9
Experiments in Political Economy

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Introduction

Voting and elections play dual roles as social choice systems. On the one hand, they act as a preference aggregation system: they are used to choose between different alternatives when citizens do not agree on their preferred choices. On the other hand, they act as an information aggregation system: when individuals share the same preferences but each has only partial information on the *state of the world*, a voting system can be used to aggregate the decentralized information, increasing the probability of choosing the best alternative.

Experimental studies have analyzed both aspects of elections and have explored the same issues as empirical researchers in political science: electoral participation, voters' strategic behavior, convergence of electoral platforms, retrospective voting,[1] coordination between voters when there are more than two alternatives, the importance of information transmission, etc.

In this chapter we address some of these topics through representative experiments in political economy, the branch of political science with a formal theoretical framework most similar to economics. Clearly, we cannot cover all the existing literature. In particular, we omit experiments on "committee decisions," which in many cases lie behind the experiments we present here.

The first two sections study the role of elections as preference aggregation mechanisms, analyzing voters' and candidates' behavior. The third section studies the capacity of voting to aggregate information, presenting some of its most important implications and paradoxes.

P. Branas-Garza et al. (eds.), *Experimental Economics*

Voters' behavior

Abstention and participation

A prominent and well-studied topic on voters' behavior is known as the *participation paradox*. In elections with a large number of voters the probability that a single vote will be decisive or pivotal is close to zero. Hence, from a cost–benefit perspective, it is irrational to vote. That is, since one single vote is almost surely irrelevant to the outcome of the election, any small voting cost (for instance, the trade-off of not going to the beach) is greater than the expected benefit.[2]

Therefore, from a rational choice perspective, the task is not to explain the relatively "low" levels of participation in large elections but, on the contrary, to explain why so many citizens decide to participate in such elections when each individual's vote has, most likely, no effect on the electoral outcome. Do voters ignore the strategic calculation of voting, which is based on the probability of being the decisive voter? Do they vote simply because they like to?

Empirical analysis of these questions using field data is difficult because the variables of interest, in particular perceptions of benefits and participation costs, are almost impossible to measure or approximate using observable variables. Thus, laboratory experiments present a particularly appealing option. But, how can we design the costs and benefits of participation in elections?

In their experiments, Bornstein (1992) and Schramm and Sonnemans (1996a, b) identify the act of voting with the procurement of tokens for a participant's group. Participants are divided into two groups competing against each other to choose the winning option.

- Each individual decides how many tokens to purchase, at a given cost, knowing that her payoff will depend on the total number of tokens acquired by her group compared to the number of tokens acquired by the other group.
- All members in a group get the same payoff.

With this design it is possible to explicitly manipulate the cost of voting (through the price of each token) and the benefits of voting (through the payoffs contingent on the number of tokens acquired by the group).

Despite the simplicity in their design, the experiments by Schramm and Sonnemans allow for the analysis of the effects, not only of the costs and benefits of voters' behavior (that is, the number of tokens each individual purchases), but also of variations in group size.

Furthermore, since the authors were able to directly characterize voters' choices, they were able to manipulate the institutional framework to explore the effects of different political institutions on voters' behavior. With regard to institutions, Schramm and Sonnemans considered two systems:

- a majority system (where there is only one winning group); and
- a proportional representation system.[3]

In the majority system only the members of the winning group receive a positive payoff, while in the proportional system each individual receives a payoff proportional to the fraction of total tokens acquired by her group. Each voter participated in 20 rounds, and the experiments were conducted with groups of 12, 24 and 48 voters in each election.

The results of the experiments are surprising. First, while participation behavior responds as expected in terms of costs and benefits (participation increases when the cost decreases and decreases when the cost increases), participation was consistently higher in the majority system than in the proportional representation system.[4] The authors also found evidence suggesting that participation (i.e., the number of tokens acquired) decreases with group size, although the effect was small and statistically insignificant.

In these experiments, costs were kept constant for all individuals, suggesting that changes in behavior for different institutional frameworks and group sizes are fundamentally due to participants' perceptions regarding the benefits of voting. In other words, these findings suggest that voters are more sensitive to perceived benefits than to voting costs.[5]

An important problem in many voting models is the existence of multiple equilibria and the high degree of strategic uncertainty among participants, complicating the interpretation of the findings (see chapter 3 of Vol. 1). Levine and Palfrey (2007) avoid this problem by using a different design. In their experiments, all members of one party (or group) obtain the same benefits, but have different

costs. Each individual's cost is private information, but individuals know the distribution of costs in their group. This design allows the experimenter to choose the distribution of costs to yield a unique equilibrium.[6]

The theoretical model behind this experiment is presented in Palfrey and Rosenthal (1985). Although we do not provide a description of the model in this chapter, we present three of its hypotheses that are tested against the experimental findings.

i. The *size hypothesis*: keeping preferences constant, participation should decrease as the number of voters increases.
ii. The *competition hypothesis*: keeping the number of voters constant, participation should increase as the fraction of voters supporting each party comes closer to 50%.
iii. The *underdog hypothesis*: supporters of the minority party (the party supported by less than half of the population) should vote in a greater proportion than those in the majority party.

The findings in the experiments of Levine and Palfrey (2007) provide support for all three hypotheses, although participation tends to be greater than theoretically predicted in elections with a larger number of voters, and lower than theoretically predicted in elections with a smaller number of voters. The findings are presented in Table 9.1, comparing the participation rates predicted by the theoretical equilibrium with those observed in the experiments.

Table 9.1 Participation rate: balance and data

Size matches (majority party–minority party)	**2–1**	**5–4**	**6–3**	**14–13**	**18–9**	**26–25**	**34–17**
Minority participation in equilibrium	54	41	46	27	30	21	24
Real participation of the minority (data)	53	44	48	38	38	33	39
Majority participation in equilibrium	64	37	45	23	30	17	23
Real participation of the majority (data)	64	40	45	28	36	27	36

Note: Reproduction of Table in Palfrey (2009). Source: Levine and Palfrey (2007).

Strategic behavior

Besides the analysis of participation, experiments also provide an opportunity to investigate to what extent voters behave strategically and choose to support candidates who, despite not being preferred, can help obtain a more favorable outcome in the elections. Strategic voting can have important consequences. For instance, consider a majority election with three candidates, A, B, and C, with the following characteristics:

- Most voters (say 60%) prefer A or B to C, but they are equally divided between the two candidates: 30% support A and 30% support B.
- The remaining 40% prefer C.

Without strategic voting, if all individuals were to vote for their favorite candidate, C would win the election, even with the majority preferring any of the other two candidates.[7] However, if those voters supporting B voted for A, A would win the election and those voters preferring B would be better off than if C were elected. Notice that strategic voting is not enough to avoid the situation of choosing the least preferred candidate since voters are required to coordinate on which candidate, among their preferred ones, they will support.

Forsythe *et al.*(1993) presents a procedure that is common in this type of experiment: with three political alternatives, participants (voters) are assigned to "voting groups" which share the same preferred option. In this way, the experimenter can manipulate payoffs, group sizes and, in particular, the degree to which the majority is split between the two alternatives with the largest support.

Overall, experimental results show that a Condorcet loser may be elected in the absence of signals indicating how individuals will vote. In these circumstances, voters, ignoring the distribution of preferences, may vote for their favorite candidate or not vote at all.

However, when there are informative signals about the distribution of preferences (e.g., through surveys or election campaigns supporting one of the majority candidates), a majority of voters behave strategically and vote for the candidate with the largest support, even if she is not their favorite candidate.

Elections and political competition

The median voter and two-candidate elections

The median voter theorem (MVT) establishes that in two-candidate majority elections, under certain conditions electoral platforms will converge to the preferred option of the median voter. In other words, if there are Condorcet winners, they will be elected. But does this actually happen? At first sight electoral platforms appear different for different candidates or parties, even in majority voting systems with a single winner. That is, not even under the appropriate theoretical conditions (a majority winner system and a two candidate election) do the political platforms converge to the preferences of the median voter.

In order to analyze this question in the laboratory, McKelvey and Ordeshook (1982) designed a series of experiments with two candidates in a two-dimensional policy space.[8] Each experiment consisted of a series of rounds where two subjects, always the same or "partners" (see chapter 7 of Vol. 1), chose strategic paths after observing the choice of the other candidate in previous rounds and the consequent electoral outcomes.

Thus, candidates were the only participants in these experiments: they had no preferences over the political issue and received benefits only if they won the election. Voters were actors simply voting for the candidate whose proposal was closer to their ideal policy. Finally, the configuration of preferences and the distribution of voters were such that there was a unique Condorcet winner.

Figures 9.1a and 9.1b summarize the policy proposals of the candidates for the first five and last five rounds in a five-voter election. One can observe that, in this two-dimensional policy space with a unique winner, candidates converge to the point of the Condorcet winner. A comparison of the graphs shows the process of learning and adjustment over time. Similar to the convergence of prices in a competitive market, electoral platforms in competitive elections converge to the Condorcet winner.

These experiments were conducted in a setting of complete information. Candidates (the experimental subjects) were fully informed about the preferences of all voters and it was assumed that voters (artificially created) voted based on the strategies (i.e., proposals) of the candidates.

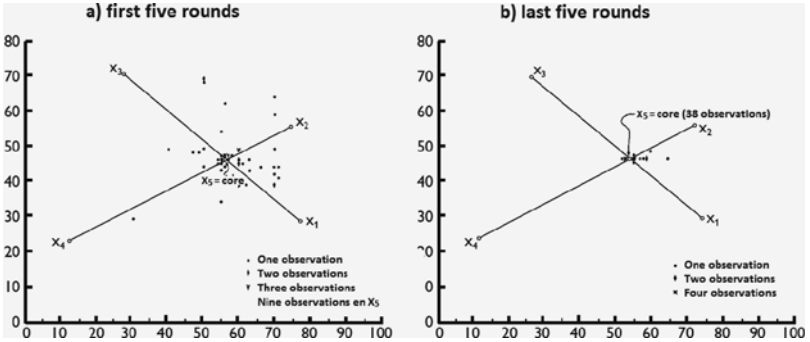

Figure 9.1 Spatial elections with five voters and equilibrium existence.
Reproduction of Figures 5.8a and 5.8b in McKelvey and Ordeshook (1990).
Source: McKelvey and Ordeshook (1982).

However, in reality candidates do not have complete information but only incomplete data on the preferences of voters. In addition, voters usually receive relatively poor information on the proposed policies that candidates will implement. Therefore, it is very relevant to know how much information on voters' preferences and candidates' policies is necessary to obtain convergence to the Condorcet winner.

Regarding information about voters' preferences, Plott (1991) conducted ten experiments where candidates did not know voters' preferences but could ask voters questions and periodic surveys on voting intentions were conducted.[9] The main conclusion in these experiments was the replication of previous findings, supporting the idea that the information provided by surveys is sufficient for the convergence of candidates' proposals. However, pilot experiments "without questions" suggest that convergence would not have happened in the absence of surveys.

Regarding the poor quality of information that voters have during elections, McKelvey and Ordeshook (1990) conducted a series of experiments in a one-dimensional policy space. Each experiment consisted of eight elections with candidates perfectly informed about voter preferences. Each session started with candidates choosing policy positions, followed by two opinion surveys, and finally, voting to determine the winner. Subjects were either informed or uninformed voters.

- A majority of voters (half plus one) were *informed* voters, who received information about the position of the candidates.
- The rest were *uninformed* voters who had to base their decision on signals like endorsements, opinion polls or their relative position compared to other voters.

The design was such that the information received by the electorate as a whole was enough to produce a rational expectations equilibrium where all voters voted as if they had perfect information on the candidates' positions.

In the experiments, uninformed voters voted "correctly" 84.9% of the time and candidates converged quickly to the preferred position of the median voter. This is evidence of the robustness of the median voter theorem in environments with incomplete information.

In other words, in a one-dimensional political system with office-motivated candidates (i.e., those deriving benefits solely from being in office) we find support for the hypothesis of total revelation of voters' information and the convergence of candidates' platforms.[10]

Although subjects participated in a series of rounds to learn the information processes, the results so far have restricted the outcomes to a single election. Alternatively, a large literature studying voting behavior suggests that voters may vote retrospectively – i.e., based on the previous policy choices of a politician in office. A large set of experiments address this issue by linking the payoff of voters with the policy position chosen by an incumbent candidate.[11]

In the absence of electoral campaigns, voters have to choose between re-electing the incumbent and choosing an alternative candidate, based exclusively on the flow of benefits received in the past. The incumbent only knows the history of policy positions chosen by previous candidates in power and the voting support they received. He must choose his policy position with this information. Findings from these experiments show once more that, on average, candidates converge to the position of the median voter, in spite of the limited information.

In summary, even for *laboratory elections* where the relevance of voting outcomes is limited, when candidates are identical and office motivated the median voter theorem is an acceptable approximation for the outcome of a two-party, spatial competition election: candidates' strategies tend to converge and the Condorcet winner is a good predictor of the outcome of competitive elections.

A second relevant implication is that the convergence result for two-candidate elections is robust to the information that voters have about candidates and the information that candidates have about voters. In fact, very little information is necessary. Therefore, it may seem irrational for voters to accumulate costly information when there are surveys, endorsements, word-of-mouth transmission, or other sources of information that are essentially free.[12]

However, as we will see in the section on *asymmetric competition*, such convergence outcomes are not immune to changes in the framework and disappear in the presence of differentiating characteristics independent of the candidates' policy positions (*valence issues*), or when candidates have policy preferences and there is uncertainty regarding the position of the median voter.

Elections with more than two candidates

Many elections are characterized by more than two candidates competing under a simple majority system. This sort of election is especially interesting because there is no conclusive theoretical result. In fact, practically anything can happen in equilibrium. Even in a three-candidate election with a Condorcet winner, a candidate choosing the Condorcet position may be crushed on both sides by the competition of the other two candidates and end up losing the election. Therefore, it is possible that Condorcet winning positions are not chosen.

Plott (1991) uses the experimental framework described in the previous section to compare elections with two and three candidates. He finds that experiments with three candidates tend to reproduce equilibrium outcomes observed with two candidates. Candidates tend to converge, although the variance is greater in elections with three candidates. However, the dynamics that result in this equilibrium are hard to predict, as it is difficult to separate the effects of candidates from those of voters, and there is evidence that voters are sophisticated and behave strategically (see the previous section on *strategic behavior*). It is possible that outcomes are sensitive to the moment when the experiment ends, that is, to the length of the election. Competition leads candidates to the median voter's position, but the candidate in the middle, squeezed by the other two candidates, changes his policy, triggering a new cycle and a new convergence process. In summary, sophisticated voting and the time when elections end seem to explain the final outcomes.[13]

So far it is the experimenter who has assigned the role of candidate and, therefore, the number and the characteristics of candidates were given exogenously. *Citizen-candidate* models solve this limitation and are a good framework for analyzing the nomination process, as well as endogeneity in the number of candidates (see Osborne and Slivinski, 1996, or Besley and Coate, 1997). Consider a set of n citizens (the experimental subjects):

- Each citizen is assigned an ideal point within an interval.
- Subjects decide whether to run as a candidate or not.
- Running as a candidate implies a cost and candidates can only run with their ideal point as their policy position.
- Payoffs are the result of the decision to run as a candidate or not, the net benefit of winning the elections (that is, the benefits of wining the elections minus the cost of being a candidate), and the distance between the ideal policy point and the winning policy.
- Voting is an automatic action, and the winner is the candidate whose ideal point is closest to a majority of voters' ideal points. In case of a tie the winner is chosen using a lottery. If no one chooses to be a candidate, a point is randomly chosen among all the ideal points.[14]

The results are revealing. When the cost of running as a candidate was high (so that the net benefit of winning was low), 86% of the observed decisions were consistent with the theoretical prediction that only one participant would present himself as a candidate, which also coincided with the position of the median point.[15]

When the cost is low, the theory is inconclusive and predicts multiple equilibria. The parameterization used in this experiment could generate equilibria with one, two or three candidates. However, the experimental results supported, in general, a symmetric equilibrium with two candidates and differentiated positions, converging slowly to equilibrium: it is only during the last five rounds that we observe a larger number of candidates from citizens on both sides of the median and a smaller number of candidates in the median position.

Asymmetric competition

Elections feature candidates with asymmetric characteristics, that is, candidates differing in aspects other than their policy positions. Common sources of asymmetry include an incumbent position,

personal valence issues or ideology. The most relevant implication of these asymmetries is that the theoretical equilibrium now predicts divergence in the policy positions of the candidates, even when the policy space is one-dimensional.

For the sake of presentation, we will focus on the case where candidates differ in an identifiable personal characteristic (i.e., a valence) but results are similar when candidates hold a political ideology or have preferences over the different policy positions.

A candidate's personal valence, such as her last name, being a movie or sports star, or her physical or personality traits, is relevant because it offers her an advantage or a disadvantage over the other candidate (independent of the support received from her spatial policy location). Consider the following experiment:

- Two candidates simultaneously choose a position between three possible alternatives: $\{L,C,R\}$.
- Candidates ignore the exact location of the median voter, but they know that the median voter is in C with probability a and that it is in L or R with the same probability, i.e., $(1\text{-}a)/2$.

Probability a is the control variable in the analysis. The experimental design is such that personal valence makes candidate 1 the advantaged candidate and hence she wins the election when both candidates are located at the same distance from the median voter.

In this context, Aragonés and Palfrey (2004, 2005) find support for the following theoretical implications: the disadvantaged candidate tends to locate in more extreme positions than the advantaged candidate; moreover, as the distribution of voters polarizes (the value of a decreases), the disadvantaged candidate shifts towards the center, while the advantaged candidates shifts towards more extreme positions.[16]

These outcomes suggest that, in the presence of personal valence and uncertainty on the location of the median voter, candidates not only diverge in their policy positions but, in general, candidates with a relative disadvantage will tend to diverge when the distribution of voters' preferences is unimodal.

Information aggregation and voting

In addition to choosing between different options or candidates, voting can serve to aggregate information distributed across different

individuals. In the standard model of information aggregation, a group of individuals share common interests and have to choose an alternative that grants different payoffs depending on the *state of the world*. The group does not know the state of the world, but bits of information are distributed across individuals.

The question is: can a voting system aggregate such decentralized information and find the true value of the state of the world, allowing the group to make the best choice?

Condorcet's jury theorem

The original information aggregation model can be found in Condorcet (1785), and the virtues of majority voting are summarized in the well-known Condorcet's jury theorem (CJT). In a few words, this theorem states that, under very general conditions, majority voting efficiently aggregates the information individuals have and is able to discover the truth, or to choose the adequate option, as long as individuals vote sincerely. For instance, if each individual has the correct information with a 60% probability, the perception of the majority will be correct more often than the perception of any particular individual. In particular, three individuals with statistically independent information who decide through majority voting will choose correctly 64% of the times, against the 60% when choosing individually. Furthermore, this probability tends to one as the group size tends to infinity. The 60% probability is just an example, but the results hold for any probability larger than 50%, that is, whenever individuals hold valuable information. Therefore, CJT asserts that majority voting is a good information aggregation system.

Experimental analysis has demonstrated the robustness of CJT, as the experiments of Ladha *et al.* (2003) and of Guarnaschelli *et al.* (2000) show.[17] Ladha *et al.* (2003) conducted the first experiments studying whether majority rule leads to an improvement against individual decisions. In those experiments a group comprised of three individuals had to discern the color of a ball drawn out of an urn filled with 60 white balls and 40 black balls. Without further information, the best option for each individual is to state that the ball is white and to be correct 60% of the times. In order to analyze information aggregation, the experimenter offered individuals a signal.

Before stating a color, each subject would draw a ball form a second urn, whose composition depended on the color of the initial ball:

- if the initial ball was black, the second urn would only contain black balls;
- if the initial ball was white, the second urn contained 60 white balls and 40 black balls.

Therefore, if an individual drew a white ball from the second urn he would know that the color of the initial ball was white. On the other hand, if he drew a black ball, the initial color could have been either white or black.[18] After receiving the signals, the three individuals in a group would decide the color by majority voting, that is, the color with at least two votes would be chosen.

Ladha's experimental results confirmed the potential for majority decision to aggregate information. Groups deciding by majority voting chose the correct color of the ball 93.75% of the times. Surprisingly, this result is not only higher than the theoretical rate of correct individual choices (76%), but also higher than the rate predicted by CJT (78.9%).[19]

The swing voter's curse

When abstention is an option, the presence of uninformed voters can result in what Feddersen and Pesendorfer (1996) coined "the swing voter's curse:" an uninformed voter may decide to abstain (either by not participating or by making his abstention public) with the intention of delegating his decision to those voters who are "better informed."

This is referred to as a curse because a vote is relevant only when it is decisive, and uninformed voters are decisive when voting against informed voters. If an uninformed voter is decisive he may hinder the choice of the informed voters sharing his same interests. It is rational, therefore, to abstain, even when voting is not costly. On the other hand, if there are *partisan* voters (voters who always support an alternative, regardless of the situation), it may be rational for an uninformed voter to vote, and do so even against his a priori information, to counter the votes of partisan voters, leaving the choice in the hands of *independent* and informed voters. This rational behavior requires a sophisticated reasoning. Are voters sophisticated enough?

Battaglini *et al.* (2010) explore this problem in the laboratory. In their experiments, two urns contain 75% of white balls each, but they differ in the color of the remaining 25% of balls. They are red in urn *A* and yellow in urn *B*. The experimenter randomly chooses one of the urns. Individuals know the probability of choosing each urn, and must guess which urn was selected. Before deciding, each individual draws one ball from the chosen urn, observes its color and puts it back in the urn. Hence,

- some citizens become informed, when they draw a red or yellow ball; while
- others remain uninformed, when they draw a white ball.

In the experiments, uninformed voters abstain 91% of the time, supporting the swing voter's curse hypothesis. Moreover, in the presence of *partisan* voters who always vote for *A*, uninformed voters show rates of participation and unconditional voting for *B* in line with the theoretical predictions. That is, uninformed voters rarely vote for *A*, while the frequency of votes for *B* increases with the number of *partisan* voters.

Conclusions

In this chapter we have presented a few representative examples of experiments in political economy. We have not been exhaustive, neither in the list of experiments nor in the topics in political economy studied by experimental economics. Many other important topics, such as the role of communication media, expenditure on electoral campaigns or the possibility of government coalitions, have also been studied in the laboratory.

Nonetheless, despite the small number of experiments covered in this chapter, we can draw two conclusions. First, there is clear evidence supporting the existence of voters' strategic and sophisticated behavior, observed for example in the electoral participation choice or in the swing voter's curse experiment. Second, although with some quantitative differences between outcomes in the laboratory and theoretical predictions (e.g., electoral participation is usually larger in the laboratory), experimental results tend to corroborate most predictions from the theoretical models, such as the potential

for majority elections to aggregate information or the divergence of policies when candidates have differing ideologies or personal characteristics.

Notes

1. Citizens vote retrospectively when they evaluate politicians in office through their past decisions.
2. The participation paradox was already identified by pioneering authors in the formal study of political theory, such as Downs (1957) or Riker and Ordeshook (1968).
3. The proportional system is dominant in Western Europe. In this system various members of Congress are elected for each electoral district, with each party receiving a number of representatives approximately proportional to the number of votes received. On the other hand, Anglo-Saxon countries, such as the United Kingdom, New Zealand, Canada and Australia, tend to use a majority system, in which only the representative with the highest number of votes in each district gets elected, leaving the rest of parties without representation.
4. Participation was around 50% during the first rounds of the majority system, decreasing consistently to 20% in the last rounds. On the other hand, initial participation in the proportional system was around 30%, gradually decreasing to 20% in the final two rounds. Nevertheless, it is important to stress that it is not possible to know if participation would have continued decreasing with experience if the experiments had continued for higher number of rounds.
5. After the 20 official rounds, Schramm and Sonnemans allowed participants to communicate with others in their group, being able to exchange their impressions about the outcomes in previous rounds. Afterwards they conducted a series of "surprise rounds" voting. In these rounds participation practically doubled, suggesting that communication (and involvement in general) may play an important role in determining electoral participation.
6. The equilibrium is characterized by critical values for costs so that:
   – all those members with costs above the critical value for their group abstain; and
   – the rest of the group, whose costs are below the critical value, vote.
7. A *Condorcet loser* is a candidate who always loses in an election against any of other candidate. In our example, candidate C is a Condorcet loser since in any pairwise election 60% of the electorate would vote against him. Similarly, a candidate is a *Condorcet winner* if he never loses in a pairwise majority vote.
8. When a vector of characteristics represents policies, we say that the policy space is multidimensional (either because the policies are intrinsically multidimensional, for instance a progressive taxing system, or because the

vector refers to a package of policies, with each dimension representing a different issue). When there is a single issue and this issue is characterized by a single parameter (for instance, a proportional tax rate), we say that the policy space is one-dimensional.

9. Candidates usually asked questions of the sort: "How many of you would prefer that I propose point *x*?"
10. However, when the analysis is extended to two dimensions, the convergence of candidates is slower. One may argue that multidimensional policy spaces imply substantially more difficult decisions and that candidates would end up converging if the number of rounds were increased. Nonetheless, such conjecture still requires to be proven.
11. See, for instance, Collier *et al*. (1987).
12. Findings in Collier *et al*. (1987) and Williams (1991) support this view when they extend the experimental environment by offering voters the possibility of acquiring, at a cost, information on the candidates' positions.
13. Indeed, only in one out of the 11 experiments is it the candidate in the middle who wins the election.
14. The details of the experiment, which was conducted with five individuals in 10 sessions, can be found in Cadigan (2005).
15. In this experiment, as it is frequently observed in *entry games* (games where there is a binary choice: to enter or not to enter), there is an excessive number of entries compared to the theoretical prediction of the Nash equilibrium.
16. These findings are robust, as they have been replicated for different subject pools and various instruction protocols.
17. Both articles find similar conclusions, although the main focus in Guarnaschelli *et al*. (2000) is on unanimity decisions, which we do not cover here.
18. In fact, if the drew a black ball, the initial ball was black with probability 62.5%. This number follows from Bayes theorem (see chapter 2 Vol. 1):

$$\Pr\left[Black \mid \text{signal\_Black}\right] = \frac{\Pr\left[\text{signal\_Black} \mid Black\right] \times \Pr\left[Black\right]}{\Pr\left[\text{signal\_Black} \mid Black\right] \times \Pr\left[Black\right] + \Pr\left[\text{signal\_Black} \mid White\right] \times \Pr\left[White\right]} = \frac{1 \times 0.4}{1x0.4 + 0.4 \times 0.6} = 0.625.$$

19. These values obtain from calculating the probability of success conditioned to the signal. An individual following the information from his signal would succeed with the following probability:

(Pr[{white,white,white}|*White*]+3x[{white,white,black}|*White*])xPr[*White*]+ (Pr[{black, black, black } | *Black*] + 3 x [{black, black, white } | *Black*]) x Pr [*Black*]= 0,648 x 0,6 + 1 x 0,4 = 0,789.