Who votes more strategically?[1]

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Abstract

Strategic voting is an important explanation for aggregate political phenomena, but we know little about how strategic voting varies across types of voters. Are richer voters more strategic than poorer voters? Does strategic behavior vary with age, education, gender or political leaning? The answers may be important for assessing how well an electoral system represents different preferences in society. We introduce a new approach to measuring and comparing strategic voting across voters that can be broadly applied given appropriate survey data. In recent British elections, we find no difference in strategic voting by education level, but we do find that older voters are more strategic than younger voters, richer voters are more strategic than poorer voters, and left-leaning voters are more strategic than right-leaning voters. In the case of age and income, the difference in strategic voting exacerbates known inequalities in political participation.

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1 Introduction

Strategic voting is fundamental to our understanding of the relationship between electoral systems and aggregate political outcomes. Most notably, Duverger postulated that plurality systems tend to have two main parties partly because strategic voters abandon less popular candidates (Duverger, 1954). This observation has since been formalized, generalized, and extended to a variety of electoral systems (e.g. Cox, 1997). Meanwhile, a large empirical literature has studied election surveys and aggregate election results to assess the proportion of voters who vote strategically.[2] The answers have varied widely, partly because of disagreements about how strategic voting should be defined and measured. In general, however, the evidence indicates that strategic voting is sufficiently prevalent to help explain aggregate results not just in plurality elections in the UK (e.g. Fisher, 2004), Canada (Black, 1978), and U.S. (Abramson et al., 1992; Hall and Snyder Jr, 2015) but also in elections held under proportional or mixed rules.[3]

In this paper we address a different question from most previous research: rather than asking to what extent voters are strategic in general, we seek to understand *inequalities in strategic voting behavior across types of voters*. Does strategic voting behavior vary systematically with voter characteristics such as age, education, income, gender or political leaning? Inequalities in strategic voting matter because voters who are less strategic will on average be less successful at electing their preferred candidates;[4] across many close elections, this difference in strategic behavior could affect how well different groups of voters are represented. (To take a prominent example, the results of the U.S. presidential elections of both 2000 and 2016 might have been reversed if left-leaning voters had voted more strategically or right-leaning voters had voted less strategically.) If there are inequalities in strategic voting, they could be addressed by improving the public's understanding of the electoral system, by raising the quality and visibility of polling information (Hall and Snyder Jr, 2015), or by adopting an electoral system that less commonly

[2]See e.g. Heath et al. (1991); Niemi, Whitten and Franklin (1992); Evans and Heath (1993); Heath and Evans (1994); Alvarez and Nagler (2000); Evans (2002); Alvarez, Boehmke and Nagler (2006); Fieldhouse, Shryne and Pickles (2007); Kawai and Watanabe (2013); Artabe and Gardeazabal (2014); Herrmann, Munzert and Selb (2015); Fisher and Myatt (2017).

[3]Strategic voting under proportional representation is examined in, e.g. Sartori (1968), Abramson et al. (2010) and Artabe and Gardeazabal (2014). Strategic voting in mixed electoral systems is examined in, e.g. Karp et al. (2002) and Gschwend (2007).

[4]This statement assumes a fixed set of candidates; the normative implications of heterogeneity in strategic voting are more subtle in equilibrium.

rewards strategic behavior.

Despite the clear normative and policy value of understanding how strategic voting behavior varies across types of voters, there has been relatively little research on the topic. A few existing studies have compared strategic voting across groups of voters, but generally only as a secondary concern (e.g. Black 1978; Abramson et al. 1992; Niemi, Whitten and Franklin 1992; Merolla and Stephenson 2007, though see Evans 1994; Fisher 2001).[5] We suspect that one reason for the relative paucity of research on heterogeneity in strategic voting is that there remains little agreement on how to measure strategic voting in the first place, with cutting-edge work in the field continuing to focus on measurement issues (e.g. Kawai and Watanabe, 2013; Herrmann, Munzert and Selb, 2015; Fisher and Myatt, 2017). This may explain why much less is known about inequalities in strategic voting than about inequalities in turnout (e.g. Verba, Schlozman and Brady, 1995; Gallego, 2014; Kasara and Suryanarayan, 2015), even though failing to vote strategically can be just as much a waste of a ballot as failing to vote at all.

We introduce and implement a generalizable and theoretically grounded way to study inequalities in strategic voting that more effectively addresses key methodological challenges. The basis of our approach is a new scalar measure of the incentive to cast a tactical vote for a candidate other than one's favorite. This measure of tactical incentives can be calculated for any voter given a proxy for the voter's cardinal preferences over candidates or parties (e.g. "like-dislike" scores in an election survey) and a model of counterfactual election outcomes. Our measure of tactical incentives plays two roles in our analysis. First, it identifies voters for whom a tactical vote would produce a better expected election outcome than a sincere vote. Given survey data indicating how each voter voted, this allows us to estimate our basic measure of "strategic-ness", called *strategic responsiveness*, which captures how much more likely voters are to cast a tactical vote when a tactical vote would benefit them than when it would not. (Unlike previous measures of strategic behavior, strategic responsiveness considers what voters do both when a tactical vote is called for and when it is not.) Second, our measure of tactical incentives acts as a control variable in our comparisons of strategic responsiveness across groups: it ensures that we do not conclude that one group of voters is more strategic than another just

[5] Loewen, Hinton and Sheffer (2015) examine "non-political, non-sociological" individual differences in strategic decision-making in the lab.

because one group faces systematically stronger incentives to cast a tactical vote. (More so than previous attempts to measure and control for tactical incentives, our measure of tactical incentives is grounded in a coherent theory of voting behavior, as explained in the next section.) With the methods we introduce in this paper, researchers can calculate our measure of tactical incentives and apply our method for comparing strategic voting behavior using data from any electoral survey that reports respondent vote choices and preferences.[6]

We apply this approach to data from the British Election Study for the 2005, 2010, and 2015 UK general elections. We look for differences in strategic responsiveness across five politically salient social characteristics: education, income, gender, age, and general left-right political orientation. In contrast to several previous studies (Black, 1978; Niemi, Whitten and Franklin, 1992; Fisher, 2001; Merolla and Stephenson, 2007), we do not find that more educated voters vote more strategically. We do, however, find that younger voters vote less strategically than older voters; we also find evidence that high-income voters are more strategic than low-income voters and voters on the left are more strategic than those on the right, though these differences vary more across election years. Notably, these differences in strategic voting by age and income would tend to exacerbate known inequalities in political participation.[7] Finally, we consider whether the inequalities we find might be explained by factors such as voters' level of general political knowledge, the accuracy of their understanding of the local contest, their stated attitude toward strategic voting, the identity of their preferred party, or the intensity of the electoral campaign in their constituency. Most of these factors do not seem to explain the differences we observe, but we find some evidence that older voters vote more strategically because they approach voting more pragmatically, and not because they are better informed.

We emphasize that our focus in this paper is on whether voters *vote* strategically (and how this varies across voters), not whether voters *think* strategically. Others may ask to what extent voters engage in valid strategic reasoning, e.g. whether they have beliefs about the likelihood that their vote is pivotal in various ways, whether they vote in a way that is consistent with

[6]It is most straightforward to apply our methods to other plurality systems, but the general approach applies more broadly.

[7]For age, see e.g., Smets and van Ham (2013); Wolfinger and Rosenstone (1980); Swaddle and Heath (1989); Denver and Johns (2012); for income, see e.g., Verba, Schlozman and Brady (1995); Lijphart (1997); Swaddle and Heath (1989); Smets and van Ham (2013); Denver and Johns (2012).

their beliefs about pivotality, whether they refer to this process of strategic thinking when they explain their vote. By contrast, we ask to what extent voters vote in a way that advances their interests (given the objective strategic incentives they face) whatever the thought process that leads to their vote: after all, the effect of a given vote is the same whether the voter thought strategically based on good information about likely outcomes, thought strategically based on *bad* information about likely outcomes, used a simple heuristic, or was simply instructed how to vote by her friends. Our approach may reveal less about voters' thought processes, but we believe it says more about possible differences in voters' ability to obtain desired outcomes in elections.

In brief, this paper makes four main contributions. First, it focuses attention on a mostly overlooked but normatively relevant question: who votes more strategically? Second, it offers a new measure of voting behavior (strategic responsiveness) that provides a better basis for comparison. Third, it defines and shows how to estimate a new, theoretically grounded measure of tactical incentives that is used both to measure and to compare strategic responsiveness across groups. Fourth, it applies these innovations to provide new evidence about inequalities in strategic voting in the British electorate. It remains to be seen whether the inequalities we find are specific to the setting we study; we hope that the approach we introduce in this paper will be used in future work to investigate the generalizability of our results.

2 A new approach to measuring and comparing strategic voting

To determine whether some voters are more strategic than others, we must first clarify what it means to vote strategically, decide how "strategic-ness" should be measured, and develop a feasible strategy for measuring and comparing strategic voting across voters. We address each of these issues in turn before summarizing our approach.

2.1 Notation and terminology

A representative voter decides how to vote in an election involving K candidates. Denote by $\mathbf{p}(j) = \{p_1(j), p_2(j), \ldots, p_K(j)\}$ the probability that each candidate is elected, conditional on the voter voting for candidate j. ($\mathbf{p}(j)$ differs from $\mathbf{p}(k)$ to the extent that a single vote may decide the outcome. We discuss the interpretation and estimation of these probabilities in the next section.) Denote by u_j the Von Neumann-Morgenstern (VNM) utility the voter receives as a result of candidate j being elected. We will refer to u_j as consequentialist utility because it depends on which candidate wins the election but not on which candidate the voter votes for. Denote by $\mathbf{u} = \{u_1, u_2, \ldots, u_K\}$ the vector of these utilities, one for each candidate; label the candidates such that $u_1 > u_j \; \forall \; j > 1$, i.e. such that candidate 1 is the voter's favorite. Note that $\mathbf{p}(j) \cdot \mathbf{u}$ is the expected consequentialist utility of the voter given a vote for candidate j.

We can now define four key terms that we use throughout the paper:

Definition A *sincere vote* is a vote for candidate 1.

Definition A *tactical vote* is a vote for a candidate $j > 1$ such that $\mathbf{p}(j) \cdot \mathbf{u} \geq \mathbf{p}(k) \cdot \mathbf{u}$ for all $k > 1$, i.e. it is the best non-sincere vote in terms of expected consequentialist utility.[8]

Definition The *tactical incentive*, τ, is the benefit or cost (in terms of expected consequentialist utility) of a tactical vote compared to a sincere vote:

$$\tau \equiv \max_{j>1} \mathbf{p}(j) \cdot \mathbf{u} - \mathbf{p}(1) \cdot \mathbf{u}. \tag{1}$$

Definition *Purely strategic voting* means casting a tactical vote when $\tau > 0$ and otherwise voting sincerely.

2.2 Departures from purely strategic voting

Voters may deviate from purely strategic voting for several reasons. They may be expressive, in the sense that they value voting according to their true preferences (Hamlin and Jennings, 2011). They may care about future policy outcomes and believe that their vote affects those outcomes directly or by affecting future elections (Piketty, 2000; Castanheira, 2003). They may have incorrect beliefs about how the election outcome depends on their vote, or they may have difficulty forming such beliefs at all.

[8] Our usage of "tactical vote" is similar to Fisher (2004)'s, except that our definition does not implicate the voter's intention. If $K = 3$ a tactical vote is a vote for one's second-favorite candidate.

To simply formalize these ideas, suppose a representative voter receives benefit $b \geq 0$ from voting for candidate 1 (which captures the expressive benefits and perceived policy benefits of a sincere vote); suppose also that if the true tactical incentive is τ, the voter perceives a benefit of $\tau - \epsilon$. Then the voter casts a tactical vote when $\tau > b + \epsilon$ and otherwise votes sincerely, and $b + \epsilon$ captures the degree to which the voter overvalues a sincere vote relative to a tactical vote due to expressiveness, perceived effects of the vote on policy, and misperceptions.

We hypothesize that no voter is purely strategic or purely expressive: in terms of the simple model just introduced, no voter approaches every voting decision with $b + \epsilon = 0$ or $b + \epsilon = \infty$.[9] Voters may differ in how closely their behavior approximates the pure strategic ideal of $b+\epsilon = 0$, however, and it is this variation that we seek to understand.

2.3 Strategic responsiveness

As noted above, a purely strategic voter is one who casts a tactical vote when $\tau > 0$ and otherwise votes sincerely. Let y_i be 1 if voter i casts a tactical vote and 0 otherwise, and let τ_i be the tactical incentive faced by voter i. We propose *strategic responsiveness* (SR) as a measure of how closely the voting behavior of a voter or group of voters approximates pure strategic voting:

$$\text{SR} \equiv E[y_i|\tau_i > 0] - E[y_i|\tau_i \leq 0].$$

In words, SR is the difference in the tactical voting rate when a tactical vote maximizes the voter's expected consequentialist utility and when it does not.[10] SR is at a maximum of 1 for purely strategic voters, at a minimum of -1 for voters who cast a tactical vote only when they should vote sincerely and vice versa, and zero for voters whose decision to cast a tactical vote is unrelated to the tactical incentive τ_i.

Strategic responsiveness is related to measures of strategic voting used in previous research, but it differs in an important respect: SR measures how much voters *respond* to tactical incen-

[9] In support of this intuition, consider the Kevin Costner movie *Swing Vote* (2008), in which two U.S. presidential candidates tie for first in New Mexico (with the Electoral College in the balance) and the lead character, whose vote was not registered in the initial count, has the chance to cast a new ballot. The question never arises whether he will vote for another candidate, even though there are six candidates shown on the ballot in an early scene.

[10] We include those for whom $\tau = 0$ in the second group, but this is arbitrary and inconsequential.

tives, not just how often they vote tactically. Most previous authors measure and compare the proportion of voters casting a tactical vote controlling for measures of tactical incentives (e.g. Niemi, Whitten and Franklin, 1992; Evans, 1994; Alvarez and Nagler, 2000) or conditional on the voter facing a decision where a tactical vote may be justified, for example because her favorite candidate finishes third or lower (Blais and Nadeau, 1996; Fisher, 2001; Alvarez, Boehmke and Nagler, 2006; Merolla and Stephenson, 2007). To see why these measures are inadequate, consider a hypothetical group of voters who cast a tactical vote with probability p regardless of the voting situation. Approaches that rely simply on the frequency of tactical voting would say that these voters are more strategic the higher p is, while our approach would assign a strategic responsiveness of 0 regardless of the value of p. Put differently, unlike previous measures of strategic-ness, SR penalizes ill-advised tactical votes.[11] In focusing on responsiveness to tactical incentives, our approach is closer to Black (1978) and Merolla and Stephenson (2007) (see also Abramson et al., 1992), who measure the strategic-ness of different groups of voters by comparing how well their vote choice is predicted by several variables that should be related to the incentive to cast a tactical vote.[12]

2.4 Measuring tactical incentives

Measuring strategic responsiveness requires measuring τ, which in turn requires (for each voter) measures of (1) the voter's VNM utility from electing each candidate and (2) the probability of each candidate being elected as a function of the voter's vote.

For (1), we suggest using ratings by voters of candidates, parties, and/or party leaders such as are commonly included on voter surveys such as the Comparative Study of Election Systems (CSES). Depending on the setting, the researcher might use one set of these ratings (e.g., party ratings, as in this paper) or combine them to form composite ratings.[13] Future researchers

[11]This is not just an abstract concern. For example, Evans and Heath (1993) critique Niemi, Whitten and Franklin (1992) for concluding that more educated voters are more strategic because they vote tactically at a higher rate, controlling for strategic context. Using Niemi, Whitten and Franklin's measures, Evans and Heath show via a simple cross-tabulation that more educated voters are more likely to vote tactically not just when they seemingly have an incentive to do so, but also when their preferred party has the best chance of winning in a seat.

[12]A shortcoming of Black (1978) and Merolla and Stephenson (2007) is that it is not clear how responsive a purely strategic voter would be to the variables in their model, so better model fit may not correspond to more strategic voting. By contrast, it is clear that the SR of a purely strategic voter is 1.

[13]In the Canadian setting, Blais and Nadeau (1996) combine ratings of party, leader, and candidate, while

should check what combination of ratings best approximates VNM utility scores.[14] Given that our goal is to compare strategic responsiveness of different groups of voters, measurement error that arises because of discrepancies between voters' ratings and their VNM utilities may attenuate our results but it leads to conclusions with the wrong sign only if it affects our measures of different groups' SR in different ways.

For (2), we suggest extracting election probabilities from a model that approximates the true *ex ante* probability of each possible election outcome. We model the vote shares of each candidate in an election using a Dirichlet distribution, which assigns a probability mass to every point on a simplex. The distribution of vote shares for K candidates can be characterized by a Dirichlet distribution with parameter vector $s\mathbf{v} \equiv \{sv_1, sv_2, \ldots, sv_K\}$, where $\mathbf{v}$ is the vector of expected vote shares and s is a precision parameter.[15] We set $\mathbf{v}$ equal to the vector of vote shares that is actually observed in an election, reflecting our view that the best guess for the average *ex ante* outcome is the observed outcome.[16] (In Appendix C we show the core results where $\mathbf{v}$ is set equal to the forecasted vote shares, which produces almost undistinguishable results.) We then choose s to maximize the joint likelihood of the predicted constituency vote shares generated from forecasting models run for each election studied; essentially, we choose a degree of precision such that the estimated probability of a counterfactual outcome that differs from the observed outcome by a given amount is roughly the same as the probability of a forecast that differs from the observed outcome by that amount. Having chosen parameters for our model, we then calculate τ for a given voter using an indirect method: we first estimate the probability of each possible pivotal event by integrating the distribution along dimensions where the voter is pivotal between each pair of candidates, and then we calculate τ as a function of these pivotal probabilities and the utility scores. We further describe our procedure for setting s and extracting pivotal probabilities in Appendix A. We present examples of how τ relates in practice to election outcomes and voter preferences in the next section.

Merolla and Stephenson (2007) average ratings of party and leader.

[14] This could be done by checking to what extent voters' preferences over hypothetical lotteries among candidates/parties/leaders agree with the implied expected ratings of those lotteries.

[15] One could instead model counterfactual election outcomes using a distribution with a more flexible covariance structure, such as a truncated multivariate normal, which would make it possible to implement different assumptions about the covariance in parties' results.

[16] Put differently, we seek to assess which voters' vote choices are best responses to a noisy version of other voters' actual votes.

To be clear, we estimate the tactical incentive τ not as the voter perceives it but as the voter *would* perceive it if she had unbiased but uncertain expectations about election outcomes and were capable of making the necessary expected utility calculations. It would clearly be unrealistic to assume that voters can predict election outcomes as well as an unbiased forecaster and can compute the benefits of a tactical vote based on these beliefs, but we stress that this is not our assumption. Our estimate of τ is an estimate of the voter's true objective tactical incentive, which may be quite different from the incentive the voter perceives. (Indeed, the voter may be incapable of even thinking in strategic terms.) We compute τ not to predict the voter's vote choice but rather to compare the voter's vote choice to what a purely strategic voter would do in the voter's position, and then to see what type of voter more closely adheres to this strategic ideal. (If we *were* trying to predict strategic vote choice, we may not even build our predictions on the rational voter model, because simple heuristics such as "vote for your favorite viable party" may be better predictors.) Voters' misperceptions of the true expected benefits of a tactical vote compared to a sincere vote (i.e. ϵ in the model above) are likely an important reason why voters depart from the purely strategic ideal, and those misperceptions are part of what we want to capture in measuring strategic responsiveness.[17]

2.5 Comparing strategic responsiveness

Suppose voters in group A are observed to have higher strategic responsiveness than voters in group B. One possible reason for this difference is that voters in group A are more strategic (e.g. that they tend to have lower $b + \epsilon$ in the model above). Another possible reason is that voters in group A face different types of voting decisions. For example, suppose voters in group B tend to be nearly indifferent between the frontrunners (perhaps because they are centrists in a system in which right-versus-left competition is common), while voters in group A tend to have stronger preferences (perhaps because they are on the right or left). In that case, the higher strategic responsiveness of voters in group A may arise only because they stand to gain or lose more from a tactical vote than voters in group B do, not because they would vote less

[17] Of course we may mis-measure τ, but this measurement error only matters for the direction of our conclusions if it differs across groups being compared. As an interesting extension to this paper, we could estimate the tactical incentive as the voter perceives it ($\tau - \epsilon$), in which case strategic responsiveness would more narrowly measure variation in b. Estimating $\tau - \epsilon$ convincingly probably requires data that is not available in typical voter surveys.

strategically when facing similar decisions.

To address this possibility, we suggest comparing strategic responsiveness across groups of voters using a regression that controls flexibly for τ. This control strategy can be justified based on the simple model above: to isolate differences in $b + \epsilon$ across groups, we want to compare tactical voting behavior conditional on τ, which is the only possible confounding variable in that model. By contrast, most previous literature controls additively for various indicators of the strategic context.[18] A key advantage of our approach is that, because τ is a scalar, we can use less parametric functional forms and present results more transparently; also, unlike many of the standard measures of preference intensity and competitiveness, τ is easily extended to elections with any number of candidates.[19] Of course, for τ to make sense as a control variable we must believe that the scale of the utility measure is roughly comparable across groups being compared; this assumption is difficult if not impossible to test, though a similar assumption is made by all previous studies that use party or candidate ratings as control variables (e.g. Fisher, 2001; Merolla and Stephenson, 2007; Fisher and Myatt, 2017).[20] At it happens, the results of this paper do not depend on whether we control for τ (as shown below), but in general we advocate controlling for τ as the best way to address potential differences in strategic contexts across groups of voters being compared.

2.6 Summary of our approach

Given a measure of a voter's VNM utility from each possible election outcome and a measure of the probability of each election outcome as a function of the voter's vote, one can estimate the expected benefit of a tactical vote (relative to a sincere vote) for the voter. We call this

[18]Previous control variables include the margin between the top two candidates (e.g. Niemi, Whitten and Franklin, 1992), the distance between the voter's preferred candidate and the leaders (e.g. Niemi, Whitten and Franklin, 1992; Evans, 1994), and the size of the preference "gaps" between the voter's first- and second-favorite and second- and third-favorite candidates (e.g. Fisher, 2001).

[19]As a control variable, τ can be seen as an extension of the tactical incentive variable introduced by Myatt (2000) and used in Fisher (2001), Herrmann, Munzert and Selb (2015), and Fisher and Myatt (2017). In a three-candidate context, Myatt's strategic incentive variable combines information about the voter's preference order and the relative electoral support for the three candidates. Like Myatt's variable, τ summarizes information about the voter's preferences and the electoral context in a single scalar variable. The difference is that τ incorporates preference intensity (and thus requires a scale comparability assumption) and can be calculated for an arbitrary number of candidates.

[20]In favor of this assumption, survey questions that elicit candidate/party/leader ratings typically associate numerical responses with anchoring phrases (e.g. 0 means "strongly dislike" in the CSES and BES), which may encourage different voters to use the scale in a similar way. Testing the assumption would require measuring how ratings correspond to other observable measures of preference and comparing this correspondence across groups.

expected benefit τ. A purely strategic voter casts a tactical vote if τ is positive and a sincere vote otherwise. Voters may not be purely strategic for various reasons.

To measure how closely voters approximate pure strategic voting, we take the difference between the probability of a tactical vote when $\tau > 0$ and when $\tau \leq 0$. We call this measure *strategic responsiveness* (SR); unlike previous approaches, SR penalizes ill-advised tactical votes.

To measure τ, we use a model of counterfactual election outcomes that approximates what an unbiased forecaster might have expected before the election. Thus τ captures how much each voter would benefit from a tactical vote if he or she had an unbiased forecaster's beliefs.

To address the possibility that different groups of voters face different types of voting situations, we suggest using τ as a single, flexible, scalar control variable that arises from a theoretically coherent model of vote choice. This requires the additional assumption that utility measures are comparable in scale across voters, but others have made a similar assumption and the alternative of ignoring preference intensity is unappealing.

3 Tactical incentives in the British electorate

We apply our framework to data from the internet panels of the British Election Study (BES) for the 2005, 2010, and 2015 general elections.[21] In this section we describe how we estimate tactical incentives in the British case, including illustrative examples, and briefly characterize the distribution of tactical incentives in the data.

3.1 Voter preferences

As proxies for utility scores, we use voters' ratings of the parties competing in their constituency. Specifically, BES respondents are asked, "On a scale that runs from 0 to 10, where 0 means strongly dislike and 10 means strongly like, how do you feel about the [e.g. Labour] Party?" Respondents in the BES are not asked to rate candidates, though they are asked to rate party leaders; future work may investigate whether there is a combination of these ratings that would better capture voter preferences than the party ratings alone. The BES's post-election wave

[21]See Clarke et al. (2006), Sanders and Whiteley (2014), and Fieldhouse et al. (2017) for the 2005, 2010 and 2015 BES data, respectively.

asks voters to rate the major parties immediately after the election (with the large majority of ratings being given during the three days following the election); in 2005 and 2010 the BES post-election wave did not ask about smaller parties, so we obtain these ratings for all years from the pre-election wave of the panel, which takes place around six weeks before the election. To the extent that voters' views of the candidates diverge from their views of the parties, and to the extent that their views of the parties in the pre-election BES diverge from the views they held on election day, we will see measurement error in τ. Given our focus on comparing types of voters, such measurement error is problematic for the direction of our conclusions only to the extent that it differs across the types of voters we compare.

In cases where a voter gives two or more parties the same top rating on the 0-10 scale, we identify the voter's preferred candidate/party using questions in which the voter is asked whether they feel closer to any particular party. If the tie is between parties A and B but the voter indicates she feels closest to party C, we exclude the voter from analysis on the basis that her preferences are inconsistent. We also exclude voters who provide like-dislike scores for fewer than three parties and those who respond that they did not vote, do not know how they voted, or refuse to report how they voted. This leaves a sample of 24,986 respondents, with the number per survey being 4,783 (2005 BES) 11,562 (2010 BES), and 8,641 (2015 BES).[22]

3.2 Pivotal probabilities

As noted above, our model of counterfactual election outcomes is a Dirichlet distribution centered on the actual election outcome, with the variance parameter tuned to maximize the likelihood of forecasts of constituency vote shares.[23] This calibration led to a level of precision corresponding to $s = 85$. At this level of precision, the standard deviation of support for a

[22]The total number of respondents to the post-election waves of the 2005, 2010 and 2015 BES is 39,252, with the number per survey being 5,910 (2005), 13,356 (2010) and 19,986 (2015). Only 29,004 of these respondents were asked party like-dislike questions, because these questions were asked of only about half of 2015 BES respondents (randomly chosen). This explains why, although the total sample size of the 2015 BES was larger than that of the 2010 BES, the estimation sample for our purposes is smaller in 2015 than in 2010.

[23]For the 2010 and 2015 elections, we use final pre-election constituency vote share estimates published by `www.electionforecast.co.uk` (Hanretty, Lauderdale and Vivyan, 2016), which draw on contemporaneous polling data as well as historical information on differences in party support across constituencies. Because `www.electionforecast.co.uk` did not publish constituency forecasts for the 2005 election, we generate expected poll-implied constituency vote shares for this election based on a uniform national swing assumption: we use the final pre-election poll published by ICM to calculate the national swing for each party compared to 2001 and add these estimated changes to the 2001 constituency vote shares.

party with mean support of 0.3 is .05; the standard deviation of support for a party with mean support of .10 is .032. The results of our analysis are nearly indistinguishable if we instead center the distribution on the forecasted outcomes (as shown in Appendix C); this is because forecasts are rarely incorrect about which parties are competitive in a given constituency, even if they often fail to identify the eventual winner. The results are also similar (as shown in Appendix C) if we assume higher levels of aggregate uncertainty by setting s to 20 or 8, which roughly doubles and triples the variance of party vote shares in the model.

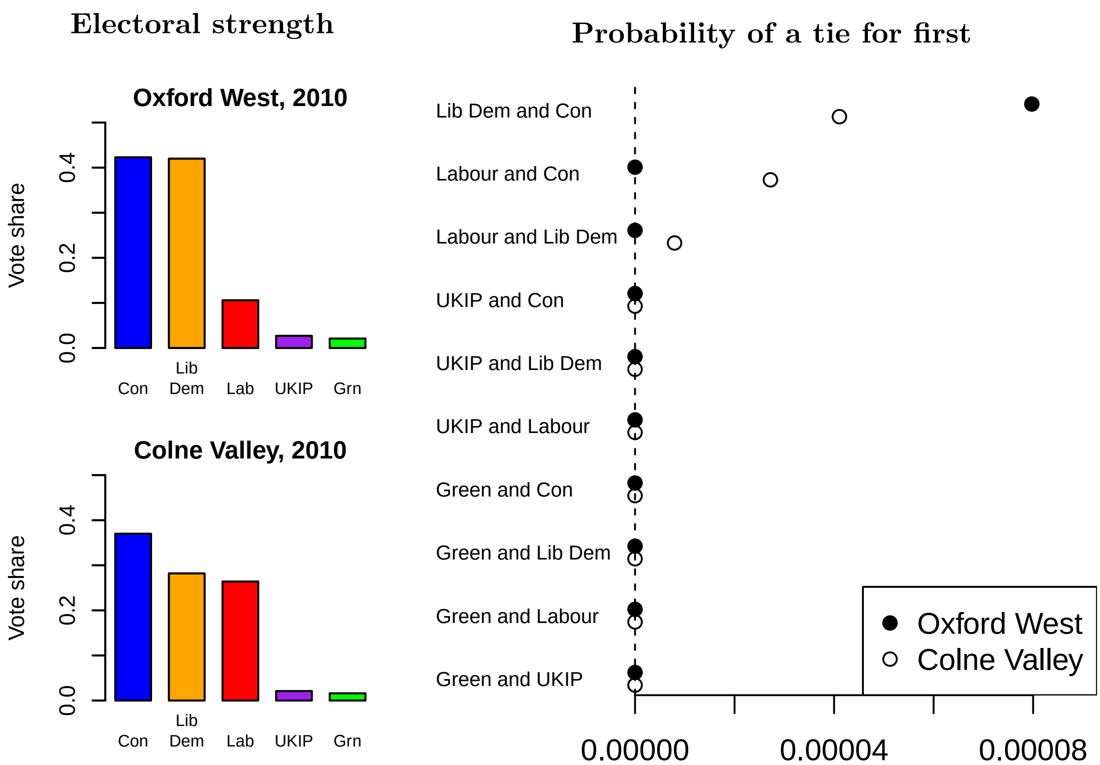
Figure 1 shows two election results (the Oxford West & Abingdon constituency and the Colne Valley constituency in 2010, left top and left bottom) along with the pivotal probabilities we calculate using these results. In Oxford, the Conservative candidate very narrowly defeated the Liberal Democrat, with Labour in a distant third and UKIP and the Greens further back. Our procedure estimates the probability of a tie for first between the two leading candidates as about 8 in 100,000, with all of the other pivotal probabilities indistinguishable from zero at this scale.[24] The order of finish in Colne Valley was the same, but the Conservative candidate won with a larger margin and Labour finished narrowly behind the Liberal Democrat. The probability of a tie for first between the Conservatives and the Liberal Democrat is about half as large in Colne Valley as in Oxford West, reflecting the larger margin; the probability of a tie for first involving the Labour candidate and the Conservative candidate is only slightly lower, followed by the Labour-Liberal Democrat pivotal probability, with all of the others effectively zero.

3.3 Tactical incentives: examples

In Figure 2 we provide examples to illustrate how the tactical incentive τ relates to voter preferences and the electoral context. Along the left side of the figure we depict eight sets of preferences, labeled (a)-(h), where in each diagram the height of the dot corresponds to the

[24]Readers may wonder whether voters would realistically distinguish a pivotal probability of 8/100,000 from zero when deciding how to vote. Our response is twofold. First, this paper examines whether voters behave as if they were maximizing expected consequentialist utility (which requires making such distinctions), but it takes no position on how they arrive at their decisions; we do not claim that any substantial proportion of voters think in terms of pivotal probabilities, for example. Second, some evidence suggests that voters' turnout decisions are indeed related to similarly small differences in their chances of being pivotal (e.g. Duffy and Tavits, 2008; Biggers et al., 2017), though see Enos and Fowler (2014).

Figure 1: Electoral strength and pivotal probabilities: two examples



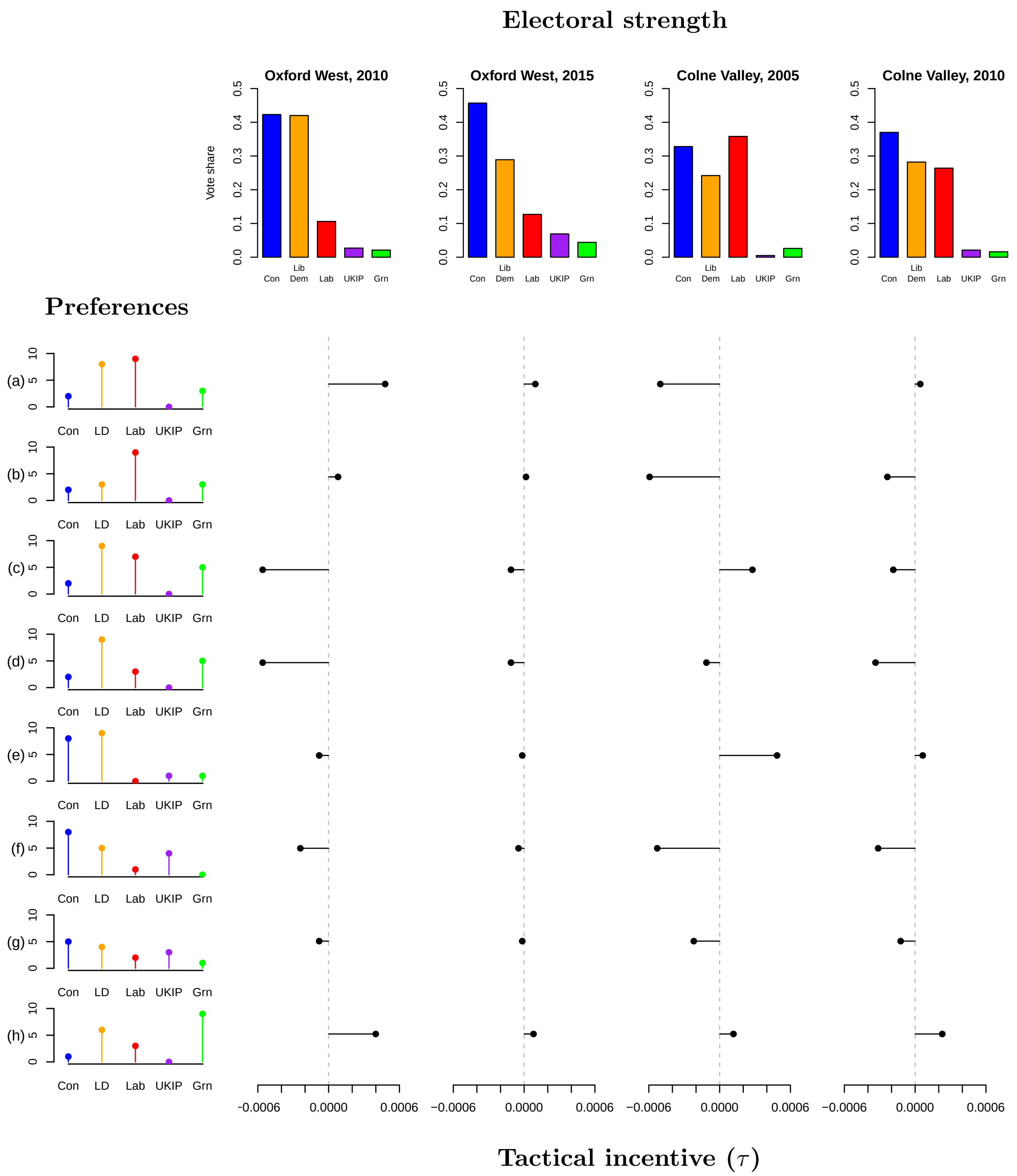
Note: We use a Dirichlet distribution to model counterfactual election outcomes based on observed results. The right panel shows the estimated probability of a tie for first between each pair of parties based on the 2010 election results (shown in the left panel) in Oxford West & Abingdon (solid circles) and Colne Valley (open circles).

rating the voter assigns to the party on the 0-10 like-dislike scale. Along the top of the figure we characterize the electoral strength of the five parties in four contests: the Oxford West & Abingdon constituency in 2010 and 2015, and the Colne Valley constituency in 2005 and 2010 (note that we plotted pivotal probabilities for the first and fourth of these contests in Figure 1 above). In the center of the figure we plot the tactical incentive τ for each combination of preferences and electoral contests, for a total of thirty-two examples.

We can summarize the lessons of Figure 1 as follows. When only two candidates could realistically tie for first, as in the Oxford elections shown here, tactical incentives are relatively simple: the sign depends on whether the voter's preferred candidate is a frontrunner, while the magnitude depends on both the strength of the voter's preference between the frontrunners and how close the election is between them. When three candidates are competitive, as in the Colne Valley elections, some things remain straightforward: a voter who prefers the leader will have a negative tactical incentive, while a voter who prefers a hopeless candidate (and has preferences among the frontrunners) will have a positive tactical incentive; in both cases the magnitude depends on preference intensity and the chance of a tie. But other subtleties arise: a voter whose most preferred candidate is running second or third may or may not benefit from a tactical vote, depending on the voter's preferences and the candidates' relative electoral strength. For example, consider the Colne Valley election in 2010, in which Labour finished third. A Labour supporter who rates the Liberal Democrats almost as highly as Labour (preference profile (a), first row) would benefit from a tactical vote for the Liberal Democrat, while a Labour supporter who rates the Liberal Democrats almost as low as the Conservatives (preference profile (b), second row) would do better with a sincere vote for Labour. A similar reversal takes place in the same election between preference profiles (d) and (e): a voter whose favorite candidate is running second is better off with a sincere vote when she strongly prefers her favorite to the frontrunner (preference profile (d), fourth row), but when she is nearly indifferent between the two frontrunners and strongly opposed to the third-place candidate, she is best off with a tactical vote (preference profile (e), fifth row).[25]

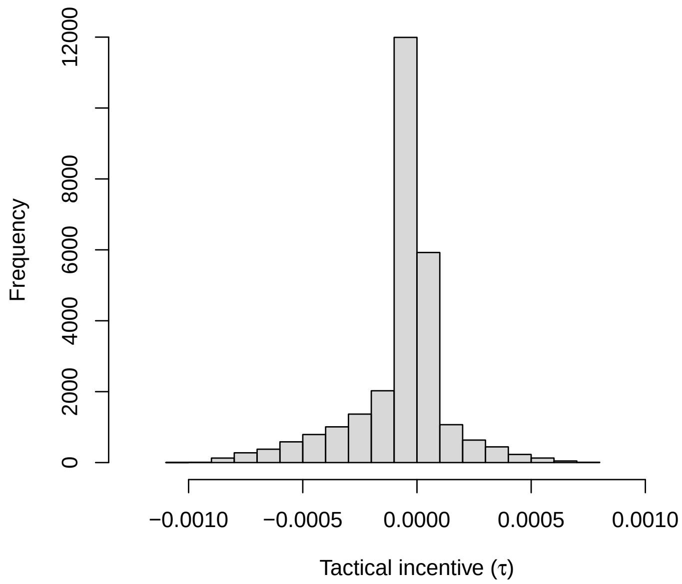
[25] The possibility of a tactical vote in this circumstance was shown by Kselman and Niou (2010).

Figure 2: Tactical incentives for different preferences in different elections



NOTE: Each column of dots shows the tactical incentive (τ) for a different hypothetical voter given electoral results indicated by the bar chart at the top of the column. The party preferences of these hypothetical voters are indicated by the diagrams along the left. For example, the third dot from the top in the left-most column shows that τ is roughly -0.0006 for a voter in Oxford West & Abingdon in 2010 who assigns ratings of 2, 9, 7, 0, and 5 to the Conservatives, Liberal Democrats, Labour, UKIP, and Greens.

Figure 3: Distribution of tactical incentives in the BES sample



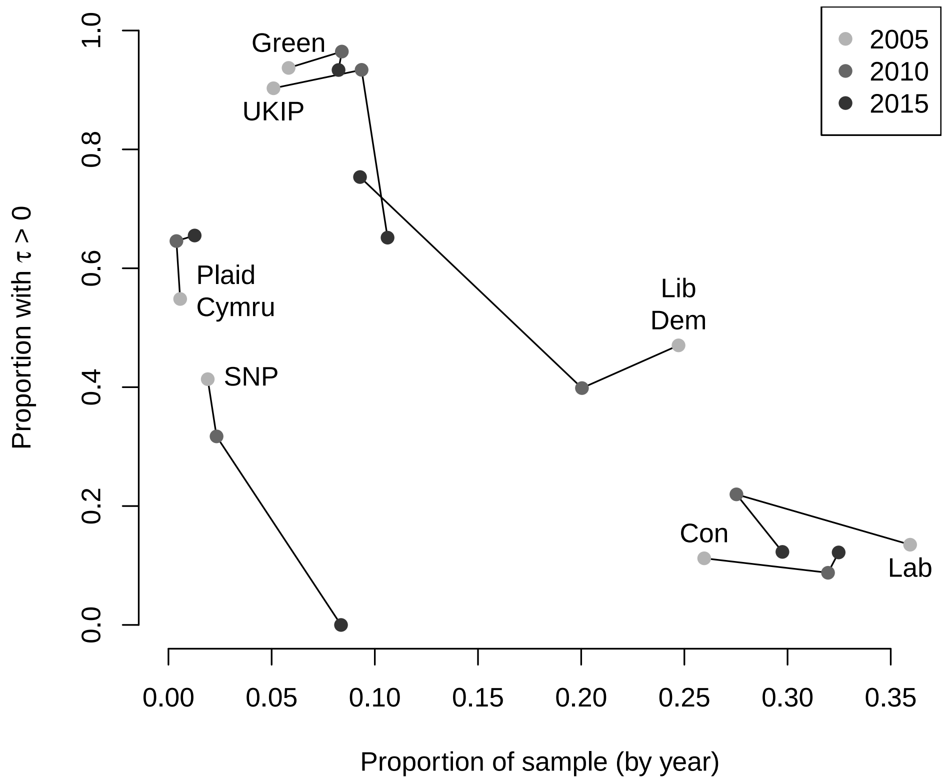
NOTE: The histogram shows the distribution of tactical incentives (τ) in our BES sample. About one-third of respondents have $\tau > 0$, indicating that a tactical vote would maximize their (short-term) consequentialist utility.

3.4 The distribution of tactical incentives in the British electorate

Figure 3 shows a histogram of tactical incentives in the BES sample. The distribution is clearly unimodal, with the mode being slightly below zero (indicating that a sincere vote is slightly more beneficial than a tactical vote). This makes sense if most voters' favorite party is a local frontrunner and most elections are not decided by narrow margins. Overall, a little under a third of all respondents have a positive tactical incentive.

Figure 4 shows how tactical incentives vary in the sample by year according to the respondent's preferred party. In the lower-right corner of the figure we find voters favoring Labour and the Conservatives, who make up the largest proportion of the sample (horizontal axis) and around 15% of whom on average would benefit from a tactical vote (vertical axis). Moving to the upper left corner of the figure, voters preferring UKIP or the Greens make up a smaller proportion of the sample and, with the exception of UKIP supporters in 2015, almost all of them would benefit from a tactical vote. (In 2015 the proportion of UKIP supporters with $\tau > 0$ dropped substantially, which might reflect both the higher success of UKIP in 2015 and UKIP preferrers' stronger preference for UKIP relative to other parties in that year.) Liberal

Figure 4: Tactical incentives by party preference and year



NOTE: Each dot shows the proportion of respondents in a given election year who most prefer a given party (horizontal axis) and the proportion of those respondents for whom $\tau > 0$, indicating that a tactical vote would maximize their (short-term) consequentialist utility.

Democrat preferrers became less common in each election and, as the party's electoral support collapsed in 2015, the proportion of Lib Dem preferrers with a positive tactical incentive jumped above 3/4. SNP preferrers experienced the opposite fate: in 2015 *every* SNP preferrer in our sample has a negative tactical incentive because the SNP finished first or second in each of the constituencies where SNP preferrers are found.

Table 1: Raw strategic responsiveness in 2005, 2010 and 2015 BES samples

	$\tau \leq 0$	$\tau > 0$
Number of observations	16981	8005
Number casting tactical vote	720	3120
Proportion casting tactical vote	0.04	0.39
Strategic responsiveness	$0.39 - 0.04 = 0.35$	

4 Measuring and comparing strategic behavior in the British electorate

4.1 Aggregate strategic responsiveness

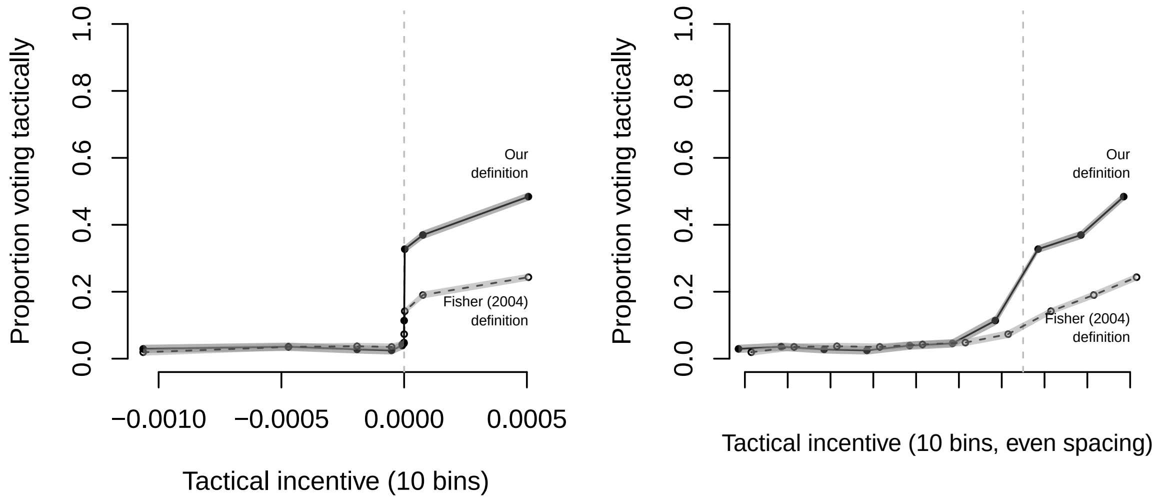
Table 1 describes the strategic voting behavior for the whole British electorate over the three elections we study. The probability of a tactical vote is very low when $\tau \leq 0$: of the nearly 17,000 BES respondents who faced $\tau \leq 0$, about 4% (720) cast a tactical vote.[26] In contrast, the probability of a tactical vote jumps substantially when τ turns positive: of the roughly 8,000 BES respondents who faced $\tau > 0$, about 39% (3,120) cast a tactical vote. Aggregate strategic responsiveness is thus .39 - .04 = .35.

Figure 5 shows the probability of a tactical vote as a function of the tactical incentive τ for the entire BES sample. We focus first on the left panel. The solid line shows the estimated relationship using our definition of a tactical vote, i.e. the best non-sincere vote in terms of the voter's expected consequentialist utility. To estimate this function, we first construct ten nearly equal-sized bins of τ: we start with bins that contain the deciles of τ and then move the smallest (in absolute value) bin boundary to zero, such that no bin has observations with positive and negative τ. The figure shows the estimated tactical voting rate in each of these bins with 95% confidence intervals shown in the shaded area.[27] In the left panel of Figure 5, the dots are located along the horizontal axis at the mean value of τ within the corresponding bin. Because the bins are so close together near $\tau = 0$, in the right panel we show the same function where the bin means are equally spaced along the horizontal axis. The figure again

[26] Voters with $\tau < 0$ may cast a tactical vote because they overestimate the benefit of a tactical vote or because they seek to send a message; for example, a Labour preferrer may choose to vote Green in a safe Labour constituency to push Labour to the left.

[27] More specifically, we estimate the tactical voting rate in each bin by regressing an indicator for whether the voter casts a tactical vote on the set of bin indicators (with no intercept). The dots show the point estimates from these regressions; the shaded area connects the 95% confidence intervals for those point estimates.

Figure 5: Tactical voting as a function of τ: aggregate



Note: Each diagram shows, as a function of τ, the proportion of respondents casting a "tactical vote" as we define it and as Fisher (2004) defines it. Roughly, we define a tactical vote as the non-sincere vote that maximizes the voter's expected utility, while Fisher (2004) defines a tactical vote as one that the voter says was tactical. The left and right diagrams show the same information on a different horizontal scale, as explained in the text.

makes clear that voters' strategic voting behavior responds to observed tactical incentives, but also shows that the relationship between tactical voting and τ is monotonic.[28]

To help link our analysis to previous literature, the dashed line in Figure 5 shows the same function when we use Fisher (2004)'s definition of a tactical vote, which is based on voters' own accounts of why they voted the way they did. (Essentially, a vote is tactical according to Fisher (2004) if the voter claimed that the vote was tactical and did not report preferences that contradict that claim.) Figure 5 shows that the proportion of voters casting tactical vote by this definition is also low and flat where $\tau < 0$ and monotonically increases as the tactical incentive becomes stronger, though the measured level of tactical voting is substantially lower.[29] This indicates that tactical incentives as measured by τ affect not only the votes voters cast but also

[28] The monotonic relationship between tactical voting and τ is also evident when we substantially increase the number of bins.

[29] Cases we code as tactical votes are sometimes not coded as tactical according to Fisher's definition because the voter offers no explanation for the vote (as happens in 5% to 12% of cases, depending on the year), an ambiguous explanation (e.g. "I dread a Tory government" or "I disliked the alternative more"), or an explanation like "I thought it was the best party". For cases in the last category, it is unclear whether the voter's like-dislike scores do not reflect their true preferences (in which case we err in calling it a tactical vote), the voter's explanation does not reflect their true thought processes (in which case Fisher errs in *not* calling it a tactical vote), or the voter somehow casts a utility-maximizing non-sincere vote without consciously reasoning strategically, e.g. because of persuasion and rationalization (in which case we and Fisher may both be correct). Again, measurement error leads to conclusions of the wrong sign only if it varies across the groups of voters being compared.

the way they explain their votes. Because we focus on differences in strategic voting rather than differences in strategic reasoning (as explained above), our main analysis employs our definition of a tactical vote rather than Fisher's, but in Appendix C we present the core analysis using Fisher's definition; we also show the core analysis where a tactical vote is defined simply as a vote for a party other than one's favorite. All differences in strategic responsiveness go in the same direction regardless of the definition of tactical voting, though differences are smaller with Fisher's definition and in the case of income and left-right orientation only marginally significant.

4.2 Strategic responsiveness and social characteristics

Next, we present analysis of whether voters with different social characteristics differ in their strategic responsiveness. We focus on heterogeneity according to five basic observable characteristics: education, age, income, gender and ideological leaning.

We choose these variables primarily because each is plausibly associated with – or in the case of ideological leaning, actively describes – preferences over political outcomes. The link between income and preferences over economic policies is well established (e.g. McCarty, Poole and Rosenthal, 2006; Gelman, 2008), but education and age are related to key emerging cleavages in recent US and UK elections and referenda, with more educated and younger voters tending to hold more socially liberal, cosmopolitan views (Ford and Goodwin, 2014; Inglehart and Norris, 2017). Regarding gender, past research also shows that men and women differ in their average preferences over gender roles and gender equality policies (Campbell, Childs and Lovenduski, 2009). Thus, if any of these variables are associated with strategic responsiveness, this would be a cause for concern on normative grounds, for it would suggest that groups who differ in their political preferences also differ in their ability to secure preferred electoral outcomes.

Of the five characteristics that we focus upon, age and education have received attention in existing studies of heterogeneity in strategic behavior across voters. Regarding age, both Evans (1994) and Fisher (2001) find no evidence that this is associated with tactical voting rates. Regarding education, Evans (1994) finds no evidence that this is associated with tactical voting rates, but Fisher (2001) shows that, when one subsets to those voters who might benefit from voting tactically, there is some evidence that tactical voting increases with education. Black (1978) and Merolla and Stephenson (2007) also find that measures of strategic incentives better explain voting behaviour among more educated voters. However, none of these studies compare age and education groups in terms of their levels of strategic responsiveness, and none utilise the tactical incentive measure we propose here to more fully control for the strategic context faced by voters with different characteristics.

Table 2 shows how raw strategic responsiveness (SR) varies by social characteristic, again pooling the 2005, 2010 and 2015 BES samples. Rows 1-3 of the table show how, when we divide the sample into three groups according to educational attainment,[30] raw strategic responsiveness does not vary greatly or consistently across these groups (SR = 0.34, SR = 0.33, SR = 0.36, respectively). Rows 4-6 of the table divide the sample by age and suggest quite substantial differences in strategic responsiveness, with voters aged below 30 notably less responsive (SR = .27) than voters aged between 30 and 59 (SR = 0.35) and 60 or above (SR = .37). Rows 7-9 divide the sample by income tercile and also reveal notable differences in strategic responsiveness, with high-income voters (those in the top income tercile in the sample) more responsive than their low- and medium-income counterparts (.39 vs. .33). Rows 10-11 suggest only small differences in strategic responsiveness comparing male and female respondents (.34 vs. .36). Finally, rows 12-13 offer some evidence that left-leaning voters – defined here as those who assign a higher like/dislike score to the Labour Party than to the Conservative Party – have higher strategic responsiveness than right-leaning voters (.37 vs. .33).

As noted above, a difference in strategic responsiveness between two groups of voters could arise because the two groups approach similar voting decisions differently or because the two groups face different types of voting decisions. We therefore compare strategic responsiveness across voter groups in a regression that allows us to control for τ. Our basic regression equation for comparing the strategic responsiveness of two groups of voters is

$$E[Y_i] = \beta_1 W_i + \beta_2 I\{\tau_i > 0\} + \beta_3 W_i \times I\{\tau_i > 0\} + g(\tau_i), \tag{2}$$

[30] The middle group ("Level 3 education") includes those who achieved A-level qualifications or equivalent; these qualifications would typically be completed at age 18. The lower group ("Level 2 or lower") has no qualifications or a qualification below this level (e.g. GCSE, typically completed at age 16), while the higher group ("Level 4+") received at least a university degree or equivalent.

Table 2: Raw strategic responsiveness by social characteristics

	Pr(tactical vote)		Raw
	$\tau \leq 0$	$\tau > 0$	SR
Level 2 education or lower	0.04	0.38	0.34
Level 3 education	0.04	0.37	0.33
Level 4+ (uni. degree) education	0.04	0.41	0.36
Age below 30	0.05	0.32	0.27
Age 30 to 59	0.04	0.39	0.35
Age 60 plus	0.04	0.41	0.37
Low income	0.04	0.37	0.33
Med income	0.04	0.37	0.33
High income	0.04	0.44	0.39
Male	0.04	0.38	0.34
Female	0.04	0.40	0.36
Con. preferrer	0.03	0.37	0.33
Lab. preferrer	0.04	0.41	0.37

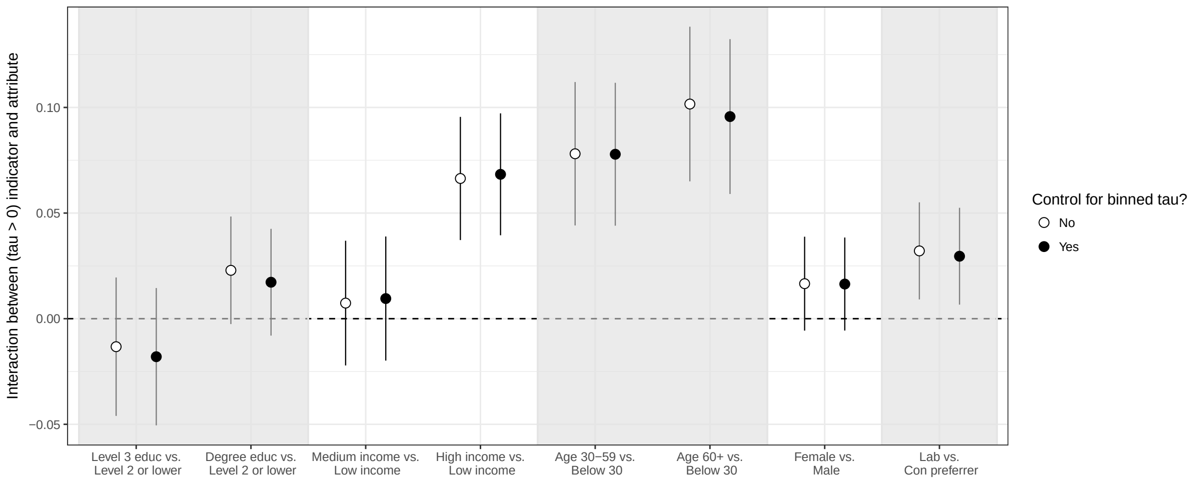
where Y_i indicates whether voter i cast a tactical vote, W_i indicates voter i's group (e.g. male vs. female), τ_i is the voter's tactical incentive, and $g(\tau_i)$ is a flexible function of τ_i. If we leave out $g(\tau_i)$, then β_3 measures the raw difference in SR between the group where $W_i = 1$ and the group where $W_i = 0$. Including $g(\tau_i)$, β_3 measures the difference in SR controlling for τ. In cases where we divide the electorate into three groups (e.g. low, middle, and high income), the regression includes two interactions, one comparing the middle group to the lowest group and the other comparing the highest group to the lowest group.

To flexibly control for τ, we include dummy variables for the ten nearly equal-sized bins of τ we used for Figure 5 above, thus allowing the baseline propensity to vote tactically to vary across bins of τ.[31] We also include an indicator for each election year and, in models which include controls for bins of τ, we interact these with the election year indicators to allow baseline responsiveness to τ to vary across years.

Figure 6 shows our estimates of and 95% confidence intervals for β_3 from regressions like expression 2 above, both with and without controls for τ (solid and open circles, respectively). The plot shows that the differences in strategic responsiveness between the youngest voters and those in older age groups are statistically significant, as are the differences between high and low income voters and between between Labour and Conservative preferrers. It also indicates

[31] Because of the way the bins of τ are designed, the $\beta_2 I\{\tau_i > 0\}$ term drops out of the regression where such bins are included.

Figure 6: Heterogeneity in responsiveness to tactical incentive by social characteristics



NOTE: Each dot shows the estimated difference in strategic responsiveness between two groups of voters (β_3 in equation 2), with 95% confidence intervals shown by vertical lines. The closed (open) circles come from regressions with (without) controls for bins of τ.

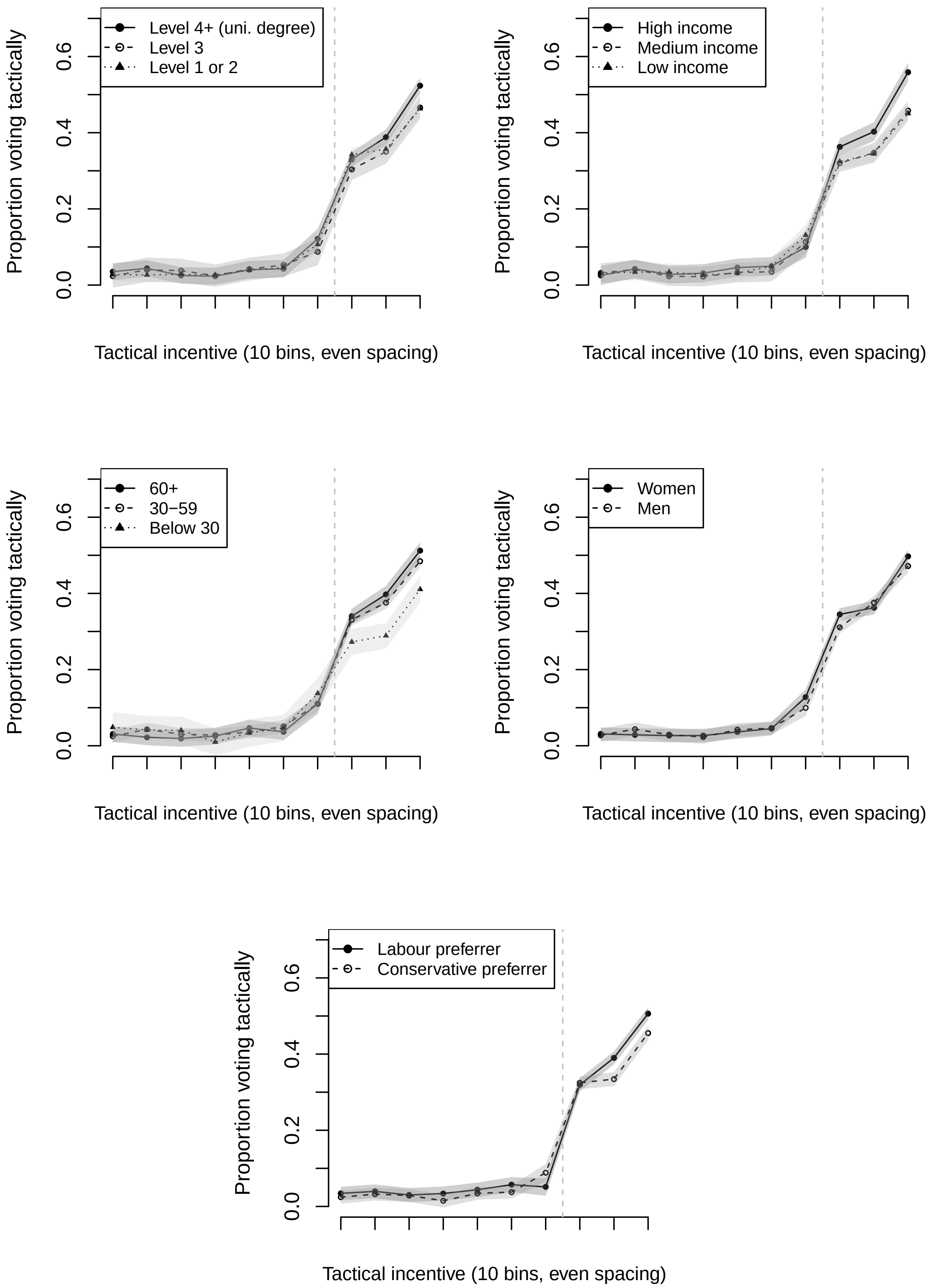
that there are no statistically significant differences in strategic responsiveness by education and gender. It turns out that our estimates do not change much when we include controls, which suggests that these groups of voters do not face significantly different distributions of τ (conditional on the sign of τ). Still, the results controlling for τ increase our confidence that the differences in SR reflect differences in decision-making rather than differences in decision contexts.

Figure 7 provides another view of the heterogeneity we detect in strategic behavior. Here we depict the tactical voting rate as a function of τ separately by social characteristic. In the cases where our regression analysis shows a significant difference in SR (age, income, and Labour-Conservative preference), the curvature of the function varies noticeably across groups.

How stable are these results when we break down our data by election year? Figure 8 shows the estimated interactions between group membership and $I(\tau > 0)$ when we estimate equation 2 separately by election year (2005, 2010, and 2015) and in all years pooled together, each time controlling for bins of τ.[32] Each point estimate in this figure comes from a separate regression. The pooled estimates (filled black dots) correspond to the estimates in Figure 6 that

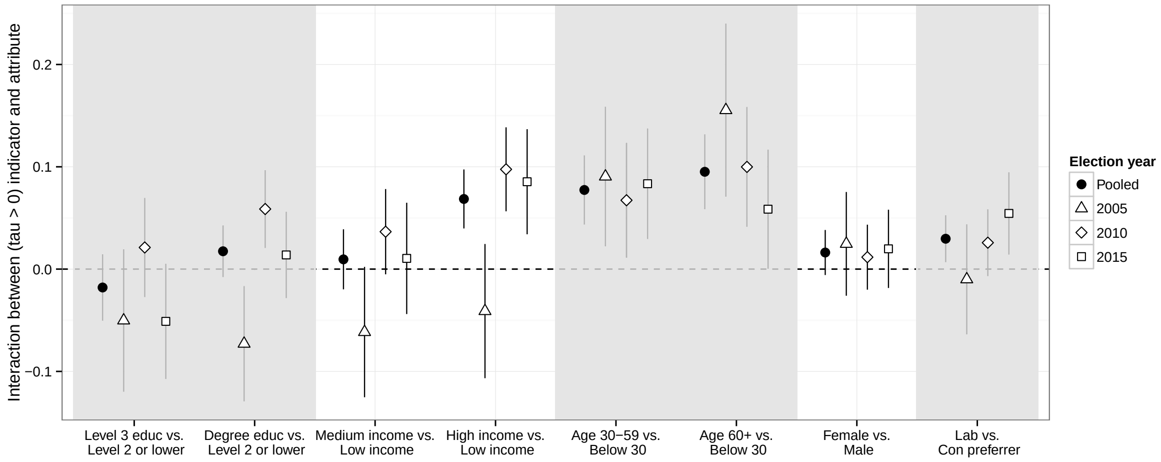
[32] Note that the election-year indicators and their interactions with bins of τ, both of which are both present in the pooled model, drop out in the election year-specific models.

Figure 7: Strategic response functions by social characteristic



NOTE: Each diagram shows, as a function of τ and with subsetting by social characteristic, the proportion of respondents casting a tactical vote.

Figure 8: Heterogeneity in responsiveness to tactical incentive across election years



NOTE: Each point shows the estimated difference in strategic responsiveness between two groups of voters (β_3 in equation 2), with 95% confidence intervals shown by vertical lines. The solid circles show estimates for all years together; others show estimates for a single election year.

control for bins of τ. For age group, gender and ideological leaning, the point estimates of the interaction coefficients appear to be reasonably stable across election years. The interactions involving education and income levels vary more across years. Regarding education, whereas in 2005 voters with a degree-level education are found to be significantly less responsive to tactical incentives than voters in the lowest education group, in 2010 those with a degree level education are found to be significantly more responsive. Regarding income, whereas there is no significant difference in the strategic responsiveness of high and low income voters in 2005, high income voters are found to be significantly and substantially more responsive in both 2010 and 2015.

In sum, our analysis suggests that voters with different characteristics do respond differently to the incentive to cast a tactical vote. In particular, in most election years analyzed, older, higher income, and left-leaning voters appear to be more strategic than their younger, lower income, and right-leaning counterparts. How can we assess the magnitudes of the differences in strategic responsiveness across social groups that we identify here? Define the rate of *effective* voting as the proportion of votes cast as a purely strategic voter would, i.e. sincerely when $\tau \leq 0$ and tactically when $\tau > 0$. If we assume that the proportion of voters in each social group for whom $\tau > 0$ is approximately 1/3 (the proportion in the entire sample above), and that the rate of effective voting when $\tau \leq 0$ is similar across groups, then the difference in effective voting rates between two groups will be equivalent to 1/3 times the difference in strategic responsiveness between the groups. For example, our results would suggest that the rate of effective voting among voters aged 60 or older is around $1/3 \times 10 \approx 3.3$ percentage points higher than that among voters younger than 30. Put differently, young voters are 3 percentage points more likely to "waste" their votes compared to their older counterparts. Applying the same logic implies that the rate of effective voting among voters in the highest income category is around $1/3 \times 7 \approx 2.3$ percentage points higher than that among voters in the middle or lower income categories, and the rate of effective voting among left-leaning voters is around $1/3 \times 3 \approx 1$ percentage points higher than that among right-leaning voters. These are not huge differences, but may be consequential in close elections when preferences over candidates are strongly correlated with membership of the above groups.

4.3 Testing explanations for heterogeneity in strategic responsiveness

What explains the differences in strategic responsiveness that we have observed across voters with different characteristics? In Appendix B we extend the basic regression specification reported above to examine a number of different plausible explanations. Each of the explanations we consider involves a third omitted variable Z_i that is associated with responsiveness to measured tactical incentives and may vary with the social characteristic of interest conditional on τ. Therefore, our strategy for testing each explanation is to re-estimate the key interaction term β_3 in a regression based on Equation 2 that additionally includes Z_i and the interaction between Z_i and $I(\tau_i > 0)$. The full details of the analysis (including of the empirical measures we use) are reported in Appendix B, but the key findings can be summarized as follows.

First, we find little evidence that observed differences in strategic responsiveness by any of the five social characteristics we study (education, age, income, gender, or left-right leaning) is explained by one of the other four factors; for example, older voters are still more responsive to tactical incentives than younger voters when we allow strategic responsiveness to vary by education, income, gender, or left-right leaning.[33]

[33] Interestingly, however, we do find that, when we control for age and its interaction with $\tau > 0$, the estimated difference in strategic responsiveness between voters with the highest and lowest levels of education becomes

Second, we find that allowing strategic responsiveness to vary depending on which party a voter supports does not alter estimated differences in strategic responsiveness by age, income, education or gender, but it does substantially attenuate the estimated heterogeneity in strategic responsiveness by left-right leaning. This suggests that observed differences in strategic responsiveness by ideological leaning may be best understood as the consequence of systematic differences in strategic responsiveness across supporters of different parties. It could be that some parties are better at convincing their supporters to vote tactically when appropriate, or it could be that voters with different levels of expressiveness or political sophistication are drawn to different parties.

Third, we examine whether inequalities in strategic voting may be driven by differences in intensity of party identification across social groups. Strength of party identification has been found to reduce voters' propensity to vote tactically (Niemi, Whitten and Franklin, 1992; Evans, 1994; Fisher, 2001), and if party identification reflects an emotive attachment to a political party that is not fully reflected in like-dislike scores, voters with stronger party identifications may be less willing to vote tactically for a given value of τ. We do find that voters who have more intense party identification are less responsive to strategic incentives. However, controlling for this variation in strategic responsiveness by intensity of party identification does not notably alter the estimated differences in strategic responsiveness by our social characteristics of interest.

Fourth, we examine whether our main findings can be explained by systematic differences in the expressiveness of different social groups. We find that estimated differences in strategic responsiveness by age are substantially attenuated when we control for the degree to which voters agree with the statement "People who vote for small parties are throwing away their vote" and disagree with the statement "People should vote for the party they like the most, even if it's not likely to win". This suggests that older voters may be more responsive to tactical incentives than younger voters because they are consciously more instrumental in their vote decisions, and not because they are better informed or more intelligent. In the terminology of the model introduced in Section 2.1, younger voters may have a larger b parameter than older voters, whether because they enjoy expressing themselves or because they care more about the

positive and significant (though still relatively small).

effect of their vote on future elections.

Fifth, we find little evidence that our main findings can be explained by systematic differences in the extent to which different social groups perceive the strategic context accurately. We examine several proxies for accuracy of perceptions of τ, including whether respondents correctly anticipate election outcomes, general political knowledge scores and measures of campaign intensity in the respondent's constituency. We also examine voters' sense of how likely they are to affect the outcome, on the basis that voters with higher perceived efficacy will perceive larger (in magnitude) tactical incentives than other voters. However, allowing strategic responsiveness to vary with any of these variables does little to affect the differences in strategic responsiveness that we find.

5 Discussion and conclusion

In their article "In Praise of Manipulation", Dowding and Van Hees (2008) argue that strategic voting is not as normatively problematic as many democratic theorists think. They recognize that it may be worrying if some voters have the "information and understanding" necessary to vote strategically while others do not (p. 4), but they downplay that concern by arguing that democracy benefits when voters seek the information and understanding that would make them better strategic voters (p. 10).

Whereas Dowding and Van Hees discuss inequalities in strategic voting as a hypothetical problem, their sanguine view may be more difficult to sustain once we take into account the findings of this paper, which shed new light on the empirical extent of such inequalities. In particular, we find that richer and older voters (who already participate in elections at a higher rate in the UK and elsewhere) appear to be further advantaged when it comes to strategic voting. While we agree with Dowding and Van Hees's view that it is good for democracy if "the inherent possibilities of strategic voting encourage voters to learn more about their democracy and the views of their fellows" (p. 10), this benefit must be weighed against the possibility that voters with systematically fewer resources to invest in studying polling data are underrepresented as a result. In the case of age, inequalities in strategic behavior may also have more to do with voters' time horizons than with their "information and understanding", which further complicates Dowding and Van Hees's case: if younger voters are more likely than older voters to "waste" their vote on the Greens or UKIP because they care more about who is in power several elections in the future, then inequalities in strategic voting will not disappear even if younger voters seek out better information and understanding (whatever other benefits this search may have for democracy). In this scenario, the only way to make younger voters more effective at determining the outcome of current elections is to make them less effective at determining the outcome of future elections. In light of these observations, we conclude that the case for "praising" or even tolerating inequalities in strategic voting becomes weaker, and the argument for adopting electoral systems that are less likely to reward strategic voting becomes stronger.

We see two main tasks for future research on inequalities in strategic voting. First, researchers can apply and improve our framework to measure inequalities in other settings. Our results should be compared with results from other elections in the UK, plurality elections elsewhere, and elections carried out under different electoral rules. Second, additional research could help us understand why differences in strategic voting arise. We took a first step by checking whether observed differences in strategic responsiveness disappear when we control for specific factors that might differ across groups, such as levels of information or general attitudes toward vote choice. Future studies might go further not just by extending our approach (ideally with better measures of these alternative factors) but also by experimentally varying the information available to voters, priming different aspects of vote choice, or collecting new data on how voters choose a candidate in contexts where strategic thinking is necessary.

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Appendix A: Details on estimating tactical incentives

The tactical incentive τ is defined as the difference in the voter's expected utility given a tactical vote (i.e. the utility-maximizing non-sincere vote) vs. a sincere vote:

$$\tau \equiv \max_j \mathbf{p}(j) \cdot \mathbf{u} - \mathbf{p}(1) \cdot \mathbf{u}. \tag{A.1}$$

A voter's expected utility depends on her vote because there is a probability (however small) that a single vote could determine the winner. Denote by π_{jk} the probability that j and k are tied for first among other voters, such that our representative voter can determine the winner. If ties are determined by a coin flip, then the voter can affect the outcome either in the event of a tie for first (in which case she can change a coin flip into a certain win for one candidate) or in the event of one candidate trailing the leader by one vote (in which case she can change a certain win into a coin flip). Assuming these events are equally likely, the probability of one's vote changing the winner from one candidate to another is the probability of a tie between those candidates.[34] Now, denote by $\mathbf{p}(\varnothing) = \{p_1(\varnothing), p_2(\varnothing), \dots, p_K(\varnothing)\}$ the set of election probabilities if the voter abstains. Then, assuming that ties among three or more candidates do not take place (as do Fisher and Myatt (2017) and others), $p_k(j) = p_k(\varnothing) - \pi_{jk}$ and $p_j(j) = p_j(\varnothing) + \sum_{k \neq j} \pi_{jk}$. It follows that $\mathbf{p}(j) \cdot \mathbf{u} = \mathbf{p}(\varnothing) \cdot \mathbf{u} + \sum_{k \neq j} \pi_{jk}(u_j - u_k)$. Substituting into expression A.1, we have

$$\tau = \max_{j>1} \sum_{k \neq j} \pi_{jk}(u_j - u_k) - \sum_{k \neq 1} \pi_{1k}(u_1 - u_k).$$

Thus we can estimate τ in terms of pivotal probabilities (e.g. π_{jk}) rather than election probabilities (e.g. $\mathbf{p}(j)$).

To estimate the pivotal probabilities, we begin with a model of counterfactual election outcomes.[35] We model counterfactual candidate vote shares using a Dirichlet distribution (c.f. Fisher and Myatt, 2017), which assigns a positive probability mass to every point on a simplex. The distribution of vote shares for K parties can be characterized by a Dirichlet distribution with parameter vector $s\mathbf{v} \equiv \{sv_1, sv_2, \dots, sv_K\}$, where $\mathbf{v}$ is the expected value of the distribution and s is a measure of precision. As noted in the main text of the article, we set $\mathbf{v}$ equal to the observed vote shares in the election. To ensure that our model has a level of uncertainty similar to that of an informed expert, we set s such that the standard deviation around the mean is similar to the gap between forecasts and actual results in the elections we study. More specifically, we solve the problem

$$\arg\max_s \prod_t \prod_i \mathrm{Dir}(\mathbf{x}_{it}; s\mathbf{v}_{it}) \tag{A.2}$$

where s is the level of precision, $\mathbf{x}_{it}$ and $\mathbf{v}_{it}$ are the vector of forecasted vote shares and actual vote shares (respectively) in constituency i at time t, and $\mathrm{Dir}(\mathbf{y}; \alpha)$ gives the density of the Dirichlet distribution with parameter vector α evaluated at $\mathbf{y}$.

The next step is to derive pivotal probabilities from this model. Fisher and Myatt (2017) show that with a Dirichlet model of election outcomes for three candidates one can calculate pivotal probabilities analytically. Here we develop a more flexible approach that can be applied

[34] Let p be the probability of A trailing B by one vote, such that B wins with certainty, and q the probability of A and B being tied, such that A wins with probability 1/2. The probability of being able to affect the outcome by voting for A is $p + q$; in each case, the probability of A being elected changes by 1/2. Thus the probability of being able to change the winner from B to A is $\frac{p+q}{2} = q$ under the assumption that $p = q$.

[35] In a similar exercise, Gelman, King and Boscardin (1998) and Gelman, Silver and Edlin (2012) use a model of U.S. presidential election outcomes to estimate the probability of casting a decisive vote in each state.

to an arbitrary number of candidates as well as alternative electoral rules.

The brute-force way to approximate the pivotal probability for a pair of candidates is to draw a large number of simulated elections from the model, calculate the proportion of simulations in which the two candidates finish in the lead with vote shares within x of each other, and divide that proportion by xn, where n is the number of voters. To see this, consider a specific outcome in which candidates 1 and 2 finish in the lead with vote shares within x of each other. One can construct a total of $xn - 1$ other distinct outcomes in which candidates 1 and 2 finish in the lead with vote shares within x of each other and candidates 3 to K receive the same vote shares as in the original outcome. If the number of votes for the leaders is even, one of the xn total outcomes is a tie for first between candidates 1 and 2; otherwise, two of the outcomes involve a margin of just one vote. This is true for *any* specific outcome in which candidates 1 and 2 are in the lead and within x of each other. Assuming that these xn outcomes are approximately equally likely, the probability of an outcome in which a single vote could determine whether candidate 1 or 2 wins is approximately p_x/xn, where p_x is the probability of candidates 1 and 2 being in the lead and within x of each other.

We introduce a numerical alternative that generally reproduces the pivotal probabilities estimated by the brute-force simulation approach but much more quickly, particularly when the pivotal probabilities are very low. Given K parties, the pivotal probability for parties 1 and 2 is approximately

$$\frac{1}{n}\int_{1/K}^{1/2} \Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y)dy, \tag{A.3}$$

where $x_1, x_2, \ldots x_K$ are realized vote shares for parties $1, 2, \ldots K$. To see this, note first that we want to calculate the probability of a vector of vote shares where 1 and 2 are essentially tied and a single vote could change the outcome. The change in a candidate's vote share accomplished by adding a single vote is approximately $1/n$ (the leading term in expression A.3).[36] $\Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y)$ describes the probability of candidates 1 and 2 tying for first with a vote share of y; we integrate for y between $1/K$ and $1/2$, which are the lowest and highest possible vote shares of two candidates tied for first. To make progress in computing expression A.3, we transform the joint probability into a conditional probability and make an independence assumption:

$$\begin{aligned}\Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y) &= \Pr(x_1 = x_2 = y)\Pr(x_3 < y, \ldots, x_K < y | x_1 = x_2 = y) \\ &\approx \Pr(x_1 = x_2 = y)\prod_{i=3}^{K}\Pr(x_i < y | x_1 = x_2 = y) \end{aligned} \tag{A.4}$$

The independence assumption we make is that the joint probability of all parties from 3 to K being below y is given by the product of the conditional probabilities for each party taken separately. This is clearly not true, but it saves us from having to calculate an integral over multiple dimensions; we show later with simulation that its implications appear to be fairly innocuous. Next we apply the "aggregate property" of Dirichlet distributions to compute this object for a specific model of election outcomes. If we have K vote shares distributed according to $\text{Dir}(\alpha_1, \alpha_2, \ldots, \alpha_K)$, the aggregate property says that the first two vote shares and the sum of the remaining vote shares are distributed according to $\text{Dir}(\alpha_1, \alpha_2, \sum_{i=3}^{K}\alpha_i)$. Thus we have

$$\Pr(x_1 = x_2 = y) = \text{Dir}\big(y, y, 1 - 2y; sv_1, sv_2, s(1 - v_1 - v_2)\big). \tag{A.5}$$

Again using the aggregate property it can be shown that if we have K vote shares distributed

[36] The Dirichlet model describes vote shares as continuous variables; multiplying by $1/n$ reconnects the model to the discrete character of elections.

according to Dir($s\mathbf{v}$), then

$$\Pr(x_3 = z | x_1 = x_2 = y) = \text{Beta}\big(\frac{z}{1-2y}; \alpha_3, \sum_{i=4}^{K} \alpha_i\big). \tag{A.6}$$

Recall that the Beta distribution is just a special case of the Dirichlet distribution when $K = 2$. To calculate the probability that the vote share of party 3 is at z (given that parties 1 and 2 are both at y), we consider parties 3 to K to be dividing up the remaining $1 - 2y$ of vote share (such that we are evaluating the probability of party 3 at $z/(1-2y)$), and we use the aggregate property to lump together parties 4 through K.

Putting all of this together, we have that $\Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y)$ is approximately

$$\text{Dir}\big(y, y, 1-2y; sv_1, sv_2, s(1-v_1-v_2)\big) \prod_{i=3}^{K} \int_0^y \text{Beta}\big(\frac{z}{1-2y}; sv_i, s\sum_{j=3}^{K} v_j - sv_i\big) dz \tag{A.7}$$

To calculate the pivotal probability for candidates 1 and 2, we substitute this expression into expression A.3 and numerically integrate across values of y between $1/K$ and $1/2$.

To demonstrate the validity of the method, we generate pivotal probabilities for election results from UK constituencies in the 2005, 2010, and 2015 general elections at three levels of s using both our analytical/numerical approximation and a brute-force simulation method. For the simulation approach, we obtain 1 million draws for each election and we judge a near-tie for first to be a case where two parties have a vote share within one percentage point of each other and all other parties are lower; with this number of simulations (and non-optimized code), calculating pivotal probabilities for a single value of s and a single election for 632 constituencies requires several hours. Our approach involves some calculation and numerical integration but is many hundreds of times faster. To validate our approach, we seek to establish that we can recover the pivotal probabilities given by the simulation for cases where the simulation should work well (i.e., cases where the true pivotal probabilities are not too small) and that our approach beats the simulation in other cases.

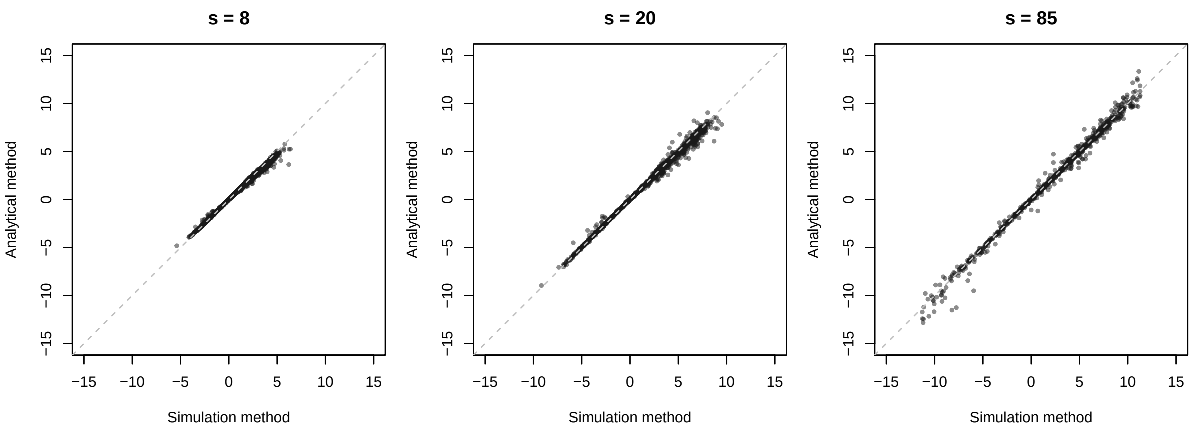
As a first validation, we compute the following for every election race using both the simulation approach and our approach:

$$\ln \frac{\pi_{Lab-Con}}{\pi_{LD-Con}} \tag{A.8}$$

where π_{A-B} is the probability of a tie for first between party A and party B. Figure A.1 compares this statistic as calculated by the simulation approach (horizontal axis) and our approach (vertical axis) for every constituency in the 2005, 2010, and 2015 general elections assuming $s = 8$ (left panel), $s = 20$ (center panel), and $s = 85$ (right panel). The results are clearly very similar in general.

Our method clearly outperforms a brute-force simulation approach in many cases not shown in Figure A.1: namely, those cases where the simulation method yielded a pivotal probability of zero (and thus the log ratio of pivotal probabilities is infinite or undefined). In these cases our approach is clearly preferred because it yields a positive pivotal probability even for very unlikely events. To give a sense of the scale of the issue, consider the case where $s = 85$. Across the elections of 2005, 2010, and 2015, there are slightly more than 16,000 party pairings for which we can calculate a pivotal probability; in the modal race there are five parties competing, meaning 10 unique pairings for which we can calculate a pivotal probability. With our approach we obtain a positive pivotal probability for all of these pairs. With the simulation approach and $s = 85$ we obtain a positive pivotal probability for only around 4,500, or 28%; the remaining

Figure A.1: Our analytical/numerical approach recovers pivotal probabilities produced by a simulation



NOTE: We compute pivotal probabilities for every pair of parties in each election in 2005, 2010, and 2015 using both a brute-force simulation approach and our analytical/numerical approach. In each panel, each dot shows the log of the ratio of the Lab-Con pivotal probability to the LibDem-Con pivotal probability for a single constituency contest using the simulation approach (horizontal axis) and our approach (vertical axis).

72% are zero. In many cases it may not matter whether the pivotal probability is zero (as with the simulation approach) or a very small positive number (as with our approach), but it does matter when all of the pivotal probabilities in a given case are quite small (as when one party has a comfortable lead). In such cases relative pivotal probabilities produced by the simulation approach may depend heavily on random variation, because for a finite number of simulations the estimated probability could be zero or a very small number, which might have very different implications for analysis; also, the simulation method could yield zeros for all pivotal probabilities in a given setting, in which case it is difficult to know how to proceed. Researchers may choose to ignore cases with very low absolute pivotal probabilities (we do not), but they should not do so simply because the simulation method gives coarse estimates of very rare events.

Appendix B: Testing explanations for heterogeneity in strategic responsiveness

What explains the heterogeneity in strategic responsiveness by social characteristics that is documented in the main text? Here we extend the basic regression specification reported above to provide some initial evidence concerning a number of different possible explanations. Each explanation we will consider involves a third *omitted variable* z_i, which is itself associated with responsiveness to measured tactical incentives and is also correlated with the social characteristic of interest (or, alternatively, is differentially correlated with levels of τ for voters with and without the social characteristic of interest).

Our strategy for testing each explanation is to assess whether the interactions reported in Figure 6 of the main text – specifically, those estimated controlling for bins of τ – are attenuated when we re-estimate each regression model and add a control for Z_i and for the interaction between Z_i and $I(\tau_i > 0)$. The explanations we consider are as follows.

First, it may be that observed differences in responsiveness to tactical incentives across voters with and without a social characteristic of interest are really explained by variation in another of the five basic characteristics considered in this study. For example, the observed increase in strategic responsiveness by age may be driven by income, if higher income voters are more responsive to τ and if income is positively correlated with age.[37] Therefore, we examine how the estimated interaction between the social characteristic of interest and $I(\tau > 0)$ changes when we re-estimate the baseline model four times, each time controlling for one of the four remaining social variables and its interaction with $I(\tau > 0)$.

Second, we examine whether observed differences in strategic responsiveness by social characteristic are explained by variation in party support, either because supporters of different parties differ systematically in their objectives (expressiveness/farsightedness) or their perceptions of pivotal probabilities, or because of differential measurement error in the mapping of preferences to like-dislike scores by party support (such that supporters of some parties tend to systematically over- or understate the differences in the utility they receive from their most-preferred and second-best party winning their seat). We test for this by controlling for a series of indicators as to which party a voter most prefers and the interaction of these indicators with $I(\tau > 0)$.[38]

Third, we examine whether differences in strategic responsiveness by social characteristics may be driven by differences in intensity of party identification, a variable found to be strongly associated with likelihood of voting tactically in previous research (Niemi, Whitten and Franklin, 1992; Evans, 1994; Fisher, 2001). If party identification reflects an emotive attachment to a political party that is not fully reflected in like-dislike scores, voters with stronger party identifications may be less willing to vote tactically for a given value of τ. If, in addition, strength of party identifications is correlated with social characteristics, this may explain why voters with certain social characteristics are more or less responsive to tactically incentives. We test for this by controlling for strength of voters' self-reported party identification and its interaction with $I(\tau > 0)$.[39]

[37] It could also be, for example, that higher income voters are more strategically responsive and that income is positively associated with τ for old voters but negatively associated with τ for young voters, generating the observed association between age and responsiveness to τ.

[38] We set Conservative support as the reference category and include indicators for Labour, Liberal Democrat, UKIP, SNP, Plaid Cymru or Green support. For voters who indicate a clear most-preferred party in their like-dislike scores, we code this party as the one they support. Where there is no clear most-preferred party according to like-dislike scores, due to ties, but where a voter reports identifying with or feeling 'closer' to a party in response to party ID questions, we code party support based these latter questions.

[39] Strength of party identification is coded into four categories: no party ID, 'not very strong', 'fairly strong',

Fourth, we examine whether observed differences in strategic responsiveness by social characteristics arise because voters with certain social characteristics more accurately anticipate election outcomes in their constituencies. To assess this explanation, we control for an indicator measuring whether a respondent correctly anticipates which party will win their seat (and the interaction between this indicator and $I(\tau > 0)$). This is measured based on whether, when asked in the campaign wave of the BES how likely it was that each party would win the election in their constituency, a respondent assigns the highest likelihood to the party that ultimately won the seat.

Fifth, we examine whether observed heterogeneity in strategic responsiveness are explained by variation in campaign intensity. Party constituency campaigns parties try to mobilise tactical votes (Fisher, 2001) and it may be that voters with certain social characteristics tend to be located in areas where party election campaigns are more intense. We test this explanation by controlling for a number of alternative proxies for the election campaign intensity a respondent is likely to have experienced (and the interaction between each proxy and $I(\tau > 0)$): previous winning margin – the difference in vote share between the first and second-placed party in the respondent's constituency at the last election – which should be negatively related to campaign intensity; anticipated winning margin, according to contemporary poll-based forecasts; an indicator measuring whether a respondent reports being contacted by a political party in the past four weeks. We also subset the data to 2015 observations only and control for reported constituency campaign spending during, respectively, the long and short campaign.[40]

Sixth, we examine whether heterogeneity in strategic responsiveness by voter social characteristics is driven by variation in individuals' political knowledge, tendency toward instrumental decision-making, or perceived vote efficacy. We expect voters higher in each of these traits to display voting behavior that is more responsive to tactical incentives, and it could be that these traits are correlated with social characteristics.[41] Our measure of political knowledge is the proportion of correct answers a respondent gives to the domestic and international political knowledge batteries contained in the 2015 BES. Our measure of self-reported tendency toward instrumental political decision-making (hereafter labeled "strategic predisposition") is based on 2015 BES respondents self-reported level of agreement with two statements, "People should vote for the party they like the most, even if it's not likely to win" and "People who vote for small parties are throwing away their vote", recorded on a five-point scale. We take the average of a respondent's level of agreement to the two statements after reversing the polarity of response scale for the first statement. Our measure of respondent perceived vote efficacy is based on responses to the question, "How likely is it that your vote will make a difference in terms of which party wins the election in your local constituency?". The response scale was a 0-10 scale where 0 represents "very unlikely" and 10 represents "very likely".

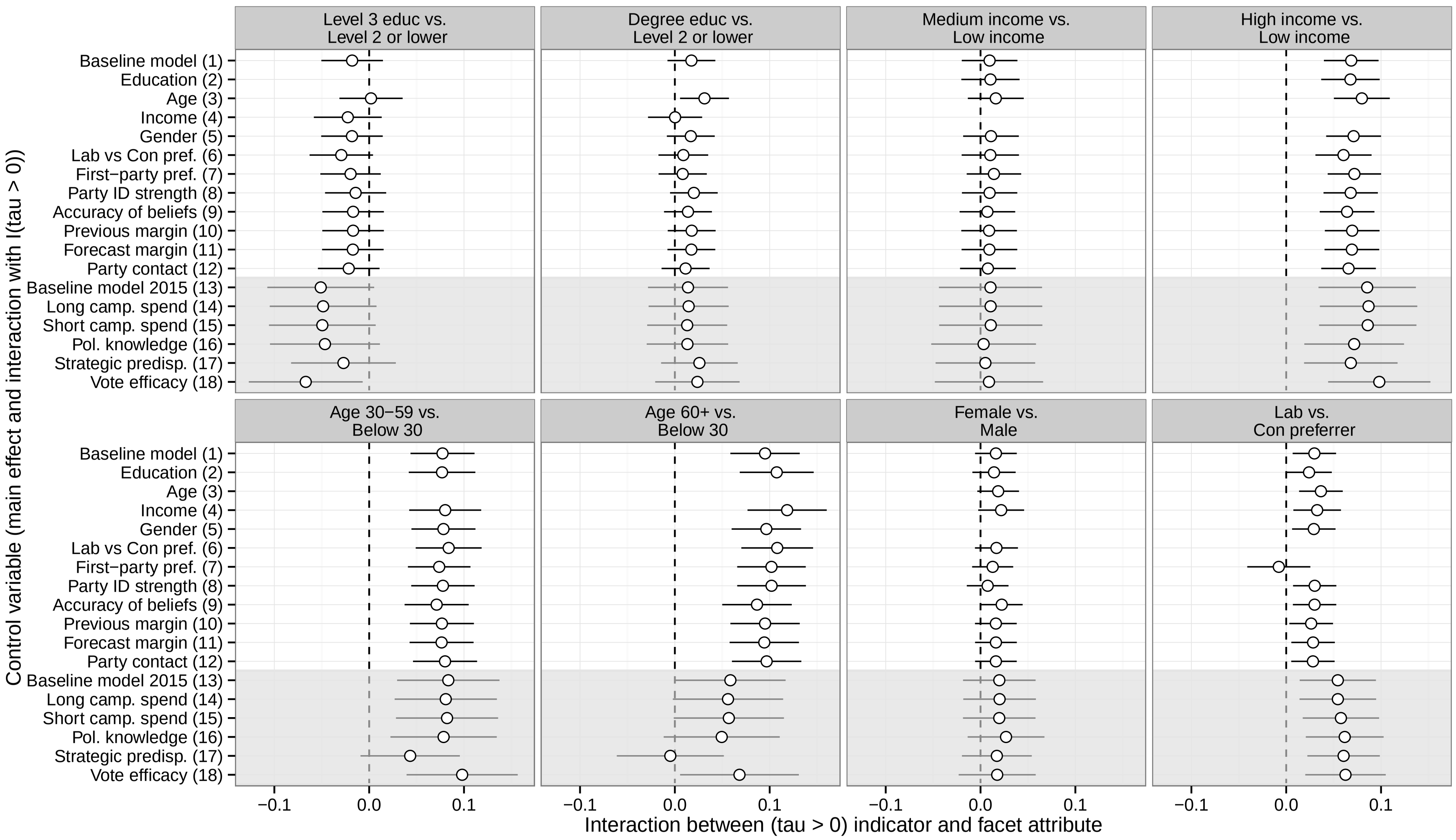
Figure B.1 reports the results of this exercise. Each panel corresponds to a particular $I\{\tau_i > 0\}\times$ group membership interaction. In each panel, row 1 plots our 'baseline' estimate of this interaction, as well as the corresponding 95% confidence interval, based on regression equation 2 in the main text. Rows 2-12 show how the estimated interaction of interest changes when we re-estimate the baseline model, each time controlling for a different Z_i variable representing one of the possible explanations for heterogeneity in strategic responsiveness. In rows 14-18 (i.e. those highlighted in gray) we deal with explanations involving a Z_i variable that is only measured

'very strong'. We set no party ID as the reference category in regressions.

[40] Our measure is based on Electoral Commission measures of party campaign spending in each constituency as a percentage of the campaign spending limit for that constituency. We take the average score of the two top-spending parties in each constituency as our measure of spending intensity.

[41] It may also be that the correlation between these traits and observed levels of τ_i differs among voters with and without a social characteristic of interest, and that this drives observed variation in responsiveness to τ_i by social characteristic.

Figure B.1: Sensitivity of estimated interactions to inclusion of controls



for the 2015 election data. Therefore, in row 13 we display a '2015 baseline' estimate of the $I\{\tau_i > 0\}\times$ group membership interaction, to serve as an appropriate point of comparison.[42]

The stability of estimates in rows 1-6 of each panel of Figure B.1 suggests that any observed heterogeneity in strategic responsiveness by one of our five demographic or political variables of interest (education, income, age, gender and political leaning) is not well explained by variation in any of the other four remaining variables. Interestingly, however, inspection of row 3 indicates that, once we control for age and its interaction with $\tau > 0$, the estimated difference in strategic responsiveness between voters with the highest and lowest levels of education becomes positive and significant, though it remains relatively small.

Furthermore, in each panel, the point estimates of the interaction of interest change little from the relevant baseline estimate when we control for strength of party identification (rows 8 vs 1), accuracy of beliefs (row 9 vs 1), campaign intensity (rows 10-12 vs 1 and rows 14-15 vs 13), political knowledge (row 16 vs 13), or perceived vote efficacy (row 18 vs 13). Thus, observed heterogeneity in strategic behavior by social characteristic is not well explained by any of these factors.

However, comparison of rows 17 vs 13 in each panel does suggest that controlling for voters' self-reported strategic predisposition does somewhat attenuate some estimated interactions, particularly that between the age group indicators and $I\{\tau > 0\}$. This suggests that the increased strategic responsiveness of older voters that was detected in the main results may be attributable at least in part to older voters being more consciously instrumental in their vote decisions.

Finally, comparison of rows 7 and 1 in each panel shows that controlling for "first-party preferences" does induce a notable attenuation in the estimated interactions between the Labour Party preferrer indicator and $I\{\tau > 0\}$. Thus, the differences in strategic responsiveness between left- and right-leaning voters may be explained by associated differences in party support.

Do these various Z_i variables differ in their ability to explain observed heterogeneity in strategic responsiveness because some are themselves more or less strongly related to such responsiveness? To answer this question, we now turn to report the results of a series of regressions where we model tactical voting as a function of each Z_i variable and its interaction with $I\{\tau > 0\}$, dropping social characteristics from the model specification. Specifically, we estimate the regression equation

$$E[Y_i] \quad = \quad g(\tau_i, \text{Year}_i) + \beta_1 Z_i + \beta_2 I\{\tau_i > 0\} + \beta_3 Z_i \times I\{\tau_i > 0\}. \qquad \text{(A.9)}$$

The control function $g(\tau_i, \text{Year}_i)$ includes indicators for deciles of τ in the British electorate and – in models which pool observations across elections – indicators for election years and their interaction with τ bins. The main coefficient of interest in Equation A.9 is β_3, which measures the change in responsiveness to $I(\tau > 0)$ when Z_i increases by one unit.

Table B.1 shows coefficient estimates when the Z_i variables are first party preference (column 1) and strength of party identification (2). The interaction terms in column 1 show that voters who most-prefer Labour, UKIP and the Greens are significantly more responsive to tactical incentives than are those voters who most prefer the Conservative Party. The interaction terms in column 2 indicate that voters with any party identification are less responsive to tactical incentives in their voting behaviour than are voters who do not identify with any party. Moreover, those voters who have a strong party identification are particularly un-responsive relative to other voters. This is broadly consistent with the notion that party indentification reduces strategic behaviour.

Table B.2 shows coefficient estimates for other Z_i variables discussed in the main text.

[42] These estimates are equivalent to the 2015 estimates displayed in Figure 8.

Table B.1: Heterogeneity in strategic responsiveness by respondent party support and strength of party identification

	(1)	(2)
1st pref Lab	0.011**	
	(0.004)	
1st pref LD	0.009	
	(0.005)	
1st pref SNP	−0.011*	
	(0.005)	
1st pref PC	0.050	
	(0.035)	
1st pref UKIP	−0.011	
	(0.012)	
1st pref Grn	0.077	
	(0.045)	
PID weak		0.051***
		(0.008)
PID moderate		0.005
		(0.007)
PID strong		−0.015*
		(0.007)
$I(\tau > 0)\times$ 1st pref Lab	0.129***	
	(0.021)	
$I(\tau > 0)\times$ 1st pref LD	−0.007	
	(0.019)	
$I(\tau > 0)\times$ 1st pref SNP	0.036	
	(0.044)	
$I(\tau > 0)\times$ 1st pref PC	0.065	
	(0.059)	
$I(\tau > 0)\times$ 1st pref UKIP	0.166***	
	(0.023)	
$I(\tau > 0)\times$ 1st pref Grn	0.208***	
	(0.049)	
$I(\tau > 0)\times$ PID weak		−0.058*
		(0.024)
$I(\tau > 0)\times$ PID moderate		−0.048*
		(0.023)
$I(\tau > 0)\times$ PID strong		−0.170***
		(0.026)
Constant	0.029***	0.030**
	(0.008)	(0.010)
Control for (binned) τ?	Yes	Yes
Control for election year?	Yes	Yes
Control for (binned) $\tau \times$ election year?	Yes	Yes
Observations	24,985	24,985
R^2	0.248	0.230
Adjusted R^2	0.246	0.229
Note:	*p<0.05; **p<0.01; ***p<0.001	

Column 1 shows that voters with more accurate beliefs about the election outcome in their seat are, as expected, significantly more responsive to tactical incentives.

Turning to proxies for campaign intensity, Columns 2 and 3 show that voters in less marginal seats (whether measured by previous or forecast election result) are more strategically responsive. On the one hand this result is puzzling given we would expect such voters to receive less intensive campaigns. On the other hand, it may be driven by a process whereby winning margin itself captures intensity of tactical incentives for a given τ decile. Column 4 shows that voters who report having been contacted by a party during the election campaign are more responsive to τ. Columns 5 and 6 show that neither local long campaign spending nor local short campaign spending are significantly associated with strategic responsiveness.

Turning to voter attributes, column 7 shows that voters who score higher in the BES political knowledge test are no more responsive to τ than voters who score lower. In line with expectations, however, column 8 shows that a voter's self-reported strategic predisposition is strongly associated with strategic responsiveness, while column 9 shows that voters who have a greater sense of vote efficacy are also more strategically responsive.

Table B.2: Heterogeneity in strategic responsiveness by additional voter and constituency attributes

	Belief accuracy	Prev. margin	Fcast margin	Party contact	Long spend	Short spend	Knowledge	Strat. disp.	Efficacy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Main effect	−0.027***	−0.002***	−0.003***	−0.017***	0.00004	−0.0001***	−0.002	−0.012**	−0.019***
	(0.004)	(0.0002)	(0.0003)	(0.003)	(0.0001)	(0.00003)	(0.005)	(0.004)	(0.005)
Interaction with $I(\tau > 0)$	0.103***	0.003***	0.005***	0.085***	0.0003	0.0001	0.010	0.324***	0.092***
	(0.012)	(0.001)	(0.001)	(0.012)	(0.0004)	(0.0001)	(0.021)	(0.018)	(0.023)
Constant	0.050***	0.054***	0.055***	0.042***	0.016*	0.039***	0.019***	0.020***	0.022***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.005)	(0.005)	(0.005)
Years	All	All	All	All	2015	2015	2015	2015	2015
Control for (binned) τ?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control for election year?	Yes	Yes	Yes	Yes	No	No	No	No	No
Control for (binned) $\tau \times$ election year?	Yes	Yes	Yes	Yes	No	No	No	No	No
Observations	24,985	24,970	24,982	24,985	8,639	8,639	8,292	8,366	7,339
R^2	0.223	0.222	0.223	0.222	0.235	0.236	0.233	0.293	0.234
Adjusted R^2	0.222	0.221	0.222	0.221	0.234	0.235	0.232	0.292	0.232

Note: $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Appendix C: Robustness checks

Results are similar when we use different definitions of tactical voting

Figure C.1 reports the same sensitivity analysis as 8 (main text) where the outcome variable is now Fisher's (2004) measure of tactical voting (which is based on respondent self-reported reasons for vote choice) rather than our measure. With this alternative outcome variable, strategic responsiveness continues to vary significantly and substantially by voter age. The differences in strategic responsiveness by income and political leaning are in the same direction as in the main results, although the pooled estimates of these differences are now marginally non-significant at the 0.05 level, and differences are smaller in magnitude as would be expected given the lower rate of measured tactical voting.

Figure C.1: **Alternative definition of tactical voting**: Fisher (2004)

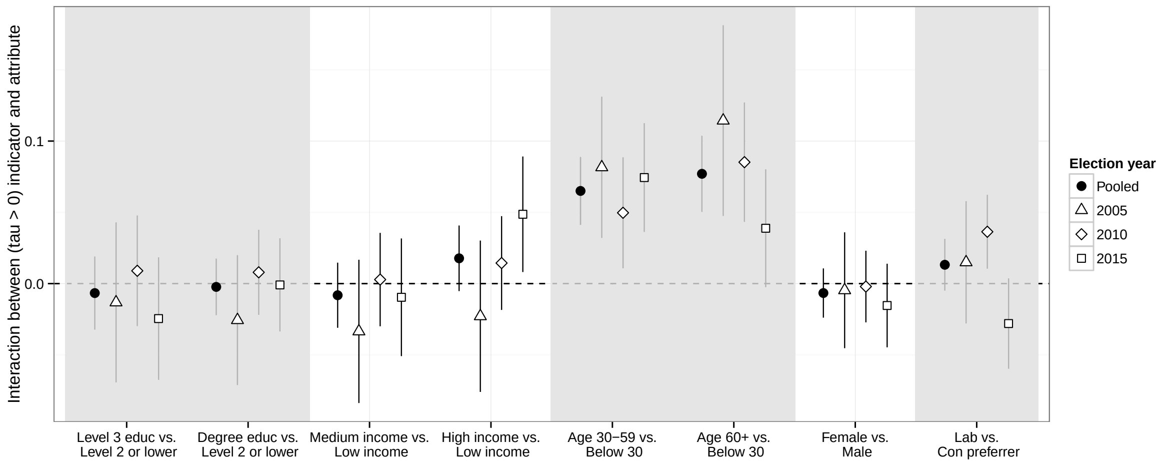


Figure C.2 reports the same sensitivity analysis as 8 (main text) where the outcome variable is now voting for a party other than one's most preferred party. The results are essentially identical to the main results.

Results are similar when our model of counterfactual election outcomes is based on forecasts rather than observed results

In the analysis in the paper and in the sensitivity analysis above, we calculated τ based on a model of counterfactual elections whose expected outcome is the actual outcome. Alternatively, we could use forecasted results as the basis of our model of counterfactual election outcomes. Figure C.3 reports the same sensitivity analysis as 8, but using forecasts as the source of expected election results. Concentrating on the pooled estimates, as in the main analysis, the youngest group of voters have significantly lower levels of strategic responsiveness than older voters, high income voters have significantly higher levels of strategic responsiveness than low income voters, and left-leaning voters have significantly higher levels of strategic responsiveness than right-leaning voters. Interestingly, in this analysis, we also find evidence that females have a significantly higher level of strategic responsiveness than males.

Figure C.2: **Alternative definition of tactical voting**: Voting for a party other than one's favorite

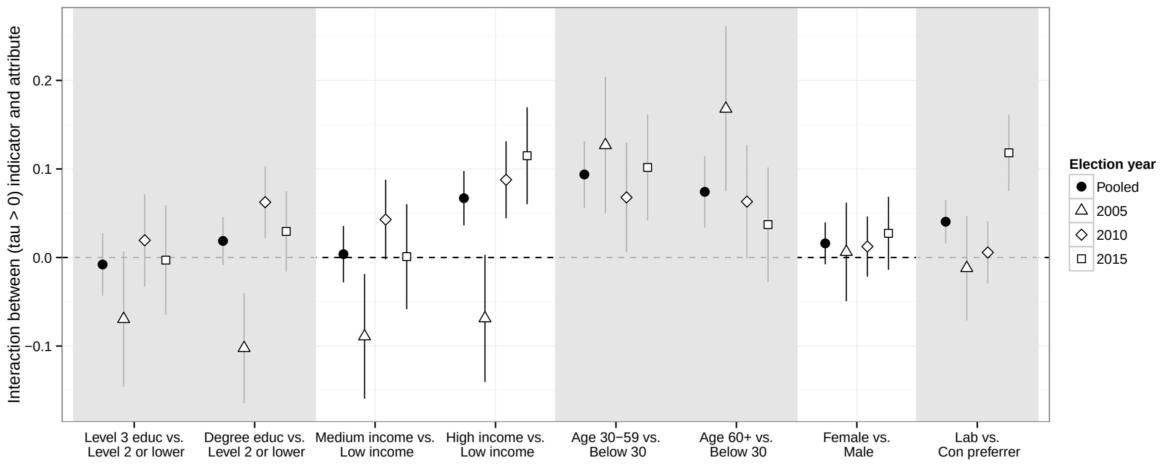
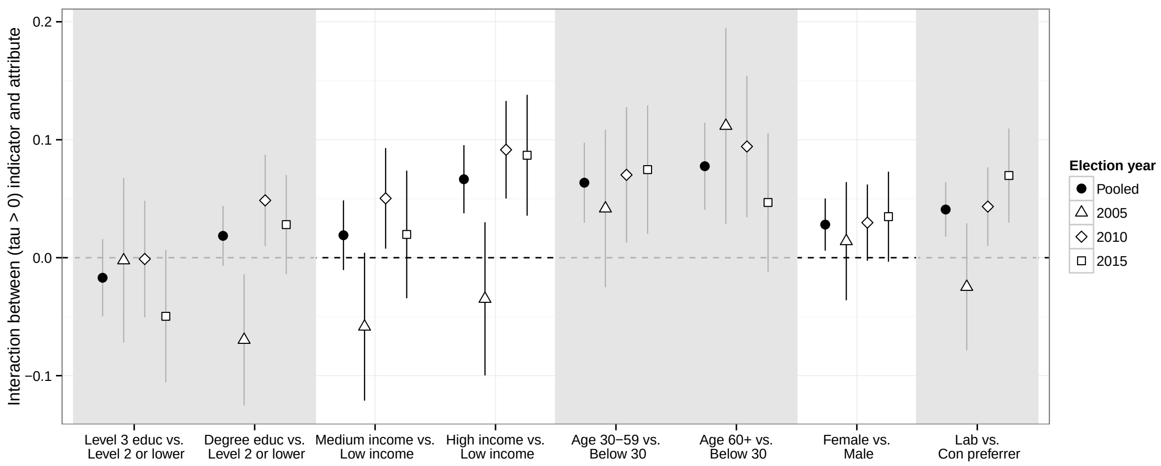


Figure C.3: **Alternative basis for the model of counterfactual election outcomes**: Model centered on forecasts rather than observed results



Results are similar when we increase the aggregate uncertainty in our model of counterfactual elections

In the analysis in the paper and in the sensitivity analysis above, we calibrated the precision of our model of counterfactual elections by setting the mean at the observed result and choosing the Dirichlet precision parameter s to maximize the likelihood of election forecasts; this led to a choice of $s = 85$. Figure C.4 reports the same sensitivity analysis as 8, but repeated for two alternative values of the precision parameter, $s = 8$ and $s = 20$. (At $s = 8$ and $s = 20$, the standard deviation of each party's vote share is roughly triple and double, respectively, that at $s = 85$.) Concentrating on the pooled estimates, across all values of s shown, younger voters are estimated to have significantly lower levels of strategic responsiveness than older voters and high income voters are estimated to have significantly higher levels of strategic responsiveness than low income voters. Regarding political leaning, left-leaning voters are consistently estimated to have higher levels of strategic responsiveness than right-leaning voters across all levels of s shown, although the difference is marginally non-significant when $s = 20$.

Figure C.4: **Greater aggregate uncertainty in model of counterfactual elections**: precision parameter set to $s = 8$ or $s = 20$ instead of $s = 85$