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

May 27, 2020

Abstract

We present a novel model for the effect of echo chambers, filter bubbles, and reinforcement on election results. Our model extends the well known voter model with zealots to include reinforcement. We analyze the behaviour of the model, determine the invariant measure, and show that reinforcement may 1) shift the distribution of votes compared to the voter model, and 2) lead to phase transitions. We test whether the model with reinforcement fit better than under its absence in election data from US presidential elections, the Brexit referendum, and parliamentary 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 finally discuss the implications and relevance of our findings and possible origins of the reinforcement behaviour in modern societies.

Word count: 5760

1 Introduction

We are living in the age of rising populism. Such statement have become abundant in recent years [25], while there is no unique, commonly accepted definition of the term "populism", in the political and sociological literature. Different authors use a wide variety of concepts to narrow down the term "populism" [12] making use of economic, social, and political aspects, as well as organization, communication, or the personality of the centrally involved figures. Among others, Mudde [29] and Mudde and Kaltwasser [30] developed the idea of populism as a "thin-centered 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 proposed by Mudde [29] is the segregating habit of populist movements, dividing the citizens into two opposing groups, a (corrupt, evil) elite and the (ordinary, plain and good) people. If a nationalistic ideology is involved, the term "people" also incorporates the notion of national community in contrast to immigrants (even when it is historically and sociologically unjustifiable). Populists divide the population in a Manichean outlook 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 segregating mindset of populists affects communication structures, that is the conception, release and acceptance 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 literally accepted but may rather be a sign of group membership. This aspect of the populist communication structure might not be predominant in all cases, but seems to be a logical consequence of the populists' world understanding. Populist parties therefore share a common rhetoric (see the investigation by the Populism Research Team, [14]) which

fuels reinforcement, filter bubbles, and echo chambers. According to this hypothesis, the communication by populist parties reinforce the belief of their partisans (or voters) and in the same time the partisans isolate themselves in a filter bubble in which only certain types of information can penetrate. A group of populist partisans would thus constitute an echo chamber in which certain points of view, while being dismissed as low value or fake in the general population, become amplified and accepted as such. We focus in the present study on that aspect of reinforcement, filter bubble and echo chamber. Our aim is here to develop a variant of the well known mathematical voter model to include reinforcement, and then to perform statistical analysis of election results to reveal traces of reinforcement. This study represents to our knowledge the first attempt to reveal the signatures of reinforcement in election data.

Statistical patterns in election data are observed and investigated since several years [6, 2, 8, 34]. This novel investigation into election results is built on the principles that mathematical models can predict expected statistical patterns which can be tracked down in the data. By deriving models with different hypotheses, it is possible to study the underlying mechanisms generating the observed patterns and election results. Two general classes of mechanisms, neutral and non-neutral, can be studied. Non-neutral approaches take the political direction of parties into account. The most prominent representative in this line of research is the Hotelling model [17], 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 [38, 40, 39].

A recent line of thinking is based on neutral models. The idea is that many of the observed statistical features of election results can be explained by models that do not take into account the political direction of parties. In these 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 [8, 36]. In the context of elections, the noisy voter model is called the zealot model. Zealots or partisans are individuals (or other influencing entities as newspapers) that do not change their political direction but stick to one given group, and influence other population members. It is successfully used to explain the variance structure in election data [3, 23], the fraction of swing voters who readily change their favorite party [37], or to obtain an idea about the time to consensus [28]. 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 crated and vanish again [16]. This latter approach explains the log-linear structure in election data observed in several countries as soon as more than 10 candidates (or parties) are present [16]. A noisy-voter model with linear branching process can also generate distributions of candidates' vote shares when the candidates are in the same party [10]. Note, however, that mathematically these models do not allow for bifurcations and phase transitions – similar to disruption, phase transitions lead to sudden fundamental changes in the system though the situation seemed to be only slightly changed. Few models exhibiting phase transitions are nevertheless used in mathematical sociology [11, 27]. Of special relevance, Nicolao and Ostilli used a Potts model to investigate twitter data related to elections [33]. The Potts model shows a phase transition for certain parameter combinations. Interestingly, the authors identify in the data parameters that often are close to those critical parameter values. In some cases, the data indicated that the twitter system spontaneously breaks the symmetry and can generate different outcome/behavior, which is to expect for a supercritical system [33].

In the present paper, we augment the zealot model by integrating reinforcement. We thus want to investigate if such neutral model with reinforcement captures observed patterns in election data, and thus if reinforcement, filter bubbles, and echo chambers are important enough for populist parties or candidates to leave statistical signatures in election data.

First, we develop the model and investigate its mathematical behavior. By investigating a strong- and a weak-effects limit for large population sizes, we find bifurcations and phase transitions. In the limit of weak effects, we derive explicitly the invariant measure for the vote share for our reinforcement model. Second, we analyze election data from several elections (US presidential, Brexit in the UK, parliamentary in Germany, Netherlands and France) and show that often the reinforcement model describes the data appropriately, and significantly better than the zealot model. We conclude that reinforcement and echo chambers represent forces that leave signatures 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). Furthermore, the traces of phase transitions are visible in election data (The Netherlands). Finally, we discuss the implications and relevance of our results and limitations of our modeling/statistical approach.

2 Model, model analysis, and model predictions

In this section, we modify the zealot/noisy voter model to include reinforcement and echo chambers. In the underlying basic voter model (without zealots) [26], 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 one opinion remains. The other opinion dies out. This outcome is naturally unrealistic, and thus the zealot model [3] assumes an additional mechanism. Apart of floating voters, i.e. individuals who change their opinion, there are zealots. Zealots are individuals with a strong opinion and thus do not change their mind, even when in contact with a distinct opinion whether from other individuals, newspapers

or other mass media. Moreover, zealots influence the opinion of floating voters, as a floating persons copies the opinion of a randomly selected individual out of the group of all individuals (floating voters or zealots). In the zealot model, all opinions persist at all time as the model has no absorbing state and a non-trivial invariant distribution [3].

We model reinforcement and echo chambers as follows. An individual who "live" in an echo chamber does not interact with a representative sample of the population, but only with a sub-group of individuals who are more likely to share the same opinion. We introduce weights $\vartheta_i \in (0, 1]$ to express the reduced interaction with the opponent group. We want to compute the share of votes for each party as a function of the model parameters (especially the reinforcement).

Let N denote the total population size, N_i the number of zealots with 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

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

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

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 thus 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 $N \to \infty$. As it is well known from parallel investigations in population genetics [41, 7, 15], two different scales of the parameters are sensible: 1) 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 (the deterministic limit) or 2) N_i are constant in N and $\vartheta_i = 1 + \mathcal{O}(N^{-1})$, called the weak effects limit in which the effect of zealots and reinforcement become small if the population size becomes large.

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 supplementary information, SI)

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

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

Particularly, in the symmetric case (all group-specific parameters N_i, ϑ_i are identical), 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 being locally asymptotically stable. One of the two opinions does 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 opinion with the reinforcement strategy does prevail (see SI).

On the one hand, the deterministic limit allows to easily analyze and visualize the long term behavior. On the other hand, population genetics studies [41, 7, 15] show that the weak effect models are more realistic when it comes to the analysis of data. In this case,

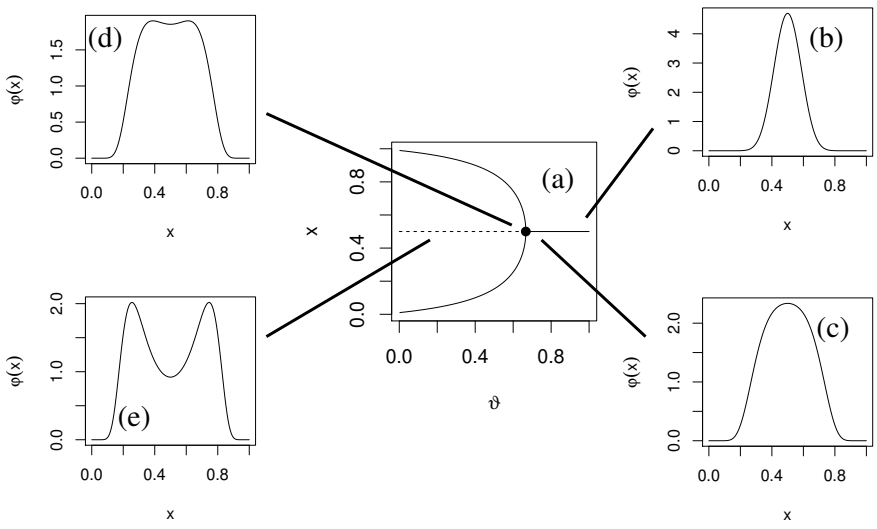


Figure 1: Behavior of the zealot model with reinforcement. (a): Stationary states (solid lines: locally asymptotically stable, dashed line: unstable) and pitchfork bifurcation (indicated by a bullet) of the deterministic limit. Panels (b)-(d): Corresponding invariant measures of the weak-effects limit. Parameters (a): $n_1 = n_2 = 0.1$, $\vartheta_1 = \vartheta_2 = \vartheta$; (b)-(d): $N_1 = N_2 = 20$, and (b) $\theta_1 = \theta_2 = 10$, (c) $\theta_1 = \theta_2 = 70$, (d) $\theta_1 = \theta_2 = 80$, (e) $\theta_1 = \theta_2 = 100$.

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 $N \to \infty$, (SI)

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

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, as predicted by the zealot model. The Beta-distribution 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.

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 [24], the positive feedback introduced by the reinforcement mechanism is able to drive the system into a phase transition.

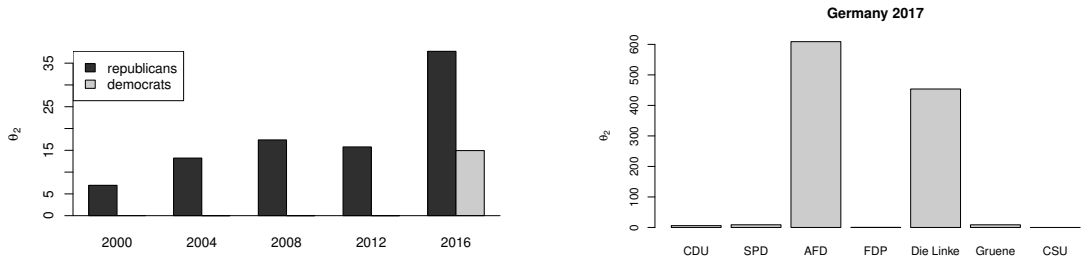
3 Data analysis

We compare in the following the theoretical predictions with empirical findings. Hereby, we assume that each election district is independent of all other districts, and identical realization of the invariant distribution of the democratic process. For each election, we obtain the results of voting for many election districts and use a maximum-likelihood method to estimate the model parameters (reinforcement parameter for each candidate/party). The Kolmogorov-Smirnov test (KS) is applied to assess the consistency of the theoretical model to empirical data, namely by obtaining the p-value that the distribution of vote share for one party against the sum of the other ones does fit our prediction from the reinforcement or the zealot model. The likelihood-ratio test (LL) to compare the performance of these models. We obtain also an estimate of the reinforcement parameter for each candidate/party.

For the data analysis, we assume that the results in different election districts are independent replicas of the election. This assumptions is, of course, a simplification. First, there is a spatial correlation in the election results [2]. Second, election districts are influenced by social covariates or nuisance variables as income or the dichotomy rural/city area. Third, we developed our theory for dichotomous elections, but apply the results also to 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 if the perturbing influences become less important. And indeed, the analysis shows that

the data are described quite well.

US presidential elections We find a good agreement of the reinforcement model and data for the recent US presidential elections 2000-2016 (Fig. SI, Fig. 1). The KS test yields p-values larger or equal 0.1 apart of the year 2000. This finding indicates that the reinforcement model cannot be rejected. The year 2000 is kind of exception, as also the green party did win a considerable percentage of votes. For the 2000 and the 2004-elections, the zealot and the reinforcement models fit equally well. For the election results between 2008-2016 the reinforcement model is superior (LL-test), and the zealot model is not appropriate (KS, see SI for details, point estimates and test results). When inspecting the reinforcement parameters for the two parties (Fig. 3), we find that the reinforcement for the democrats is rather unimportant (in comparison to that of the republicans) before 2016. In the 2016 election, the reinforcement of the democrats jumps to the averaged value of the republicans before 2016, while the reinforcement of the republicans shows a more than twofold increase (Fig. 3). We associate this effect to the consequences of the populist attitude of the republican candidate Donald Trump.



(a) (b)

Figure 2: Estimates of reinforcement parameters for elections in the USA (a), in Germany (b). (a) Estimates of the reinforcement parameter for the USA presidential elections in 2000–2016. Note that in 2000-2012, the reinforcement-parameter for the democrats is negligible small, and only in 2016 it becomes visible. (b) Reinforcement parameter for several parties, from the parliamentary elections in 2017 for whole Germany.

Brexit The reinforcement-model is statistically clearly superior to the zealot model to describe the Brexit data (likelihood-ratio test $p < 10^{-10}$, see also SI, Fig. 2). 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 the model that allows for more reinforcement in brexetiers than in remainers is highly superior (the hypothesis that the reinforcement parameters for both groups are identical is rejects at p <1e-10). The model hints to the fact that populist tendencies have been at the brexetiers part, and only in a minor amount in the remainders side.

Germany If we investigate the detailed parliamentary (Bundestag) election results from 2017 for the seven parties that are present in the parliament, we find that reinforcement plays a role particularly for two parties: "AFD" and "Die Linke". Both parties are known as populist parties [22, 19, 18] on either side of the political spectrum. For all other parties, reinforcement is not statistically significant. We further find that the reinforcement of the AFD is strongly connected with the "new" states (the states/regions that are located in the former DDR/Eastern Germany) and not in the "old" states (states/regions of the former Western Germany, see SI), while the reinforcement of "Die Linke" seems to be independent of the geographic location of "old" and "new" states.

France We analyzed the election data for the first and the second round of the presidential elections to detect signatures of reinforcement. When especially studying the 2017 elections, and focusing on the candidate of the Front National, Marine Le Pen, the

reinforcement model does not fit better than the zealot model (LL: $p \approx 1$). These results are obtained at the scale of department administrative units as well as at the smaller units of the canton. From our analysis point of view, it appears that Marine Le Pen does not exhibit the populist reinforcement observed for the republicans in the US, the Brexiters in the UK and the AFD party in Germany. When studying the first round of the presidential elections since 1965, we find that in several instances, the reinforcement model fits better than the zealot model, for example (SI,Table 5) for De Gaulle (1965), Chaband-Delmas (1974), Chirac (1981, 1988, 1995, 2002), Jospin (2002), Sarkozy (2007, 2012), Hollande (2012) and Fillon (2017). The parameter of reinforcement often is above 0.5 meaning that if there is any effect, it reflects the ability of the candidates to retain their supporters in the long term. It is also possible, that the model – that is only build for two parties - fails to appropriately interpret the data of the multi-party system in France.

Phase Transition Our model predicts that a phase transition is possible which impacts the outcome. In effect, some groups may become supercritical, leading to a bimodal distribution appearing in the election data. We observe such bimodal distributions in The Netherlands 1967 parliamentary elections (Fig. 3).

The Netherlands have a proportional voting system, where many parties compete for votes. In order to handle this situation, we focus on one group and merge all other groups in a pseudo-party. As shown in Fig. 3, the model is able to fit the overall structure of the data. 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. During the active time of the party, especially before 1971, the reinforcement model is highly superior to the zealot model (LL: $p < 10^{-10}$). We clearly

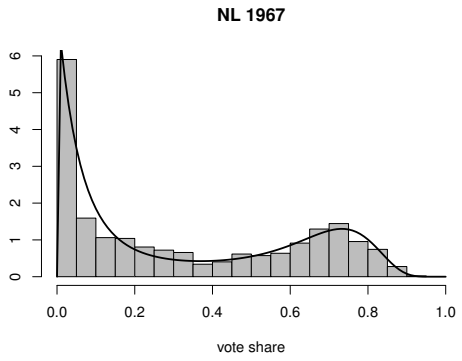


Figure 3: The model for the 1967 election in The Netherlands where the focal group is the Catholic People's Party. We did fit the model using the focal group versus the pooled remaining groups.

find a bimodal distribution (Fig. 3).

4 Discussion

A first major result of our study is that neutral models, that is, models that do not take political content into account, are able to reveal fundamental structures 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 evolutionary and ecological 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, 21, 20]. We expect that also in the political sciences, models as those proposed in the present study gain importance.

The second central finding of the present paper is that the method proposed is able to detect reinforcement in election data. Interestingly, in these empirical findings, the groups identified to use reinforcement are im general populist parties or candidates. It

is a central argument in the literature (see introduction) that populist parties fuel and use echo chambers and communication bubbles, a finding which we confirm here using a mathematical and statistical neutral model. However, it is intriguing that not all populists groups leave detectable traces in election data. While Trump in the US, the Brexit, or the German AFD clearly can be identified as candidates/elections/groups where reinforcement played a role, our model does not show a signal for Le Pen in France. Marie Le Pen is one of the central persons in contemporary France politics, and classically defined as a far right wing populist. Our method detects derivations of the vote share distributions from the beta distribution, predicted by the zealot model. The results of Le Pen does not show that spatial heterogeneity which is detectable by our method. We offer several non-mutually exclusive explanations. The central organization of French politics and French administrations (for exemple relatively to Germany) may promote homogeneity, thus making the populist signature not observable by our method. The reinforcement for populist parties may take place in social groups that are not spatially segregated. In the later case, the segregation triggered by reinforcement cannot be detected using spatial data. Finally, the social and political structure in France may generate an overall polarization effect which decreases the observable signatures of echo chambers in the votes. In other words, polarization (reinforcement) for ar against a candidate appear to fairly common for several candidates per election as suggested by the analysis of several presidential election results.

The third central finding is the prediction of phase transitions in electoral systems by populist parties and candidates; this prediction is confirmed in data from The Netherlands. The prototypical model in statistical physics exhibiting phase transitions is the Potts model respectively the Glauber dynamics [24, 13]. Also in application close to election data (twitter data ahead of elections) indicated that this system is close to a phase transition [33]. As the basis of the Glauber dynamics (so-called low temperature

limit) is a majority rule, while the model presented here is based on interactions of single individuals, we think that our model is more appropriate for social dynamics.
The social mechanisms that create the phase transitions are clearly visible in the Dutch Catholic People's Party in the 1970s. The data show that 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. The spatial model shows that also the reverse direction is possible: alignment of the opinion with close neighbors yields locally homogeneous population, such that in consequence different opinions prevail in different regions, with sharp spatial transitions.

We interpret our findings in the context of perceptual psychology. The main point of the present study is the question how individuals form their opinion. In that, the various aspects 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 in the close social environment. This interpretation of the confirmation bias/reinforcement resembles the emphasis of "tradition" for the development of knowledge in the theory of Feyerabend [9]. 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 practical implications and consequences of these findings? 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 climes-scientists only argument rationally, the rational information pressure has to be high to shift the overall opinion in the society towards the appropriate actions. A recent example, where this mechanisms may have been decisive, is the Brexit: The brexitiers results show a strong reinforcement component, while the model detected rather little reinforcement on the remainers' side. And indeed, the brexitiers have been successful with this strategy. If the mechanisms addressed here are well understood, they have the potential to be used and miss-used for a kind of social engineering.

We might speculate about the bases 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 few speculative interpretations. In Europe populism has gained importance in recent years [25, 14]. We can speculate that this may be a consequence of neo-liberalism, which gained importance since 1980s. As neo-liberalism tends to strongly emphasizes the predominance of individual values versus societal values, this can lead to weaken the agreement on common values, common ideas, and common communication codes. In this situation, sub-groups or candidates can challenge the accepted communication framework, such as the far right-wing populist party AFD in Germany, breaking away from the well established convention on how to address the Holocaust question in Germany.

Another explanation is discussed by Van Reybrouck [43]. He suggests that modern democracies tend to become technocracies, and due to the complexity of modern societies and economics, experts do influence politics and policies substantially. Moreover, supra-national organizations (IMF, WTO, UN, EU, ...) and supra-national treaties have become important. However, these organizations are rather complex and opaque structures and more or less democratically legitimized. As such, they are the perfect targets fuelling populist movements ideas of an international corrupted elite.

Lastly, there may even be evolutionary mechanisms promoting reinforcement. About 150 000 years ago, modern humans formed small groups or tribes that did compete for food and resources. According to Tomassello [42], each of these groups established an "objective" moral, which was group-specific. This "objective" morale established and enforced norms and standards for the group members that may have guaranteed the (optimal) functioning of the group. Therefore, the tendency of humans to align with their social environment, and therewith the origin of reinforcement, may be even seen as the heritage of behavioural selection in 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] A. Etheridge. *Some Mathematical Models from Population Genetics*. LNM 2012. Springer, 2011.

[8] 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.

[9] P. K. Feyerabend. *Science in a Free Society*. Verso Books, 1982.

[10] S. Fortunato and C. Castellano. Scaling and universality in proportional elections. *Physical review letters*, 99(13):138701, 2007.

[11] S. Galam. Sociophysics: A review of Galam models. *International Journal of Modern Physics C*, 19, 03 2008.

[12] N. Gidron and B. Bonikowski. Varieties of populism: Literature review and research agenda. *Political Science*, 13-0004, 2013.

[13] R. J. Glauber. Time-dependent statistics of the ising model. *Journal of Mathematical Physics*, 4(2):294–307, feb 1963.

[14] K. Hawkins, R. Aguilar, B. Castanho Silva, E. Jenne, B. Kocijan, and R. K. C. Measuring populist discourse: The global populism database. In *Paper presented at the 2019 EPSA Annual Conference in Belfast, UK*, 2019.

[15] V. Hösel, C. Kuttler, and J. Müller. *Population Genetics and Bacterial Cooperation*. World Scientific, 2020.

[16] V. Hösel, J. Müller, and A. Tellier. Universality of neutral models: Decision process in politics. *Palgrave Communications*, 5(1), 2019.

[17] H. Hotelling. Stabity in competition. *The Economic Journal*, 39:41–57, 1929.

[18] 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.

[19] 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.

[20] 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.

[21] A. D. Kern and M. W. Hahn. The neutral theory in light of natural selection. *Molecular biology and evolution*, 35(6):1366–1371, 2018.

[22] S. Kim. The populism of the alternative for germany (AfD): an extended essex school perspective. *Palgrave Communications*, 3(1), oct 2017.

[23] A. Kononovicius. Empirical analysis and agent-based modeling of the lithuanian parliamentary elections. *Complexity*, 2017, 2017.

[24] P. L. Krapivsky, S. Redner, and E. Ben-Naim. *A Kinetic View of Statistical Physics*. Cambridge University Press, 2017.

[25] P. Lewis, C. Barr, S. Clarke, A. Voce, C. Levett, and P. Gutiérrez. Revealed: the rise and rise of populist rhetoric. *The Guardian*, 6th March 2019.

[26] T. Liggett. *Interacting Particle Systems*. Springer, 1985.

[27] J. Mimkes. A thermodynamic formulation of social science. *Econophysics and Sociophysics: Trends and Perspectives*, pages 279–309, 2006.

[28] M. Mobilia. Commitment Versus Persuasion in the Three-Party Constrained Voter Model. *Journal of Statistical Physics*, 151(1-2):69–91, APR 2013.

[29] C. Mudde. The populist zeitgeist. *Government and Opposition*, 39(4):541–563, 2004.

[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. Ostilli. 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] S. Redner. Reality-inspired voter models: A mini-review. *Comptes Rendus Physique*, 20(4):275–292, may 2019.

[37] 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.

[38] N. Schofield. A valence model of political competition in Britain: 1992-1997. *Electoral Studies*, 24(3):347–370, SEP 2005.

[39] 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.

[40] N. Schofield and I. Sened. Multiparty competition in Israel, 1988-96. *British Journal of Political Science*, 35(4):635–663, OCT 2005.

[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.