civility and WikiLove. They are a form of warm fuzzy: they are free to give and they bring joy to the recipient.*

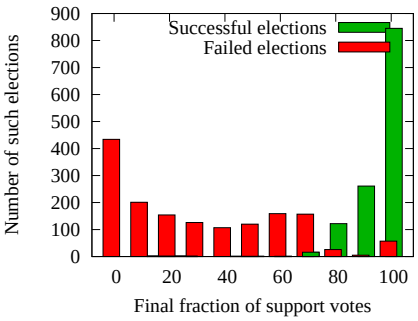


Figure 2: Final fraction of support votes for elections that resulted in promotion and those that did not.

(2008) have previously studied the Wikipedia promotion process, but focusing on the characteristics of candidates rather than on voters as we do here; they analyze textual features describing contributions and user activity to build classifies for predicting adminship election outcomes.

Dataset description

In Wikipedia any user can be nominated for promotion to adminship. When a candidate is considered for a promotion there is a public discussion and vote. Each vote is signed by the user who produced it, and votes are generally accompanied by some explanatory text written by the voter. After the election the record and all the votes are kept in the Wikipedia archives. We collected data on all the elections in the English part of Wikipedia between September 17, 2004 and January 6, 2008, which gave us a set of 2,794 elections.

Votes can be cast in one of three categories: support, oppose and neutral. In our dataset there is a total of 114,040 votes: 83,962 support, 23,118 oppose and 6,960 neutral. This yields a baseline probability of a support vote of 0.784. Each vote can get discussed or commented on by other users and thus rich discussions can develop. Overall 7% of support votes got discussed, while 82% of the oppose votes were commented on or further discussed.

When a candidate is considered for promotion, after about a week-long voting period a Wikipedia bureaucrat in charge of overseeing the election decides whether the nomination for promotion was successful. The bureaucrat makes this decision based on a consensus of voting users. Overall 1,248 (44.6%) elections resulted in successful promotion. In successful elections (i.e., those that resulted in promotion) on average there were 52.2 support, 1.5 neutral and 3.1 oppose votes. On average successful elections concluded with 94.7% of all votes supporting the promotion. For failed elections there were on average 12.5 oppose, 3.3 neutral and 11.9 support votes, and these elections closed with an average of 31% of the votes supporting the promotion. Figure 2 plots the histogram of final fraction of support votes for successful and failed elections.

In principle, any registered Wikipedia user can cast a vote. However a very small fraction them actually do so. 8,298 distinct users participated in elections either as voters (7,499 users) and/or candidates (2,539 users). Notice the number of candidates is smaller than the number of elections as a single candidate can go up for election multiple times until he or she is elected. Table 1 gives statistics about the user population, which we split into the following three disjoint classes:

User type	N	f_v	p_s
Administrators	1,235	44%	0.794
Unsuccessful candidates	1,304	12%	0.748
Other users (voters)	5,759	44%	0.783

Table 1: User statistics. N: number of users, f_v: fraction of votes casted, p_s: probability of a support vote.

- *Administrators* are users for which some election turned out successful.
- *Unsuccessful candidates* are users who went up for promotion but for whom the election(s) turned out unsuccessfully.
- *Other users* are editors that only cast votes but were never considered for promotion to adminship.

For the analyses described in the remainder of the paper we discarded all neutral votes and consider only elections with at least 10 votes. In a small number of cases when a user changed her mind and recast the vote, we consider the last vote cast by that user as the vote.

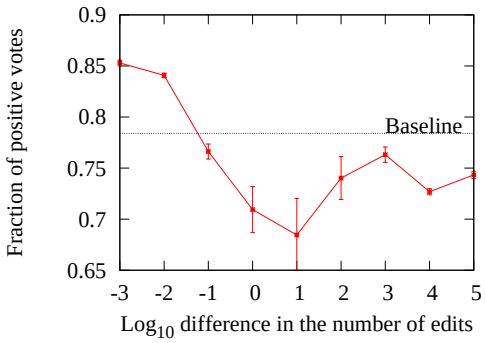
Relative Merit of Candidates and Voters

We begin by considering properties of a voter V and a candidate C that affect V's decision on whether to vote positively or negatively on C.

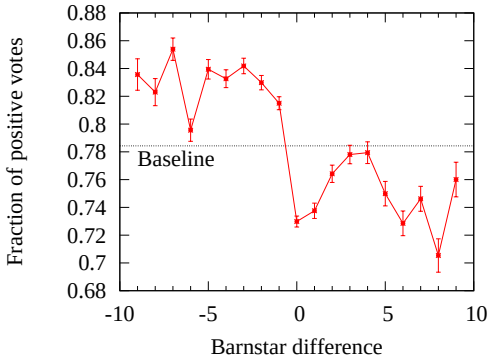
To provide some context for this, recall that Burke and Kraut (2008) analyzed the success of a Wikipedia promotion candidate C based on characteristics exhibited by C. Their work leaves open two qualitatively distinct possibilities. First, it may be that the probability that C receives a positive vote is a function primarily of C's attributes alone — in other words, there are certain criteria for a person to become an admin (i.e., a certain number of edits, a certain number of barnstars, and so forth), and the decision of any voter is mainly an application of these common criteria. Alternately, it may instead be that the probability of C receiving a positive vote depends in a significant way on the relationship between characteristics of C and characteristics of the voter V who casts the vote. In other words, we may want to model voter V as performing a relative assessment of C through implicit (even if not overt) comparison to V's own merit. This latter possibility is particularly intriguing, given several recent lines of work suggesting the importance of relative comparisons between an individual and a peer group, in contrast to absolute evaluations of merit (Burt 2009; Leskovec et al. 2010).

We approach this question by computing univariate measures derived from differences in merit between C and V; this allows us to identify one-dimensional relationships based on these differences. As we now show, there is strong evidence that such measures of *relative merit* between C and V play a significant role in the empirical probability that V votes positively on C.

Relative Merit. In our analysis of relative merit, we will be interested in the *positive-vote fraction*: the overall frac-



(a) Positive vote fraction based on edit-count difference



(b) Positive vote fraction based on barnstar difference

Figure 3: Probability of V voting positively on C given the difference in merit between V and C. (a) Difference in the number of edits between V and C. (b) Difference in the number of barnstars.

tion of positive votes received by candidates from voters, restricted to different sub-populations of the candidates and voters. We consider ways of evaluating a candidate C relative to a voter V based on different figures of merit. We begin with the number of edits to articles, which can be taken as a basic measure of the total activity (and hence, in some sense, contributions) on Wikipedia.

In Figure 3(a), we show the probability that a voter V will support a candidate C as a function of the signed logarithm ($\text{sign}(x) \cdot \log_{10}(|x|)$) of the difference in the number of edits they've each made. (Thus a negative value means that V has made fewer edits than C, while a positive value means that V has made more edits than C, and these differences appear on the x-axis on a logarithmic scale.) We observe several important features of this plot. First, it is significantly higher to the left of 0 (when candidate C has more edits) than it is to the right of 0 (when voter V has more edits). This is the most basic indication that the relative merit of V and C is playing a role. Moreover, the effect on the positive-vote fraction is significant over multiple orders of magnitude in the difference of edit counts.

Non-Monotonic Effects of Relative Merit. There is a further striking point to note about Figure 3(a): not only is there a drop in the positive-vote fraction as we move from negative log-differences to positive ones, but there is also a "rebound" in which the positive vote fraction climbs again once the log-difference exceeds 1. (The error bars indicate that this effect is significant.) This means that, in aggregate, voters are *least likely* to support candidates who have edit counts that are approximately the same as their own. Note that even though there is a rebound when V has higher edit count than C, the probability of V voting positively is still below the baseline.

In Figure 3(b) we perform the same analysis for a different relative figure of merit: the difference between the number of barnstars received by the candidate C and the voter V. (Again, a negative difference means that the candidate has more barnstars than the voter.) The shape of the curve is surprisingly similar, given that the measure of merit is quite different; again we see the drop from negative differences to positive ones, and the same non-monotonicity around 0. There is an additional interesting feature in Figure 3(b): the single biggest change in the positive-vote fraction occurs when we move from negative barnstar differences to non-negative barnstar differences. This suggests that in analyzing relative merit based on barnstars, the sign of the difference — i.e. the simple contrast between whether the voter has more barnstars than the candidate or fewer — is more salient that the actual numerical value of the difference.

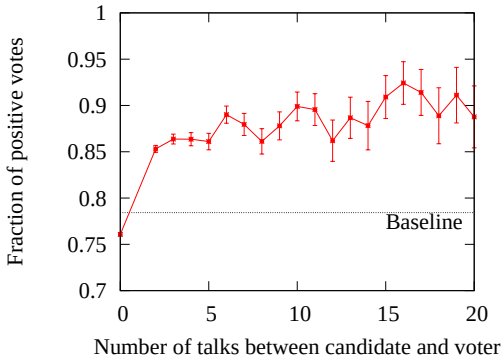
The non-monotonicity around 0, and the fact that it shows up so significantly in both curves, suggests some intriguing conjectures about relative merit. In particular, it suggests that voters are particularly critical of candidates whose level of achievement is comparable to their own — a contrast with the simpler (and incorrect) hypothesis that the support of voters for candidates should be purely monotonic in this relative level of achievement. Such a conjecture forms an interesting connection to the recent lines of research in social networks mentioned earlier, studying the roles played by relative assessments in comparison to a peer group.

Direct Voter-Candidate Interactions. Finally, we consider an even more direct kind of relationship between a candidate C and a voter V: the extent to which C and V communicated prior to the election. We use edits that C and V made to each other's user-talk pages on Wikipedia as the trace data for the history of communication between them.

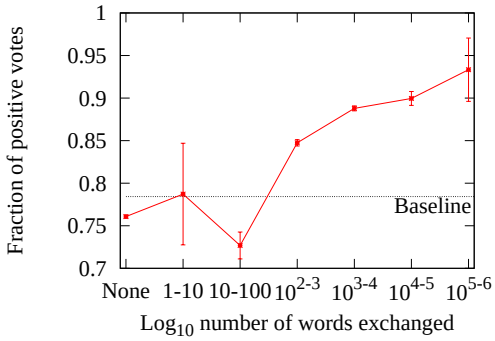
Figure 4 examines this by plotting the probability of a support vote versus the number of talk-page edits between the candidate and the voter (Figure 4(a)) and the total number of words exchanged by the voter and the candidate on their respective talk pages (Figure 4(b)). We see that there is a clear upward effect in which the probability that V will vote positively on C tends to increase with the amount of direct communication that the two have had. Figure 4(a) in particular indicates that the simple existence or non-existence of prior communication between C and V has a large effect on the probability of a positive vote.

Thresholds and Diversity in Voter Behavior

So far we examined how voters make decisions by comparing the candidate to themselves. Now, we examine how voters evaluate the candidate in the context of previous votes in the election. We explore how voters make decisions in the context of a specific election, as it unfolds over time and in public. In this context we are interested in threshold-based



(a) Positive vote fraction based on talk activity



(b) Positive vote fraction based on number of exchanged words

Figure 4: Probability of V voting positively on C given the number of talk interactions and the total number of exchanged words between V and C.

models that characterize changes in voter behavior based on the current state of the election. Our investigation addresses two basic issues: the relevance of threshold-based models, and the diversity of thresholds across different voters.

Threshold-Based Analysis of Voting Behavior. The first issue is the relevance of threshold-based models in analyzing how voters behave in an election. For any vote cast in any election, we can define its *positive precedent* to be the fraction of positive votes in the election up to that moment. (In other words, if a vote was cast in an election at a moment when the current vote count was 16 in favor and 4 against, then the positive precedent of that vote would be $16/(16+4) = 0.8$.) Now, we define a *response function* $f(x)$ as follows: over all votes with a positive precedent of x, we set $f(x)$ equal to the fraction that were positive.

The fact that the elections are carried out sequentially in public forms the motivation for this function: it is possible for a voter to know the current fraction of positive votes (i.e. the positive precedent) at the moment she casts her vote. If, for example, each voter flipped a coin with bias equal to the current fraction of positive votes, and used this as her vote, then we would see a response function $f(x) \approx x$. The extent to which a plot of $f(x)$ deviates above or below the line $y = x$ can thus be taken as evidence of a deviation from this baseline.

In Figure 5, we show a plot of the function $f(x)$, compared to the diagonal line $y = x$. We see that $f(x) > x$ for small values of x (up to about 0.3) and $f(x) < x$ for larger values of x (above 0.3, with the effect becoming particularly pronounced above 0.6). This is consistent with recent theories of sequential expressions of opinion in on-line settings (Wu and Huberman 2008); these theories argue that such deviations represent a tendency for users to be more motivated to express an opinion when it goes against the prevailing outcome. In this case, the argument would be that users who view a candidate positively would be particularly motivated to cast a positive vote (rather than simply not to vote at all) if they see that the fraction of positive votes is particularly low. The corresponding reasoning concerning negative opinions would support the observed downward deviation of $f(x)$ at larger values of x.

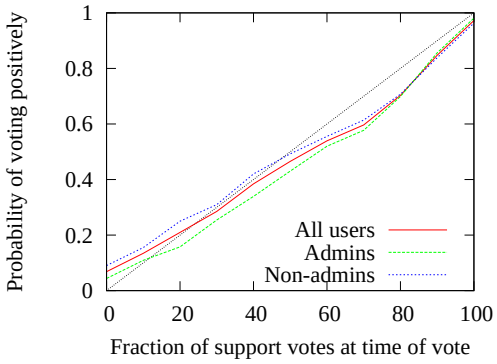
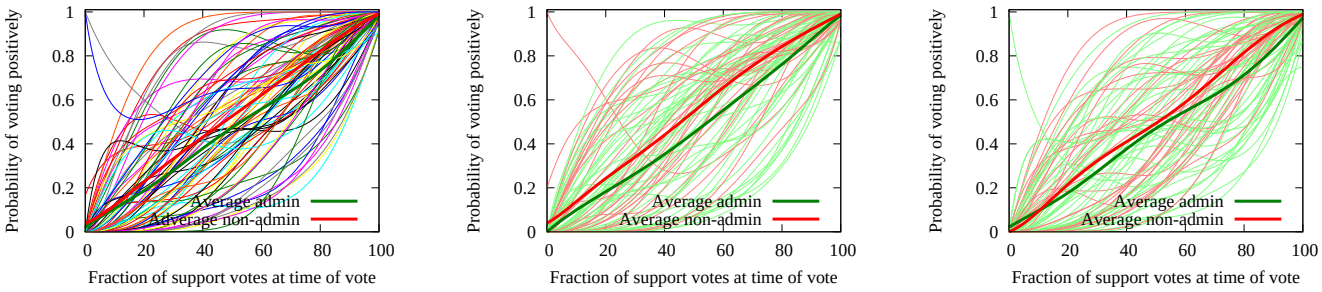


Figure 5: Response function $f(x)$, and also aggregated separately over the sub-populations of admins and non-admins.

Figure 5 also shows plots of $f(x)$ aggregated over the sub-populations of admins and non-admins. (Non-admins are Unsucessful-candidates and Other users.) This partition of the full population is a useful one in a number of our analyses in this section: although any Wikipedia user is allowed to vote in a promotion election, the admins are the ones who have successfully passed through the promotion process themselves, and they are the ones most overtly charged with ensuring that Wikipedia functions effectively. Thus, this division into the two sub-populations provides us with a way to separately study the users who are most invested in the outcome of the process and the users who are participating in the process but less invested. In the plot, we find that when x is small, $f(x) \approx x$ holds more closely in the admin population than in the non-admin population; non-admins in aggregate appear to be significantly more generous with their positive votes in elections where the positive-vote fraction is low. At large values of x, the two sub-populations agree very closely.

Diversity of Individual Response Functions. Just as we defined a function $f(x)$ for the whole population, we can define a *personal response function* $f_i(x)$ for each voter i. We define $f_i(x)$ to be simply the analogue of $f(x)$ applied only the votes of voter i: over all votes with a positive precedent of x that were cast by i, we set $f_i(x)$ equal to the fraction that were positive.

The natural worry in defining such a function is that there will not be enough data on any individual i to be able to



(a) Votes in all elections (b) Votes in first half of elections (c) Votes in second half of elections

Figure 8: 78 voters that participated in more than 200 elections. We take all their participation and only first and only second half of elections they participate in.

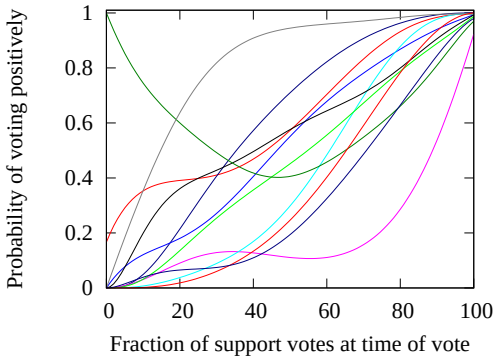


Figure 6: Personal response functions for 11 users that voted on more than 400 elections.

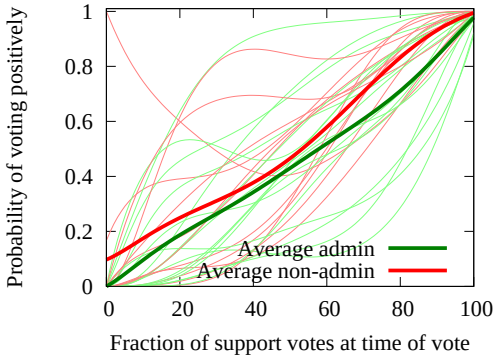


Figure 7: Response functions of admins (green) vs. non-admins (red). Notice large variations in each sub-population.

meaningfully estimate $f_i(x)$. But on Wikipedia, there are close to a hundred users who have voted in more than 200 elections, and for these users we can reasonably estimate $f_i(x)$ with x rounded to the nearest multiple of 0.1.

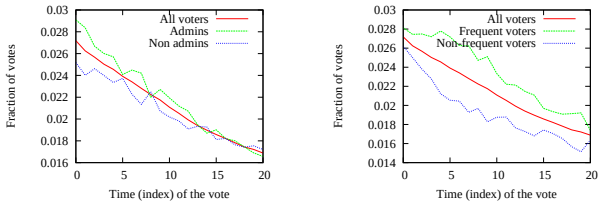
Figure 6 plots the estimated personal response functions $f_i(x)$ for the 11 users who each voted in more than 400 elections, and Figure 7 plots the estimated personal response functions for the 28 users who each voted in more than 300 elections. What is immediately striking is the considerable diversity in the shapes that these functions take. Some users tend to vote overwhelmingly negatively whenever the current fraction of positive votes is below 70%, while others are likely to vote positively even when most votes thus far in the election have been negative. The comparison of this diversity with the approximately diagonal shape of the cumulative function $f(x)$ suggests that $f(x)$ represents in aggregate, over the whole population, what is in reality an averaging of a highly diverse set of individual response functions. This is an important issue to bear in mind whenever we study such population aggregates; what is unusual in this case is that we have a non-trivial collection of individuals with sufficiently extensive personal histories in the system that we can actually build curves for each of their individual patterns of behavior.

In Figure 7, we also average separately over the admin and non-admin sub-populations of this group of extremely frequent voters. The fact that the admin curve is uniformly lower than the non-admin curve is consistent with the more conservative approach to voting — in aggregate — that we saw for the admin sub-population in Figure 5 as well.

Finally, given the extensive personal histories of 78 users who have voted in over 200 elections each, we can study how their voting behavior evolves over time, by looking at a voter i's personal response function $f_i^{(1)}(x)$ built only over the first half of the elections that i participated in (in chronological order), and the function $f_i^{(2)}(x)$ built only over the second half of the elections that i participated in. We find (in Figure 8) a general tendency for voters to become more conservative in their use of positive votes over time, and particularly for non-admins: the population average of $f_i^{(2)}(x)$ over the non-admins in this group is clearly lower than the population average of $f_i^{(1)}(x)$ over this group. For the admins, on the other hand, the population averages of these two functions are more similar, indicating a kind of aggregate stability in the voting behavior of frequently voting admins as they "grow older" in Wikipedia.

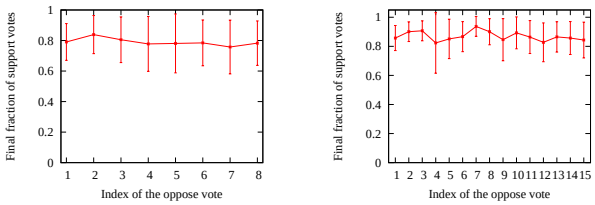
Timing of Entry. A further issue is when, over the sequence of votes in an election, different voters tend to arrive to cast their votes. For a given voter, the timing of one's arrival affects how much information one has about earlier votes, which may in turn affect one's own vote.

In Figure 9, we show when different sub-populations of voters tend to cast their votes, relative to the overall population average. We find much less difference between the admin and non-admin population (panel (a)) than we do between the populations of frequent and infrequent voters



(a) Admins (b) Frequent voters

Figure 9: (a) Time when admins and non-admins cast their votes. (b) Time when heavy and non-heavy voters cast votes.



(a) First 8 votes (b) First 15 votes

Figure 12: Average fraction of support votes in the election as a function of the index of the first oppose vote.

(panel (b)); in this latter case, frequent voters tend to cast their votes earlier in the election than non-frequent voters do. Interestingly, however, we do not find any significant dependence between the time at which a voter casts her vote and the positive/negative value of that vote.

Dynamics of Elections over Time

In the previous section, we considered how the aggregate dynamics of an election over time affected the decision of a particular voter at the time that he or she arrived to cast a vote. We now examine the same process at much finer resolution. We consider how the fine grained temporal dynamics of votes affects the overall election outcome — namely, we study how vote order affects the election outcome. Our main finding is that the temporal order of votes — taking the final tally as given — does not have a significant effect on the outcome, with a few exceptions that we note below.

The History of an Election. We make these question precise as follows. Consider an election e, and let p_e and n_e be the total number of positive and negative votes, respectively, that were cast in election e. The full record of a public election with sequential voting also includes the order in which the votes were cast; we define $p_e(j)$ and $n_e(j)$ to be the number of positive and negative votes in election e up through the point at which j votes in total had been cast. We define the *history* of the election e to be the sequence of points $\{(n_e(j), p_e(j)) : j = 0, 1, 2, \ldots, \text{length(e)}\}$, and we define the *running fraction* of positive votes to be the sequence of fractions $\{p_e(j)/j : j = 1, 2, 3, \ldots\}$. Figure 10(a) provides a visual representation of the histories of all elections; each history is a sequence of two-dimensional points leading from origin at $(0, 0)$ to the final tally (n_e, p_e).

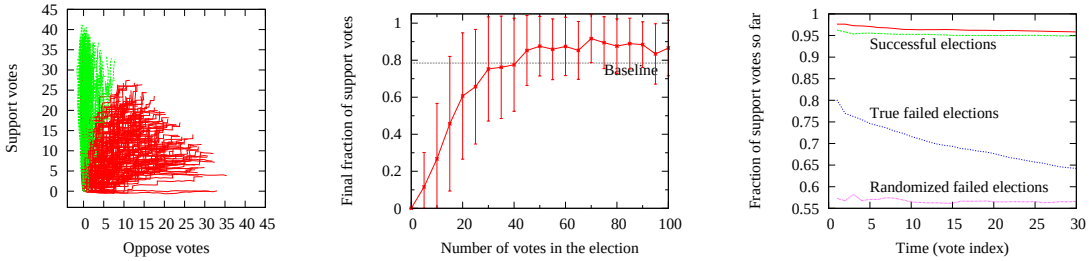
We begin with some basic initial observations about the histories of the elections in our dataset. First, as shown in Figure 10(b), the Wikipedia bureaucrats who regulate the election process tend to end very negative elections early, so that elections with long histories (of about 40 votes or more) tend to be the more successful ones. Second, we find that unsuccessful elections tend to be "top-heavy" with an overrepresentation of positive votes early, and an overrepresentation of negative votes later. Figure 10(c) provides an analysis of this: in an unsuccessful election, the running fraction of positive votes declines over time, down to the randomized baseline one gets by randomly permuting the order of the votes. Successful elections, on the other hand, exhibit a relatively stable running fraction of positive votes; it resembles the running fraction one would get even if the order of the votes were randomly permuted. One conjecture is that in unsuccessful elections, a candidate's close supporters vote early, leading to an elevated fraction of positive votes, but this then declines as a broader set of voters arrives.

The Prefix of an Election's History. We also consider the specific effect of the very first few votes in an election's history. Figure 11 shows a tree of all possible prefixes of lengths 1, 2, 3 that an election's history can have, and gives the total number of elections and the number of successful elections for each such prefix. Considering the prefixes that each contain the same number of positive and negative votes reveals an interesting pattern.

When considering the length-2 prefixes with a 1:1 tally we see that (support,oppose) produces elections with a considerably lower rate of success, 0.127, than for (oppose,support), which has a success rate of of 0.192, even though the vote count is the same at the end of these two prefixes. For length-3 prefixes, there are three patterns with the tally 2:1 and three patterns with the tally 1:2. In each of these cases, the two patterns that do not start with (support,oppose) have essentially the same success rates as one another whereas the pattern that starts with (support,oppose) has a lower success rate. For example, the prefixes (support,support,oppose) and (oppose,support,support) have rates of 0.328 and 0.323 respectively, whereas (support,oppose,support) has a considerably lower rate of 0.277.

The discrepancy between these cases can be taken as a further reflection of the idea from Figure 10(c), that in unsuccessful elections, a candidate's close supporters tend to vote early. This discrepancy also forms an interesting contrast with results in economic theory suggesting that initial positive votes can induce "herding," elevating the probability of success (Banerjee 1992; Bikhchandani et al. 1992). The difference between (support,oppose) and (oppose,support) shows the opposite contrast in our case, due to the selection effects of a candidate's endorsers voting early.

Finally, we ask whether, in an election where support is very strong, the timing of a single early negative vote can have a significant effect. As shown in Figure 12, it does not: in elections where the tally after the first 8 votes is 7 positive and 1 negative (panel (a)), and in elections where the tally after the first 15 votes is 14 positive and 1 negative (panel (b)), the position in which the one negative vote occurs has essentially no effect on the probability of a successful overall outcome. This again reflects the ways in which timing effects appear to be more noticeable in unsuccessful elections than successful ones.



(a) Election progression (b) Election success (c) Election drift

Figure 10: (a) Progression of the election over time. Each election is a trail of support and oppose votes. (b) Probability that election results in promotion as a function of the number of votes. (c) Current fraction of positive votes as a function of time for failed and successful elections. Successful elections remain positive over time, while in negative elections the fraction of positive votes decreases over time.

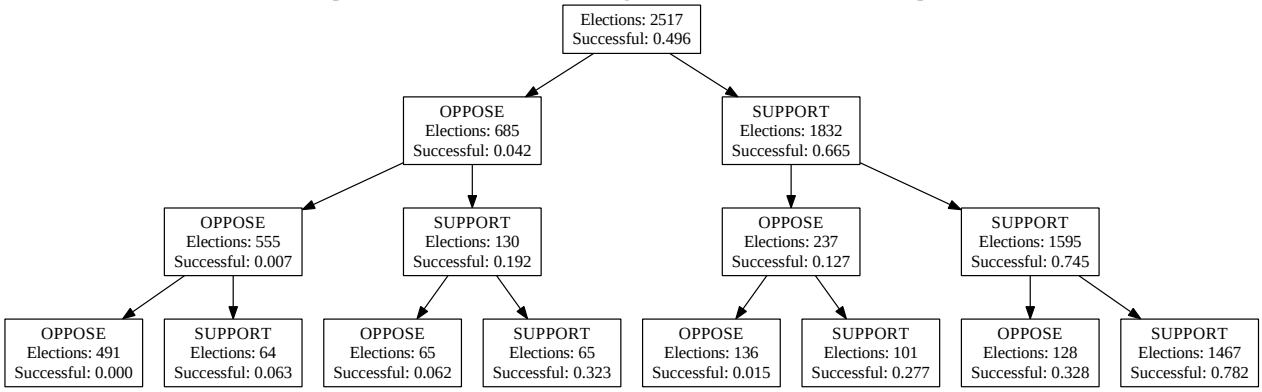


Figure 11: Election tree. Notice that the order is not important but only the number of positive/negative votes.

Conclusion

As a case study of social-media governance, we have investigated the Wikipedia promotion process from the perspective of the voters engaged in group decision-making. We have identified several forms of *relative assessment* that play an important role in how voters make decisions; these include how relative characteristics of voters and candidates affect the probability of positive votes, as well as how voters' decisions depend on the state of the election at the time they cast their votes. We have also investigated the temporal dynamics of the elections, identifying ordering effects that contrast with standard theories of herding and information cascades.

This style of analysis suggests a range of further interesting questions related to governance and deliberation. It would be interesting to connect our findings on the relative merit of voters and candidates more closely to the recent work of Burt (2009) and others on the role that relative comparison plays in social networks. We would also like to try integrating our analyses of temporal dynamics in elections with Bayesian models of information cascades (Banerjee 1992). Finally, we believe that the style of analysis used here could be productively combined with textual analysis of the content of discussions that arise as part of deliberation on social-media sites; such a hybrid of textual and structural approaches could well yield further insights.

References

Backstrom, L.; Huttenlocher, D.; Kleinberg, J.; and Lan, X. 2006. Group formation in large social networks: Membership, growth, and evolution. In *KDD*, 44-54.

Banerjee, A. 1992. A simple model of herd behavior. *Quarterly Journal of Economics* 107:797–817.

Beschastnikh, I.; Kriplean, T.; McDonald, D. 2008. Wikipedian self-governance in action: Motivating the policy lens. *ICWSM*.

Bikhchandani, S.; Hirshleifer, D.; and Welch, I. 1992. A theory of fads, fashion, custom and cultural change as information cascades. *J. Political Econ.* 100:992–1026.

Burke, M., and Kraut, R. 2008. Mopping up: Modeling wikipedia promotion decisions. In *Proc. CSCW '08*, 27–36.

Burt, R. S. 2009. *Neighbor Networks: Competitive Advantage Local and Personal*. Oxford University Press.

Cosley, D.; Frankowski, D.; Kiesler, S. B.; Terveen, L. G.; and Riedl, J. 2005. How oversight improves member-maintained communities. In *Proc. ACM CHI*, 11–20.

Danescu-Niculescu-Mizil, C.; Kossinets, G.; Kleinberg, J.; Lee, L. 2009. How opinions are received by online communities: A case study on Amazon.com helpfulness votes. In *WWW*, 141–150.

Kossinets, G., and Watts, D. 2006. Empirical analysis of an evolving social network. *Science* 311:88–90.

Kriplean, T.; Beschastnikh, I.; and McDonald, D. W. 2008. Articulations of wikiwork: uncovering valued work in wikipedia through barnstars. In *CSCW*, 47–56.

Lerman, K., and Galstyan, A. 2008. Analysis of social voting patterns on Digg. In *1st Workshop on Online Social Networks*.

Leskovec, J.; Adamic, L.; and Huberman, B. 2006. The dynamics of viral marketing. In *Proc. ACM EC*.

Leskovec, J.; Huttenlocher, D.; and Kleinberg, J. 2010. Signed networks in social media. In *Proc. CHI*.

Wu, F., and Huberman, B. A. 2008. How public opinion forms. In *Proc. WINE*, 334–341.