Physics peeks into the ballot box

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Electoral results show universal features, such as statistics of candidates’ performance and turnout rates, in different countries and over time. Are voters as predictable as atoms?

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The idea that humans, in particular circumstances, might behave like social atoms, i.e. they might obey rules that yield predictable collective patterns, just like atoms and molecules, dates back many years and has several illustrious fathers, like political philosopher John Stuart Mill and social scientists Auguste Comte and Adolphe Quetelet. The principle is that, when a great multitude of individuals interact, the choice of each of them, which in principle is free, is constrained by the presence of the others, and regular collective behaviors may emerge. In the last two decades this idea has developed into a flourishing field of investigation, due to the unprecedented availability of large datasets on social phenomena, and powerful computers to process them. Statistical physics, developed to deal with systems composed of many particles, has naturally provided a conceptual framework for understanding such systems, even if here nothing less than humans are the elementary constituents. Clearly, such an endeavor does not come without obstacles. The complexity of individual “social atoms” and the intricacy of their interactions rule out the possibility to formulate principles and laws as rigorous as in the physics of matter. Nevertheless, regular patterns in collective social phenomena abound, and they call for explanations, ideally via simple models.

Works of physicists on elections started to appear in the late 90s. As of now, many different types of elections in several countries have been studied and modelled, and various issues have been addressed. In this study we discuss recent results on the competition between candidates in proportional elections and on the statistics of turnout rates.

I. THE PERFORMANCE OF CANDIDATES

In electoral competitions many candidates compete for one or few seats. Their success can range from landslide victory to complete failure with only a handful of votes received. How does this huge variability come about?

In 1999 Costa Filho et al. studied vote statistics in Brazilian Parliamentary proportional elections. In this kind of elections, at odds with what occurs in the US, in each electoral district, a few to a few dozens seats are awarded simultaneously, and the number of seats won by a party is proportionate to the number of votes received. Costa Filho et al. considered all candidates, winners and losers, regardless of their electoral district or political affiliation and computed the histogram of the number of votes received by each of them. In the central range of the number of votes, the histogram has a regular profile, where the number of candidates receiving \( v \) votes appears inversely proportional to \( v \). This means that the number of candidates who obtained 1000 votes, say, is approximately 10 times higher than the number of candidates who collected 10000 votes. This type of analysis neglects a factor that is fundamental in the political life of most countries: the influence of parties. A great deal of the electoral success of a candidate depends on the popularity of the party’s political agenda he/she is running for. The observed histogram reflects the complex intertwined effect of the competition among parties and the competition among different candidates within parties. Given the peculiarities of the specific political landscape of each country, one can hardly expect to see similar results across different countries.

For this reason, we have proposed a different analysis for proportional elections where voters select a party and in addition express a preference for one of the candidates within the party list. To disentangle the role of the party and the role of the candidate, the key variable is not the absolute candidate performance, expressed by the number of votes obtained, but the performance relative to the average performance of competitors within the same party. For each party list, we divide the number \( v \) of votes collected by each candidate by the average score \( v_0 \) of all candidates in the list. The histogram of the relative performance \( v/v_0 \) turns out to be not only very stable for different elections in the same country, but also across countries [Fig. 1 (left)]. The generality of this result, and the stability of the performance curve over more than half a century, suggests that we are facing a basic feature of social dynamics, independent of the cultural, historical, economic and technological context where the elections took place.

We model the electoral campaign of candidates as a word-of-mouth process, starting from the candidates and branching out to the community of voters, through their
social relationships. Each candidate convinces his/her immediate contacts with a certain probability \( r \). Only voters who have not yet made up their mind may be convinced to choose a candidate. Convinced voters, in turn, become activists and campaign in favor of the candidate they have chosen. The number of contacts of each individual is a random variable \( k \), broadly distributed as \( p(k) \sim k^{-\alpha} \) to account for the large variability in personal inclinations and social stance.

The process stops when each voter has picked a candidate. The model yields a distribution of candidates’ performance which matches well the empirical one [Fig. 1 (left)] and is rather robust with respect to variations of the parameters \( r \) and \( \alpha \). It turns out that the most successful candidates are those who manage to acquire the largest number of voters in the initial stages of the process. Indeed, with an initially high number of activists on their side, they may target and eventually gain a high number of supporters, thus limiting the opportunities of their competitors.

II. TURNOUT RATES

Imitation and adaptation are the main features of the social atom, and frequently overrule the individual freedom to make decisions. Knowing how people’s decisions are affected by those of their contacts is fundamental in marketing, policy making, panic situations, etc. Borghesi et al. have used space-resolved election data to address this issue. They focused on the main decision of a voter: shall I vote or not? Turnout statistics are available at the municipal level for many countries and years. For each municipality one can easily extract the geographical location as well. In this way it is possible to check whether there are spatial correlations between turnout rates of different towns, i.e. whether the decision of many people to go to vote (or not to go) in one place is related to the behavior of the voters in nearby places.

Borghesi et al. studied the logarithm of the ratio between the number of registered voters who participated in each election and the number of those who did not. The histogram of this variable, called logarithmic turnout rate (LTR), is a skewed bell-shaped curve that, after proper rescaling, is essentially the same in different countries and elections, for municipalities having approximately the same population. The main result of the analysis, however, is that participation to elections is not independent in different places. Turnout rates are correlated over long ranges in space [Fig. 1 (right)]; quantitatively, the correlation function of LTR decays logarithmically with the distance \( r \) between the locations \( C(r) \sim \ln L/r \), where \( L \) is of the order of the size of the country.

The phenomenology uncovered can be reproduced in terms of a decision model where a voter actually participates to the election only if his own propensity to vote overcomes a threshold. The propensity of each voter is modeled as a continuous unbounded variable, resulting from the sum of three contributions: an idiosyncratic dis-

position (specific to each individual and varying in time), a city-dependent term (with short-scale correlations) and a slowly varying “cultural field”. The latter transports (in space) and keeps the memory (in time) of the collective intentions and is responsible for the long-range spatial correlations of turnout rates. The evolution of this cultural field is affected by two types of mechanisms. People travel to neighbouring cities and interact with acquaintances, carrying their own local cultural specificity and exchanging ideas and beliefs. In so doing, cultural differences between near areas tend to narrow and this implies that the cultural field undergoes a diffusion process over geographically separated locations. The mood of the community in a given area may also be influenced by special events, like the closing down of a factory, or the construction of new infrastructure, which can be modeled by a random noise term. The cultural field thus obeys a diffusion equation in the presence of random noise, whose solution, after a transient leading to stationarity, displays the same spatial correlation profile found in the electoral data. The fit of the model predictions with the empirical distributions reveals that the equilibration time of the cultural field dynamics is very long, of the order of a century, which is consistent with the observed historical persistence of the voting habits in different areas of a country.

The findings we have discussed confirm that elections are phenomena that can be understood quantitatively with the concepts and tools of physics. This new line of research has just started to scratch the surface of the wealth of information contained in electoral data. It promises to shed light on the decisional processes of voters, with potential strong impact on the policy of governments and parties, the design of electoral systems and the organization of political campaigns.

III. ADDITIONAL RESOURCES

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Figure 1: (Left) Histogram of the performance of a candidate with respect to the average score of his/her party competitors in proportional Parliamentary elections with open lists. The resulting pattern is the same in different countries and years, hinting to the presence of a simple underlying mechanism behind the candidates’ competition. A model based on word-of-mouth spreading describes well the universal curve (black dots). © 2007 from the American Physical Society. (Right) Heat map of the turnout rates for the 2004 European Parliament election in France, Germany, Italy, Poland and Spain. Red and blue indicate municipalities with high and low turnout rates, respectively. The pattern is heterogeneous and displays long-range correlations between different geographical areas: locations with high (low) turnout are likely to be in geographical proximity of locations with high (low) turnout.