

Filter Bubbles, Echo Chambers, and Reinforcement: Tracing Populism in Election Data

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Abstract

We present a novel model for the effect of echo chambers, filter bubbles, and reinforcement on election results. We analyze the model, determine the invariant measure, and show that reinforcement may lead to phase transitions. We use that model to analyze election data from US presidential elections, the Brexit referendum, and elections in France, The Netherlands, and Germany. We find in many cases that populist parties and candidates can be clearly identified by a high level of reinforcement. Furthermore, we find the phase transition predicted by the model back in data. We discuss implications and relevance of our findings.

1 Introduction

We are living in the age of rising populism. A statement like that is quite abundant in recent publications. Though we often come over the term “populism”, there is no unique, commonly accepted definition in the political and sociological literature. Different authors use a wide variety of concepts to narrow down the term “populism” [15]: Economic, social, and political aspects, organization, communication, or personality of persons centrally involved are used to propose a characterization. Right- and left populist movements and parties are described, the variants of populism on the different continents have been analyzed, etc. Among others, Mudde and Kaltwasser [30] developed the idea of populism as a “thin ideology”. In that fruitful interpretation, populism expresses a structural and organizational framework that can be associated with any ideology rather than being an ideology in itself. One central aspect discussed is the segregating habit of populist movements. They often divide the citizenship into a (corrupt, evil) elite and the (ordinary, plain and good) people. If a right ideology is involved, the term “people” also incorporates a connotation of natives in contrast to immigrants (even where historically and sociologically unjustifiable). Populists divide the population into an in- and an out-group, where the in-group is good and accepted, while the out-group is bad and must either be converted or fought.

This strongly segregating mindset may also affect discussion and communication structures, or the conception and release of news and fake-news. Members of a populist group tend in a higher degree than the average population to accept uncritically the opinion of their own group and to refuse other opinions [1]. The opinion, or even fake-news, is not taken verbally but rather as a sign of the group membership. This aspect in the communication structure might not in all cases be predominant, but seems to be a logical consequence of the populist’s world understanding.

We focus on that aspect, and augment well known models for democratic elections, variants of the Voter model, by reinforcement.

Statistical patterns in election data are observed and investigated since several years [6, 2, 10, 34]. Step by step, mechanisms that cause these patterns become visible. It is possible to distinguish neutral and non-neutral explaining mechanisms. Non-neutral approaches take the political direction of parties into account. The most prominent representative in this line of research is the Hotelling model [19], that uses game theory to understand how parties position themselves in the political arena. That model is refined, e.g., into the valence model, which is able to describe the political landscape of many western democracies [37, 39, 38].

A recent line of thinking is based on neutral models: Many of the observed statistical features can be explained by models that do not take into account the political direction of parties. In those models, parties are assumed to stand for groups of individuals who are committed to a common attitude. A well investigated example is the noisy voter model [10]. In the context of elections, this model is called the zealot model, and successfully used to explain several structures appearing in election data, as the variance structure [3, 25], the fraction of swing voters who readily change their favorite party [36], or to obtain an idea about the time to consensus [29]. The voter model with party dynamics is an alternative approach, where the fixed number of parties in the zealot model is replaced by a dynamical mechanism, in which parties can be created and vanish again [18]. This approach explains the observed log-linear structure in election data. Fortunato and Castellano [12] give reason for the characteristic distribution of candidates' vote shares (were the candidates are in the same party) by a linear branching process. All these models do not allow for bifurcations and phase transitions. Also models that exhibit phase transitions are used in mathematical sociology [13, 28]. Particularly, Nicolao and Ostilli used a Potts model to investigate twitter data related to elections [33]. The Potts model (in the variant of the Curie-Weiss model) shows a phase transition for certain parameter combinations. In their data analysis, the authors identify parameters that often are close to those critical parameter values. In some cases, the data indicated that the twitter system spontaneously breaks the symmetry, which is to expect for a supercritical system.

In the present paper, we augment the zealot model by reinforcement. In that, we are able to contribute to the answer of the question if reinforcement, filter bubbles, and echo chambers are important enough for populist parties or candidates to leave a clear trace in statistical pattern of election data. We investigate a strong- and a weak-effects limit for large population sizes. Here we find bifurcations and phase transitions, as in the Potts model. In the limit for weak effects, we derive explicitly the invariant measure for the vote share in the reinforcement model. Analysis of election data show that often the reinforcement describes the data appropriately, and significantly better than the zealot model. Obviously, reinforcement and echo chambers represent forces that are visible in the empirical data. Astonishingly, it is often (but not always) possible to clearly identify populist parties and candidates as they show a high reinforcement parameter (US, Germany, Brexit, but not France). Also the traces of phase transitions are visible in election data (US and The Netherlands). At the end, we discuss the implications and the relevance of our results.

2 Model, model analysis, and model prediction

In the present section, we modify the zealot/noisy voter model to cover basic effects of echo chambers and reinforcement. In the underlying basic voter model (without zealots) [27], each individual adopts an opinion (opinion 1 or opinion 2). At rate $\mu > 0$, a person rethinks his/her opinion, and copies the opinion of a randomly chosen population member. In the situation of a finite, homogeneously mixing population, this Markov process will end up in an absorbing state, where only opinion 1 or opinion 2 is present. The other opinion dies out. This outcome is unrealistic. In the zealot model [3], apart of floating voters (persons who change their opinion), there are zealots. Zealots represent persons who have a strong opinion and will not change their mind, or other influences that advocate a distinct opinion, as newspapers or other mass media. Moreover, zealots influence the opinion of floating voters: a floating persons copies the opinion of a randomly selected individual out of the group of all individuals – floating voters as well as zealots. In that, all opinions persist for all times. The zealot model has no absorbing state and a non-trivial invariant distribution.

We augment that model by reinforcement and echo chambers. Persons who “life” in an echo chamber will not interact with a representative sample of the population, but with a sample of persons who are more likely to share his/her opinion. We introduce weights $\vartheta_i \in (0, 1]$ to express the reduced interaction with the opponent group.

Let N denote the total population size, N_i the number of zealots for opinion $i \in \{1, 2\}$, and $\vartheta_i \in (0, 1]$ the weights for the opposite opinion. If X_t is the number of supporters for opinion 1, while $N - X_t$ is that for opinion 2, then

$$X_t \rightarrow X_t + 1 \quad \text{at rate} \quad \mu(N - X_t) \frac{\vartheta_1(X_t + N_1)}{\vartheta_1(X_t + N_1) + (N - X_t + N_2)}, \quad (1)$$

$$X_t \rightarrow X_t - 1 \quad \text{at rate} \quad \mu X_t \frac{\vartheta_2(N - X_t + N_2)}{(X_t + N_1) + \vartheta_2(N - X_t + N_2)}. \quad (2)$$

Note that ϑ_1 is the probability of group-2-individuals to interact with group 1, and ϑ_2 that of group-1-members to interact with group 2. To be clear: ϑ_2 measures the strength of reinforcement of group 1. Obviously, this model agrees with the zealot model in case of $\vartheta_1 = \vartheta_2 = 1$.

In order to understand the properties of the model, we investigate the vote share in the continuum limit $N \rightarrow \infty$. As it is well known from parallel investigations in population genetics [41, 9, 17], two different scales of the parameters are sensible: Either N_i are constant in N and $\vartheta_i = 1 + \mathcal{O}(N^{-1})$ (weak effects limit, the effect of zealots and reinforcement become small if the population size becomes large), or the number of zealots scale linearly with N , s.t. $N_i = n_i N$, while the reinforcement parameters ϑ_i are constant in N (deterministic limit).

We start with the deterministic limit. If the intrinsic and extrinsic influences are strong, often the state can be well approximated by a normal distribution with a variance that declines with the inverse of the population size. In the limit, we obtain an ordinary differential equation (ODE) for the fraction of opinion-1-supporters, (n_i are the ratio of zealots over free voters, N_i/N , for a derivation see the SI I)

$$\dot{x} = -\mu x \frac{\vartheta_2(1 - x + n_2)}{(x + n_1) + \vartheta_2(1 - x + n_2)} + \mu(1 - x) \frac{\vartheta_1(x + n_1)}{\vartheta_1(x + n_1) + (1 - x + n_2)}. \quad (3)$$

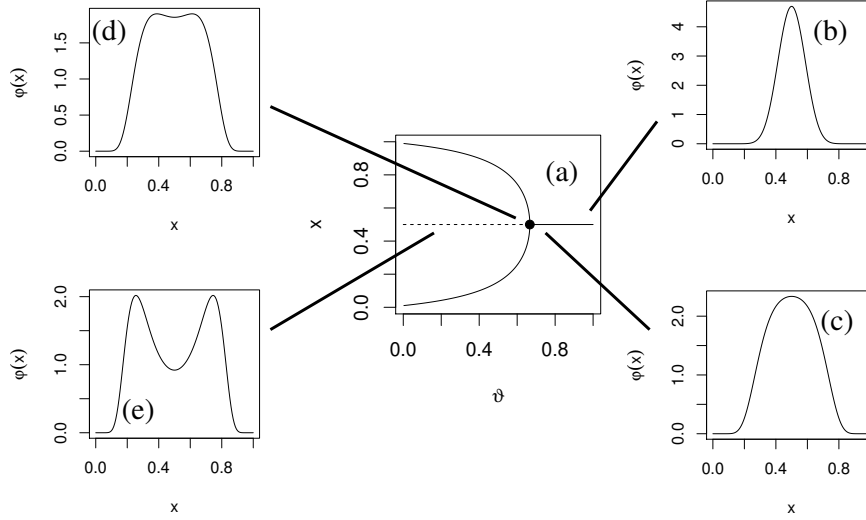


Figure 1: Panel (a): Stationary states (solid lines: locally asymptotically stable, dashed line: unstable) and pitchfork bifurcation (indicated by a bullet). Panels (b)-(d): invariant measures. Parameters (a): $n_1 = n_2 = 0.1$, $\vartheta_1 = \vartheta_2 = \vartheta$; (b)-(d): $N_1 = N_2 = 20$, $\theta_1 = \theta_2 = 10$ in (a), $\theta_1 = \theta_2 = 70$ in (b), $\theta_1 = \theta_2 = 80$ in (c), $\theta_1 = \theta_2 = 100$ in (d).

It is possible to analyze bifurcations (change-points in the structure of stationary solutions, see Fig. 1 (a) and SI I).

Particularly, in the symmetric case (all group-specific parameters N_i , ϑ_i are identical for both groups), we find a Pitchfork bifurcation if the reinforcement becomes large. If ϑ_i (the probability to interact with the opposite group) drops below a certain threshold, suddenly two stationary states appear, both of them are locally asymptotically stable. One of the two opinions will prevail, and the other opinion (which has the potential to also prevail) cannot influence the population strongly enough to change this state. In non-symmetric cases, the group that follows a strong reinforcement strategy also has a strong advantage versus the opponent's group. Even if the opponent group has way more zealots, the reinforcement strategy leads to a situation where that opinion prevails (see SI I).

The deterministic limit allows to easily analyze and visualize the long term behavior. Population genetics [41, 9, 17] shows the weak effects rather more realistic if it comes to the analysis of real world data. That is, the zealots are constant in number, and the reinforcement declines with the inverse of the free voters' number, $\vartheta_i = 1 - \theta_i/N$. Under these assumptions we obtain an explicit formula for the invariant distribution of group 1's vote share x for $N \rightarrow \infty$, (SI I)

$$\varphi(x) = C e^{\frac{1}{2}(\theta_1 + \theta_2)x^2 - \theta_1 x} x^{N_1-1} (1-x)^{N_2-1}. \quad (4)$$

The second term, $x^{N_1-1} (1-x)^{N_2-1}$, only depends on the zealot's numbers. This term is a beta distribution, which is modified by the first factor $e^{\frac{1}{2}(\theta_1 + \theta_2)x^2 - \theta_1 x}$ that reflects the effect of reinforcement. The multiplicative constant C ensures that the integral of the distribution is 1.

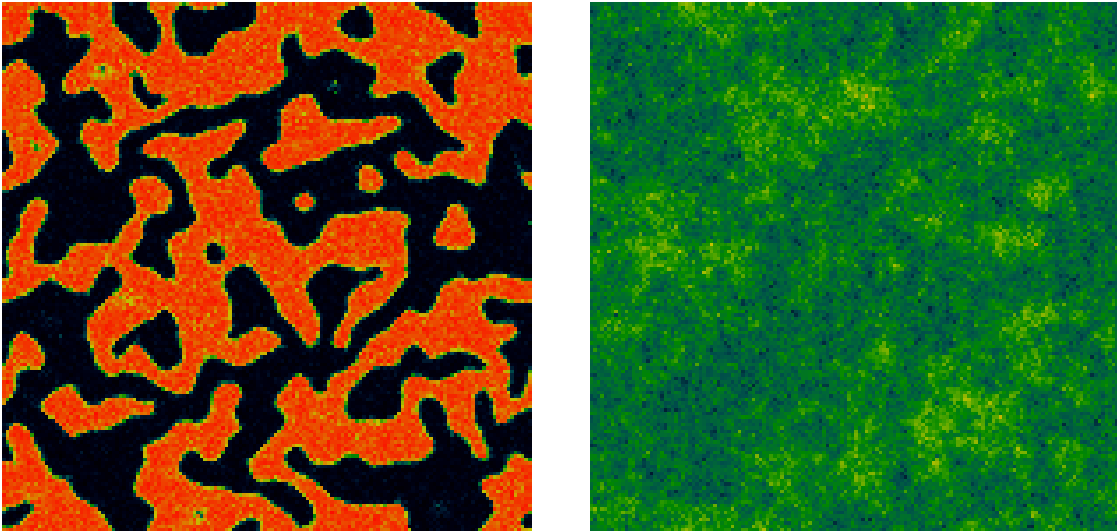


Figure 2: Simulation of the spatial reinforcement model. Left: $N_a = N_b = 6$, $\vartheta_1 = \vartheta_2 = 109$, $\gamma = 200$. Right: $N_a = 16$, $N_b = 26$, $\vartheta_1 = \vartheta_2 = 110$, $\gamma = 200$.

As indicated in Fig. 1 (b)-(d), the bifurcations in the deterministic limit can be found back in the invariant measure of the weak-effects limit. If the scaled reinforcement parameters θ_i become large, the unimodal distribution becomes bimodal, which corresponds to the pitchfork bifurcation observed above. In terms of statistical physics [26], the positive feedback introduced by the reinforcement mechanism is able to drive the system into a phase transition.

Up to now, we assumed that we only consider a homogeneous population. However, real world populations are heterogeneously, either induced by spatial, or by social structure. In an attempt to define a simple model covering that effect, we introduce a squared lattice, where in each node a subpopulation is located. The subpopulations communicate with neighboring subpopulations. Under the assumption of weak effects, we are able to determine the invariant measure. Simulations reveal that the spatial reinforcement model behaves in the same way as the Ising model, given appropriate parameter values (Fig. 2). Particularly, we find heterogeneous patterns which are built up from homogeneous regions, paralleling the magnetic domains in the Ising model. Within those domains, the state is rather homogeneously distributed around one of the two bistable states, such that the resulting distribution resembles that of a standard zealot model without reinforcement. Only if the domain that we consider is large enough to contain different homogeneous regions, the reinforcement becomes clearly visible. As the range of those domains depend on the parameter of the models, it might be that a whole country looks homogeneously, in which case the reinforcement is difficult to detect in data.

3 Data analysis

The results derived so far are intriguing, but exclusively theoretical. In the present section we compare the theoretical predictions with empirical findings. Hereby, we assume that each election district is an independent and identical realization of the invariant distribution of an

democratic process. This assumption is of course a simplification: First of all, there is a spatial correlation in the election results [2]. Furthermore, election districts are influenced by social covariates or nuisance variables as income or the dichotomy rural/city area. Furthermore, we developed our theory for dichotomous elections, but apply the results also for multi-party systems in focusing on one given party, and lumping all other parties together into one pseudo-group. However, if we pool the districts, it is possible that some of the perturbing influences become less important. And indeed, as we will find out, our models describe the data quite well. We particularly use a maximum-likelihood method to estimate parameters, which is somewhat subtle in the present context [40]. The Kolmogorov-Smirnov test (KS) will be applied to check if the theory is consistent with empirical data, and the likelihood-ratio test (LL) to compare the performance of the reinforcement model and the well introduced zealot model.

US presidential elections We find a good agreement of the reinforcement model and data for the recent US presidential elections 2004-2016 (Fig. 3). The Kolmogorov-Smirnov test yields p -values larger or equal 0.12, indicating that the model cannot be rejected. For the 2004-elections, the pure zealot model fits equally well, but for 2008-2016, step by step, the reinforcement model becomes more and more superior, until the zealot model has to be rejected highly significantly in favour to the reinforcement model for the 2016-elections (see SI II for details, point estimates and test results).

If we inspect the reinforcement parameters for the two parties (Fig. 4), we find that the reinforcement for the democrats is rather unimportant (in comparison to that of the republicans) before the 2016 elections. In the 2016 election, the reinforcement of the democrats jumps to the value of the republicans before 2016. Furthermore, the reinforcement of the republicans in 2016 suddenly shows a threefold increase. We detect here the consequences of the populist attitude of the republican’s candidate Trump.

Brexit The reinforcement-model is statistically clearly superior to the zealot model to describe the Brexit data (likelihood-ratio test $p = 1.3 \cdot 10^{-11}$). Also the Kolmogorov-Smirnov test clearly indicates that the reinforcement-model cannot be rejected ($p = 0.75$), but the zealot model that does not incorporate reinforcement is not appropriate (KS: $p = 0.0009$). Interestingly, the point estimates for θ_i , suggests that the brexiters are responsible for over 99% of the reinforcement. In order to investigate this finding more thoroughly, we use the likelihood-ratio test to compare a restricted model where both groups do have the same reinforcement parameters ($\theta_1 = \theta_2$) and the model where the reinforcement parameter for both groups are arbitrary. It turns out that there is no significant superiority of the full model over the restricted model. That is, though the point estimate seems to hint that the brexiters have been way more prone to reinforcement in comparison with the remainers, there is no statistically significant signal supporting that finding. In any case, we find a high influence of reinforcement, which is in line with the overall perception of the Brexit process.

Germany If we investigate the detailed election results from 2017 for the 7 parties that are present in the parliament, we find that reinforcement plays a role for particularly two parties: the “AFD” and the “Die Linke”. Both parties are known as populist parties [24, 21, 20], one at the political right- and one at the left wing. For all other parties, reinforcement is not statistical significant. If we compare the results for whole Germany and the “old” states only (see SI II),

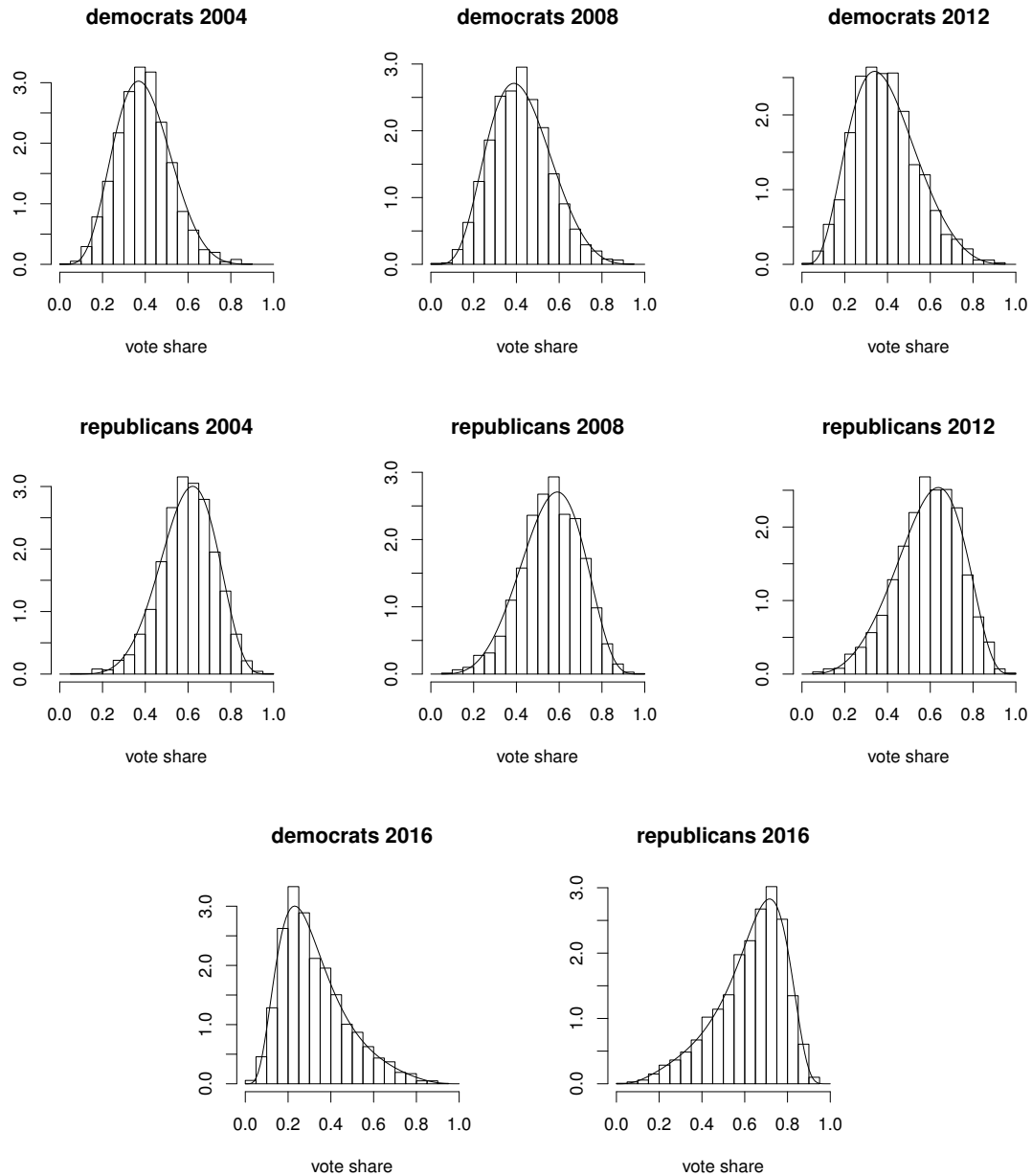


Figure 3: Distribution of the vote share of republicans/democrats in 2004, 2008, 2012 and 2016 presidential elections. We find a good agreement (Kolmogorov-Smirnov-test, $p \geq 0.12$ for all elections shown here). Only from 2008 on, the reinforcement model is significantly better ($p < 0.005$) than the zealot model.

we find that the reinforcement of the AFD is strongly connected with the “new” states (the states that are located in the former DDR/Eastern Germany), while the reinforcement of “Die Linke” seems to be independent of the classification in “old” and “new” states.

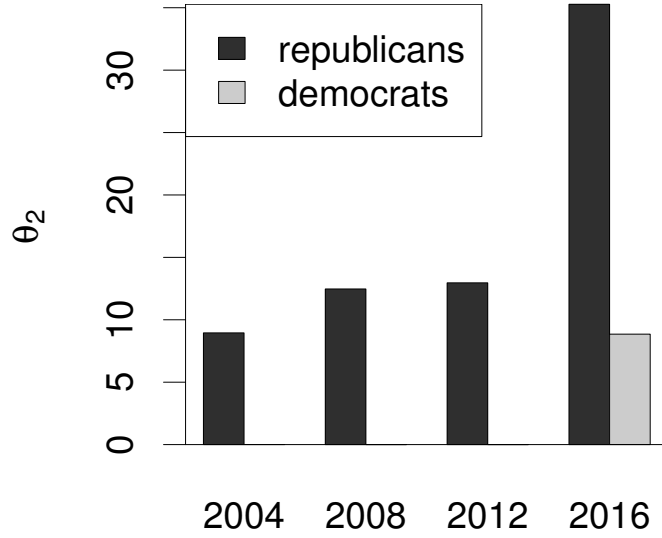


Figure 4: Plot of the reinforcement parameter. Note that in 2004-2012, the reinforcement-parameter for the democrats is negligible small, and only in 2016 it becomes visible.

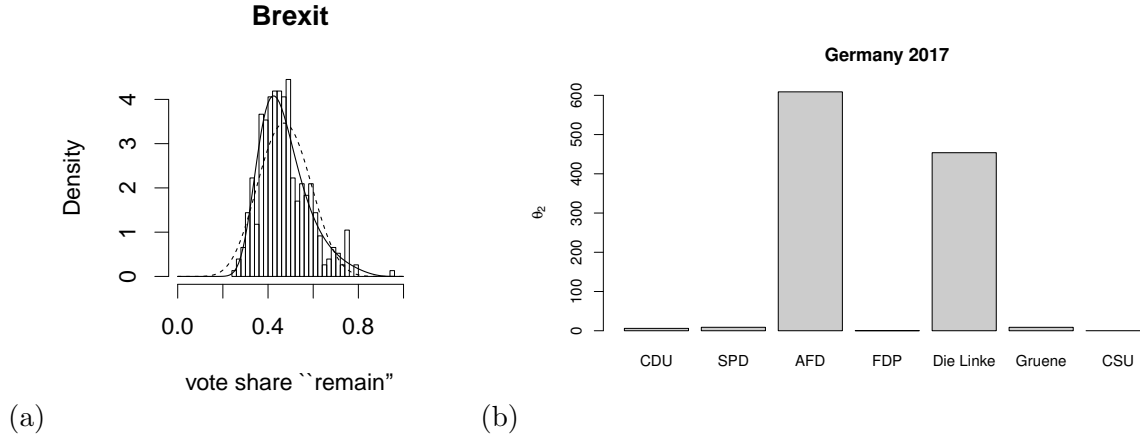


Figure 5: (a) Vote share for “remain” in the Brexit vote, together with the reinforcement model (solid line) and the zealot model (dashed line). (b) Reinforcement parameter for several parties, from the election data (2017) for whole Germany.

France - Le Pen Marie Le Pen is one of the central persons in contemporary France politics, and a right wing populist. In 2017, she was a candidate in the presidential elections, and made

it into the runoff election. In that second round she did loose against the current president Emmanuel Macron. We analyzed the election data for the first and the second round of the election to detect traces of reinforcement, in both cases without any success (the zealot model fits well, KS: $p \approx 0.42$ resp. $p = 0.31$ for first and second round), and the reinforcement model does not fit better than the zealot model, LL: $p \approx 1$ resp. $p = 0.96$). This result is interesting in the view of the ability of our method to detect reinforcement in populist parties/candidates in the US, Brexit, and Germany. The method proposed detects derivations of the vote share distributions from the beta distribution (predicted by the zealot model). The results of Le Pen doe snot show that spatial heterogeneity that can be detected by that method. It might be that the centralist organization in France leads to homogeneity, though Marie Le Pen is a populist. In another interpretation, the reinforcement takes place in social groups that are not spatially segregated. If this is the case, the segregation triggered by reinforcement cannot be detected using spatial data.

Phase Transition Our model predicts that a phase transition is possible. Some groups may become supercritical, and in that, a bimodal distribution appears in the election data. And indeed, for example data form the US presidential election from the year 2000, or also data from The Netherlands show that predicted bimodal distribution. Note that in both cases we do not have only two groups, but at least three relevant groups (US) or even more (The Netherlands) take part in the election: In the US, apart of the republican and the democrat candidate, also the green candidate got a non-negligible vote share. The Netherlands have a proportional system, where many parties compete for votes. In order to handle these situation, we focus on one group and merge all other groups in a pseudo-party. In that, we cannot expect that our fit is as precise as it is for an intrinsically binary system. However, as we see in Fig. 6, the model is able to cover the overall structure of the data, in case of The Netherlands, even in a quantitative way.

The Dutch party we address is the "Katholieke Volkspartij (KVP)", the Catholic People's Party. After the second world war, this party played a major role in The Netherlands with a vote share of about 0.33; only after 1967, the vote share dropped to around 0.25. The party did merge with two other parties 1980, and did already before, from 1977 on, appeared in a coalition with two other religions parties.

During the active time of the party, the reinforcement model is highly superior to the zealot model (LL: $p < 10^{-10}$). We clearly find a bimodal distribution (Fig. 6).

Obviously, this party did divide the population. The religious segregation at that time corresponded to a certain spatial segregation: Catholic and Protestant population tended to separate. Spatial or social segregation is for sure one of the major driver for reinforcement, as this segregation creates a homogeneous environment that minimizes the contact with different opinions. This observation is also reflected by the parameter estimation: the number of zealots of that party is estimated by a value close to zero; the strength of the party is solely explained by a strong reinforcement component, that was increasing over time. One can speculate that the religious basis of the Catholic People's Party did strongly promote this reinforcement.

4 Discussion

First of all, the present study has a major methodological outcome: Neutral models, that is, models that do not take political content into account, are able to reveal fundamental structures

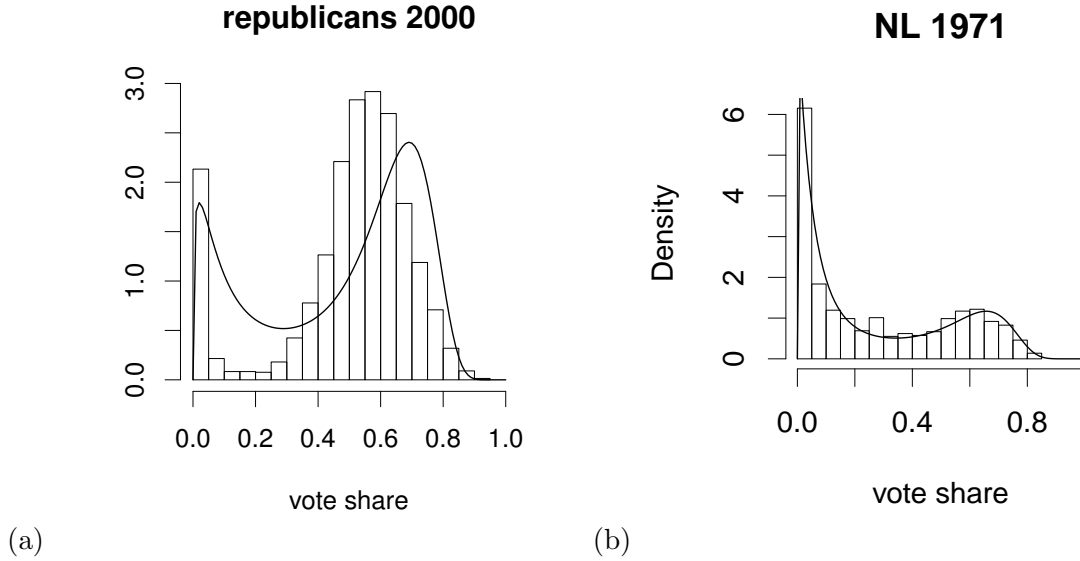


Figure 6: (a) Distribution for the 2000 presidential elections for the republicans. (b) The model for the 1971 election in The Netherlands where the focal group is the Catholic People’s Party. In both cases, we did fit the model using the focal group versus the pooled remaining groups.

in the political process. At present, such models do not play a major role in the scientific discussion. The situation resembles that of population genetics and ecology 20 years ago, when neutral models for the analysis of fundamental ecological and evolutionary mechanisms have been proposed. Only after a long discussion (that partially is still going on), these tools have been accepted as a valuable way to access important research questions [5, 23, 22]. We expect that also in the political sciences, models as those proposed in the present study gain importance.

A central finding in our data analysis is that populist parties or candidates show a high degree of reinforcement, which can be mostly detected by the model-based analysis of election data. Echo chambers and epistemic bubbles do not only exist since the appearance of the internet, but even before electronic mass media became abundant, newspapers targeting on a certain clientele, clubs, or simply the social environment provided echo chambers. Though the existence of echo chambers are statistically confirmed [14, 7], the strength of their effect is under debate [8]. Filter bubbles and echo chambers might be part of the populist’s communication strategy: There is an agreement that a central aspect of populism is the fight of the “the people” against the “the elite” [30]. The populism considers itself to represent the common sense, while experts and scientists are part of the elite, who are suspected to have hidden interests. Therefore, the common sense as defined by the populist’s party is more reliable than expert knowledge. This attitude leads straight to echo chambers – conflicting opinions are considered to be due to the corrupt elite.

Echo chambers are usually organized by social structures – groups find together according to their social background, their interests, and of course also according to their opinions. It is possible but not necessary that the social structure is correlated with spatial structure

(Urban/country, or upside/down town). The data we investigate are spatially structured (election districts). That is, we are not always able to filter out populist parties, but only if the division of society caused by populist parties also correlates with spatial segregation. In traditional times, religion (Catholics/protestants) often did habit in different quarters. We find a trace of that fact back in the Dutch data for the Catholic People's parts. Also the financial power of individuals and families are correlated with different quarters in cities. Other topics, as xenophobia, is not necessarily reflected in spatial separation. In that, we cannot expect to find traces of echo chambers and populist parties in all cases, but only if the focal topic of that party will affect different election districts with different intensity. That could be the reason why we were unable to identify Le Pen as a populist leader with the methods developed in the present study.

The second central finding is the prediction of phase transitions in electoral systems by populist parties and candidates; this prediction is confirmed in data from the US and The Netherlands. The prototypical model in statistical physics exhibiting phase transitions is the Potts model respectively the Glauber dynamics [26, 16]. Also in application close to election data (twitter data ahead of elections) indicated that this system is close to a phase transition [33]. The mechanisms of the Potts model and the reinforcement model that create the phase transitions, however, are different: In the so-called low temperature limit of the Potts model, the Glauber dynamics becomes a majority rule. Individuals tend to adopt the predominant opinion. In some sense that is a non-local dynamics: An individual is required to have a complete overview over the state of the population to estimate the transition rates. It is unclear how such a mechanism can be realized in a large population. In the reinforcement model, a group tends to blinding out the opposite group. Apart of that, we still have a model that is based on pairwise interaction, as it is at the heart of the voter model.

It is interesting that in the examples for supercritical states presented here, always more than two groups are involved. We conjecture that reinforcement carries a multi-group system more easily into a supercritical state than a dichotomous system.

We interpret our findings in a different setting. The main point of the present study is the question how individuals form their opinion. In that, the various forms of the information bias plays a role. A focal individual forms his/her opinion based on new, external information, and based upon his/her pre-knowledge resp. prejudices. A main aspect of external information is "framing". Particularly complex information are often simplified and presented in a (group-specific) representation/interpretation [4]. In our model, the effect of framing can be identified with the effect of zealots. A person, however, filters incoming information based on his/her experiences, including his/her social (network) contacts. As a result, we find the "confirmation bias". Individuals seem to rather select external information that agrees with his/her own opinion [32]. The present study is a hint that the confirmation bias is active, at least on a group level. Our results might indicate that confirmation bias does not only depend on the information *per se*, or the mindset of a focal individual, but that also the context of the social environment influences the readiness to accept new arguments. While the term "confirmation bias" mainly focus on an individual and the information at hand, it is likely that information is also rejected as it does not align with the opinion of the social environment. This interpretation of the confirmation bias/reinforcement resembles the emphasis of "tradition" for the development of knowledge in the theory of Feyerabend [11].

The effect of confirmation bias/reinforcement, understood in the sense discussed above, is rather strong. It is even possible that the prevailing opinion cannot be predicted based on the parameters - we are faced with a bistable setting. What are the implications and consequences of this finding? At the present time, the society is faced with major tasks as the implication of the climate change [31] of the effect of strong inequalities in the society [35], to name but a few. Even if there is an almost perfect consensus about a topic at the rational level, as it is in the case of the climate change, only the society is the one who can take actions. At that point, e.g. climate-change deniers as well as climate-scientists will use framing. The topic is too complex to be discussed in each detail, and not all details may be known. In any case, climate-change deniers tend also to organize in populist groups and parties (Trump, AFD), which clearly establish structures based on the confirmation bias/reinforcement. We have seen that the reinforcement mechanism is strong as individuals that join that group tend to stay within that group. If the climate-change deniers use reinforcement, while the climate-scientists only argue rationally, the rational information pressure has to be high to shift the overall opinion in the society towards the appropriate actions. If the mechanisms addressed here are well understood, they have the potential to be used and mis-used for a kind of social engineering.

We might speculate about the basis of populism and in particular of reinforcement. We emphasize that what follows is not a direct consequence of the model and the model-based data analysis, but rather possible speculative interpretations. In the (European) perception, populism gains importance in recent years. This perception might be a consequence of a Eurocentric point of view, as e.g. in Latin America populism has been present since quite a time.

However, one aspect could be the consequences of Neo-Liberalism. These ideas gained strength in the 1980's. Neo-Liberalism strongly emphasizes the individual as the central entity, and weakens the importance of the society. In the long run, the unifying forces of the society are weakened, and particularly the agreement on common values, common ideas, and common communication patterns are crumbling. In this situation, certain sub-groups might be able to establish new frameworks. An example is the right-wing populist party AFD in Germany, that breaks with the well established convention how to address the Holocaust in Germany.

Another approach is discussed by Van Reybrouck [43]: According to him, modern democracies tend to become technocracies. Due to the complexity of modern societies and modern economics more and more experts influence politics substantially. Also supra-national organizations as the IWF or the EU gain influence. These organizations are rather complex and opaque structures, which could be vulnerable to undocumented lobbying and back-room politics. They are only in minor extent or not at all democratically legitimized. In that, they are the perfect surface onto which populist movements project their idea of a corrupt and an evil elite.

Also evolutionary mechanisms promoting reinforcement can be identified. About 150 000 years ago, modern humans formed small groups or tribes that did compete for food and resources. According to Tomasello [42], each of these groups established an "objective" moral. That moral was group-specific; it is possible that different groups would implement different moral systems. This "objective" morale established and enforced norms and standards for the group members that guaranteed the (optimal) functioning of the group. It was of utmost importance that all group members agreed upon those standards and did act accordingly – only in that case, the group would successfully compete with other groups. The tendency of humans to align with the social environment, and therewith the origin of reinforcement, perhaps is the heritage of the early mankind.

References

- [1] K. Arceneaux, M. Johnson, and C. Murphy. Polarized political communication, oppositional media hostility, and selective exposure. *The Journal of Politics*, 74(1):174–186, jan 2012.
- [2] C. Borghesi, J.-C. Raynal, and J.-P. Bouchaud. Election turnout statistics in many countries: Similarities, differences, and a diffusive field model for decision-making. *PLoS ONE*, 7(5):e36289, may 2012.
- [3] D. Braha and M. A. de Aguiar. Voting contagion: Modeling and analysis of a century of us presidential elections. *PloS ONE*, 12(5):e0177970, 2017.
- [4] D. Chong and J. N. Druckman. Framing theory. *Annual Review of Political Science*, 10(1):103–126, jun 2007.
- [5] J. S. Clark. Beyond neutral science. *Trends in ecology & evolution*, 24(1):8–15, 2009.
- [6] R. Costa Filho, M. Almeida, J. Andrade, J. Moreira, et al. Scaling behavior in a proportional voting process. *Physical Review E*, 60(1):1067, 1999.
- [7] M. Del Vicario, G. Vivaldo, A. Bessi, F. Zollo, A. Scala, G. Caldarelli, and W. Quattrociocchi. Echo chambers: Emotional contagion and group polarization on facebook. *Scientific reports*, 6:37825, 2016.
- [8] E. Dubois and G. Blank. The echo chamber is overstated: the moderating effect of political interest and diverse media. *Information, Communication & Society*, 21(5):729–745, 2018.
- [9] A. Etheridge. *Some Mathematical Models from Population Genetics*. LNM 2012. Springer, 2011.
- [10] J. Fernández-Gracia, K. Suchecki, J. J. Ramasco, M. San Miguel, and V. M. Eguíluz. Is the voter model a model for voters? *Physical review letters*, 112(15):158701, 2014.
- [11] P. K. Feyerabend. *Science in a Free Society*. Verso Books, 1982.
- [12] S. Fortunato and C. Castellano. Scaling and universality in proportional elections. *Physical review letters*, 99(13):138701, 2007.
- [13] S. Galam. Sociophysics: A review of Galam models. *International Journal of Modern Physics C*, 19, 03 2008.
- [14] R. K. Garrett. Echo chambers online? Politically motivated selective exposure among Internet newsusers. *Journal of Computer-Mediated Communication*, 14:265–285, 2009.
- [15] N. Gidron and B. Bonikowski. Varieties of populism: Literature review and research agenda. *Political Science*, 13-0004, 2013.
- [16] R. J. Glauber. Time-dependent statistics of the ising model. *Journal of Mathematical Physics*, 4(2):294–307, feb 1963.
- [17] V. Hösel, C. Kuttler, and J. Müller. *Population Genetics and Bacterial Cooperation*. World Scientific, 2020.

- [18] V. Hösel, J. Müller, and A. Tellier. Universality of neutral models: Decision process in politics. *Palgrave Communications*, 5(1), 2019.
- [19] H. Hotelling. Stability in competition. *The Economic Journal*, 39:41–57, 1929.
- [20] D. Hough and D. Keith. The German Left Party: A case of pragmatic populism. In G. Katsambekis and A. Kioupkiolis, editors, *The Populist Radical Left in Europe*, pages 129–144. Taylor & Francis Ltd., 2019.
- [21] D. Hough and M. Koß. Populism personified or reinvigorated reformers? The German Left Party in 2009 and beyond. *German Politics and Society*, 27(2):76–91, jun 2009.
- [22] J. D. Jensen, B. A. Payseur, W. Stephan, C. F. Aquadro, M. Lynch, D. Charlesworth, and B. Charlesworth. The importance of the neutral theory in 1968 and 50 years on: A response to Kern and Hahn 2018. *Evolution*, 73(1):111–114, 2019.
- [23] A. D. Kern and M. W. Hahn. The neutral theory in light of natural selection. *Molecular biology and evolution*, 35(6):1366–1371, 2018.
- [24] S. Kim. The populism of the alternative for germany (AfD): an extended essex school perspective. *Palgrave Communications*, 3(1), oct 2017.
- [25] A. Kononovicius. Empirical analysis and agent-based modeling of the lithuanian parliamentary elections. *Complexity*, 2017, 2017.
- [26] P. L. Krapivsky, S. Redner, and E. Ben-Naim. *A Kinetic View of Statistical Physics*. Cambridge University Press, 2017.
- [27] T. Liggett. *Interacting Particle Systems*. Springer, 1985.
- [28] J. Mimkes. A thermodynamic formulation of social science. *Econophysics and Sociophysics: Trends and Perspectives*, pages 279–309, 2006.
- [29] M. Mobilia. Commitment Versus Persuasion in the Three-Party Constrained Voter Model. *Journal of Statistical Physics*, 151(1-2):69–91, APR 2013.
- [30] C. Mudde and C. R. Kaltwasser. *Populism: A Very Short Introduction*. Oxford University Press, 2017.
- [31] B. R. Newell, R. I. McDonald, M. Brewer, and B. K. Hayes. The psychology of environmental decisions. *Annual Review of Environment and Resources*, 39(1):443–467, oct 2014.
- [32] R. S. Nickerson. Confirmation bias: A ubiquitous phenomenon in many guises. *Review of general psychology*, 2(2):175–220, 1998.
- [33] L. Nicolao and M. Ostili. Critical states in political trends. How much reliable is a poll on twitter? The Potts model and the inverse problem in Social Science. *Physica A: Statistical Mechanics and its Applications*, 533:121920, 2019.
- [34] F. Palombi and S. Toti. Voting behavior in proportional elections from agent-based models. *Physics Procedia*, 62:42–47, 2015.

- [35] T. Piketty. *Capital in the Twenty-First Century*. Harvard University Press, 2017.
- [36] F. Sano, M. Hisakado, and S. Mori. Mean field voter model of election to the house of representatives in Japan. In *Proceedings of the Asia-Pacific Econophysics Conference 2016 — Big Data Analysis and Modeling toward Super Smart Society — (APEC-SSS2016)*. Journal of the Physical Society of Japan, 2017.
- [37] N. Schofield. A valence model of political competition in Britain: 1992-1997. *Electoral Studies*, 24(3):347–370, SEP 2005.
- [38] N. Schofield, A. Martin, K. Quinn, and A. Whitford. Multiparty electoral competition in the Netherlands and Germany: A model based on multinomial probit. *Public Choice*, 97(3):257–293, DEC 1998.
- [39] N. Schofield and I. Sened. Multiparty competition in Israel, 1988-96. *British Journal of Political Science*, 35(4):635–663, OCT 2005.
- [40] C. Schröder and S. Rahmann. A hybrid parameter estimation algorithm for beta mixtures and applications to methylation state classification. *Algorithms for Molecular Biology*, 12(1), aug 2017.
- [41] S. Tavaré. Ancestral inference in population genetics. In J. Picard, editor, *Lectures on Probability Theory and Statistics*, pages 3 – 180. LNM 1837, Springer, 2004.
- [42] M. Tomasello. *A Natural History of Human Morality*. Harvard University Press, 2016.
- [43] D. Van Reybrouck. *Against Elections*. Random House UK Ltd, 2016.