(Ir)rational Voters?

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Abstract

Social scientists have long speculated about the extent of agents' rationality, especially in the context of voting. However, existing attempts at classifying voters as (ir)rational have been hampered by the fact that preference orderings and, thus, optimal strategies are generally unobserved. Exploiting the incentive structure of Germany's electoral system, this paper develops a novel set of empirical tests in order to pit the canonical rational choice model against behavioral theories according to which voters simply choose their most preferred candidate. The results indicate that neither approach can rationalize the most-salient features of the data. The findings are consistent, however, with a simple hybrid model in which boundedly rational agents suffer a small psychic cost from acting strategically.

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1. Introduction

Rational choice theory is, without question, the dominant paradigm in economics and much of political science. Even issues once thought to be far beyond the realm of traditional economics have long been analyzed through the lens of rational choice (see, e.g., Becker 1993). At the same time, a large behavioral literature suggests that agents face cognitive constraints, and that deviations from strict, unbounded rationality may matter for many real-world outcomes (Simon 1955, 1972; see also the surveys by Conlisk 1996; Camerer 2006; and DellaVigna 2009). If economics is to be a positive science of actual human behavior—as opposed to a normative one of how people should behave—then understanding how prevalent these deviations are is a matter of first-order importance.

An area of economics within which scholars have long been interested in this question is social choice (e.g., Black 1948; Downs 1957; Duverger 1954; Farquharson 1969; Sen 1970). On the one hand, practically every reasonable electoral system fails to be strategy-proof, and voters are known to have a systematic incentive to misrepresent their true preferences in order to affect the outcome of an election (Arrow 1951; Gibbard 1973; Satterthwaite 1975). On the other hand, pivot probabilities in large elections are often vanishingly small. If voters suffer even a small cost from abandoning their favorite candidate or from determining their optimal strategy, then one may not expect any of them to act strategically (Downs 1957; Green and Shapiro 1994; Sen 1970).

Given the theoretical merits of both arguments, it may not be surprising that there exists no consensus on how voters actually behave. Some model voters as strategic, unboundedly rational individuals seeking to affect electoral outcomes (e.g., Austen-Smith and Banks 1988; Besley and Coate 1997; Bouton 2013; Feddersen and Pesendorfer 1996). Others, however, cast voters as behavioral agents who naïvely choose their most preferred candidate, irrespective of her chances of winning (e.g., Callander 2005; Osborne and Slivinski 1996; Palfrey 1984). As practically all formal theories in which agents face more than two alternatives require an *assumption* about the rationality of individuals, and given that the conclusions from nearly identical models may depend critically on whether voters are taken to be strategic or sincere (compare, for instance, Besley and Coate 1997 with Osborne and Slivinski 1996), it is crucial to close this gap in knowledge. More generally, studying voter behavior in large elections with (arguably) weak electoral incentives helps to understand to what extent agents act "as if" they are unboundedly rational.

Of course, how people actually behave is ultimately an empirical question. Yet, outside of the laboratory it has proven extremely difficult to estimate the extent of instrumentally rational voting. The key problem is that individuals' true tastes are generally unobserved. Without imposing further assumptions, it is, therefore, impossible to know whether ballots

deviate from the underlying preference orderings. In fact, in an important paper, Degan and Merlo (2009) prove that *any* cross section of votes can be explained by some utility function, without resorting to strategic behavior.

To illustrate the problem, consider the 2000 presidential election in Florida, in which George W. Bush beat out Al Gore by a margin of 537 votes, and as a result, won the U.S. presidency. Although Florida was widely expected to be a swing state, more than 138,000 voters chose third-party candidates. Viewed through the lens of the canonical rational choice model, these 138,000 voters could not have behaved strategically, as doing so would have required them to abandon their favorite candidate and vote for either Bush or Gore. Unfortunately, all one can infer from data like these is that at least 138,000 out of almost 6 million voters did not behave in accordance with standard theory.[1] In order to derive more meaningful results, one would ideally like to know how many voters actually prefered a third-party candidate, whom they *should* have abandoned in favor of Bush or Gore. With this information in hand, it would be straightforward to determine whether the observed number of "mistakes" is economically large or small.

Given the prominence of the pivotal voter model, i.e. the assumption of cognitively unconstrained actors attempting to affect the outcome of an election, this paper's primary goal is to quantify deviations from this baseline. As a matter of terminology, agents are said to be *not* instrumentally rational if they fail to abandon a candidate who has no chance of winning.

In order to circumvent the fundamental identification problem, the present paper exploits the incentive structure of parliamentary elections in Germany. Under the German system, individuals have two votes. Both are submitted simultaneously and are used to elect representatives to the same chamber of parliament. Critically, they are associated with very different incentives. The *list vote* is cast for a party and counted at the national level. Up to a first-order approximation, list votes determine the distribution of seats in the Bundestag. Since mandates are awarded on a proportional basis (conditional on clearing a 5%-threshold), it is in most agents' best interest to reveal their (induced) preferences over which party they wish to gain the marginal seat by voting for said party.[2]

By contrast, the *candidate vote* is counted in a first-past-the-post system at the district level. Whichever candidate wins the plurality of votes in a given district is automatically

[1] Kawai and Watanabe (2013) call this "misaligned voting." Clearly, the set of agents who cast misaligned votes is only a (potentially small) subset of strategic voters, i.e. those who would abandon their preferred candidate if need be.

[2] Note that individuals' preferences over which party wins the marginal seat in parliament need not coincide with their deep ideological convictions. Nevertheless, it is useful to think of preferences in this narrowly defined way, as it conditions on expectations about post-election coalition formation, beliefs about the behavior of other voters, the influence of campaign activities, etc.

elected. Votes cast for any other contestant are "lost." Although the candidate vote is primarily used to determine the identity of local representatives, by securing a disproportionate share of districts parties may actually increase their seat totals (see Section 2 for details). The important point is that when it comes to choosing among different candidates, voters have a clear incentive to behave tactically. As in all elections under plurality rule, agents who act in accordance with standard rational choice theory should never vote for a party's nominee if she is known to be "out of the race." Only by choosing one of the candidates who remain in contention for victory can voters hope to affect the outcome of the race.

Under the assumption that voters are not exactly indifferent about who carries their home district, it is possible to shed light on whether individual choices are consistent with leading theories of how voters behave. To see why the German context is helpful, consider an agent who cast his party vote for the small, libertarian FDP. Although the FDP fields candidates in practically all district-level races, they are almost never in contention for victory. Thus, as long as this voter knows that the FDP candidate in his district is "out of the race," he should not vote for her. Doing so would be inconsistent with instrumental rationality. Instead, conditional on supporting the FDP, he should split his ticket and vote for the candidate of another party—one who actually is in contention for victory.

While it is tempting to think of the list vote as a proxy for agents' preferences over parties and the associated candidates—especially if one believes that voters do not have strong incentives to behave strategically under proportional representation—it is important to emphasize at the outset that such an assumption is *not* required for testing rational choice theory. Voting for a candidate who is known to be "out of the race" is inconsistent with instrumental rationality, irrespective of why a given individual chose to support the associated party.

Hence, instead of asking the difficult question of what fraction of voters sticks with their preferred candidate despite her having no chance of winning, the German electoral system allows us to tackle a much simpler one: Conditional on having a strategic incentive to split their ballot, how many voters fail to do so? That is, how many of a party's supporters simply vote for the associated candidate despite her being "out of the race?"[3]

As Figure 1 demonstrates, the answer turns out to be "most." Restricting attention to candidates who trailed the runner-up by more than 10 percentage points, the figure displays a semiparametric estimate of the relationship between precinct-level vote shares of a candidate's party and the candidate herself. If individuals behaved as prescribed by the standard

[3]It is important to note that the usual reasoning for split-ticket votes, as in Alesina and Rosenthal (1996), does not apply in the context of Germany. After all, politicians elected via the candidate vote enter the same chamber of parliament as their colleagues elected via the list vote. Thus, voters seeking to balance the legislature should (except in knife-edge cases) choose the same party with both votes.

pivotal voter model and were not "irrationally" optimistic about these candidates' chances of being in contention for victory, then none of them should have gotten any votes, irrespective of how popular the party happened to be in a particular precinct. The data resoundingly reject this prediction. In fact, the slope estimate indicates that more than 60% of party supporters stick with candidates who are "out of the race."

This and all other findings are based on previously unavailable, official precinct-level data from the 2005 and 2009 federal elections. In Germany, precincts are the smallest administrative units at which votes are counted, and each precinct is fully contained within one electoral district. Since races take place at the district level, these data allow for the use of within-candidate variation only, thereby *conditioning* on the characteristics of candidates and their competitors, pivot probabilities, and various other sources of unobserved heterogeneity.

The results in this paper speak directly to large theoretical literatures on tactical voting (e.g., Austen-Smith and Banks 1988; Bouton 2013; Cox 1994; Feddersen and Pesendorfer 1996; Myatt 2007; Myerson 2002; Myerson and Weber 1993) and strategyproofness in social choice (see Barberà 2011 for a recent review). On a purely descriptive level, the empirical evidence indicates that the fundamental assumption in rational choice studies of voting fails for the vast majority of individuals.

At the same time, behavioral theories according to which voters sincerely choose their most preferred candidate are also at odds with the data. Instead of simply positing that the 35% of voters who cast split tickets when it is optimal to do so are acting strategically, the German context allows for an explicit test of sincere voting. The intuition for this test is, again, quite simple. Under the null hypothesis of sincere behavior, an agents' list vote must reveal his true party preference. If preferences over parties and candidates are sufficiently correlated, then list and candidate vote shares should track each other almost one for one. After controlling for candidate quality, this turns out to be the case in situations in which voters have no incentive to cast split ballots, but *not* when strategically splitting one's ballot would be instrumentally rational. In total, the data are inconsistent with sincere behavior for about one in ten voters.

In sum, both the canonical rational choice model as well as the leading alternative are rejected. The evidence is consistent, however, with a simple hybrid model in which agents are boundedly rational in the sense that they face a heterogenous cost of behaving strategically. Such "psychic" costs could, for instance, stem from a preference for consistency across domains, social image, true cognitive limitations, or any other impediment to making optimal choices.[4]

[4]DellaVigna et al. (2013), for instance, argue that social image plays an important role in explaining turnout. That is, individuals vote because they derive pride from telling others that they went to the polls.

Support for the assertion that agents act "as if" they are boundedly rational comes from several key pieces of evidence. First, not only do individuals who cast split tickets substitute toward the nominee of a potential coalition partner, but the tendency to abandon candidates who are "out of the race" is higher among voters faced with at least one palatable alternative than among those who can only choose between two evils. Second, voters' choices are less likely to violate instrumental rationality in elections perceived as "critical" than in ordinary ones. Lastly, ancillary results show that individuals' sophistication varies systematically with observational characteristics, such as socioeconomic status and experience with the electoral system. That is, poor, inexperienced agents are less likely to behave in accordance with the canonical rational choice model than their wealthy and more experienced counterparts.

The latter findings contribute to a nascent literature on "who is behavioral." Benjamin et al. (2013), for instance, show that preference anomalies are related to cognitive skills, and Choi et al. (2014) demonstrate that decision-making ability in laboratory experiments correlates strongly with socio-economic status and wealth. That is, wealther individuals violate the axioms of rationality less frequently than poorer ones.

The remainder of the paper proceeds as follows. The next section provides a more detailed description of Germany's electoral system and explains how to detect deviations from instrumental rationality. Section 3 provides a first look at the data, while the main results appear in Section 4. Section 5 studies how the share of behavioral agents varies with voters' observational characteristics. The penultimate section places the results in the context of the relevant literature, and the last section concludes.[5]

2. Germany's Electoral System

2.1. *Political Landscape and Electoral Rules*

The political landscape in Germany has traditionally been dominated by five major parties: CDU/CSU (conservative), SPD (center-left), FDP (libertarian), Green Party (green/left-of-center), and The Left (far left). Among these, the CDU/CSU and the SPD each have nearly as many supporters as the three smaller parties combined. Neither party, however, can govern on the federal level without a coalition partner. Since the mid-1980s, the CDU/CSU's traditional partner has been the FDP, whereas the SPD, whenever possible, entered into coalitions with the Green Party. These "preferences" are well-known to voters.

[5]There are five appendices available on the author's website. Appendix A explains the algorithm for calculating each party's number of seats in the Bundestag, while Appendix B provides a partial test of sincere voting in the proportionality-rule part of the German system. Precise definitions of all variables used throughout the analysis appear in Appendix C. Lastly, Appendix D replicates the main results using a structural model of voting decisions with Appendix E elaborating on the numerical methods used in the structural analysis.

In order to shed light on the prevalence of deviations from instrumental rationality, the present paper exploits the incentive structure of elections to the Bundestag, the lower house of the German legislature. Elections are held every four years according to a mixed-member system with approximately proportional representation. Except for minor modifications, the same system has been in place since 1953.[6]

As mentioned in the introduction, each voter casts two different votes. The first vote, or *candidate vote* (Erststimme), is used to elect a constituency representative in each of 299 single-member districts. District representatives are determined in a first-past-the-post system. That is, whichever contestant achieves the plurality of candidate votes in a given district is automatically awarded a seat in the Bundestag. Winners are said to hold *direct mandates*, and votes cast for any other candidate are discarded.[7]

The arguably more important vote, however, is the *list vote* (Zweitstimme). It is cast for a party list, and the total number of party members who enter the Bundestag is roughly proportional to a party's share of the national list vote among parties clearing a 5%-threshold. To achieve approximately proportional representation despite potentially lopsided outcomes in the candidate vote, the German electoral system awards *list mandates*. First, all list votes are aggregated up to the national level, and a total of 598 preliminary seats are distributed to parties on a proportional basis. Each party's allotment is then broken down to the state level and compared to its number of direct mandates in the same state. Whichever number is greater determines how many seats the party will actually receive.

More formally, let $d_{p,s}$ denote the number of districts that party p won in state s, and let $l_{p,s}$ be how many mandates it would have received in the same state under proportional representation. Then, the final number of seats that p retains in s equals

$$n_{p,s} = \max\{d_{p,s}, l_{p,s}\},$$

and its total in the Bundestag is given by $n_p = \sum_s n_{p,s}$ (see Appendix A for a detailed, algorithmic description).

If $d_{p,s} < l_{p,s}$, then, in addition to the district winners, the first $l_{p,s} - d_{p,s}$ candidates on p's list are elected as well. Otherwise, only holders of direct mandates receive a seat. Parties are said to win *overhang mandates* (Überhangmandate) whenever $d_{p,s} > l_{p,s}$. In such cases the total number of seats in the Bundestag increases beyond 598. Since the total number of

[6] In describing the German electoral system this section borrows from Spenkuch (2014).

[7] Appendix Figure A.1 shows the party affiliation of all district winners in the 2005 and 2009 elections. Although the CDU/CSU secured the majority of direct mandates in both years, there remains ample geographic variation, as well as some variation over time. Of the five major parties, only the FDP did not win any districts—despite gaining a nontrivial fraction of votes. Since the introduction of the two-ballot system in 1953, no independent candidate has ever won a district.

mandates awarded under proportional representation, i.e. $\sum_p \sum_s l_{p,s}$, exceeds the number of districts, $\sum_p \sum_s d_{p,s}$, by a factor of two, situations in which $d_{p,s} > l_{p,s}$ are not as common as one might expect. For instance, relative to its share of the list vote, the CDU/CSU received an additional 7 mandates in 2005, whereas the SPD secured 9 extra seats. In 2009, there were 24 overhang mandates, 21 of which accrued to the CDU.

It is also important to point out that a party can field only one direct candidate per district and that all of Germany's five major parties do so in almost every district. Candidates can run in only one district, but the vast majority of them also appear on the respective party's list in the same state—often in prominent positions. By law, no one is allowed to appear on multiple parties' lists or on lists in different states.

2.2. *Detecting Deviations from Instrumental Rationality*

Although the list vote is more important in practice, for the purposes of this paper the incentives associated with the candidate vote are what matters the most. As in all elections under plurality rule, if a particular candidate is known to be "out of the race," then instrumentally rational agents can *always* do better by voting for somebody else.

To see this, note that a single vote matters only if it is pivotal, i.e. if (at least) two candidates are running neck-and-neck ahead of all others. In large elections, such a tie is orders of magnitudes more likely to involve contestants believed to be front-runners than an underdog (cf. Myerson 2000). Thus, only a subset of candidates can be serious contenders, and instrumentally rational voters behave as if they are restricting their choice set to contestants who are "in the race." This is because, by definition, instrumentally rational agents seek to affect the outcome of the election, and voting for anybody but a serious contender would be akin to "wasting" one's vote.

Of course, this argument assumes that voters are not *exactly* indifferent to who carries their home district. A small preference for one candidate over another, however, seems reasonable, as who wins a particular district can affect the aggregate distribution of seats. But even if voters were to take the distribution of seats as given, they likely still care about sending "good" local representatives to parliament, i.e. ones who are more closely aligned with their own political views. Such considerations may be especially important because representatives elected via the candidate vote are much more likely to become members of committees that allow them to serve their geographically based constituency (see Stratmann and Baur 2002). In fact, in the 2009 German Longitudinal Election Survey (GLES), almost three out of four respondents said that it is either "important" or "very important" that candidates represent the interests of their home districts. Lastly, by voting for one of the front-runners, agents can determine whether a particular party's direct candidate or the marginal candidate on the

same party's list in the same state enters parliament. Although expected payoffs are unlikely to be very large, the important point is that as long as instrumentally rational voters are not exactly indifferent to who wins their district, they should *never* waste their vote on a candidate who is "out of the race."

Since exact indifference is a nongeneric case, the German system allows for a straightforward way of identifying individuals who do not behave in accordance with standard rational choice theory. As stated in the introduction, quantifying deviations from the canonical pivotal voter model amounts to inferring the share of individuals who stick with a candidate who is "out of the race," conditional on voting for the associated party. Simply put, agents who—for whatever reason—cast their list vote for a party whose direct candidate is not in contention for victory violate instrumental rationality if they *also* choose the respective candidate.

The converse, of course, does not hold. That is, individuals who do cast split tickets may, but need not necessarily, be strategic. For instance, some may desert a particular party's candidate not because she is "out of the race," but simply because they dislike her. Thus, without imposing further assumptions, the empirical strategy outlined above will recover a lower bound on the extent to which agents' observed actions contradict the predictions of standard theory.

Naturally, estimating a lower bound leaves open the possibility that voters do not behave strategically at all. In order to rule out sincere voting, the next section constructs a simple empirical test.

3. A First Look at the Data

3.1. *Data Sources and Descriptive Statistics*

Before doing so, however, it is useful to get a sense of the broad patterns in the data. Table 1 shows aggregate frequencies of different list and candidate vote combinations in the 2009 federal election.[8] First and foremost, the evidence suggests that some, but not all, voters desert weak candidates. Although nominees of FDP, Greens, and other minor parties are rarely in contention for victory, they are abandoned by only about half of their followers. At the same time, the numbers show that, conditional on abandoning their own party's candidate, about 83% of all FDP supporters voted for a contestant of the CDU—its coalition partner—whereas 72% of Green Party adherents chose an SPD nominee. It, therefore, appears that voters who do desert noncontenders substitute toward close political

[8]Table 1 is based on a 3.9% random sample of actual votes. German electoral law requires the Federal Returning Officer to publish descriptive statistics on vote combinations, as well as voting behavior by age and gender (see Bundeswahlleiter 2010). Unfortunately, the micro data are not publicly accessible.

allies.

Although Table 1 is suggestive of some voters behaving strategically, with others likely being sincere, it is ultimately insufficient to quantify the prevalence of either type of behavior. Again, some FDP supporters might have chosen CDU candidates not because of tactical considerations, but because they are better qualified or more charismatic. Also, not all CDU and SPD adherents voted for their own party's nominee. In fact, almost one-third of those who deviate end up picking a political rival. While it is possible that these voters chose among the lesser of two evils in districts in which the CDU or the SPD candidate happened to be "out of the race," it is also plausible that their voting decisions were based on candidate idiosyncrasies.

In fact, the descriptive statistics in Table 2A demonstrate that candidates differ along several dimensions.[9] For instance, only 19% of CDU candidates are female, compared with 35% of Social Democrats and 34% of Green Party nominees. 95% of SPD candidates are also on the party list, compared with 43% of their colleagues from The Left. Moreover, relative to their FDP, Left, or Green Party counterparts, CDU and SPD contestants are about four times more likely to be a current member of parliament and more than forty times as likely to be an incumbent. Therefore, any argument linking differences in the distribution of list and candidate votes to (ir)rational behavior must be based on an econometric strategy that carefully controls for candidates' idiosyncratic appeal.

To this end, the present paper relies on official results of the 2005 and 2009 federal elections, by polling precinct (Wahlbezirk).[10] These data have been obtained from the Federal Returning Officer and were until recently not publicly available. In Germany, precincts are the smallest administrative units in which votes are counted. Each precinct is fully contained within an electoral district and associated with one polling station where a returning officer oversees the election. By law, no precinct can contain more than 2,500 eligible voters. As of 2009, there were 299 electoral districts and almost 89,000 precincts. Since races take place at the level of the electoral district, precinct-level data allow for all estimates to be based on within-candidate variation only, thereby *conditioning* on all observable as well as unobservable characteristics of candidates and their competitors, the marginal candidates on parties' lists, pivot probabilities, and many other sources of unobserved heterogeneity across

[9]The information in Table 2A has been compiled from official publications by the Federal Returning Officer (Bundeswahlleiter 2005c, 2009b).

[10]It is useful to restrict attention to 2005 and 2009, as in these years, all important parties were widely expected to clear the 5%-threshold. For instance, more than 90% of adults sampled in the 2009 pre-election survey of the German Longitudinal Election Study (GLES) expected the FDP and Green Party to receive more than five percent of the list vote. It is, therefore, not necessary to assume that all supporters of, say, the Green Party are inevitably sincere whenever their party fails to clear the 5%-threshold. Especially in a world with aggregate uncertainty, such an assumption seems undesirable.

candidates and districts.

Differentiating between East and West Germany as well as election year, Table 2B displays summary statistics for all precinct-level variables. Compared with the U.S., turnout is fairly high. Averaging across 2005 and 2009, almost 75% of the electorate went to the polls. Together with an average size of 821 eligible voters, this means that precincts handle about 615 votes. As is well-known, CDU, SPD, FDP, and the Green Party fare substantially better in West Germany than in the East. The opposite is true for The Left. Moreover, CDU and SPD receive more candidate than list votes. Given that the nominees of these two parties are serious contenders in most districts, this could, but need not, be due to strategic voting.

3.2. *Testing the Null Hypothesis of Sincere Voting*

Following the argument in the introduction, it is straightforward to test the null hypothesis that voters are "behavioral" in the sense that they fail to internalize the electoral incentives. If, as in a substantial part of the theoretical literature, all individuals simply choose their most preferred option—meaning that they cast sincere list *and* sincere candidate votes—and if preferences over parties are sufficiently correlated with that over candidates, then, after carefully controlling for nominees' idiosyncratic appeal, it should be the case that list and candidate vote shares track each other almost one for one. That is, under the null hypothesis of sincere voting, an extra list vote should translate into an additional vote for the nominee of the respective party.

The results in the upper panel of Table 3 show that this is not the case. The ordinary least squares estimates therein correspond to the econometric model

$$v^C_{k,r,t} = \chi_{m,k,t} + \phi v^L_{k,r,t} + \epsilon_{k,r,t}, \tag{1}$$

where $v^C_{k,r,t}$ denotes contestant k's share of the candidate vote in precinct r during election year t, and $v^L_{k,r,t}$ is her party's share of the list vote in the same precinct. To allow for arbitrary forms of autocorrelation in the residuals as well as for correlation within and across districts, standard errors are clustered by state.[11] Going from the left of the table to the right, the set of fixed effects grows steadily. The most inclusive specification contains $\chi_{m,k,t}$, a municipality- and year-specific candidate fixed effect. It, therefore, controls nonparametrically for the appeal of individual candidates (and that of their competitors) as perceived by the voters in a given town or village.[12]

[11]Note that there are only 16 states in Germany, which raises issues associated with a small number of clusters. In order to account for this issue when testing hypotheses, the reported p-values are based on the wild bootstrap procedure suggested by Cameron et al. (2008).

[12]There are usually multiple precincts per municipality, and most districts are comprised of many munic-

Using this model, one can dismiss the null of sincere voting if it is possible to reject $H_0 : \phi = 1$. Clearly, in all specifications of Table 3 that control for candidates' idiosyncrasies, the slope between list and candidate votes is considerably smaller than one ($p < .001$). On average, only nine out of ten voters stick with the same party's candidate. Put differently, for about 10% of agents observed choices are inconsistent with sincere behavior.

Of course, all hypothesis tests are joint tests of the null *and* the underlying assumptions. Under the null hypothesis, list and candidate votes *must* reveal voters' true preferences over parties and candidates, respectively. The actual identifying assumption then is not that list votes proxy for preferences, but that tastes for parties and candidates are heavily correlated, at least after strongly controlling for candidate quality. This assumption is testable.

To see that is does appear to hold, consider the lower two panels in Table 3. The middle one restricts attention to the eventual winner and runner-up of each race. Voters who support the parties associated with these candidates have no strategic reason to cast split ballots. After all, surprises in large-scale elections are very rare, and partisans have no incentive to desert someone they should have believed to be in contention for victory. Thus, if party votes are, indeed, heavily correlated with individuals' preferences over candidates, then, in this subsample of the data, party and candidate vote shares ought to track each other *very* closely. Conversely, seeing a slope considerably smaller than unity should lead one to question the identifying assumption.

Fortunately, there is no indication that this is warranted. After accounting for candidate quality, candidate and list vote shares move together almost one for one. Taking the estimate in column (5) at face value, it appears that, on the margin, an extra list vote results in about .989 additional candidate votes. Although the point estimate is quite precise, it is *not* possible to rule out that it is exactly equal to one.[13]

By contrast, the bottom panel focuses on candidates who finished in third place or worse. At least some agents who voted for the parties associated with these candidates had a strategic incentive to cast split ballots; and about one in three did so. Taken together, the results in Table 3 reject the null hypothesis that all voters are "behavioral."

4. Quantifying Deviations from Instrumental Rationality

4.1. *Econometric Approach*

Strictly speaking, the evidence thus far only shows that observed choices are incompatible with sincere behavior for about 10% of voters. It does not rule out that most agents are

ipalities. This allows for straightforward identification of $\chi_{m,k,t}$.

[13] Appendix Table A.1 repeats this exercise, but allows for ϕ to vary with candidates' rank. Again, for those candidates whom voters ought to have expected to be "in the race," ϕ is very close to unity.

strategic but happen to cast ballots that are also consistent with sincerity. In order to shed light on how frequently the predictions of canonical rational choice theory are actually violated, and to inform our understanding of the extent to which individuals behave "as if" they are unboundedly rational, this section pursues two related empirical strategies.

The first strategy identifies the share of voters whose choices deviate from instrumental rationality by considering only candidates who were clearly not in contention for victory. This approach's main requirement is that, conditional on the equilibrium being observed by the econometrician, one can find a subset of nominees whom rational voters cannot have believed to be "in the race." For this set of candidates, one then estimates

$$v^C_{k,r,t} = \chi_{m,k,t} + \lambda v^L_{k,r,t} + \epsilon_{k,r,t}, \tag{2}$$

where all symbols are as defined above.[14]

The parameter of interest is λ. It denotes the fraction of party supporters who stick with the associated candidate despite her being "out of the race." As explained at the end of Section 2, the share of agents whose observed choices violate the canonical pivotal voter model is a lower bound on the actual fraction of noninstrumentally rational voters. The reason is that, without observing individuals' true preferences, some choices will appear consistent with instrumental rationality, even though agents were not strategically motivated.

Thus, one reason to control for candidate quality by including municipality- and year-specific candidate fixed effects, i.e. $\chi_{m,k,t}$, is to tighten the estimated bound. The more important reason, however, is to ensure that λ can, in fact, be interpreted as a lower bound. In the absence of individual-level data on vote combinations, there remains the possibility that candidate k received a substantial share of her votes from the supporters of other parties. Although the behavior of these individuals is also inconsistent with instrumental rationality, simply dividing the number of candidate votes by the number of party votes might lead to an overestimate of the *share* of behavioral agents—in extreme cases this ratio might even exceed one. It is, therefore, preferable to explicitly control for candidate quality and estimate λ at the margin. That is, λ is identified from changes in candidates' vote shares as a result of cross-precinct variation in the vote shares of the associated parties.[15]

Of course, if one were willing to assume that list votes are a good proxy for voters' (induced) preferences over candidates, then most of these issues would become moot. In the ideal case

[14]It is straightforward to derive equation (2) from a simple model along the lines of Myerson and Weber (1993), extended to include a sincere type of voter (see Spenkuch 2013).

[15]It turns out that simply dividing the number of candidate votes by the number of party votes would result in estimates that are qualitatively similar, but a few percentage points higher than those in the following subsection. The empirical strategy in this paper thus errs on the side of being conservative when it comes to classifying choices as inconsistent with instrumental rationality.

in which preferences over parties and candidates are perfectly correlated, λ would exactly identify the fraction of voters who fail to abandon their prefered candidate despite her being out of the race. While the evidence in the middle panel of Table 3 suggests that such an assumption may not be completely unreasonable—especially after carefully controlling for candidates' idiosyncrasies—it is important to emphasize that it is *not* required. Without it, the point estimates still recover a lower bound on the share of behavioral agents.

Also note that, as long as there is no heterogeneity in λ, it is irrelevant if the set of candidates who are included in the sample used to estimate equation (2) is chosen too conservatively, i.e. if one discards some candidates who were also believed to be "out of the race." Settling on a too narrowly defined set of noncontenders would only come at a loss of statistical power, but it would not prevent consistent estimation of λ.

If, however, there is heterogeneity in λ *and* if this heterogeneity is systematically correlated with who remains in contention for victory, then restricting attention to supporters of parties that field candidates who trail far behind might lead to biased estimates. The second (and, therefore, preferred) empirical strategy addresses this problem by adopting a data-driven approach to classifying contestants.[16]

To see that the actual data are highly predictive of which candidates end up competing for a direct mandate, consider Table 4, which shows a cross-tabulation of candidates' own rank (based on the candidate vote) against the standing of their party among voters in the same district (based on the list vote). Out of the 598 contestants whose party placed first, only 41 did not win a direct mandate, and a mere 2 finished third or worse. In contrast, none of the candidates who ran for a party ranked fourth or below came in first, and only 3 finished second. Overall, the correlation between list and candidate vote based rank is .93. The evidence, therefore, suggests that voters coordinate on the nominees of the district's most popular parties.

If one believes that agents do, indeed, play focal equilibria of this type, then contestants backed by one of a district's two favored parties should be considered serious contenders, whereas candidates of parties ranked fourth and below are "out of the race." The only ambiguity arises with respect to those in third place. In practice, almost 10% of third ranked contestants finish first or second. Hence, one would want to classify some (but not all) of them as contenders, especially in cases in which only a few percentage points separate their own party from the one in second place.[17]

[16]Unfortunately, pre-election surveys in Germany are too small to derive reliable estimates of voters' expectations. For instance, in only 50 electoral districts did the German Longitudinal Election Study (GLES)—the best available data source—survey more than 15 adults prior to the 2009 elections.

[17]There are always at least two candidates "in the race," even if one of them trails far behind (see Myerson 2000; Myerson and Weber 1993). Cox (1994) shows that there may even exist equilibria with three or more

Drawing from the literature on structural breaks in time series data, it is possible to estimate a cutoff value, κ, separating candidates into contenders and noncontenders. More specifically, the second empirical strategy classifies candidate k as a contender if, and only if, her party trails a district's second most popular candidate by less than κ percentage points.

With this definition in hand, the estimating equation becomes

$$v^C_{k,r,t} = \chi_{m,k,t} + \lambda v^L_{k,r,t} \times \mathbf{1}\left[\overline{v}^{L,2^{nd}}_{d,t} - \overline{v}^L_{k,d,t} > \kappa\right] + \gamma v^L_{k,r,t} \times \mathbf{1}\left[\overline{v}^{L,2^{nd}}_{d,t} - \overline{v}^L_{k,d,t} \leq \kappa\right] + \epsilon_{k,r,t}. \tag{3}$$

Here, $\overline{v}^L_{k,d,t}$ denotes the list vote share of candidate k's party in district d, and $\overline{v}^{L,2^{nd}}_{d,t}$ is that of the second most popular party in the same district.

If (3) is correctly specified, then searching for the value of κ that maximizes the R^2 yields a super-consistent estimate of the true break point (Hansen 2000). Moreover, under the null hypothesis that such a point exists, estimates of the model's other parameters are normally distributed, and standard errors need not be adjusted for sampling variability in the location of the break (see, e.g., Bai 1997).

Although intuitively appealing, there is no guarantee that this method classifies all candidates correctly. For this reason, Section 4.4 performs a series of robustness checks, demonstrating that the main results are qualitatively and quantitatively robust to more than 25 alternative assumptions on how voters form beliefs about which candidates are in contention for victory.

4.2. *Main Results*

Focusing on nominees of the five major parties, Table 5 displays the main results. The upper panel follows the first empirical strategy and restricts the sample to candidates who trailed the runner-up by more than 10 percentage points. The lower panel implements the second approach.

The first row within each panel presents estimates of the share of behavioral voters, i.e. those who stick with a party's candidate despite her having no chance of winning. Controlling for the idiosyncrasies of candidates and their competitors, estimates of λ range from .613 to .657 and are fairly precise. Moreover, it is worth noting that the evidence from both empirical approaches lines up very well. Despite small standard errors, estimates from the first and second approaches are statistically indistinguishable. Taken at face value, the results indicate that (at least) 65% of voters do not behave in accordance with the canonical rational choice model.

An important question is whether most agents who do cast split ballots when it is optimal

contenders.

to do so are, in fact, strategically motivated. Strictly speaking, any model that predicts the candidate–list vote gradient for noncontenders to lie between zero and one is consistent with the evidence presented in Table 5. For instance, some fraction of individuals might simply vote for whichever candidate advertises the most, and advertising expenditures may be highly correlated with who remains in contention for victory. It would, therefore, appear as if some voters abandon weak candidates, despite the fact that most agents do not behave tactically. In such a case, the estimates above might severely understate the extent of "behavioral" voting.

In order to rule out mechanical explanations of this kind, Table 6 compares estimates of λ across a number of different settings. The first set of results demonstrates that the extent to which observed behavior violates instrumental rationality depends on *who* remains in contention for victory. That is, conditional on voting for a party whose candidate is "out of the race," agents are about 25 percentage points less likely to stick with a noncontestant when the candidate of an allied party is still "in the race" than when faced with the choice among two evils, i.e. less palatable alternatives.[18] A Chow test for equality of coefficients rejects the null hypothesis of equal point estimates at the 1%-level.

Moreover, distinguishing between races that were "close" and those that were not, sincere voting appears to have been less prevalent in the former—though the difference is not statistically significant—and disaggregating the data by election year shows that desertion of noncontenders was significantly more common in 2005 than in 2009 ($p < .001$).

This is not surprising. The 2005 election followed a failed motion of confidence that triggered the dissolution of the Bundestag and was widely perceived to be a "critical election," in which differences between parties and, therefore, the stakes were significantly higher than usual (Korte 2009).[19] In line with these results, official statistics show a substantially larger fraction of split tickets in 2005, and an approximately 7 percentage points higher turnout than in 2009 (Bundeswahlleiter 2006, 2010).

The change in turnout, however, is too small to account for the entire difference in λ. Estimating the share of behavioral voters for each municipality-year combination separately and regressing the resulting $\lambda_{k,t}$ on turnout in the respective village in the same year yields a point estimate of $-.698$ (with a standard error of .173). Based on this evidence, a 7 percentage point increase in turnout would be predicted to lead to an approximately 4.9 percentage

[18]The following parties are defined as allies: CDU and FDP, SPD and Green Party. Results are qualitatively similar if supporters of The Left are assumed to consider SPD candidates to be close substitutes. Also, note that there were no uncontested races in 2005 and 2009.

[19]Campaigning to stay in office, Chancellor Schröder and his SPD–Green coalition promised to undo some of their unpopular labor market and welfare reforms while raising taxes on the rich. In stark contrast, led by Angela Merkel, the conservative–libertarian bloc sought to further increase the pace and scope of deregulation, slashing income taxes and public spending in the process.

points lower fraction of behavioral voters. While the available evidence does suggest that inframarginal voters are considerably more likely to violate instrumental rationality than marginal ones, a 7 percentage point increase in turnout would not cause a near 50% change in the estimated extent of sincere voting. Some simple back-of-the-envelope calculations show that this conclusion continues to hold even if every additional voter is assumed to behave strategically.[20]

Importantly, the results in Table 6 are at odds with many mechanical theories for why voters abandon candidates who are "out of the race." Any model in which voters desert candidates for nonstrategic reasons would not only have to predict a correlation between desertion rates and a contestant's chance of winning, but it would also have to explain why defection is more common among marginal voters, when the stakes are higher, and why it depends on which candidates remain in contention for victory. The patterns above, as well as the fact that voters who do cast split tickets substitute toward candidates of a potential coalition partner (cf. Table 1), suggests that desertion is, in fact, driven by instrumentally rational considerations.

4.3. *Interpreting the Evidence*

Neither the canonical rational choice model nor behavioral theories in which agents simply vote for their favorite candidates are able to explain the findings above. Instead, the evidence suggests that it might be more appropriate to consider strategic behavior a conscious decision rather than an agent's "type." That is, all agents may be capable of voting tactically, but only for a subset of them do the subjective benefits outweigh the (psychic) costs of abandoning the candidate of one's preferred party or of figuring out one's optimal strategy. In such a richer model, λ would not refer to the population share of behavioral "types," but to the fraction of voters whose costs are below some endogenously determined threshold.[21]

If a large share of voters have costs very close, but not exactly equal, to zero, then such a hybrid model with boundedly rational agents would predict the two most-salient features of the data: *(i)* most voters do not (find it worthwhile to) abandon weak candidates, but *(ii)* when the stakes increase, agents' tendency to "waste their vote" plummets. That is, a

[20] In 2005, about 13.3 million voters chose a party whose direct candidate is estimated to be "out of the race," and almost half of them also abandoned the respective nominees. Suppose that every single one of the approximately 4 million additional voters in 2005 chose a party whose direct candidate was not in contention for victory *and* deserted the respective direct candidate. If this were, indeed, the case, then about 70% of the inframarginal voters, i.e. 6.5 out of 9.3 million, would not have behaved instrumentally rational. Even under these extreme assumptions, the difference in turnout cannot account for only the entire change in λ.

[21] Strictly speaking, the findings above are silent on the source of these costs. For instance, plausbile sources of "psychic" costs are a preference for consistency across domains, social image or identity, true cognitive constraints, or any other impediment to making optimal choices. Even irrational optimisim about underdogs' chances of winning would produce qualitatively similar patterns.

significant share of agents are close enough to the margin, so that small changes in absolute payoffs cause large shifts in observed behavior.

Another potential explanation for the preceding findings is that individuals receive a heterogeneously distributed utility boost from voting for the eventual winner of the election. If the utility benefit from doing so was close, but not exactly equal, to zero for sufficiently many agents, then such a model of "bandwagon effects" (Simon 1954) would be able to rationalize *(i)*. Moreover, if the benefit of voting for the winner depends on the perceived stakes of the election, then bandwagon effects might also be consistent with *(ii)*.

The key testable difference between both theories is that the latter predicts runner-ups to be abandoned as well, especially those who trail far behind and are, therefore, unlikely to win. By contrast, a pivotal voter model in which agents face a cost from behaving strategically predicts that agents do *not* abandon the runner-up, even if her chances of winning are very small. This is because if a race were to be tied—however unlikely that may be—the tie would almost certainly involve the second-ranked candidate (see Myerson 2000, 2002; Myerson and Weber 1993), in which case voting for her would change the outcome of the election. Thus, even agents who choose to cast tactical ballots would not abandon a runner-up who trails far behind.

Although counterintuitive, the evidence in Table 7 supports this prediction. The numbers therein refer to the slope parameter, i.e. ϕ in equation (1), estimated separately for first- and second-ranked candidates, by distance between the two. Perhaps surprisingly, all point estimates are rather close to one, and, if anything, the coefficients for second-ranked candidates are slightly larger than those for their first-ranked counterparts. This helps to rule out alternative explanations based on bandwagon effects.

4.4. *Sensitivity and Robustness Checks*

Misclassification of Contenders For the main results to correctly identify λ, it must be the case that the regressors are uncorrelated with the error term. One obvious source of bias may be systematic misclassification of contenders. While it is unproblematic to falsely classify some candidates whom voters believed to be "out of the race" as contenders, at least as long as λ is not heterogenously distributed, making the opposite mistake would lead to upward bias in λ and, therefore, to an overstatement of the extent to which observed behavior violates instrumental rationality. To ameliorate this concern, Table 8 presents estimates of λ employing more than twenty-five alternative definitions of contenders (listed in the column on the left). For each definition, the table shows two estimates: one based on candidate-year fixed effects, and another one using candidate-year fixed effects that are specific to individual municipalities. For comparison, the top row displays the main results from the lower panel

of Table 5.

Although individual point estimates do, of course, vary, the majority of them are very close to their baseline values. For instance, assuming that voters have perfect foresight regarding the winner and runner-up of the election, one would estimate the fraction of behavioral votes to equal 66.3% instead of 65.6%, whereas adaptive expectations based on the outcome of the last election (i.e. the winner and runner-up in the previous federal election are believed to be "in the race") would lead to point estimates ranging from 67.8% to 71.3%. Of the fifty-two additional estimates in Table 8, the lowest one is 58.9% and the highest one equals 71.6%. Slightly more than 90% of coefficients fall *within* the original 95%-confidence intervals. The evidence, therefore, suggests that misclassification of contestants is not a first-order problem.

Exact Indifference Some individuals could be *exactly* indifferent about who carries their district, and might therefore stick with a candidate who is "out of the race." The empirical strategy in this paper would classify these agents as "behavioral," leading to estimates of λ that include indifferent voters.

One piece of evidence suggesting that the vast majority of voters are *not* indifferent to who represents them in parliament comes from the fact that less than 2% of those going to the polls cast invalid or no candidate votes (despite the fact that it *is* possible to cast a valid list vote while leaving the candidate vote blank). For the U.S., for instance, it has been argued that ballot roll-off (i.e. voters not completing one of several sections on the ballot) is a sign of voters not caring "enough" about a particular race (e.g., Bullock and Dunn 1996; Burnham 1965). If Germans were exactly indifferent about district-level races, then one would not expect them to be willing to incur even a small "hassle cost" to cast their candidate vote. The fact that more than 98% of voters do cast valid candidate votes suggests that the potential bias from exact indifference is likely very small.

Endogenous Nomination of Candidates Another concern relates to the behavior of parties. Depending on the anticipated likelihood of winning the district, parties might nominate a particularly "good" or "bad" candidate. Since the empirical strategy relies on within-candidate variation, this sort of behavior could bias the point estimates if candidate quality *interacts* with the share of voters who choose to behave sincerely—say, because voters might be reluctant to abandon very charismatic contestants. Although plausible, the data do not suggest that "good" candidates, as measured by $\chi_{k,t}$, are less likely to be deserted when they are "out of the race." If anything, estimating separate slope parameters for all candidate-year combinations and regressing them on the estimated fixed effects shows that the covariance between $\chi_{k,t}$ and a noncontender's $\lambda_{k,t}$ is slightly negative.

One may also be worried that parties field "better" candidates in districts in which they

have more supporters and that this may lead to bias in λ. However, estimating λ for each candidate-year combination and regressing the resulting $\lambda_{k,t}$ on the district-wide list vote as a measure of party strength yields a point estimate of .001 with a standard error of .003, which is not only economically small but also statistically indistinguishable from zero. Put differently, local party strength is nearly uncorrelated with the estimated share of voters who stick with the respective candidate.

To get a sense of how λ varies with candidates' observational characteristics, consider Appendix Table A.2. Although voters appear to desert younger candidates somewhat more frequently than older ones, the point estimates have a very similar range as those in Table 8, which suggests that there is no single type of candidate that drives the results. That is, even if one were to focus on the types of candidates delivering the most-extreme estimates, one would still conclude that neither the pivotal voter model nor a theory based on sincere voting provides an accurate description of reality.

Also note that the results cannot be driven by comparisons between direct candidates and those on the party list. While it is theoretically possible that some agents desert their favorite party's candidate because they would like someone else on the party list to enter parliament instead (see Section 2 or Appendix A for details on how seats are allocated), this behavior should not affect the estimates. The reason is simple. None of the identifying variation comes from candidates who are in contention for victory, i.e. who have a realistic chance of entering the Bundestag and for whom this sort of comparison is theoretically relevant. Moreover, whatever voters may think about the marginal candidates on parties' lists, it continues to be true that voting for someone who is not in contention for victory will not affect the outcome of the election and is, therefore, inconsistent with the predictions of the pivotal voter model.

Strategic List Votes As explained above, interpreting λ as a lower bound on the share of "behavioral" voters does *not* require an assumption as to whether list votes accurately reveal voters' preferences—although Table 3 contains some suggestive evidence that it may not be unreasonable to think so, especially since proportional representation provides voters with much weaker strategic incentives than plurality rule. The clear benefit of imposing such an assumption would be that λ need not be regarded as a lower bound anymore. In order to provide additional evidence consistent with voters choosing their favorite party according to their (induced) preferences, Appendix B presents an explicit (though imperfect) test of strategic voting in the PR part of the German system. Intuitively, if voters cast strategic list votes, one would expect parties to "bunch" near thresholds where they gain (or lose) a seat—simply because parties can only be awarded integer mandates. In reality, however, fractional mandates are approximately uniformly distributed on the unit interval, as one would expect if strategic list votes were quantitatively unimportant.

Additional Robustness Checks The remainder of Table 9 demonstrates that the results do not depend on the weighting scheme nor on whether one also includes candidates of "micro parties."

5. Observed Violations of Instrumental Rationality and Voter Characteristics

The evidence above shows that a nontrivial fraction of agents does not behave as predicted by standard theories of voting. Though it does appear that the share of voters whose behavior violates canonical rational choice decreases with the electoral stakes, most agents just stick with weak candidates. Simple averages, however, may conceal considerable heterogeneity across individuals, which is why it is also important to understand *who* votes "behaviorally."

In order to infer whether λ varies with the characteristics of the electorate, the present paper relies on official statistics for the universe of German cities and villages, published by the Federal Statistical Office and the statistical offices of the Länder (Statistische Ämter des Bundes und der Länder 2007, 2011).[22] After aggregating election results to the village level and focusing on the set of municipalities that are fully contained within an electoral district, it is straightforward to estimate specifications that allow for λ to increase or decrease in some village characteristic.

Table 10 displays the results. The first column demonstrates that aggregation to the municipality level does not materially affect the point estimates. The remaining four columns examine how λ changes with population density, income tax revenue per capita, as well as the gender and age composition of the electorate. For ease of interpretation, covariates have been demeaned, so that the estimates in the second row refer to the share of behavioral voters at the sample average.

Interestingly, urban voters are not less behavioral than rural ones, nor is there a significant gender gap. The results do, however, indicate differences with respect to socioeconomic status (as proxied by income tax revenue per capita) and age.

Since the income tax variable captures only revenues that accrue to the respective municipalities, and given that the German tax system is highly nonlinear, it is easiest to judge the magnitude of the coefficient by an example. Consider two villages: one's per capita income tax revenue is a standard deviation below the mean, while that of the other village is one standard deviation above the sample average.[23] The share of voters who do not abandon a weak candidate is estimated to be almost 6 percentage points lower in the latter.

Disparities by age are even larger. Taken at face value, the coefficient in column (5) suggests

[22]Unfortunately, comparable data for polling precincts do not exist. Polling precincts are too small to produce reliable estimates from existing data sets.

[23]On average, municipalities receive about 13% of all income tax revenues. Thus, the per capita sample mean is 260 EUR and the standard deviation equals 110 EUR.

that observed violations of the pivotal voter model are almost universal among voters below the age of 30, i.e. those who could have participated in, at most, three federal elections. Of course, the respective estimate is based on limited variation and is therefore not very precise. But, together with the results in column (4), it suggests that sophistication and experience correlate with the extent to which agents act in accordance with traditional rational choice theory.

To further investigate the effect of experience, the remainder of this section uses the German Reunification as a natural experiment. Although the German Democratic Republic (GDR) held regular, formal elections to the *Volkskammer* (People's Chamber), they were effectively meaningless. East Germans could only choose from candidates on a single list controlled by the Socialist Unity Party (SED), and it was customary to cast one's ballot in public, simply accepting all nominated candidates. Unsurprisingly, official approval rates often exceeded 99%. Free, democratic elections were only held on March 18, 1990—after months of peaceful political protest. The newly elected government then negotiated the end of the GDR.

In stark contrast, citizens of the Federal Republic of Germany had the opportunity to participate in free elections since 1949, and, from 1953 on, under a two-ballot system almost identical to the current one. Thus, they had more than 40 years of democratic experience by the time the GDR joined the West.

The first parliamentary elections in unified Germany were held on December 2, 1990 and were subject to (essentially) the same rules that had previously been used in the West and that continue to be in place today.[24] If experience and familiarity with the electoral system do indeed matter, then one would expect large initial differences in the share of agents whose behavior is at odds with instrumental rationality, which should disappear over time.

This prediction is borne out in Figure 2. For each election since 1990, the figure plots the estimated difference in the share of behavioral voters between East and West Germany. Negative values indicate more violations of the pivotal voter model among residents of the former GDR.[25]

The results show that just two months after reunification, East Germans were almost 16 percentage points more likely to stick with a noncontender than their Western counterparts. By 2005, however, the gap had vanished. Although none of the point estimates is very precise,

[24]The most important exception was that the 5%-threshold applied separately to East and West Germany. Thus, in 1990 a party had to gain more than 5% of the list vote in only one of the two regions to enter the Bundestag.

[25]The specification on which the estimates are based is similar to equation (3) but allows for different slopes and cutoff values in East and West Germany. A qualitatively similar picture would emerge if one were to restrict the cutoff to be the same in both regions.

one can nevertheless reject the null hypothesis of a constant difference at the 1%-significance level. Moreover, both the initial gap as well as the speed of convergence are in line with the "age effect" in Table 10.[26]

6. Related Literature

There exists a large empirical literature concerned with the extent of instrumental rationality in voting. Within this literature, laboratory experiments provide typically convincing evidence of tactical behavior by some, but not all, individuals (e.g., Duffy and Tavits 2008; Eckel and Holt 1989; Esponda and Vespa 2013). Interestingly, the share of strategic agents generally increases with subjects' experience and the availability of coordination devices, such as pre-election polls (e.g., Forsythe et al. 1993, 1996). However, given the relatively small number of subjects in the laboratory, it remains unknown whether these results generalize to large, real-world elections.

The evidence on this question is decidedly mixed. Coate et al. (2008), for instance, reject the pivotal voter model based on the finding that it is unable to replicate winning margins in Texas liquor referenda. Reed (1990) and Cox (1994), however, argue that the distribution of votes in Japan's multimember districts does conform to the predictions of rational choice theory. More recently, Fujiwara (2011) uses a sharp regression discontinuity in Brazilian mayoral elections to show that third-place candidates are more likely to be deserted in races under simple plurality rule than in runoff elections. The most comprehensive study to date is Cox (1997). His findings are suggestive of strategic behavior in a number of electoral systems but indicate a lack thereof in others.

Even less is known about the *extent* of instrumental rationality among voters, or violations thereof. Two recent exceptions are Spenkuch (2014) as well as Kawai and Watanabe (2013). Spenkuch (2014) exploits a highly unusual by-election in Germany, which allowed a party to gain one seat by receiving *fewer* votes, to show that at least 9% of voters did not behave sincerely.

Kawai and Watanabe (2013) estimate a fully structural model of voting decisions in Japan's general election, concluding that between 63% and 85% of voters are strategic—but in equilibrium less than 5% cast misaligned votes. Put differently, Kawai and Watanabe (2013) estimate that, at most, 37% of Japanese voters are sincere, whereas this paper derives a *lower* bound of about 65%. Whether this discrepancy is due to systematic differences in the environment (say, higher stakes in Japanese elections), true differences in the rationality

[26]Of course, not only did East Germans gain familiarity with the electoral system, but other economic factors changed as well. If these factors had an independent effect on the propensity to cast tactical ballots, then the estimates in Figure 2 would not need to capture the true impact of experience. Convergence in per capita incomes, however, is almost an order of magnitude too small to explain the results.

of the underlying populations, or differences in the empirical approach is (as of yet) unknown. Although Japan uses a mixed-member electoral system similar to the German one, it is important to note that the analysis in Kawai and Watanabe (2013) makes no use of party votes. All identification comes from variation in candidate vote shares and observable characterictics of voters.

Recall, the fundamental difficulty in inferring (non)strategic behavior from naturally occurring data is that voters' preferences are not observed. Thus, any existing evidence is either based on indirect tests (as in Coate et al. 2008; Cox 1997; Fujiwara 2011; Spenkuch 2014), or preference orderings are structurally estimated in order to compare them to actual vote counts (as in Kawai and Watanabe 2013).

A separate strand of the literature tries to circumvent these problems by using survey data on voting decisions and political orientations (see, e.g., Abramson et al. 1992; Blais et al. 2001; Kiewiet 2013; Niemi et al. 1993; or, for Germany, Gschwend 2007; Pappi and Thurner 2002). Estimates in this tradition are often very low. Wright (1990, 1992), however, points to important survey biases and raises serious doubts about conclusions based on self-reported votes. Alvarez and Nagler (2000) even show that, depending on the survey design, estimates of instrumentally rational voting differ by as much as a factor of seven.

7. Concluding Remarks

Whether individuals act approximately "as if" they are unboundedly rational is an important question in economics. In the context of social choice it has interested scholars for more than six decades. Yet, outside of the laboratory it has proven extremely difficult to quantify deviations from the baseline pivotal voter model. By exploiting the incentive structure of parliamentary elections in Germany, the present paper presents evidence indicating that at least 65% of voters do not behave as predicted by standard rational choice theory.

Of course, in light of a plethora of anecdotal evidence, one might not have expected literally all agents to be "perfectly rational," especially not in large elections with arguably weak electoral incentives. Nevertheless, the results above are noteworthy for at least two reasons. First, the magnitude of the point estimates implies that the single most common assumption about the behavior of voters is violated for the vast majority of agents. Second, the leading alternative theory according to which voters sincerely choose their most preferred candidate is also rejected by the data.

Instead, the findings indicate that individuals' tendency to deviate from the predictions of standard rational choice theory varies substantially with the circumstances. That is, *even* in large elections with weak incentives, small absolute changes in expected payoffs are associated with large shifts in behavior. Viewed through the lens of a model in which boundedly rational

agents pay a "psychic" cost to behave strategically, the results suggest that a significant number of people face very low costs and are thus close to the margin of acting strategically.

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APPENDIX MATERIALS

A. Calculating a Party's Number of Seats

Following Spenkuch (2014), this appendix explains the algorithm that is currently used to calculate a party's number of seats in the Bundestag. Let $d_{p,s}$ denote the number of direct mandates accruing to party p in state s. $v_{p,s}$ is the number of list votes that p received in s, with the equivalent number on the national level given by $\overline{v}_p = \sum_s v_{p,s}$. With this notation in hand, party p's seat total is calculated in three steps:

Step 1: Proportional Allocation of List Mandates to Parties. Absent overhang mandates, there are 598 seats in the Bundestag. These are allocated by proportionality rule to the set of parties clearing the 5%-threshold or winning at least three direct mandates. That is, the number of list mandates of party p equals

$$\bar{l}_p \cong \begin{cases} 598 \frac{\overline{v}_p}{\sum_{p' \in \widetilde{P}} \overline{v}_{p'}} & \text{if } p \in \widetilde{P} \\ 0 & \text{otherwise} \end{cases},$$

where $\widetilde{P} = \left\{ p | \frac{\overline{v}_p}{\sum_{p'} \overline{v}_{p'}} \geq .05 \vee \sum_s d_{p,s} \geq 3 \right\}$ and $\cong$ represents equality after rounding according to the Sainte-Laguë method, which ensures that $\sum_p \bar{l}_p = 598$.[27]

Step 2: Proportional Allocation of Mandates to State Lists. German electoral law requires parties to compete with different lists in each state. Therefore, list mandates need to be allocated to the respective state lists. In practice, the number of mandates awarded to a party's state list is proportional to the list's contribution to the party's vote total. More precisely, for all s and all p,

$$l_{p,s} \cong \begin{cases} \bar{l}_p \frac{v_{p,s}}{\overline{v}_p} & \text{if } p \in \widetilde{P} \\ 0 & \text{otherwise} \end{cases},$$

where $\cong$ is defined as above.

Step 3: Determination of the Actual Number of Seats. However, the *actual* number of seats that party p receives in state s is given by

$$n_{p,s} = \max \{ d_{p,s}, l_{p,s} \}.$$

If $d_{p,s} < l_{p,s}$ then, in addition to the district winners, the first $l_{p,s} - d_{p,s}$ candidates on p's list in s are elected to the Bundestag as well. Otherwise, only holders of direct mandates

[27] In 2005 the method of Hare-Niemeyer was used instead.

receive a seat.

Note that only if $d_{p,s} \leq l_{p,s}$ for all s, will party p's seat total, $\overline{n}_p = \sum_s n_{p,s}$, be equal to the number of seats it would be assigned under proportional representation, i.e. $\bar{l}_p$.

B. Testing for Strategic Voting under Proportionality Rule

The main text notes that if one is willing to assume that strategic voting in the plurality rule part of the German system (i.e. with the list vote) is unimportant, then list votes provide an empirical proxy for voters' preferences. This implies that the estimates in the main part part of the paper can be interpreted as the fraction of voters who stick with their preferred candidate despite her being "out of the race." Table 3 provides some suggestive evidence that such assumption, though strong, may not be unreasonable. This appendix provides an additional test.

Given that the main results focus on the 2005 and 2009 elections, in which all major parties were widely expected to clear the 5%-threshold, voters should have no theoretical incentive to cast strategic list votes if the party they would like to gain the marginal seat in parliament could, indeed, be awarded the fractional mandate associated with an additional vote. In reality, however, parties can only be awarded whole mandates, which means that some may be closer to thresholds where they gain (or lose) a seat. Thus, if voters casted strategic list votes one would expect parties to "bunch" near the endogenously determined cutoff levels.[28] By contrast, if voters cast sincere list votes one would expect parties' number of fractional mandates to be approximately uniformly distributed on the unit interval.

Table A.2 presents the results of this test. The upper panel shows the initial distribution of fractional mandates according to the list vote on the national level (i.e. before applying the rounding methods of Hare-Niemeier or Sainte-Laguë). The lower panel displays parties' initial number of fractional mandates by state. While the former distribution determines the total number of list mandates a given party receives in parliament, the latter one governs how a party's number of seats are allocated *across* states (cf. Appendix A). The p-values below each panel refer to Kolmogorov-Smirnov tests of the null hypothesis that the distribution of fractional mandates is uniform on the unit interval.

Clearly, based on this approach it is not possible–neither on the national nor on the state level—to reject the null and, therefore, the assumption that individuals cast list votes that reveal their (induced) preferences over which party wins the marginal seat in parliament.

[28] In 2005 the method of Hare-Niemeyer for "rounding", whereas the Sainte-Laguë method was used in 2009. It is important to note that whether a party's number of seats in parliament is adjusted upwards or downwards depends in both of these methods not just on its own (fractional) vote share, but also on that of other parties.

C. Variable Definitions

This appendix provides a description of all data used in the paper, as well as precise definitions together with the sources of all variables.

C.1. *Election Results*

Data containing the official results of the 1980, 1983, 1987, 1990, 1994, and 1998 federal elections by municipality (Gemeinde) as well as the 2002, 2005, and 2009 elections by polling precinct (Wahlbezirk) have been purchased from the Federal Returning Officer. These data include information on the number of list and candidate votes for each party and each candidate, the number of eligible voters, as well as the number of valid and invalid votes. In 2009 there were approximately 89,000 precincts. Whenever necessary precinct level numbers are aggregated using the municipality identifiers contained in the raw data. Municipalities spanning multiple districts are discarded. Throughout the analysis the following variables are used:

Number of Eligible Voters is defined as the number of residents of each precinct that were allowed to vote in the particular year. In general this encompasses all German citizens over the age of 18, who have not been declared mentally unfit, or whose voting rights have not been suspended due to criminal behavior.

Turnout is defined as the number of actual voters over the number of eligible voters. This number cannot be calculated for absentee precincts, as absentee voters are included in the number of eligible voters in their district of residence. Hence, in-person turnout in each district needs to be adjusted for absentee voters. In practice, this is done by multiplying the number of issued absentee ballots by .95 (which corresponds to the empirical frequency with which they are cast) and adding them to the ballots that are cast in person.

Share of List Vote is defined as the portion of all valid list votes (in %) that are cast for a particular party. "Micro parties", i.e. those not clearing the 5%-threshold, are grouped together.

Share of Candidate Vote is defined as the portion of all valid candidate votes (in %) that are cast for the candidate of a particular party. Votes for candidates of "micro parties" are pooled.

Absentee Precinct is an indicator variable equal to one if a given precinct handles only absentee ballots.

C.2. *Candidate Characteristics*

Prior to every election to the Bundestag the Federal Returning Officer publishes information on certain characteristics of all official list and direct candidates. This paper focuses only on the latter. The data have been compiled from Bundeswahlleiter (2005c, 2009b). Throughout the analysis the following variables are used:

Age at the time of the election is defined as election year minus year of birth.

Female is an indicator variable equal to one if a candidate is female, and zero otherwise.

Doctorate is an indicator variable equal to one if a candidate holds a doctoral degree and/or a professorship, and zero otherwise. As doctoral degrees are part of Germans' official names, this variable has been created using a text search for "Dr." and "Prof.".

Currently Member of Parliament is an indicator variable equal to one if the candidate holds a list or direct mandate, and zero otherwise.

Holds Direct Mandate is an indicator variable equal to one if the candidate holds a direct mandate, and zero otherwise.

Also on Part List is an indicator variable equal to one if the candidate does not only run in the district race, but is also on her party's state list (and could thus enter the Bundestag either way).

Position on Party List denotes the candidate's rank on her party's state list (conditional on having been placed on the list).

C.3. *Municipality Characteristics*

Information on municipalities' demographic and socio-economic characteristics is taken from *Statistik lokal 2007* and *Statistik lokal 2011* (Statistische Ämter des Bundes und der Länder 2007, 2011). *Statistik lokal* is an annual publication of the German Federal Statistical Office and the statistical offices of the Länder containing data on various characteristics of approximately 12,000 municipalities and administrative units in Germany as of about two years before to the publication date. These data have been linked with the election results described above using the municipality identifier (Allgemeiner Gemeindeschlüssel) contained in both data sets. Below follows a brief description of all municipality level variables used throughout the analysis.

Population Density is defined as a municipality's total average population (in thousands) per square kilometer during the respective calendar year.

Fraction of Voters Female is defined as the share of women among a municipality's population over the age of 18.

Income Tax Revenue Per Capita is defined as the total income tax receipts (in 1,000 EUR) accruing to the respective municipality divided by its population during the same calendar year.

Fraction of Voters under Age 30 is defined as the fraction of individuals aged 18–30 among those over the age of 18.

D. Structural Analysis

Although the reduced form results in the main text provide evidence of sincere as well as strategic voting, they are subject to some limitations. For instance, the assumption that candidate quality enters (2) linearly might be overly restrictive. Taken literally, linearity could lead to predicted vote shares that are greater than one or even negative. To properly account for the drawbacks of the reduced form analysis and to be able to assess the impact of non-instrumentally rational behavior, this section seeks to replicate the main results in Table 5 by estimating a structural model of voting decisions in the 2009 federal election. Again, list votes provide a crucial source of identifying variation.[29]

D.1. *Adding Structure*

In order to replicate the main results about the average extent of non-instrumentally rational voting, it is convenient to group voters into two sets: strategic agents, and sincere, non-instrumentally rational ones. Doing so comes at the cost of ignoring a voters' choice to act strategically, but it simplifies the analysis considerably. Given the very limited variation in district size, and therefore pivot probabilities, it would be extremely challenging to identify the distribution of psychic cost, especially near zero. The current approach can be thought of as approximating a the population distribution by placing a mass point at zero and estimating its "size."

The Magnitude Theorem in Myerson (2000) shows that voters will generally group contestants into two categories: candidates who are "in the race" and those who are not. It is, therefore, natural to model agents' decisions as a discrete choice problem in which sincere and strategic voters face different equilibrium choice sets. The former choose among all contestant in a particular district, whereas the latter consider only candidates who are in contention for victory. When it comes to the list vote, however, all voters pick from the set of major parties.

[29] Results are qualitatively similar when looking at the 2005 election instead.

In order to represent agents' (induced) preference profiles in a tractable yet flexible fashion, assume that individual i receives utility

$$u_{i,p}^{L} = \xi_{p,m} + \zeta_{i,p} + \eta_{i,p} \tag{4}$$

from voting for party p's list. Here, $\xi_{p,m}$ denotes the average utility that agents living in municipality m derive from voting for p, and $\zeta_{i,p}$ are individual specific deviations from the mean. $\eta_{i,p}$ is an i.i.d. type-I extreme value (T1EV) taste shock. Any strategic considerations with respect to the list vote are assumed to enter via this error term.

Moreover, define the underlying utility from casting one's candidate vote for the nominee of party p to equal

$$u_{i,k}^{C} = \xi_{p,m} + \zeta_{i,p} + \chi_k + \varepsilon_{i,k}, \tag{5}$$

where k indexes candidates, and χ_k is voters' assessment of k relative to that of her party (and to the party's marginal list candidate in the same state). That is, χ_k plays a very similar role as the candidate fixed effect in the reduced form part of the analysis. $\varepsilon_{i,k}$ denotes another i.i.d. T1EV shock.[30]

It is critical to note that $\xi_{p,m}$ and $\zeta_{i,p}$ appear in both (4) and (5), implying that official party positions influence not only voters' perceptions of the respective organizations, but also that with respect to their candidates. This assumption captures the fact that German politicians campaign heavily on their own party's platform and it introduces the correlation between list and candidate votes that has been the identifying source of variation in the reduced form part of the analysis.

To allow individuals' preferences to systematically deviate from the average in their municipality, $\zeta_{i,p}$ is assumed to follow a multivariate normal distribution with an unrestricted covariance matrix. That is, $(\zeta_{i,p})_{p \in P} \sim N(0, \Sigma)$.[31] Hence, supporters of the conservative CDU may, for example, also have a taste for the FDP, while holding more negative views of the communist Left.

While $\xi_{p,m}$ and $\zeta_{i,p}$ model commonalities in voters' assessments of parties and the respective contestants, $\eta_{i,p}$ and $\varepsilon_{i,k}$ allow for differences in tastes that go beyond the common perception of candidate quality, i.e. χ_k. The T1EV assumption is convenient because it results in a smooth closed form representation of individual choice probabilities.

[30] The mean utility from abstaining is normalized to zero. Since the available data do not allow turnout to be calculated for individual precincts, the analysis in this section is conducted at the municipality level instead (restricting attention to the set of municipalities that are fully contained within an electoral district).

[31] As the variance of $\zeta_{i,p}$ is determined by the distribution of the logit error, it is not necessary to impose a normalization.

Given the structure of preferences, party p's expected share of the list vote in municipality m equals

$$\widehat{v}_{p,m}^{L} = \int \frac{\exp\left(\xi_{p,m} + \zeta_{i,p}\right)}{1 + \sum_{p' \in P} \exp\left(\xi_{p',m} + \zeta_{i,p'}\right)} d\Phi\left(\zeta\right), \tag{6}$$

where P denotes the set of electable parties. Note that $\widehat{v}_{p,m}^{L}$ does not depend on the share of strategic voters. After all, even tactical agents have an ex ante incentive to cast truthful list votes.

This is not true when it comes to the candidate vote. The candidate vote is a mixture of sincere and strategic ballots:

$$\widehat{v}_{k,m}^{C} = \lambda \widehat{v}_{k,m}^{C,S} + \left(1 - \lambda\right) \widehat{v}_{k,m}^{C,T}.$$

Here, $\widehat{v}_{k,m}^{C,S}$ denotes candidate k's share among sincere voters, and $\widehat{v}_{k,m}^{C,T}$ that among tactical ones. As before, λ is the fraction of agents who are sincere.

Since sincere voters consider every candidate, $\widehat{v}_{k,m}^{C,S}$ is given by

$$\widehat{v}_{k,m}^{C,S} = \int \frac{\exp\left(\xi_{p,m} + \zeta_{i,p} + \chi_{k}\right)}{1 + \sum_{k' \in K(d)} \exp\left(\xi_{p',m} + \zeta_{i,p'} + \chi_{k'}\right)} d\Phi\left(\zeta\right), \tag{7}$$

where $K(d)$ marks the set of all contestants in district d. Tactical agents, however, behave as if they are choosing only among the set of serious contenders, $C(d)$. That is, irrespective of the underlying utility in (5), strategic voters disregard all candidates that are not "in the race." Consequently, k's share among strategic individuals equals

$$\widehat{v}_{k,m}^{C,T} = \begin{cases} \int \frac{\exp(\xi_{p,m} + \zeta_{i,p} + \chi_{k})}{1 + \sum_{k' \in C(d)} \exp\left(\xi_{p',m} + \zeta_{i,p'} + \chi_{k'}\right)} d\Phi\left(\zeta\right) & \text{if } k \in C(d) \\ 0 & \text{otherwise} \end{cases}. \tag{8}$$

A seemingly natural way to estimate $(\xi, \chi, \Sigma, \lambda)$ would be to find the parameter combination that produces the best fit between predicted vote shares and the data. This, however, entails that preferences would be partially identified from candidate votes, which may confound strategic desertion with simple distaste. In order to avoid this problem, electorates' average tastes should be inferred solely from list votes.

Accordingly, with data on $C(d)$ and actual vote shares in hand, estimates of $(\xi, \chi, \Sigma, \lambda)$ could be obtained by minimizing the objective function:

$$SSR\left(\xi, \chi, \Sigma, \lambda | v^{C}, v^{L}\right) = \sum_{d \in D} \sum_{m \in M(d)} \sum_{k \in K(d)} \left(\widehat{v}_{k,m}^{C} - v_{k,m}^{C}\right)^{2} \tag{9}$$

subject to the set of constraints

$$\widehat{v}^{L}_{p,m} = v^{L}_{p,m} \quad \forall p, m, d. \tag{10}$$

Yet, as $C(d)$ is not observed, it needs to be estimated as well. Based on the evidence of focal equilibria in Section 4.1, a candidate is assumed to be a contender if, and only if, her party trails the district's second most popular one by less than κ percentage points. Thus, estimating $C(d)$ adds the following set of equilibrium constraints

$$\overline{v}^{L,2^{nd}}_{d} - \overline{v}^{L}_{k,d} \leq \kappa \quad \forall k \in C\left(d\right), \forall d \tag{11}$$

$$\overline{v}^{L,2^{nd}}_{d} - \overline{v}^{L}_{k,d} > \kappa \quad \forall k \notin C\left(d\right), \forall d \tag{12}$$

as well as the additional parameter κ.[32]

Given the granularity of the data, the optimization problem defined by equations (9)–(12) is extremely large. Finding the solution involves optimizing over more than 63,000 parameters, solving about 61,500 non-linear constraints, and approximating roughly 120,000 different five dimensional integrals. To keep the computational burden manageable without compromising the quality of the solution, the analysis relies on recent advances in numerical methods, such as integration on sparse-grids (Heiss and Winschel 2008) and mathematical programming with equality constraints (Dube et al. 2012; Su and Judd 2012). For a description of these methods see Appendix E.

Before proceeding to the results it is useful to provide some intuition on how the parameters are identified. Identification of $\xi_{p,m}$ is straightforward. From Berry (1994) it follows that, for every Σ, there exists a unique vector ξ which solves (10). Economically, this means that the list vote pins down the average taste in different markets.

Akin to the analysis in the main text, identification of λ is based on the intuition in Figure 1. That is, the share of sincere voters can be inferred from the ratio of non-contenders' observed vote shares (depicted on the y-axis) to those they would receive if all agents acted solely based on their preferences (proxied by the position on the x-axis).

Candidate quality, i.e. χ_k, can be gleaned by comparing contestant's actual performance in different municipalities with predictions thereof based on party preferences and λ. χ_k will be positive for candidates whose vote shares systematically exceed their predicted values, and negative for those who underperform.

Lastly, Σ is identified from the empirical covariance between non-contenders' list and contenders' candidate votes. Take, for instance, a district in which the FDP candidate is out of

[32] Experimentation with a subset of the contender classifcations in Table 8 yielded qualitatively similar results.

the race, while the nominee of the CDU is a contender. If the latter receives, on average, more votes in villages that have a greater taste for the FDP, then the respective parameter in the covariance matrix will be positive. Analogous arguments apply to the remaining elements of Σ.

D.2. *Results and Counterfactual Experiments*

With 73.7% (and a standard error of 7.8%) the estimated share of behavioral voters, i.e. λ, is strikingly close to the corresponding reduced form results in Tables 5 and 6. Unfortunately, few of the model's other parameters are easily interpretable by themselves. Thus, instead of listing parameter estimates, the following discussion presents results in a way that relates straightforwardly to common intuition.[33]

In order to judge the model's fit consider Figure A.2. The upper two panels contrast the true marginal distributions of candidate and list votes (dark bars) with those predicted by the model (light bars). Given that $(\xi, \chi, \Sigma, \lambda, \kappa)$ have been chosen to mimic these data, there are practically no discernible differences.

The lower panel depicts the frequency of valid list and candidate vote *combinations*. It is important to note that information on the joint distribution of votes come from an independent source (Bundeswahlleiter 2009a, 2010) and were *not* used to fit the model. Thus, the lower panel of Figure A.2 provides a strong quasi-out-of-sample test of whether the estimation results are reasonable. Although there do exist differences, on the whole the predicted distribution matches the qualitative features of its real world counterpart fairly well, lending credibility to the results.

Table A.4 compares actual and simulated outcomes of district level races. As can be seen from the entries on the diagonal, the model does an excellent job at ranking candidates. In particular, it predicts almost 95% of winners correctly.

While Figure A.2 and Table A.4 are useful in evaluating the goodness of fit, a more interesting question might be for whom supporters of different parties would vote if their preferred candidate was out of the race. In order to shed light on the ordering of preferences, Table A.5 shows the frequency with which voters would substitute toward the candidate of any other party, assuming that all but their preferred contestant were still in the race. Thus, the entries correspond to the probability of some other party's candidate being "the next best choice." The model predicts FDP adherents to substitute toward candidates of the CDU, whereas most supporters of the Green Party and The Left would choose SPD contenders instead. Given parties' ideological positions, these patterns conform exactly to what one would expect.

[33] A list of all estimates is available from the author upon request.

Based on the structural estimates, Figure A.3 presents several counterfactual election results by which to judge the impact of strategic voting.[34] The top left panel shows the actual distribution of seats in the Bundestag, whereas the panel on the right displays the distribution that would prevail if mandates were awarded based solely on a single vote counted under proportionality rule with a 5%-threshold, i.e. the list vote. Evidently, the current Bundestag mirrors a parliament formed under proportional representation fairly closely: all five major parties are represented, with more than 60% of seats accruing to the CDU and the SPD. In the current equilibrium, distortions introduced through strategic candidate votes are very small.

The remaining two panels assume a single vote counted under plurality rule on the district level (akin to the candidate vote, or elections to the House of Representatives in the U.S.) The counterfactual on the bottom left shows the model's predictions for such a first-past-the-post scheme with 26.3% of voters behaving instrumentally rational *and* the current set of candidates. In the panel on the bottom right all voters choose sincerely (between party's current candidates).

In line with common intuition, relative to proportional representation a "winner-take-all" system would result in dramatic losses for small parties. However, as comparing the panels on the right shows, these losses are due to the way different electoral rules map vote shares into mandates and not to instrumentally rational behavior.

The impact of strategic behavior can be gleaned from comparing the two counterfactuals on the bottom. Given its estimated extent, tactical voting has only a modest effect on the overall allocation of seats. Not a single party's share of seats would change by more than 5 percentage points, often substantially less. Yet, looking only at seat totals misses an important point. The evidence in Table A.6 indicates that, compared to the current equilibrium, about one in ten districts would change hands if all voters were to cast sincere ballots.

E. Numerical Methods

This appendix describes the numerical methods used to solve the optimization problem defined by equations (9)–(12) as well as the construction of counterfactual election results in Appendix D.2.

E.1. *Mathematical Programming with Equality Constraints*

Typically, to recover mean utilities in models of discrete choice (i.e. $\xi_{p,m}$) researchers turn to inverting the system of non-linear markets share equations via the nested fixed point (NFP) algorithm in Berry (1994) and Berry et al. (1995). Recently, however, Su and Judd (2012)

[34] For details on the computation of these counterfactuals see Appendix E.

and Dube et al. (2012) have shown how to recast extremum estimators in general, and the one in the Berry et al. (1995) in particular, as a mathematical programming problem with equality constraints (MPEC).

Key to the MPEC approach is the insight that the inner loop can be eliminated entirely by recasting the estimator as an optimization problem subject to a set of non-linear constraints, i.e. (10), which require predicted market shares to equal observed ones.

Since objective function and market share equations are usually smooth, one can rely on state-of-art optimization software to find candidate solutions. Moreover, dispensing with the inner loops avoids numerical problems associated with loose inner loop error tolerances (see Dube et al. 2012 for a discussion of the NFP algorithm's numerical properties), and it may significantly increase computational speed because the system of market share equations does not have to be solved exactly at each iteration. (The constraints have to be satisfied only at the solution.) Importantly, Su and Judd (2012) prove that MPEC and NFP solve the same problem, yielding the same estimates with the same statistical properties.

The implementation of MPEC in this paper is based on the MATLAB code of Dube et al. (2012), using both of the KNITRO solver's interior-point and active set algorithms (Byrd et al. 1999, 2004, 2006). To improve numerical accuracy as well as computational performance, KNITRO is provided with hand-coded first-order analytical derivatives of the objective function and the constraints, second order derivatives, as well as the sparsity patterns of the constraint Jacobian and the Hessian. Since the Hessian contains almost 4×10^9 elements of which only about 1.8×10^6 are non-zero, supplying the solver with the sparsity pattern is critical in order to economize on memory usage and time. To increase the likelihood of finding the global optimum five different starting points are used. Relative optimality and feasibility error tolerances, i.e. the maximum violation of the first order conditions and the constraints, have each been set to 10^{-6}. Reported standard errors are based on the block-bootstrap with 100 iterations.

In order to provide the solver with a completely smooth optimization problem, the constraints in (11)–(12) have been rewritten as an indicator function for each candidate, $c_k(\kappa)$, and are numerically approximated by the hyperbolic tangent. That is,

$$c_k(\kappa) = \frac{1}{2} + \frac{1}{2}\tanh\left(\rho\left(\kappa + \overline{v}_{k,d}^{L} - \overline{v}_{d}^{L,2^{nd}}\right)\right)$$

for $\rho = 5{,}000$. Thus, equation (8) becomes

$$\widehat{v}_{k,m}^{C,T} = \int \frac{c_k \exp\left(\xi_{p,m} + \zeta_{i,p} + \chi_k\right)}{1 + \sum_{k' \in K} c_k \exp\left(\xi_{p',m} + \zeta_{i,p'} + \chi_{k'}\right)} d\Phi(\zeta).$$

E.2. *Sparse Grid Integration*

Instead of solving the approximately 120,000 five dimensional integrals in equations (6), (7), and (8) using simulation methods, the present paper relies on sparse grid integration (SGI), introduced into economics by Heiss and Winschel (2008). SGI provides a way to approximate integrals numerically avoiding the curse of dimensionality associated with conventional quadrature rules (see Judd 1998). Monte Carlo evidence by Skrainka and Judd (2011) indicates that SGI imposes a significantly lower computational burden than simulation methods achieving the same level of accuracy.

SGI is closely related to conventional Gaussian quadrature rules, but by exploiting symmetry properties it relies only on a small subset of nodes and (appropriately rescaled) weights. This paper uses a Konrad-Patterson rule with Gaussian kernel for choosing nodes, as explained in Heiss and Winschel (2008). This particular rule has only 151 nodes; yet it exactly integrates (over five dimensions) all complete polynomials of total order less than 7. Experimentation with more accurate rules yielded essentially the same point estimates, but required significantly more CPU time.

E.3. *Construction of Counterfactuals*

The counterfactual election results in Section D.2 of the Appendix have been constructed by simulation. More specifically, for each municipality in the data 100 times its actual number of voters have been simulated by randomly drawing ζ, η, and ε from the respective (estimated) distributions. A fraction λ of simulated voters (rounded to the nearest integer) are designated to behave sincerely. Next, each voter's candidate and party specific utilities are calculated and his (partial) preference orderings for the list and candidate vote are determined. Naturally, sincere voters consider all candidates, whereas tactical voters choose only among those contestants who are estimated to be contenders. Election results are then constructed by aggregating votes to the appropriate level, and applying the specified electoral rule.

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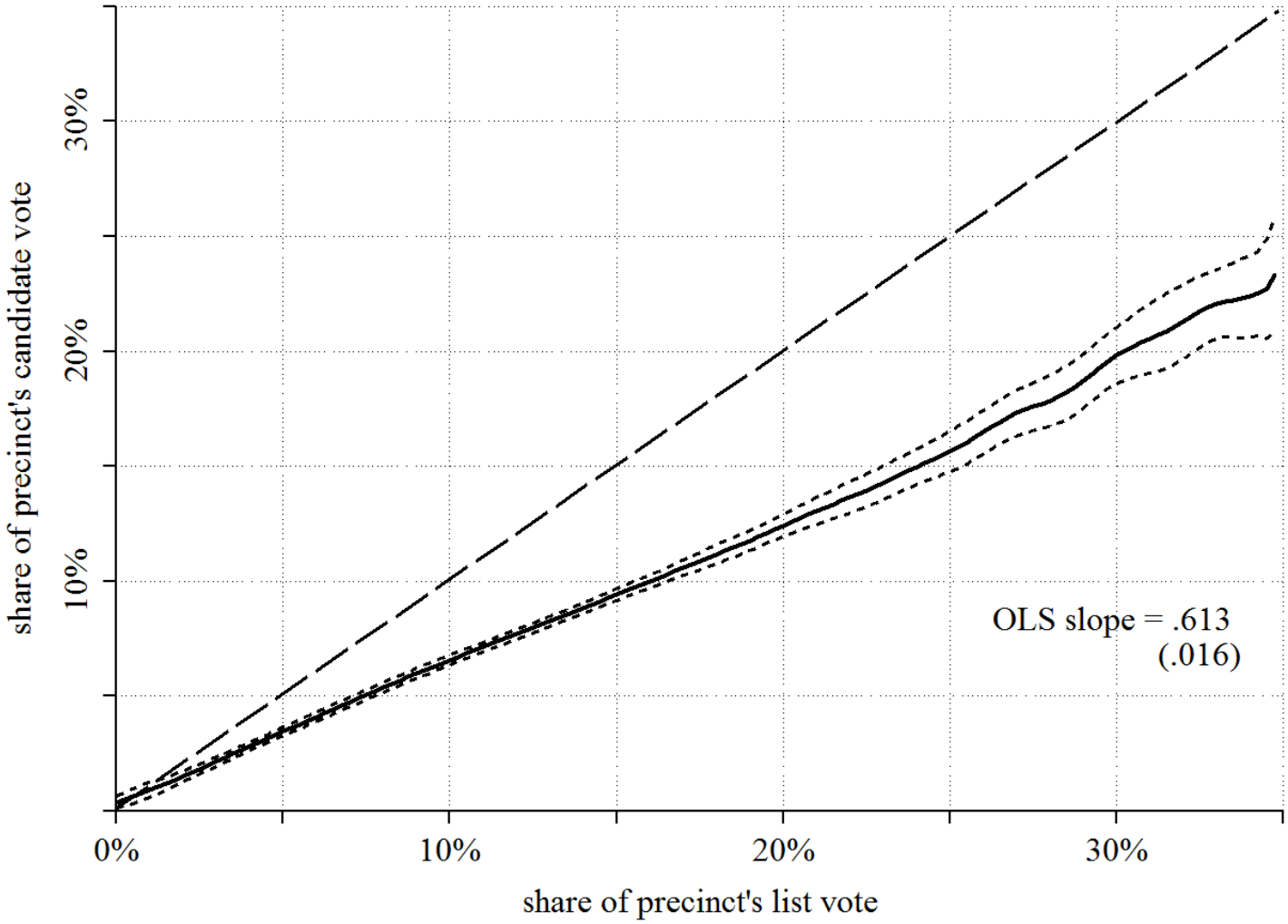
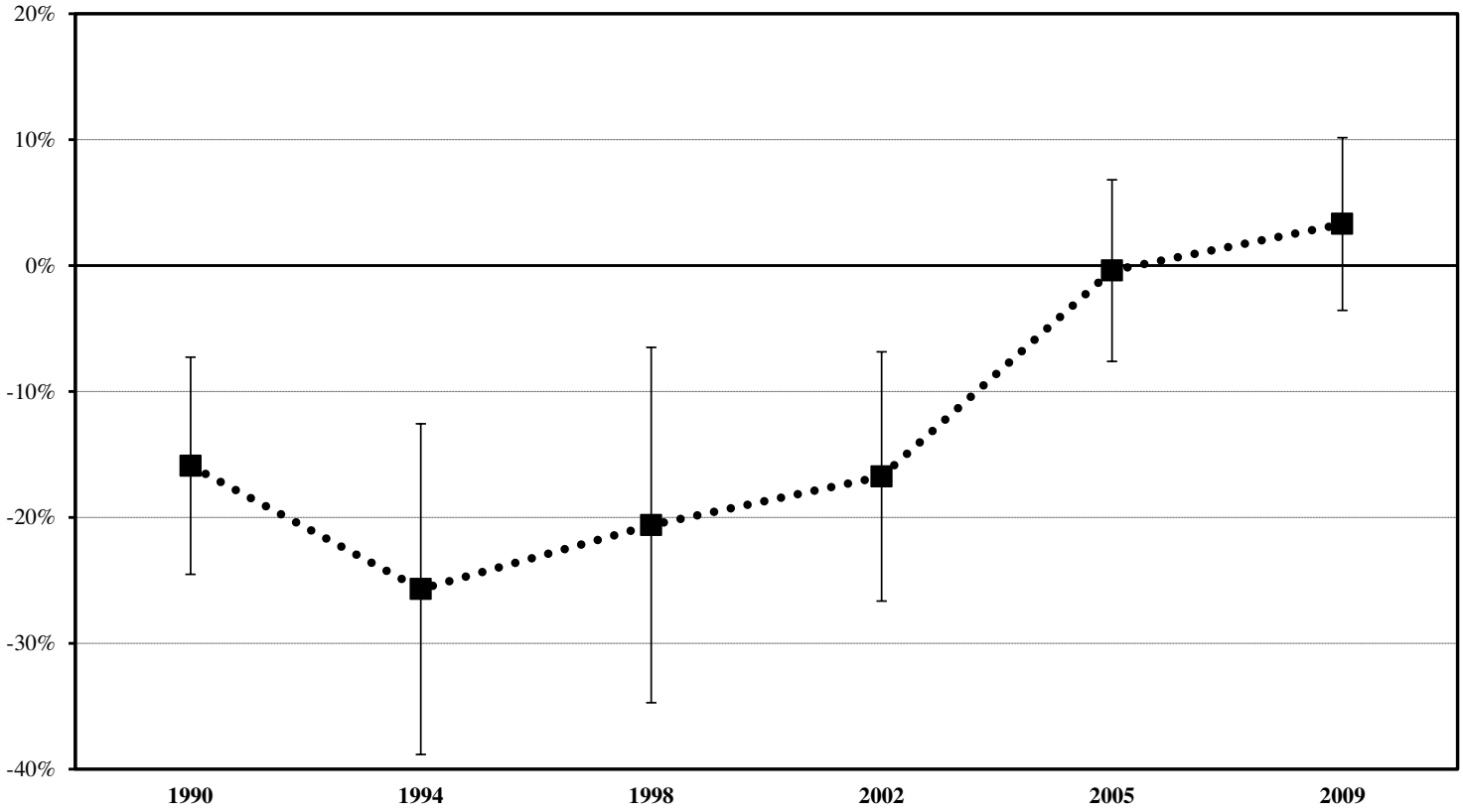
Figure 1: Relationship between List and Candidate Votes for Candidates Trailing Far Behind



Notes: Figure shows a semiparametric estimate of the relationship between list and candidate votes for candidates of the five major parties who trail the runner-up in their district by more than 10 percentage points as well as the associated asymptotic 95%-confidence intervals. The estimating equation is $v^C_{k,r,t} = \chi_{m,k,t} + f(v^L_{k,r,t}) + \epsilon_{k,r,t}$, where $v^C_{k,r,t}$ denotes the vote share of candidate k in precinct r during election year t, $v^L_{k,r,t}$ is the list vote share of the assicoated party, and $\chi_{m,k,t}$ is a municipality and year specific candidate fixed effect. $f(\cdot)$ is approximated by cubic B-splines with knots at every 1.5 percentage points. Standard errors account for clustering at the state level and have been calculated using the nonparametric bootstrap with 1,000 iterations.

Figure 2: Difference in Incidence of Behavioral Voting between East and West Germany, 1990–2009



Notes: Figure shows the percentage point difference in the incidence of behavioral voting between East and West Germany for each federal election from 1990 to 2009 as well as the associated 95%-confidence intervals. Negative values indicate more ballot combinations that violate instrumental rationality among residents of the former GDR. The null hypothesis of a constant difference across all years can be rejected at the 1%-significance level, and that of an equal difference in 1990 and 2009 is rejected at the 1%-level as well.

Table 1: Distribution of List and Candidate Votes in the 2009 Federal Election

Party	Number of Direct Mandates	Share of Candidate Vote	Share of List Vote	Candidate Vote as Fraction of Party's List Vote						
				CDU/CSU	SPD	The Left	Green Party	FDP	Others	Invalid
CDU/CSU	218	38.7%	33.3%	**.876**	.042	.007	.017	.048	.005	.006
SPD	64	27.5%	22.7%	.045	**.858**	.024	.052	.011	.004	.006
The Left	16	10.9%	11.7%	.031	.128	**.757**	.048	.017	.014	.005
Green Party	1	9.0%	10.6%	.061	.333	.036	**.536**	.021	.008	.004
FDP	0	9.3%	14.4%	.458	.048	.011	.021	**.448**	.009	.005
Others	0	2.9%	5.9%	.133	.130	.114	.125	.090	**.378**	.030
Invalid	--	1.7%	1.4%	.117	.079	.025	.013	.021	.013	**.732**

Notes: Entries denote each party's number of direct mandates, share of list and candidate votes, as well as the frequency of different list and candidate vote combinations (calculated as a fraction of a party's list vote) in the 2009 federal election. Due to rounding, entries may not add up to unity.
Source: Author's calculations based on Bundeswahlleiter (2009a, 2010).

Table 2A: Characteristics of Direct Candidates

Variable	Full Sample	Party Affiliation					
		CDU/CSU	SPD	FDP	The Left	Green Party	Others
Age	47.16	49.14	48.87	44.96	49.29	44.01	46.94
	(11.97)	(9.72)	(9.83)	(11.29)	(10.48)	(10.97)	(14.45)
Female	.226	.191	.353	.169	.259	.344	.139
	(.418)	(.393)	(.478)	(.375)	(.438)	(.475)	(.346)
Doctorate	.109	.204	.134	.161	.090	.105	.041
	(.312)	(.403)	(.341)	(.367)	(.287)	(.306)	(.199)
Currently Member of Parliament	.231	.652	.602	.161	.083	.148	.002
	(.422)	(.477)	(.490)	(.367)	(.277)	(.356)	(.039)
Holds Direct Mandate	.111	.376	.403	.000	.009	.003	.001
	(.315)	(.485)	(.491)	(.000)	(.092)	(.058)	(.028)
Also on Party List	.626	.759	.950	.888	.434	.546	.414
	(.484)	(.428)	(.218)	(.316)	(.496)	(.498)	(.493)
Position on Party List | Also List Candidate	12.89	13.26	17.36	17.47	9.40	8.89	7.32
	(12.86)	(12.79)	(15.46)	(15.32)	(8.19)	(6.94)	(7.02)
	4,257	598	598	598	587	593	1,283

Notes: Entries are means and standard deviations of characteristics of direct candidates running in the 2005 or 2009 federal elections, by party affiliation. See the Data Appendix for the precise definition and source of each variable.

Table 2B: Summary Statistics for Electoral Precincts

		West Germany		East Germany	
Variable	Full Sample	2005	2009	2005	2009
Number of Eligible Voters	820.7	821.5	834.2	782.9	802.5
	(406.1)	(385.4)	(387.6)	(460.3)	(487.7)
Turnout	.747	.789	.727	.751	.658
	(.087)	(.071)	(.083)	(.069)	(.084)
Share of Candidate Vote (in %):					
CDU/CSU	41.07	44.81	41.94	29.65	32.94
	(13.02)	(13.33)	(11.49)	(9.93)	(10.32)
SPD	32.23	38.73	28.80	31.35	20.03
	(12.61)	(12.66)	(10.71)	(8.28)	(7.54)
FDP	7.04	4.59	9.66	5.16	8.17
	(3.93)	(2.25)	(3.74)	(2.85)	(3.73)
The Left	9.66	3.95	7.35	24.86	28.61
	(9.67)	(3.06)	(4.01)	(7.37)	(8.46)
Green Party	6.87	5.46	9.32	3.76	5.53
	(5.29)	(3.78)	(5.23)	(5.80)	(6.08)
Others	3.08	2.38	2.88	5.22	4.72
	(2.88)	(2.75)	(2.59)	(3.10)	(2.70)
Share of List Vote (in %):					
CDU/CSU	35.47	38.67	35.59	26.21	30.65
	(11.60)	(12.48)	(10.25)	(8.59)	(8.92)
SPD	27.98	34.22	23.62	29.96	17.95
	(10.91)	(10.84)	(8.63)	(7.16)	(5.94)
FDP	12.01	10.10	15.18	8.00	10.57
	(4.83)	(3.56)	(4.61)	(3.25)	(3.76)
The Left	10.43	4.83	8.40	25.05	28.27
	(9.23)	(3.09)	(4.26)	(6.26)	(7.56)
Green Party	8.83	8.38	10.93	4.78	5.90
	(5.38)	(4.87)	(5.25)	(4.13)	(4.93)
Others	5.23	3.71	6.23	6.01	6.66
	(2.85)	(2.03)	(2.76)	(3.03)	(3.03)
Absentee Precinct	.148	.155	.166	.090	.098
	(.355)	(.362)	(.372)	(.286)	(.297)
Number of Observations	177,425	71,614	72,056	17,110	16,645

Notes: Entries are means and standard deviations for all precinct-level variables used in the analysis, differentiating between East and West Germany as well as election year. See the Data Appendix for a precise definition of each variable.

Table 3: Testing the Null Hypothesis of Sincere Voting

A. All Voters

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote (ϕ)	1.205	1.018	.936	.937	.891
	(.022)	(.012)	(.007)	(.008)	(.014)
Constant	-3.440				
	(.430)				
H_0: ϕ=1 [*p* -value]	< .001	.165	< .001	< .001	< .001
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.936	.961	.979	.980	.987
Number of Observations	882,061	882,061	882,061	882,061	882,061

B. Voters with No Strategic Incetives to Cast Split Ballots

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote (ϕ)	1.078	1.061	1.001	1.021	.989
	(.010)	(.010)	(.009)	(.011)	(.018)
Constant	2.394				
	(.573)				
H_0: ϕ=1 [*p* -value]	< .001	< .001	.933	.064	.544
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.895	.903	.946	.950	.968
Number of Observations	354,462	354,462	354,462	354,462	354,462

C. Voters with Strategic Incentives to Cast Split Ballots

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote (ϕ)	.795	.798	.730	.695	.663
	(.065)	(.026)	(.023)	(.029)	(.029)
Constant	-.476				
	(.471)				
H_0: ϕ=1 [*p* -value]	.024	< .001	< .001	< .001	< .001
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.712	.813	.888	.897	.934
Number of Observations	527,419	527,419	527,419	527,419	527,419

Notes: Entries are coefficients and standard errors from estimating equation (1) by ordinary least squares. The upper panel restricts the sample to all candidates of Germany's five major parties. The middle panel considers only candidates who finsihed first or runner-up, giving supporters of the associated parties no strategic incentives to cast split ballots. The lower panel restricts attention to candidates who finished third or worse, meaning that at least some supporters of the associated parties had a strategic incentive to cast split ballots. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses. To account for the small number of clusters, reported *p* -values are based on the wild bootstrap procedure suggested by Cameron et al. (2008) with 10,000 iterations. See the Data Appendix for the precise definition and source of each variable.

Table 4: Ranking of Candidates in the 2005 & 2009 Federal Elections

Rank Based on Candidate Vote	Rank Based on List Vote					
	1	2	3	4	5	6
1	**557**	38	3	0	0	0
2	39	**502**	54	3	0	0
3	2	44	**369**	139	39	5
4	0	14	131	**306**	138	9
5	0	0	39	139	**332**	87
6	0	0	2	11	88	**474**
Total	598	598	598	598	597	575
First or Runner-Up	99.7%	90.3%	9.5%	0.5%	0.0%	0.0%

Notes: Entries denote the number of candidates for each combination of own rank based on received candidate votes (left column) and the within-district ranking of the associated party based on the list vote in the same year (top row). For instance, out of the 598 candidates whose party received the most list votes within a particular district, 557 won the direct mandate for that district, 39 candidates finished in second place, and 2 ended up third. The rank order correlation within districts is .93.

Table 5: Quantifying Deviations from Instrumental Rationality

A. Candidates Trailing Far Behind

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote (λ)	.621	.682	.670	.632	.613
	(.027)	(.013)	(.010)	(.014)	(.016)
Constant	.676				
	(.193)				
H_0: λ=1 [*p*-value]	< .001	< .001	< .001	< .001	< .001
H_0: λ=0 [*p*-value]	< .001	< .001	< .001	< .001	< .001
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.622	.717	.816	.832	.885
Number of Observations	463,544	463,544	463,544	463,544	463,544

B. All Candidates

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote	.819	.765	.696	.657	.656
× Noncontender (λ)	(.063)	(.022)	(.021)	(.019)	(.026)
Share of List Vote	1.118	1.060	.982	1.004	.978
× Contender (γ)	(.016)	(.010)	(.010)	(.012)	(.021)
Noncontender	-.596	3.664	-3.887		
	(.441)	(.433)	(.614)		
Contender	.649	6.477	-.742		
	(.767)	(.717)	(.140)		
Structural Break	.009	.021	.065	.064	.023
H_0: λ=1 [*p*-value]	.027	< .001	< .001	< .001	< .001
H_0: λ=0 [*p*-value]	< .001	< .001	< .001	< .001	< .001
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.951	.965	.980	.982	.989
Number of Observations	882,061	882,061	882,061	882,061	882,061

Notes: Entries are coefficients and standard errors from estimating equation (3) (upper panel) and equation (4) (lower panel) by ordinary least squares. The upper panel restricts the sample to candidates who finished more than 10 percentage points behind second place, whereas the lower panel includes all candidates. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses. To account for the small number of clusters, reported *p*-values are based on the wild bootstrap procedure suggested by Cameron et al. (2008) with 10,000 iterations. See the Data Appendix for the precise definition and source of each variable.

Table 6: Comparative Statics

Restriction	Share of Behavioral Voters Fixed Effects: Candidate × Year	Share of Behavioral Voters Fixed Effects: Candidate × Municipality × Year
Baseline	.657	.656
	(.019)	(.026)
By Availability of Close Substitute:		
Allied Party's Candidate in the Race	.586	.556
	(.024)	(.024)
Only Rival Parties' Candidates in the Race	.829	.817
	(.012)	(.014)
By Difference Between Winner and Runner-Up:		
< 1%	.618	.606
	(.043)	(.034)
1% and 5%	.644	.621
	(.026)	(.028)
> 5%	.688	.662
	(.026)	(.026)
By Year:		
2005	.548	.488
	(.027)	(.016)
2009	.764	.726
	(.025)	(.021)

Notes: Entries are coefficients and standard errors on λ estimated from equation (4), using different subsamples of the data. The respective restriction is indicated on the left of each row. See the Data Appendix for the precise definition and source of each variable.

Table 7: Candidate–List Vote Gradient among First- and Second-Ranked Candidates

	Slope	
	Second-Ranked Candidate	First-Ranked Candidate
Entire Sample:		
Based on Preferences	1.003	.965
	(.024)	(.017)
Based on Ex Post Outcome	1.018	.965
	(.018)	(.017)
By Distance between First- and Second-Ranked Candidate, based on Preferences:		
< 2%	1.008	.992
	(.017)	(.020)
2% to 5%	.988	.962
	(.017)	(.017)
5% to 10%	1.032	.955
	(.019)	(.018)
10% to 15%	.996	.934
	(.035)	(.020)
> 15%	.992	.926
	(.044)	(.023)
By Distance between First- and Second-Ranked Candidate, based on Ex Post Outcome:		
< 2%	1.003	.987
	(.018)	(.015)
2% to 5%	1.021	.963
	(.014)	(.018)
5% to 10%	1.032	.959
	(.018)	(.018)
10% to 15%	1.036	.949
	(.025)	(.020)
> 15%	1.004	.943
	(.025)	(.024)

Notes: Entries denote the candidate–list vote gradient for first- and second-ranked candidates, i.e. ϕ in equation (1), by distance between the them. The respective cutoffs are shown in the column on the left. All estimates control for candidate-municipality-year fixed effects. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses.

Table 8: Sensitivity Analysis Using Alternative Classifications of Contenders

	Share of Sincere Votes	
Fixed Effects:		Candidate ×
Classification of Contenders	Candidate × Year	Municipality × Year
Baseline (Preference Based, Original Cutoff)	.657	.656
	(.019)	(.026)
Ex Post Outcome of Races (Original Cutoff)	.655	.651
	(.018)	(.026)
Preference Based Using Different Cutoffs:		
> 1% behind Second-Ranked Candidate	.705	.668
	(.029)	(.028)
> 2% behind Second-Ranked Candidate	.693	.661
	(.027)	(.027)
> 5% behind Second-Ranked Candidate	.669	.641
	(.021)	(.020)
> 8% behind Second-Ranked Candidate	.648	.623
	(.017)	(.018)
> 10% behind Second-Ranked Candidate	.634	.609
	(.015)	(.014)
> 12% behind Second-Ranked Candidate	.615	.589
	(.012)	(.009)
Ex Post Outcome of Races Using Different Cutoffs:		
> 1% behind Second-Ranked Candidate	.690	.658
	(.027)	(.028)
> 2% behind Second-Ranked Candidate	.682	.652
	(.026)	(.026)
> 5% behind Second-Ranked Candidate	.663	.635
	(.020)	(.021)
> 8% behind Second-Ranked Candidate	.650	.626
	(.018)	(.020)
> 10% behind Second-Ranked Candidate	.632	.613
	(.014)	(.016)
> 12% behind Second-Ranked Candidate	.618	.597
	(.011)	(.011)
Ranked First or Second Based on Preferences	.716	.676
	(.030)	(.030)
Ranked First, Second, or Third Based on Preferences	.701	.665
	(.023)	(.017)
Ranked First or Second Based on Ex Post Outcome	.695	.663
	(.029)	(.029)
Ranked First, Second, or Third Based on Ex Post Outcome	.629	.600
	(.013)	(.014)
Finished First or Second in Last Federal Election	.713	.678
	(.032)	(.034)
Finished First, Second, or Third in Last Federal Election	.681	.643
	(.015)	(.011)
Finish in Last Federal Election (Original Cutoff)	.684	.670
	(.026)	(.031)
Finish in Last Federal Election Using Different Cutoffs:		
> 1% behind Second-Ranked Candidate	.709	.674
	(.031)	(.032)
> 2% behind Second-Ranked Candidate	.704	.670
	(.030)	(.032)
> 5% behind Second-Ranked Candidate	.687	.656
	(.027)	(.029)
> 8% behind Second-Ranked Candidate	.678	.648
	(.024)	(.027)
> 10% behind Second-Ranked Candidate	.671	.642
	(.022)	(.023)
> 12% behind Second-Ranked Candidate	.663	.634
	(.019)	(.019)

Notes: Entries are coefficients and standard errors on λ using alternative classifications of "contender." The respective definition is shown in the column on the left. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses.

Table 9: Additional Sensitivity and Robustness Checks

	Share of Behavioral Voters	
Fixed Effects:		Candidate ×
Restriction	Candidate × Year	Municipality × Year
Baseline	.657	.656
	(.019)	(.026)
Difference Estimator	.653	.678
	(.027)	(.038)
In States without Overhang Mandates	.624	.609
	(.029)	(.031)
Weighted by Number of Party Supporters	.678	.672
	(.029)	(.037)
Including "Other" Party Candidates	.659	.645
	(.020)	(.025)

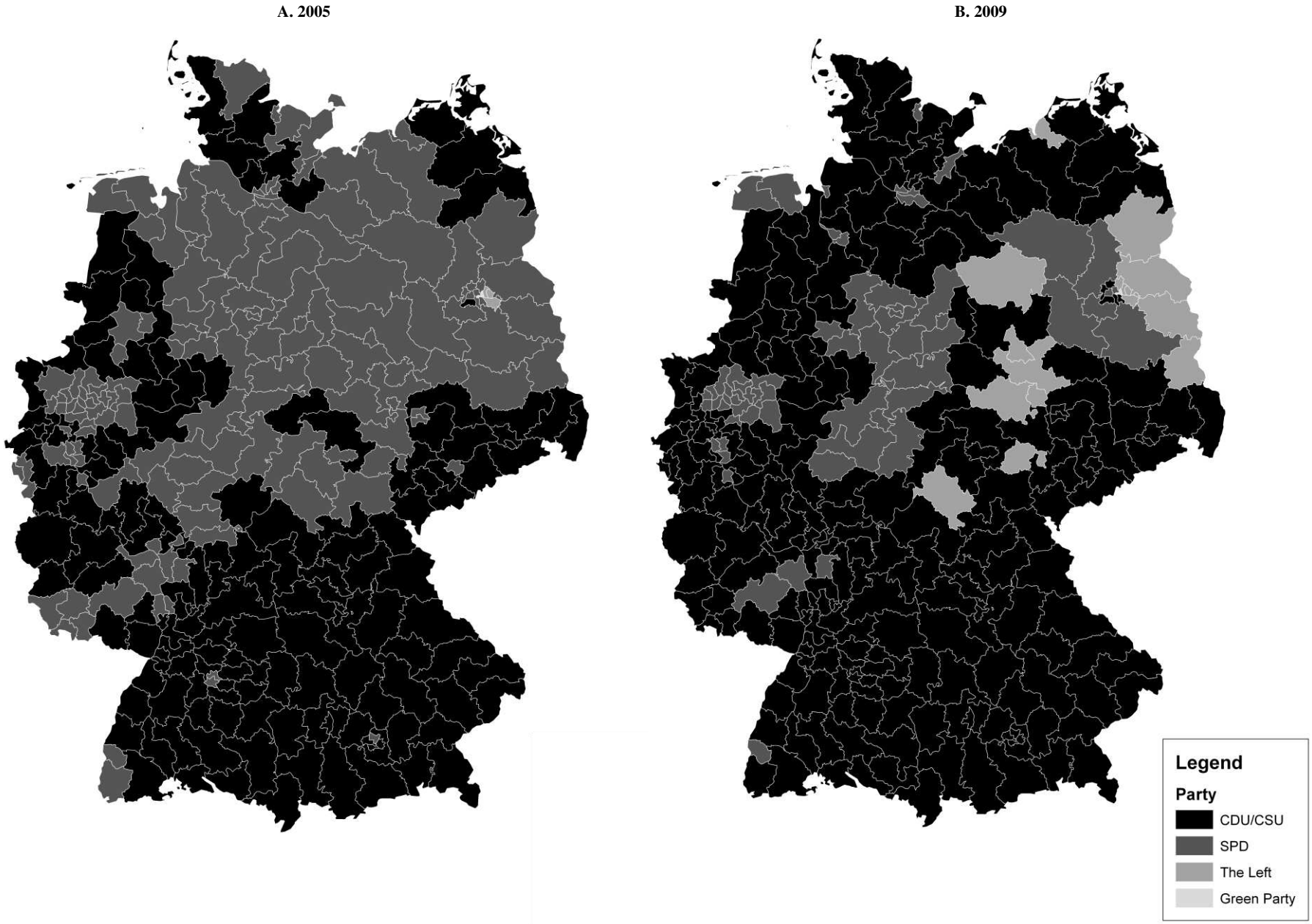
Notes: Entries are coefficients and standard errors on the share of behavioral voters, i.e. λ, using different subsamples of the data and weighting schemes. The respective restriction is indicated on the left of each row. See the Data Appendix for the precise definition and source of each variable.

Table 10: Correlates of Sincere Voting

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote	1.008	1.008	1.008	1.008	1.008
× Contender	(.009)	(.009)	(.009)	(.009)	(.009)
Share of List Vote	.666	.644	.664	.605	.679
× Noncontender	(.031)	(.029)	(.030)	(.033)	(.022)
Share of List Vote		-.005			
× Noncontender × Population Density		(.007)			
Share of List Vote			.019		
× Noncontender × Fraction of Voters Female			(.023)		
Share of List Vote				-.271	
× Noncontender × Income Tax Revenue per Capita				(.078)	
Share of List Vote					.244
× Noncontender × Fraction of Voters under Age 30					(.074)
Candidate × Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
R-Squared	.984	.984	.984	.984	.984
Number of Observations	120,700	120,700	120,700	120,700	120,700

Notes: Entries are coefficients and standard errors from estimating specifications analogous to equation (4) by ordinary least squares, with a structural break at κ=.064. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses. For ease of interpretation, covariates interacted with Share of List Vote × Noncontender have been demeaned. In addition to the variables shown in the table, indicator variables for missing values on each covariate are also included in the regressions. See the Data Appendix for the precise definition and source of each variable.

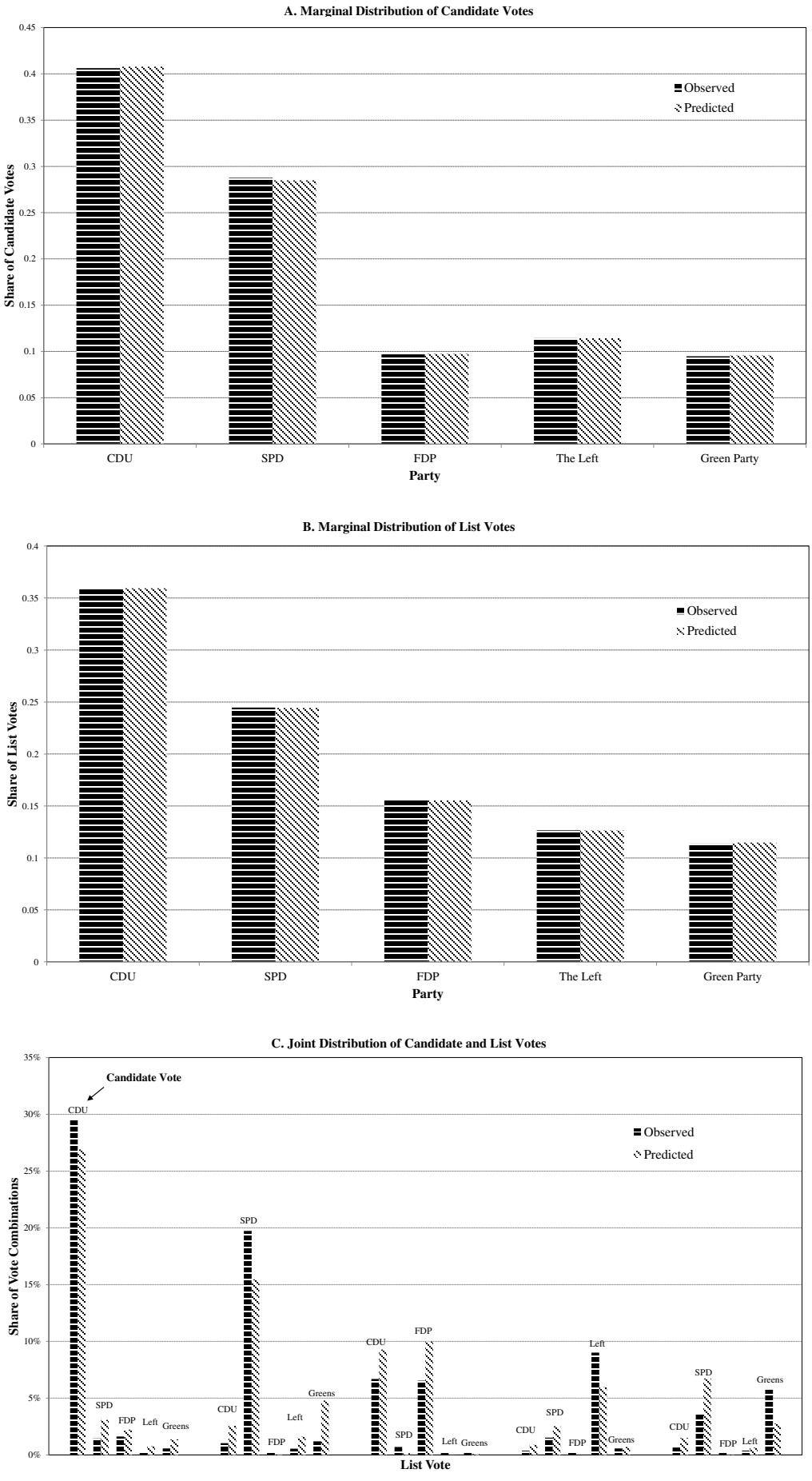
Figure A.1: Distribution of Direct Mandates in the 2005 and 2009 Federal Elections



Notes: Figure depicts majority of the candidate vote by electoral district and candidates' party affiliation in the 2005 (left) and 2009 (right) federal elections. In the 2005 (2009) election, candidates running for the CDU/CSU won the plurality of votes in 150 (218) out of 299 electoral districts. SPD candidates gained 145 (64) direct mandates. Candidates of the The Left won 3 (16) districts, and the Green Party achieved 1 (1) direct mandate. No FDP contestant won a district race.

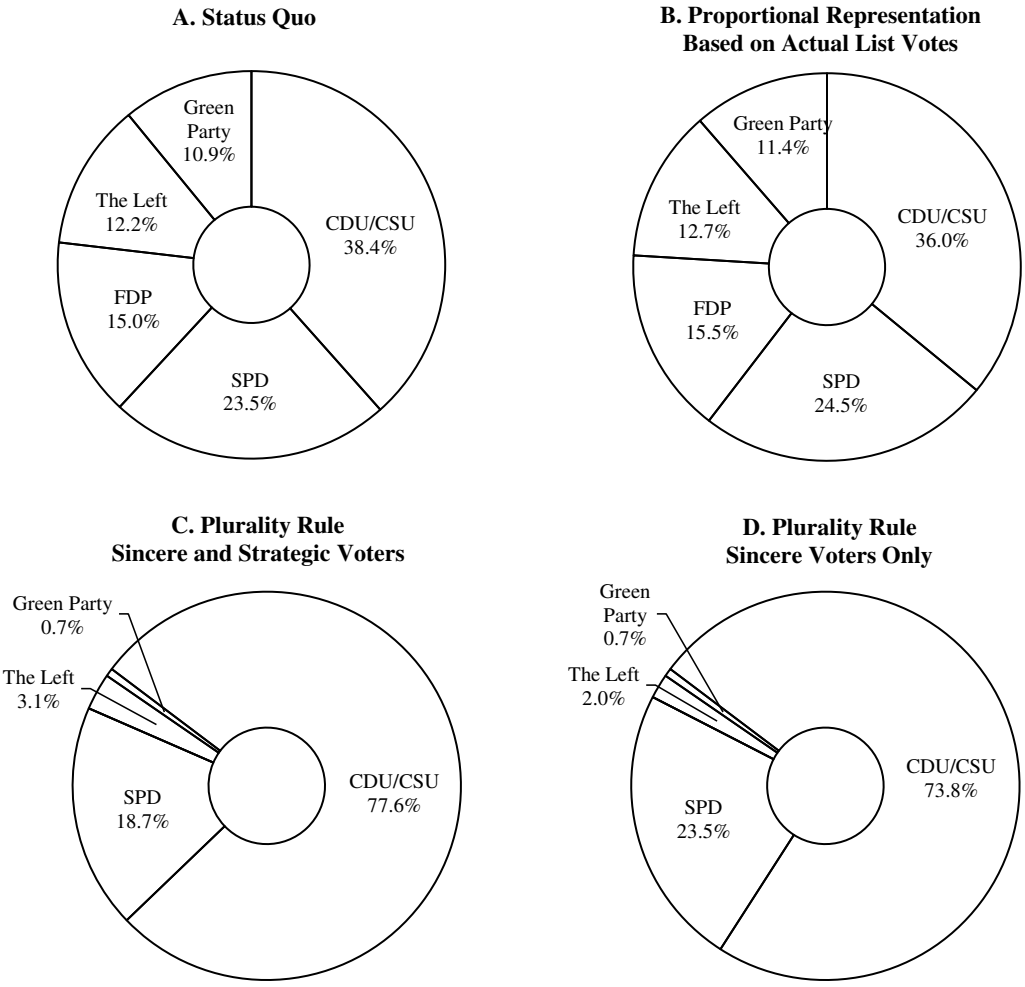
Sources: Based on Bundeswahlleiter (2005a, 2005b, 2008, 2009a).

Figure A.2: Observed vs Predicted Distribution of Votes based on Structural Analysis, 2009 Federal Elections



Notes: Figure depicts actual and predicted vote shares in the 2009 federal election. Panel A shows the marginal distribution of candidate votes, and panel B that of list votes. Panel C depicts the frequency of valid list and candidate vote combinations, i.e. their joint distribution. Dark columns are based on official statistics by the Federal Returning Officer (Bundeswahlleiter 2009, 2010). Light columns corresponds to the predictions of the structural model in Appendix D.

Figure A.3: Counterfactual Seat Distributions in the 17th Bundestag



Notes: Figure depicts counterfactual seat distributions in the Bundestag following the 2009 federal election. Results are based on the structural estimation in Appendix D. See the appendix for a description of the assumptions underlying each panel.

Table A.1: Candidate-List-Vote Gradient, by Preference-Based Rank

	Share of Candidate Vote				
Independent Variable	(1)	(2)	(3)	(4)	(5)
Share of List Vote	1.023	1.004	.983	.998	.965
× Ranked First	(.024)	(.019)	(.008)	(.011)	(.017)
Share of List Vote	1.141	1.062	1.011	1.037	1.003
× Ranked Second	(.019)	(.012)	(.017)	(.015)	(.024)
Share of List Vote	1.066	.852	.780	.730	.686
× Ranked Third	(.075)	(.053)	(.045)	(.053)	(.055)
Share of List Vote	.707	.711	.691	.653	.601
× Ranked Fourth	(.026)	(.026)	(.030)	(.031)	(.026)
Share of List Vote	.809	.846	.795	.782	.767
× Ranked Fifth	(.018)	(.014)	(.014)	(.014)	(.014)
Share of List Vote	.817	.823	.787	.765	.740
× Ranked Sixth	(.044)	(.042)	(.014)	(.047)	(.049)
Fixed Effects:					
Party	No	Yes	No	No	No
Candidate	No	No	Yes	No	No
Candidate × Year	No	No	No	Yes	No
Candidate × Municipality × Year	No	No	No	No	Yes
R-Squared	.953	.965	.980	.982	.989
Number of Observations	882,061	882,061	882,061	882,061	882,061

Notes: Entries are coefficients and standard errors from regressing the variables shown on the left on a candidate's vote share. Heteroskedasticity robust standard errors are clustered by state and reported in parentheses. Columns (1)–(3) also include indicator variables for candidates' rank. See the Data Appendix for the precise definition and source of each variable.

Table A.2: Initial Distribution of Fractional Mandates by Party, 2005 & 2009 Federal Elections

A. National Level

	Fractional Mandates					
Election Year	CDU	SPD	FDP	The Left	Green Party	CSU
2005	.919	.170	.184	.208	.524	.996
2009	.517	.557	.655	.636	.115	.519

H_o: Fractional Mandates ~ U[0,1]
All Years: p-value = .721
2005: p-value = .542
2009: p-value = .310

B. State Level

	Fractional Mandates					
State & Election Year	CDU	SPD	FDP	The Left	Green Party	CSU
Bavaria, 2005	--	.761	.843	.209	.440	.996
Bavaria, 2009	--	.480	.377	.329	.534	.519
Baden-Württemberg, 2005	.066	.080	.106	.873	.279	--
Baden-Württemberg, 2009	.416	.467	.062	.743	.066	--
Brandenburg, 2005	.246	.388	.414	.460	.066	--
Brandenburg, 2009	.789	.124	.909	.831	.238	--
Berlin, 2005	.382	.387	.997	.981	.382	--
Berlin, 2009	.751	.122	.923	.139	.387	--
Bremen, 2005	.085	.043	.385	.401	.686	--
Bremen, 2009	.184	.507	.530	.713	.766	--
Hamburg, 2005	.588	.808	.110	.780	.870	--
Hamburg, 2009	.608	.575	.725	.461	.028	--
Hesse, 2005	.901	.754	.146	.346	.521	--
Hesse, 2009	.960	.958	.766	.001	.594	--
Lower Saxony, 2005	.070	.070	.595	.691	.715	--
Lower Saxony, 2009	.523	.098	.664	.713	.967	--
Mecklenburg-West Pomerania, 2005	.863	.141	.814	.078	.523	--
Mecklenburg-West Pomerania, 2009	.205	.113	.255	.708	.701	--
North Rhine-Westphalia, 2005	.413	.874	.451	.949	.398	--
North Rhine-Westphalia, 2009	.508	.418	.534	.642	.852	--
Rhineland-Palatinate, 2005	.558	.812	.661	.733	.297	--
Rhineland-Palatinate, 2009	.225	.666	.370	.024	.104	--
Saarland, 2005	.516	.778	.619	.535	.498	--
Saarland, 2009	.622	.126	.022	.826	.579	--
Saxony, 2005	.474	.547	.538	.918	.685	--
Saxony, 2009	.714	.837	.405	.129	.216	--
Saxony-Anhalt, 2005	.710	.246	.537	.054	.786	--
Saxony-Anhalt, 2009	.299	.985	.829	.741	.904	--
Schleswig-Holstein, 2005	.224	.620	.275	.033	.923	--
Schleswig-Holstein, 2009	.583	.338	.854	.875	.984	--
Thuringia, 2005	.905	.692	.509	.961	.930	--
Thuringia, 2009	.613	.187	.776	.231	.081	--

H_o: Fractional Mandates ~ U[0,1]
All Years: p-value = .362
2005: p-value = .271
2009: p-value = .798

Notes: Entries denote the number of fractional mandates by party in the 2005 and 2009 federal elections, as explained in Appendix B. The upper panel does so for the national level, whereas the lower panel refers to the state level. H_o refers to the null hypothesis that the number of fractional mandates is uniformly distributed on the unit interval. The respective p-values are based on Kolmogorov–Smirnov tests. For a detailed description of how mandates are allocated to parties, see Appendix B.

Table A.3: Estimated Share of Behavioral Voters by Candiate Characteristics

	Share of Behavioral Voters	
	Candidate × Year	Candidate × Municipality × Year
By Gender:		
Male	.645	.632
	(.021)	(.024)
Female	.686	.707
	(.022)	(.029)
By Age:		
< 30	.586	.582
	(.021)	(.034)
30 to 50	.636	.642
	(.020)	(.030)
50 to 70	.709	.698
	(.023)	(.026)
> 70	.730	.723
	(.024)	(.027)
By Education:		
Doctoral Degree	.579	.580
	(.030)	(.044)
No Doctoral Degree	.666	.665
	(.018)	(.025)
By Membership in Parliament:		
Currently in Parliament	.744	.731
	(.046)	(.050)
Not Currently in Parliament	.636	.635
	(.014)	(.020)
By List Candidate Status:		
Also on Party List	.632	.636
	(.026)	(.035)
Not on Party List	.708	.702
	(.013)	(.014)

Notes: Entries are coefficients and standard errors on the share of behavioral voters, i.e. λ, using different subsamples of candidates. The respective restriction is indicated on the left of each row. See the Data Appendix for the precise definition and source of each variable.

Table A.4: Actual vs Predicted Ranking of Candidates, Structural Analysis of 2009 Federal Elections

	Predicted Rank (as Fraction of Actual Rank)				
Actual Rank	1	2	3	4	5
1	**94.6%**	5.1%	0.3%	0.0%	0.0%
2	5.1%	**91.8%**	3.1%	0.0%	0.0%
3	0.3%	3.1%	**88.1%**	7.5%	1.0%
4	0.0%	0.0%	8.2%	**86.1%**	5.8%
5	0.0%	0.0%	0.3%	6.5%	**93.2%**

Notes: Entries denote the frequency with which the predictions of the structural model in Appendix D coincide with observed outcomes, considering only candidates of the 5 major parties.

Table A.5: Voters' Partial Preference Orderings

First-Choice	Second-Choice Candidate (as Fraction of First Choice)				
Candidate	CDU/CSU	SPD	FDP	The Left	Green Party
CDU/CSU	--	26.8%	50.0%	8.1%	15.1%
SPD	16.1%	--	0.3%	15.5%	68.0%
FDP	98.9%	0.6%	--	0.1%	0.4%
The Left	18.0%	60.4%	0.1%	--	21.5%
Green Party	14.5%	77.1%	0.4%	8.1%	--

Notes: Entries denote the simulated relative frequency of voters' second-choice candidate, conditional on their first choice. See Appendices D and E for details.

Table A.6: Joint Distribution of District Winners under Sincere and Strategic Voting, Structural Analysis

District Winner	District Winner with Sincere and Strategic Voters				
with Sincere Voters	CDU/CSU	SPD	FDP	The Left	Green Party
CDU/CSU	**70.8%**	1.7%	0.0%	1.0%	0.3%
SPD	6.5%	**16.7%**	0.0%	0.3%	0.0%
FDP	0.0%	0.0%	**0.0%**	0.0%	0.0%
The Left	0.0%	0.3%	0.0%	**1.7%**	0.0%
Green Party	0.3%	0.0%	0.0%	0.0%	**0.3%**

Notes: Entries compare the simulated distribution of district winners in a first-past-the-post system with only sincere voters (left column) to the distribution that would obtain with a mixture of types (top row). Summing across columns gives the percentage of districts that would acrue to a particular party if all voters behaved sincerely, whereas summing across rows gives a party's share of districts if 26.3% of voters behaved strategically. Consequently, adding the entries on the diagonal shows that about 90% of districts would accrue to the same party. See Appendix E for details on the simulation.