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 right-leaning voters more strategic than left-leaning voters? Are men more strategic than women? Does strategic behavior vary with age, education, or income? 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 applied to essentially any electoral survey. 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 candidates who are not in contention for first place (Duverger, 1954). This observation about the relationship between individual behavior and aggregate outcomes has since been formalized, generalized, and extended to a wide variety of electoral systems (e.g. Cox, 1997). Meanwhile, a very 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, in part because of disagreements about how strategic voting should be defined and measured. In general, however, the evidence indicates that strategic voting behavior is sufficiently prevalent to help explain aggregate patterns 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]

We seek to address a different question from most previous research: rather than asking to what extent voters are strategic in general, we seek to understand *how strategic voting behavior varies across voters*. Do voters on the left of the political spectrum vote more or less strategically than those on the right? Does strategic behavior vary systematically with gender, age, education, or income? The normative imperative to answer these questions becomes clear if one draws an analogy between strategic voting and turnout. Regarding the latter, it is well known that groups in society differ in their propensity to vote in elections (Verba, Schlozman and Brady, 1995; Gallego, 2014; Kasara and Suryanarayan, 2015) and that groups that are less likely to vote are less likely to see their preferred candidates win (Citrin, Schickler and Sides, 2003) and their preferred policies implemented (Gilens, 2012; Leighley and Nagler, 2013; Bartels, 2016). The same logic implies that, in systems where voters often face strategic incentives to vote

[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]For analyses of strategic voting in systems of proportional representation, see e.g. Sartori (1968), Abramson et al. (2010) and Artabe and Gardeazabal (2014). For studies of strategic voting in mixed electoral systems, see e.g. Karp et al. (2002) and Gschwend (2007)

for a candidate other than their favorite, voters who simply vote for their preferred candidate regardless of the strategic circumstances are similarly disadvantaged: after all, people who fail to vote strategically in such cases are, like people who fail to vote, effectively wasting their ballot.[4] Just as inequalities in turnout may be addressed by lowering the cost of voting or making voting compulsory (Lijphart, 1997; Enos, Fowler and Vavreck, 2014; Bechtel, Hangartner and Schmid, 2016; Hoffman, León and Lombardi, 2017), inequalities in strategic voting could be addressed by improving the public's understanding of how the electoral system works, by raising the quality and visibility of polling data (Hall and Snyder Jr, 2015), or by adopting an electoral system that less commonly rewards strategic behavior. It is therefore important to determine whether and to what extent some voters vote more strategically than others.

While we know a large and increasing amount about inequalities in turnout and how to address them, we know much less about inequalities in strategic voting. Over the years, a few 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). 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 be occupied with measurement issues (e.g. Kawai and Watanabe, 2013; Herrmann, Munzert and Selb, 2015; Fisher and Myatt, 2017).

In this paper, 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 who would benefit from a tactical vote; given survey data indicating how each voter voted, this allows us to estimate our basic measure of "strategic-ness", called *strategic responsiveness*,

[4]For example, Republican victories in the U.S. presidential elections of 2000 and 2016 could have been reversed if left-leaning voters had either been more inclined to vote or more inclined to vote strategically.

which captures how much more likely voters are to cast a tactical vote when a tactical vote would benefit them than otherwise. (Unlike previous measures of strategic behavior, strategic responsiveness is at a maximum when voters are purely strategic, i.e. when they vote in a way that yields the best expected election outcome according to their preferences.) 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 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, which we present in the next section.) With methods we introduce in this paper, researchers can calculate our measure and apply our method for comparing strategic voting behavior using data from any electoral survey that reports respondent' vote choices and preferences.[5]

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.[6] 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. We find some evidence that older voters vote

[5]It is most straightforward to apply our methods to other first-past-the-post systems, but the general approach can be applied more broadly.

[6]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).

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 those beliefs, 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, their vote has the same effect whether they thought strategically about likely outcomes or were simply instructed how to vote by their 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 five 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 a new, theoretically grounded measure of tactical incentives that is used both to measure and to compare strategic responsiveness across groups. Fourth, in order to estimate this measure of tactical incentives it introduces a new method of calculating the probability of hypothetical election outcomes in multi-candidate contests. Fifth, it applies these innovations to provide new evidence about inequalities in strategic voting in the British electorate. As we discuss in the conclusion, it remains to be seen whether these inequalities are specific to the elections 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 comparing strategic voting across voters. In this section we address each of these issues before comparing our approach to approaches taken in previous studies.

2.1 A model of vote choice

We begin with a simple decision-theoretic model of vote choice. The model clarifies terminology, advances a simple theory of why strategic behavior varies across voters, and informs our empirical strategy.

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 further the interpretation and estimation of these probabilities in the next section.) Denote by u_j the utility the voter receives as a result of candidate j being elected. We will refer to u_j as an "outcome-dependent 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. We make two assumptions about these utilities: first, they are Von Neumann-Morgenstern utilities, meaning that faced with two lotteries over candidates the voter prefers the lottery that yields a higher expected utility;[7] second, the scale of the utilities is comparable across individuals, meaning that observable features of the intensity of voters' preferences over pairs of candidates (such as the language they use to describe the candidates, or data from brain scans) map into utility differences in a consistent way across voters. (We discuss this assumption further in the next section.) Note that $\mathbf{p}(j) \cdot \mathbf{u}$ is the outcome-dependent expected utility of the voter given a vote for candidate j.

We can now define three 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

[7] More formally, given the utility vector $\mathbf{u}$ and election probability vectors $\mathbf{p} = \{p_1, p_2, \ldots, p_K\}$ and $\mathbf{p}' = \{p'_1, p'_2, \ldots, p'_K\}$, it must be the case that $\mathbf{p} \cdot \mathbf{u} > \mathbf{p}' \cdot \mathbf{u}$ if and only if the voter prefers the lottery described by $\mathbf{p}$ over the lottery described by $\mathbf{p}'$ for any $\mathbf{p}$ and $\mathbf{p}'$.

$k > 1$, i.e. it is the best non-sincere vote in terms of outcome-dependent expected utility.[8]

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

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

When $\tau > 0$, the vote that maximizes the voter's outcome-dependent expected utility is a tactical vote; otherwise, it is a sincere vote.

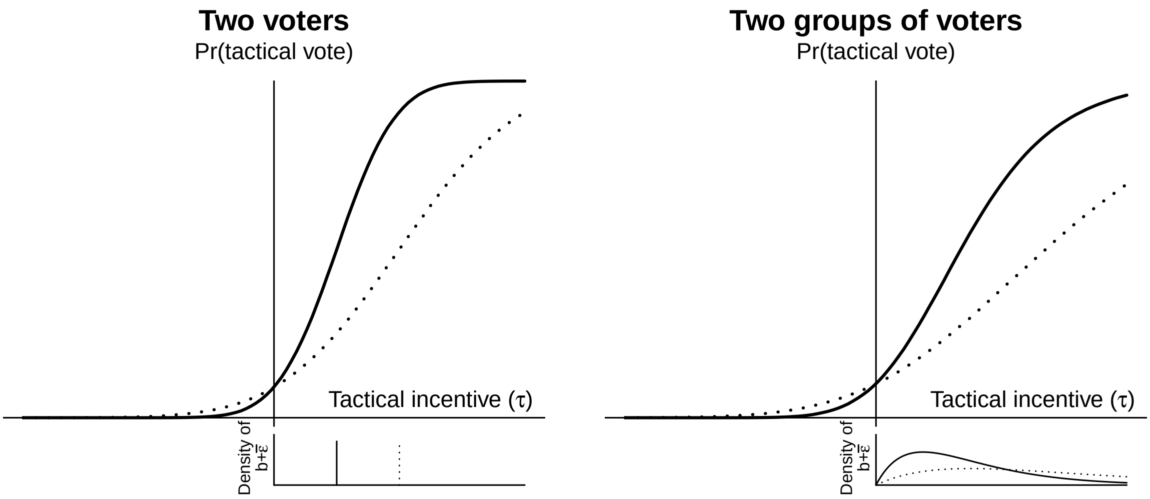
We assume that voters may depart from the pure strategic ideal (i.e. outcome-dependent expected utility maximization) in two respects. First, the voter receives benefit $b \geq 0$ from voting for candidate 1, which reflects the "warm glow" of voting according to one's true preferences (Hamlin and Jennings, 2011) and/or the perceived value of a single vote in affecting future policy decisions or election outcomes (Piketty, 2000; Castanheira, 2003). Thus the voter's expected utility if she votes for candidate 1 is $\mathbf{p}(1) \cdot \mathbf{u} + b$, while her expected utility if she votes for any other candidate $j > 1$ is $\mathbf{p}(j) \cdot \mathbf{u}$. Second, we assume that the voter imperfectly perceives the tactical incentive τ: if the true tactical incentive is τ, the voter perceives a benefit of $\tau - \epsilon$.

Given this setup, the voter casts a tactical vote if and only if $\tau > b + \epsilon$. Consider how the voter might vote in many hypothetical voting scenarios that vary in the voter's utility vector $\mathbf{u}$ and/or the election probabilities $\mathbf{p}(1), \mathbf{p}(2), \ldots, \mathbf{p}(K)$. Let y be an indicator variable equal to 1 if the voter casts a tactical vote and 0 otherwise. The solid curve in the left panel of Figure 1 shows the probability of a tactical vote as a function of τ, $E[y|\tau]$, for a voter for whom ϵ is distributed normally with mean $\bar{\epsilon}$. We will refer to the function $E[y|\tau]$ as the *strategic response function* (SRF) because it describes how a voter's strategic behavior responds to the incentive to cast a tactical vote.[9] The dashed curve shows the SRF for another voter with a higher value of $b + \bar{\epsilon}$, i.e. a higher level of expressiveness and/or greater tendency to underestimate the benefits of a tactical vote, which shifts the SRF to the right. (The assumed values of $b + \bar{\epsilon}$ are shown in the small set of axes below the main figure.) We also assume that the second voter's

[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.

[9]Because $E[y|\tau] = \Pr(\tau > b + \epsilon)$, the strategic response function is the cumulative distribution function of $b + \epsilon$.

Figure 1: Illustrative strategic response functions



NOTE: In both the left and the right panel we see two strategic response functions $E[y|\tau]$ and, below that, the distribution of $b + \bar{\epsilon}$ (expressiveness plus average under-estimate of tactical incentives) for each function. In both plots we assume a larger variance on ϵ (i.e more variable perceptiveness) in the dotted curve.

misperception of the strategic stakes is more variable (i.e. the variance of ϵ is higher), which makes the SRF flatter and increases the probability of an ill-advised tactical vote when $\tau < 0$. A perfectly strategic voter (i.e. one with $b = \epsilon = 0$) would have an SRF that is a step function jumping from 0 to 1 where $\tau = 0$.

We can also describe the voting behavior of a collection of voters in terms of a strategic response function $E[y|\tau]$, where the expectation is taken across voters. Assuming that $b + \epsilon$ is independent of τ across voters, the proportion of voters casting a tactical vote at a given level of τ is the proportion for whom $\tau > b + \epsilon$; thus the shape of the SRF will reflect the distribution of $b + \epsilon$ across voters. The right panel of Figure 1 shows SRFs for two hypothetical collections of voters under this independence assumption, with the solid curve describing voters who are less expressive and/or less likely to under-estimate the value of a tactical vote. The assumed distributions of $b + \bar{\epsilon}$ are shown on the small set of axes below the main figure; again we assume that the variance of ϵ is higher for the dashed curve.

2.2 Measuring and comparing strategic voting

In light of our simple model of strategic vote choice, how should we proceed to measure and compare strategic voting across voters? Our basic approach to assessing "strategic-ness" is to measure the extent to which voters cast a tactical vote if and only if a tactical vote maximizes their outcome-dependent expected utility. More specifically, we measure the difference in the probability of a tactical vote when a tactical vote would yield higher outcome-dependent expected utility than a sincere vote and when it would not: $E[y|\tau > 0] - E[y|\tau \leq 0]$. We call this difference *strategic responsiveness* because it is a coarse summary of the strategic response function. For a perfectly strategic voter, for whom $b = \epsilon = 0$, strategic responsiveness achieves a maximum of one. For a voter who is totally unresponsive to tactical incentives (e.g. because the expressive benefit b is very large), SR is zero.

Although strategic responsiveness offers a useful summary of strategic behavior, the model highlights one key shortcoming of SR as the basis for measuring and comparing strategic voting: the probability of a tactical vote in the model depends not just on b and ϵ, which describe the voter's decision-making type, but also on τ, which combines information on the voter's preferences and the strategic context to summarize the nature of the decision the voter faces. Thus two voters or groups of voters with the same strategic response function could have different values of strategic responsiveness merely because of differences in the kinds of voting decisions they faced.[10] Our solution is to compare SR across groups of voters controlling (in a regression framework) for τ. (See Equation 3 below for the regression specification.)

2.3 Comparison to previous literature

We highlight two key differences between our approach to measuring and comparing strategic behavior and previous approaches.

First, our basic approach to measuring strategic-ness is different. While 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; Fisher,

[10]More technically, SR can be written as $\int_0^\infty E[y|\tau]f(\tau)d\tau - \int_{-\infty}^0 E[y|\tau]f(\tau)d\tau$, where $f(\tau)$ is the distribution of τ at which SR is measured. SR could differ across voters either because of differences in the SRF, $E[y|\tau]$, or because of differences in the distribution of τ, $f(\tau)$.

2001), we focus on how *responsive* voters are to tactical incentives, i.e. how much more likely they are to cast a tactical vote in situations when a tactical vote would benefit the voter than otherwise. Why does this difference matter? An approach that measures strategic-ness by counting the proportion of all voters casting a tactical vote ($E[y]$, in our notation) rewards ill-advised tactical votes: a group of voters who cast a tactical vote in all circumstances would (incorrectly) be judged as more strategic than a group of voters who cast a tactical vote only when it maximizes outcome-dependent expected utility.[11] The same critique applies (albeit to a lesser extent) to Fisher (2001) and other analysis that measures and compares the tactical voting rate among voters whose preferred candidate is running third or lower: because some of these voters are actually better off with a sincere vote, such an approach would judge a group of voters who invariably votes tactically to be more strategic than a group of perfectly strategic voters.[12]

Two studies of Canadian voters (Black, 1978; Merolla and Stephenson, 2007) focus, like us, on how different groups of voters respond to strategic incentives, but their approach is subject to a different critique. Both Black (1978) and Merolla and Stephenson (2007) model the decision to cast a tactical vote as a function of several variables that measure tactical incentives; to compare the strategic-ness of voters with different education levels, they fit separate models for more and less educated voters, concluding that more educated voters are more strategic because the model fit (in terms of pseudo-R^2 or correct prediction rate) is higher in that sample.[13] The problem is that there is no guarantee that model fit is higher for voters who are more strategic, for at least two reasons. First, the regressors might be highly predictive of vote choices, but not in a way that is consistent with strategic voting: for example, voters might be more responsive to the viability of their candidate than a purely strategic voter would be. Second, model fit depends not just on how responsive the outcome is to the regressors, but also on the variability

[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] (See also Blais and Nadeau, 1996; Alvarez, Boehmke and Nagler, 2006; Merolla and Stephenson, 2007).

[13] Similarly, Abramson et al. (1992) fit separate models of tactical voting in U.S. presidential primaries as a function of tactical incentives for Democrats and Republicans.

of the outcome; model fit could be higher for less strategic voters because there is less variance in the outcome to explain.

The second key difference between our approach and previous literature is that we use a single scalar variable τ to summarize and control for relevant aspects of voter preferences and the electoral context that might vary across voters, whereas previous efforts tend to control for measures such as 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), the sizes of the preference "gaps" between the voter's first- and second-favorite and second- and third-favorite candidates (e.g. Fisher, 2001), etc. To the extent that these aspects affect vote choice and vary across groups being compared, it makes sense to control for them in a regression comparing strategic responsiveness across groups. Nevertheless, we argue that our approach of controlling flexibly for τ has three clear advantages over controlling additively for features like the ones listed above. First, τ combines information about preferences and the competitive situation according to a coherent theory of vote choice. In that theory, τ is the only confounding factor (although it would certainly be correlated with each of the features listed above). No one has advanced a model of voter choice that justifies additively controlling for the winning margin, the favorite candidate's distance from contention, the first-second preference gap, etc., though it remains to be seen whether these features are more or less predictive of vote choice than τ. Second, because τ is a scalar, it allows for more flexible control strategies, more transparent presentation of results, and more efficient comparisons than multivariate alternatives. Third, unlike many of the standard measures of preference intensity and competitiveness, τ is easily extended to elections with any number of candidates.

Our tactical incentive variable τ can be thought of as an extension of the 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; if the value of this variable is larger than the voter's relative preference for her favorite candidate compared to her second-favorite candidate, a tactical vote is optimal. Like

Myatt's strategic incentive variable, our tactical incentive variable τ summarizes information about the voter's preferences and the electoral context in a single scalar variable. There are two key differences, however. First, whereas Myatt's measure uses only the preference *order*, our measure also incorporates information about preference *intensity* (under the assumption that we have a measure of VNM utilities); Myatt's measure thus relies on weaker assumptions but also encodes less information about the voter's preferences and (as a result) cannot say whether a tactical vote is optimal for the voter. Second, Myatt's measure can only be calculated for a three-candidate race, whereas our measure can be calculated for an arbitrary number of candidates.

3 Implementing our approach

In this section we consider some general issues that arise with implementing our approach to measure and compare strategic voting. In the next section we begin applying these insights to the context of British elections.

3.1 Measuring utilities

Our approach assumes the existence of a set of utility measures (one for each voter with respect to each candidate) that (a) act as Von Neumann-Morgenstern (VNM) utilities for each voter and (b) lie on a comparable scale across voters. These assumptions will never be precisely met for any set of measures, but we suggest that ratings by voters of candidates, parties, and/or party leaders (commonly included on voter surveys such as the Comparative Study of Election Systems, CSES) may be adequate. 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.[14] Future researchers should check what combination of ratings (if any) approximates VNM utility scores.[15] The assumption that utilities lie on a comparable scale across voters is

[14]In the Canadian setting, Blais and Nadeau (1996) combine ratings of party, leader, and candidate, while Merolla and Stephenson (2007) average ratings of party and leader.

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

not necessary for measuring strategic responsiveness,[16] but some degree of scale comparability is required for τ to act as a useful control variable in comparing strategic responsiveness across groups of voters. What sort of comparability is needed? Roughly, we require that if we are comparing voters of group A and group B, members of the two groups would on average report the same gap in ratings when they exhibit the same observable preference intensity between a pair of candidates.

It is difficult to assess whether scale comparability holds, but skeptics should keep several considerations in mind. First, the alternatives are not more attractive. If one wants to avoid any assumptions about the comparability of ratings, one must either ignore the scale of the ratings entirely and compare raw strategic responsiveness across individuals or do this comparison controlling only for the tactical incentive as it relates to preference order and electoral viability.[17] Either way, apparent differences in strategic behavior could be explained by differences in the strength of voters' preferences among the frontrunners. Second, previous research has used raw ratings as predictors or control variables, implicitly relying on scale comparability (e.g. Fisher, 2001; Merolla and Stephenson, 2007; Fisher and Myatt, 2017); indeed, all regressors rely to some extent on scale comparability across observations, even when the scale is difficult to interpret as in this case. Third, survey questions that elicit candidate/party/leader ratings typically anchor the responses with common language that encourages scale comparability,[18] and respondents to election surveys have no reason to misrepresent their attitudes. Fourth, strategic response functions provide a partial test of these assumptions: if the scale of ratings is completely incomparable across individuals, we would expect to see only a very weak relationship between tactical voting and the magnitude of τ conditional on $\tau > 0$. (To preview our analysis, we actually see a strong relationship in the British case.)

[16] To see this, note that strategic responsiveness depends only on the sign of τ, not its magnitude, and that the sign of τ does not depend on the scale of utilities: suppose that the utilities used to calculate τ, $\mathbf{u}$, were replaced by a re-centered and re-scaled version, $a\mathbf{u}+c$, with $a > 0$; Equation 1 tells us that if the original tactical incentive τ is x, then the version using the re-centered and re-scaled utilities is ax.

[17] In the three-candidate setting, this implies controlling for Myatt's strategic incentive variable discussed above. Alternatively, one can follow Abramson et al. (1992) and normalize ratings across voters to lie between e.g. 0 and 1, but this only implies a different assumption about scale comparability.

[18] For example, the CSES asks voters to rate parties and leaders using a 0 to 10 scale in which 0 means "strongly dislike" and 10 is labeled "strongly like".

3.2 Estimating election probabilities

Estimating τ in data requires estimating election probabilities for each voter. Specifically, for each voter we need the probability that each candidate is elected as a function of the vote cast by the voter. The first question to ask is, "Whose beliefs are these probabilities meant to capture?" One answer (which might be called the *subjective* approach) is that they should capture the voter's own beliefs, perhaps elicited through a set of detailed questions about hypothetical events.[19] In this paper, we instead rely on what we call the *objective* approach, which is to measure beliefs that an unbiased election forecaster would have on the eve of the election; we think of these as the true *ex ante* probability of each possible election outcome, given observed results and reasonable assumptions about the level of aggregate uncertainty in elections. If we take the subjective approach to estimating election probabilities, our analysis would ask which voters' vote choices are more strategic given what they *believed* other voters would do. By taking the objective approach, we ask instead which voters' vote choices are more strategic given what other voters *actually did*. Both approaches could yield interesting insights, but the objective approach has the practical advantage that it can be implemented with data available in typical voter surveys and thus can be implemented widely with existing data. Furthermore, the objective approach is a better match for our normative goal: if voters in group A are judged to have higher strategic responsiveness than voters in group B when measured by the objective approach, it means that on average voters in group A should experience more favorable election outcomes, all else equal.[20]

In estimating τ it helps to restate election probabilities in terms of *pivotal probabilities*, i.e. the probability of ties for first between given pairs of candidates. 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,[21] and denote by $\mathbf{p}(\varnothing) = \{p_1(\varnothing), p_2(\varnothing), \ldots, p_K(\varnothing)\}$ the set of election probabilities if the voter abstains. Then, assuming that ties among three or more candidates

[19] Abramson et al. (1992) and Merolla and Stephenson (2007), for example, measure subjective viability of candidates using a survey question asking respondents how likely it is each candidate wins the election.

[20] In the subjective approach this may not be true: voters in group A could have less accurate beliefs.

[21] 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 being pivotal is the probability of a tie.

do not take place,[22] $p_k(j) = p_k(\varnothing) - \pi_{jk}$ 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 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 objective pivotal probabilities, we begin with a model of counterfactual election outcomes.[23] We model counterfactual candidate vote shares using a Dirichlet distribution (c.f. Fisher and Myatt, 2017), which assigns a positive probability to every point on a simplex. The distribution of vote shares for K parties can be characterized by a Dirichlet distribution with parameter vector $s\mathbf{v} \equiv \{sv_1, sv_2, \ldots, sv_K\}$, where $\mathbf{v}$ is the expected value of the distribution and s is a measure of precision.[24] To ensure that our model is unbiased relative to observed results, we set $\mathbf{v}$ equal to the vector of vote shares that is actually observed in an election.[25] 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

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

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

[22] This assumption is common. See for example Fisher and Myatt (2017).

[23] 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.

[24] 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.

[25] In an appendix we show all results where $\mathbf{v}$ is set equal to the forecasted vote shares; results are almost undistinguishable, which makes sense because forecasts and actual results invariably agree on who the competitive parties are (even if they sometimes differ on who finishes first).

pivotal probabilities analytically. We develop a more flexible approach that can be applied 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.[26] In the appendix we introduce and validate a better approach based on numerical integration of the Dirichlet distribution under a naive but useful independence assumption.[27] Our validation shows that our approach generally reproduces the pivotal probabilities estimated by the brute-force simulation approach, and it performs better than the simulation approach when the pivotal probabilities are very low.

4 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.[28] 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.

4.1 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?"

[26]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. There are xn distinct outcomes in which other candidates receive the same vote shares as in this specific outcome and candidates 1 and 2 finish within x of each other. If the number of votes for the leaders is even, one of these outcomes is a tie for first between candidates 1 and 2; otherwise, two of the outcomes involve a margin of just one vote. (These can be enumerated by exchanging votes between candidate 1 and 2.) 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 a tie for first between candidates 1 and 2 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.

[27]Briefly, given that parties 1 and 2 have both achieved a vote share of y, we must calculate the probability that no other party has achieved a vote share above y; to make the problem tractable, we make an independence assumption under which this probability can be approximated by calculating the conditional probability of each party $(3, 4, \ldots K)$ achieving a vote share below y and multiplying these together.

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

Respondents in the BES are not asked to rate the candidates themselves, though they are asked to rate the 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 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 survey, 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- or post-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 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 for whom the vote choice is missing. 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).[29]

4.2 Pivotal probabilities

For our model of counterfactual election outcomes, we use a Dirichlet distribution centered on the actual election outcomes, with the variance parameter tuned to maximize the likelihood of the observed forecasts as described in the previous section.[30] This calibration led to a level of

[29] 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). Note, however, that only 29,004 of these respondents were asked party like-dislike questions. This is because such questions were asked of only approximately half of 2015 BES respondents (randomly chosen). This also 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.

[30] Forecasts were obtained from `www.electionforecast.co.uk` (Hanretty, Lauderdale and Vivyan, 2016).

precision corresponding to $s = 85$. At this level of precision, the standard deviation of support for a 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 centered the distribution on the forecasted outcomes (as shown in the Appendix); 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.

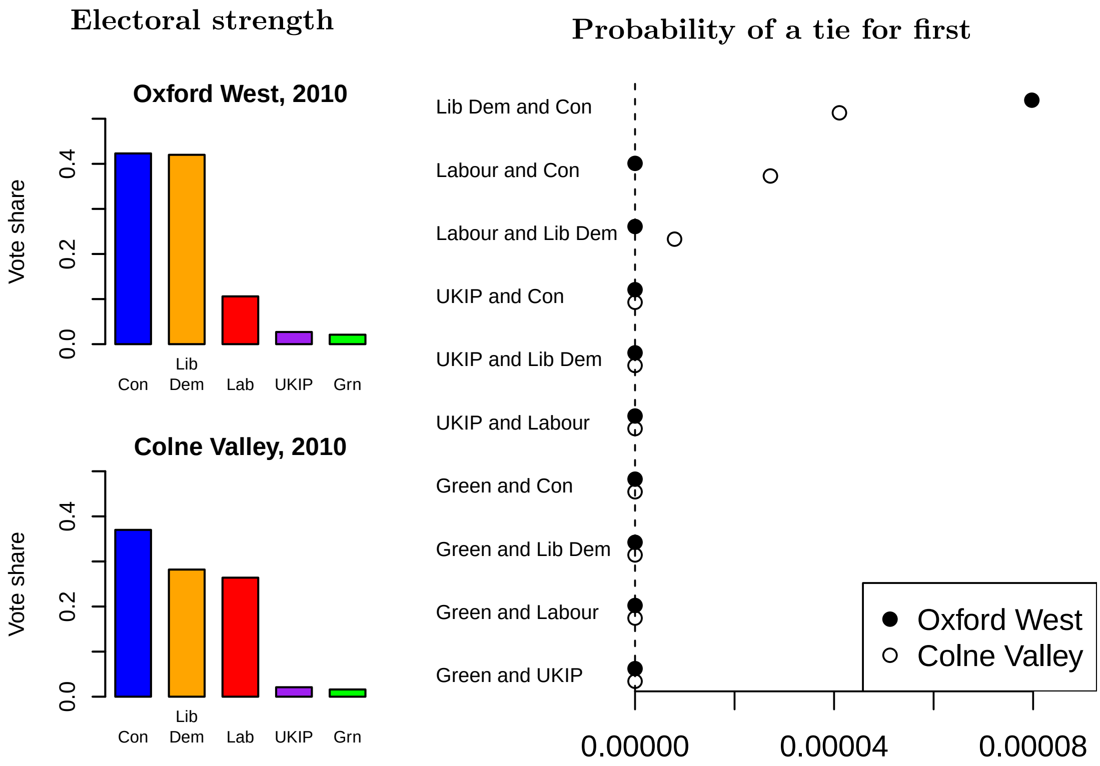
Figure 2 shows two election results (the Oxford West & Abingdon constituency and the Colne Valley constituency in 2010, left top and left bottom) along with the pivotal probabilities we calculate using these results. In Oxford, the Conservative candidate very narrowly defeated the Liberal Democrat, with 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 (at this scale) from zero.[31] 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.

4.3 Tactical incentives: examples

In Figure 3 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 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

[31] None of them are actually zero: for example, we estimate the probability of a tie for first between UKIP and the Greens as roughly 1 in 1 billion^2.

Figure 2: Electoral strength and pivotal probabilities: two examples

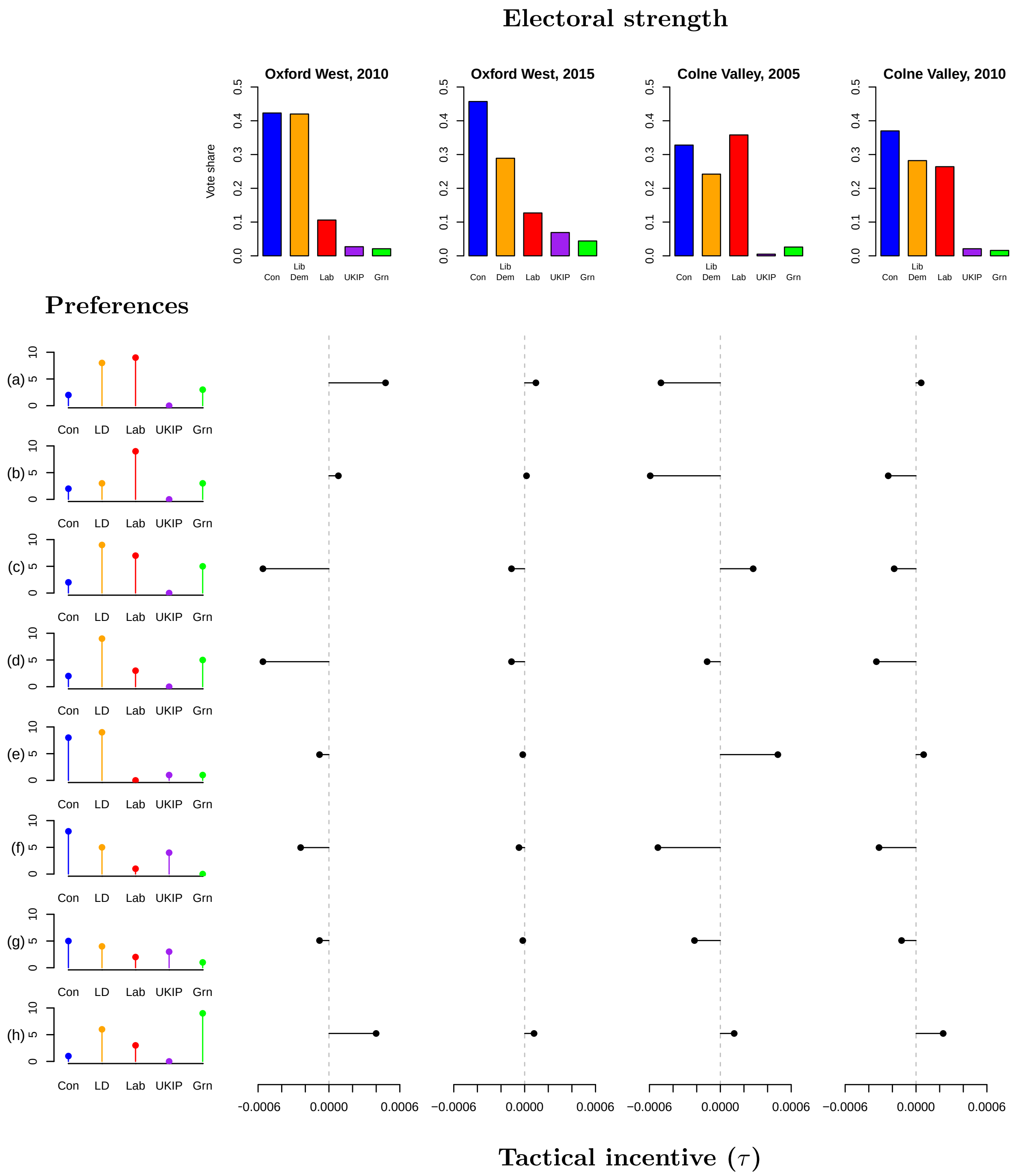


2 above). In the center of the figure we plot the tactical incentive τ for each combination of preferences and electoral contests, for a total of thirty-two examples.

Consider first the tactical incentive in the Oxford West election of 2010, shown in the first column. As shown in Figure 2, the only pivotal event worth considering in this two-way marginal election is a tie for first between the Conservative and the Liberal Democrat. If we assume that all other pivotal probabilities are zero, then (based on Equation 3.2) the magnitude of the tactical incentive is $\pi_{C,LD} \times |u_C - u_{LD}|$ (where C indexes the Conservative candidate and LD indexes the Liberal Democrat), with the sign being negative for voters whose preferred candidate is one of the frontrunners and positive otherwise. Inspecting the first column of tactical incentives in Figure 2, we can confirm that τ is negative only where the voter's most preferred party is the Conservatives or Liberal Democrats and that the magnitude depends on the gap in the voter's rating of those two parties.

Next, consider tactical incentives in the Oxford West election of 2010 (shown in the second column), in which the gap between the Conservative and the Liberal Democrat widened con-

Figure 3: Tactical incentives for different preferences in different elections



siderably. The pivotal probabilities in this election look similar to those in 2015, except that the chance of a tie for first between the two frontrunners is less than half as large. Accordingly, the tactical incentives in the 2015 election have the same direction as those for 2010 but are smaller in magnitude.

In the Colne Valley elections (columns 3 and 4) three parties were in contention, which makes the calculation of tactical incentives more complicated. In 2005 (third column), Labour narrowly defeated the Conservatives, with the Liberal Democrats somewhat behind. A voter whose first preference is Labour and who rates the Conservatives far below Labour has a strong negative tactical incentive (first two rows).[32] For a voter whose first preference is the Liberal Democrat and who rates the Liberal Democrats far above the Conservatives (third and fourth rows), the sign of the tactical incentive depends on the voter's rating of Labour relative to the Conservatives: when the voter strongly prefers Labour to the Conservatives (third row), τ is positive, indicating that she should cast a tactical vote for Labour; when the voter's preference for Labour over the Conservatives is weak (fourth row), τ is negative, indicating that she should cast a sincere vote for the Liberal Democrats. Thus a voter who prefers a candidate who is running third may or may not benefit from a tactical vote. A voter who prefers the Conservatives has a negative tactical incentive whose magnitude depends on intensity of preferences (sixth and seventh rows), while a voter who prefers the hopeless Green candidate (last row) has a positive tactical incentive, in this case to vote Liberal Democrat.[33]

Finally we consider the Colne Valley election in 2010. The first two rows show the same reversal we saw in rows three and four of the Colne Valley 2005 case: a Labour preferrer who has a strong preference between the two frontrunners benefits from a tactical vote for the Liberal Democrat (first row), but a Labour preferrers who barely prefers the Liberal Democrat to the Conservative is better off with a sincere vote (second row). In the next two rows, a voter who prefers the Liberal Democrat candidate is best off voting sincerely for that candidate, but in the fifth row we have an interesting case in which a voter whose preferred candidate runs second

[32]In first row (preference profile (a) in Colne Valley 2005), a vote for the Liberal Democrats is a utility-enhancing tactical vote, as the expected cost of breaking a tie for first with Labour is lower than the expected benefit of breaking a tie for first with the Conservatives. In the second row this is reversed and a vote for the Liberal Democrats is utility decreasing. Because the value of a tactical vote is positive in the first case and zero in the second, τ is larger in the second case than the first.

[33]A vote for Labour would also be beneficial, but not as beneficial as a Liberal Democrat vote.

has a positive tactical incentive to vote for the candidate who runs first; this is because the expected cost of breaking a tie for first between the Conservative and the Liberal Democrat is small compared to the expected benefit of breaking a tie for first between the Conservative and the Labour candidate.[34] In rows 6 and 7, we see that a voter who prefers the front-running Conservative has a negative tactical incentive whose magnitude depends on preference intensity, while in the last row the Green preferrer again has a positive incentive to vote tactically (here, for the Liberal Democrat).

We can summarize the lessons of Figure 2 as follows. When only two candidates could realistically tie for first, 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, 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.

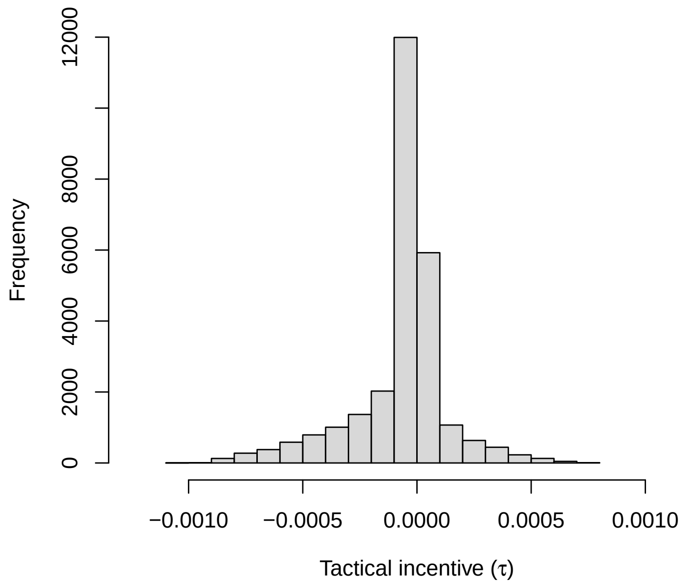
4.4 The distribution of tactical incentives in the British electorate

Figure 4 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 5 shows how tactical incentives vary in the sample by year according to the respondent's preferred party. Focusing on the lower-right corner of the figure, the proportion of voters who prefer the Conservatives was around 26% in 2005, rising to around one-third in 2010

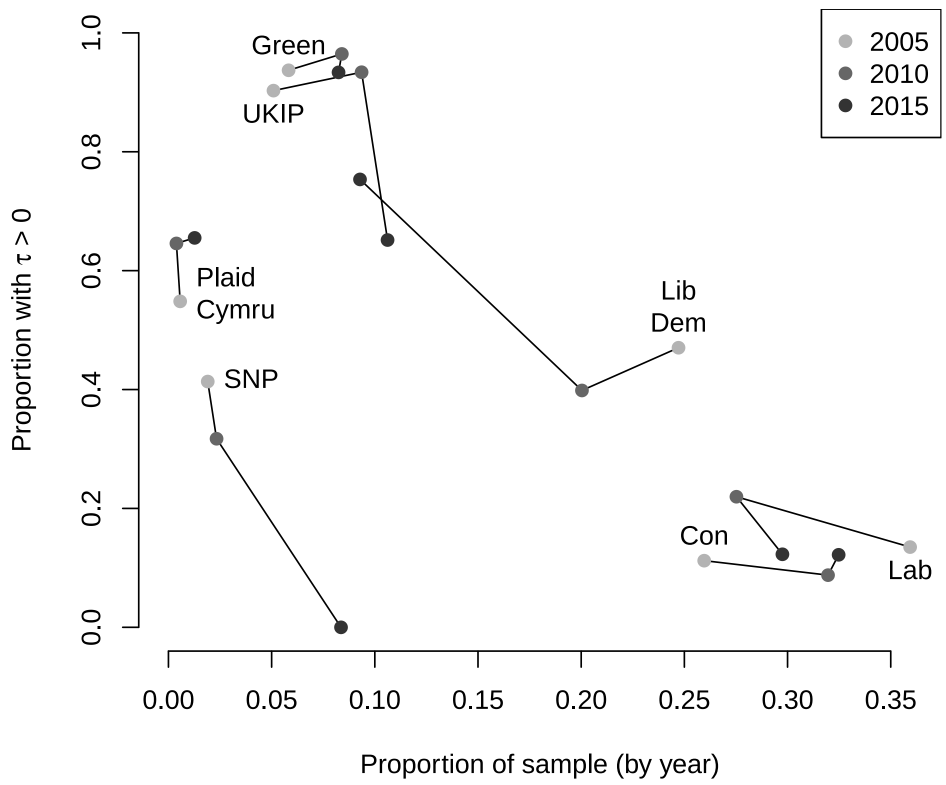
[34] Fisher (2004) speculated that this was possible and Fisher and Myatt (2017) proved it for Dirichlet beliefs.

Figure 4: Distribution of tactical incentives in the BES sample



and 2015; throughout, only around 15% of these had a positive tactical voting incentive, which makes sense given that the Conservatives are competitive in most constituencies. (Just over half of Conservative preferrers with a positive tactical incentive are found in Scotland and Wales.) The proportion of Labour preferrers with a positive tactical incentive is a bit higher. Moving to the upper left corner of the figure, voters preferring UKIP or the Greens made up a similar proportion of the sample in 2005 and 2010, with almost all of these voters having a positive tactical incentive; in 2015, UKIP preferrers became slightly more numerous and far less likely to have a positive tactical incentive (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 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.

Figure 5: Tactical incentives by party preference and year



5 Measuring and comparing strategic behavior in the British electorate

5.1 Aggregate strategic responsiveness

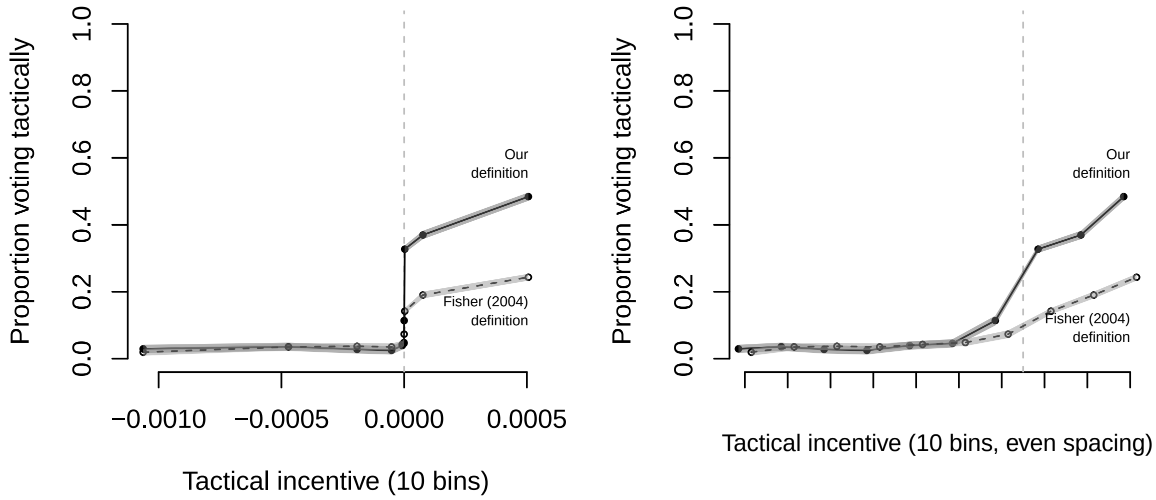
Figure 6 shows the strategic response function (i.e. the probability of a tactical vote as a function of the tactical incentive τ) for the entire BES sample. We focus first on the left panel. The solid line shows the estimated SRF using our definition of a tactical vote, i.e. the best non-sincere vote in terms of the voter's expected outcome-dependent utility. To estimate the SRF for each outcome, 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 all bins are either above or below $\tau = 0$. The figure shows the estimated tactical voting rate in each of these bins with 95% confidence intervals shown in the shaded area.[35] In the left panel of Figure 6, 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 τ, in the right panel we show the SRF where the bin means are equally spaced along the horizontal axis. The figure makes clear that voters' strategic voting behavior responds to observed tactical incentives. The probability of a tactical vote is very low where $\tau < 0$,[36] jumps substantially when τ turns positive, and increases with τ where $\tau > 0$. This monotonic relationship between tactical voting and τ is also evident when we substantially increase the number of bins. This suggests that τ (or something closely related to it) is indeed a determinant of strategic voting behavior and, if not controlled for, could be an important confounder in comparisons of strategic voting behavior across types of voters.

To help link our analysis to previous literature, the dashed line in Figure 6 shows the estimated SRF 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

[35] 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.

[36] Note that roughly 15% of voters in the bin with the weakest negative tactical incentive nonetheless cast a tactical vote. In our model, such errors occur because voters overestimate the benefit of a tactical vote, as shown in Figure 1. They may also occur because voters seek to send a message in an uncompetitive race: e.g. a Labour preferrer may choose to vote Green in a race where Labour is expected to win by a large margin.

Figure 6: Aggregate strategic response function



according to Fisher (2004) if the voter claimed that the vote was tactical and did not report preferences that contradict that claim.) Figure 6 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. This indicates that tactical incentives as measured by τ affect not only the votes voters cast but also the way they explain their votes. In the rest of the paper we use our definition of a tactical vote rather than Fisher's, though in the Appendix we present the core analysis using Fisher's definition. Fisher's definition may be more appropriate for studies that focus on possible differences in voters' decision-making processes, but in this paper we focus on who *votes* more strategically rather than who *thinks* more strategically.[37]

5.2 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 charac-

[37] Fisher's definition yields a lower overall level of tactical voting than our definition in part because the two definitions seek to measure different concepts: we focus on the consequences of the vote while Fisher's definition focuses on the thought process that produces it. The difference in levels in Figure 6 also reflects measurement error: Fisher's measure likely has many false negatives due to voters refusing to explain their vote (which occurs in between 5% and 12% of our estimation sample depending on the year) or giving ambiguous explanations (e.g. "I dread a Tory government" or "I disliked the alternative more"), while our measure also likely has many false positives due to voters' preferences over candidates not being well captured by their party like-dislike scores. For analysis using either definition, this measurement error leads to bias in comparisons of strategic behavior across voters only if the measurement error varies across the groups of voters being compared.

teristics: 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. McCarthy, Poole and Rosenthal, 2006; Gelman, 2008), but education and age have been shown to be 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 behaviour 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.

5.2.1 Graphical results

As an initial examination of strategic responsiveness by social characteristics, Figure 7 plots the estimated SRF of different social groups in the electorate using the same approach as in the right panel of Figure 6.

The top left panel divides the electorate into three groups according to education level: those whose highest qualification is below level 3; those whose highest qualification is at level 3 (equivalent to A-levels); and those who have completed at least a degree-level qualification (level 4 or above). It shows little clear evidence of a difference in strategic responsiveness according to education: when the tactical incentive is nonpositive (the left hand-side of the dashed vertical line), there is little discernible difference in the rate of tactical voting by education level; when the tactical incentive becomes positive (the right hand-side of the dashed vertical line), there is initially still little difference in tactical voting rates, although those in the highest education group do appear to vote tactically at a slightly higher rate when tactical incentives are particularly high.

The top right panel shows clearer evidence of strategic heterogeneity by voter income: when the tactical incentive is moderate to strong, high income voters (those in the top income tercile in the sample) are more likely to cast a tactical vote, although differences between voters in the middle income (middle tercile) and low income (bottom tercile) are less clear. There also appear to be clear differences by age (middle left panel), with young voters seeming to be least strategic. For gender (middle right panel) the differences are less clear. Finally, the bottom panel offers 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 – are more inclined to vote tactically when there is an incentive to do so than are right-leaning voters.

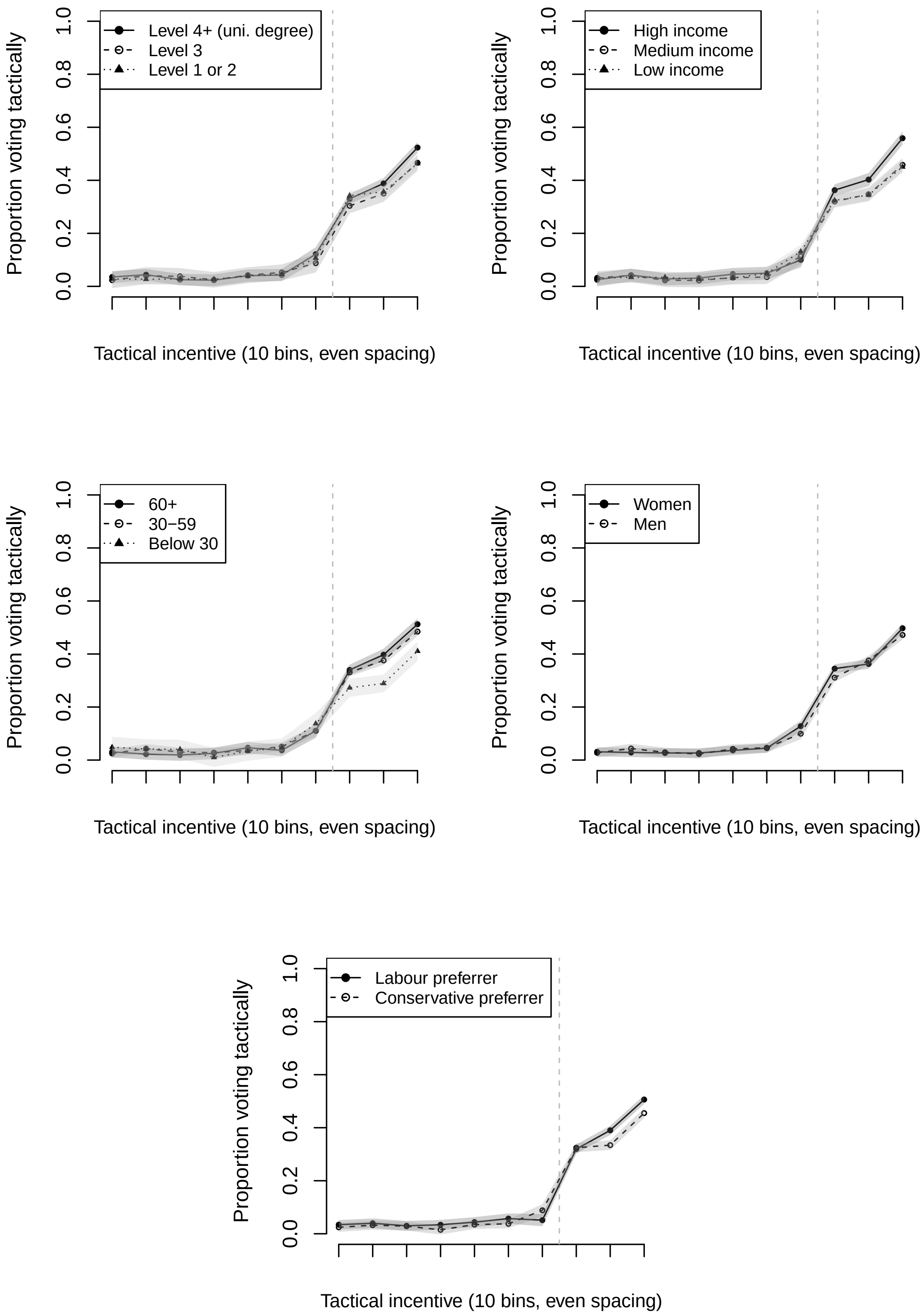
5.2.2 Model-based results

We now turn to regression analysis. Our basic regression equation for comparing the strategic responsiveness of two groups of voters is

$$E[Y_i] = \beta_1 W_i + \beta_2 I\{\tau_i > 0\} + \beta_3 W_i \times I\{\tau_i > 0\} + g(\tau_i), \tag{3}$$

where Y_i indicates whether voter i casts a tactical vote or not, $W_i \in \{0, 1\}$ identifies voter i's group membership, $I\{\tau_i > 0\} \in \{0, 1\}$ indicates whether voter i benefits from a tactical vote or not (based on the voter's preferences and our model of counterfactual election outcomes), and

Figure 7: Strategic response functions by social characteristic



$g(\tau_i)$ flexibly controls for the strength of i's tactical incentive. If we run this regression without $g(\tau_i)$, then the coefficient β_2 measures strategic responsiveness for voters with $W_i = 0$ and the coefficient β_3 measures the difference in SR between voters with $W_i = 1$ and voters with $W_i = 0$. By including $g(\tau_i)$, we additionally control for differences in the distribution of τ across groups. The key coefficient, β_3, thus captures the difference in strategic responsiveness between groups controlling for possible differences in tactical incentives faced by the two groups.

Several approaches to specifying $g(\tau_i)$ are possible. We include in the regression the ten nearly equal-sized bins of τ used in the construction of Figure 6 above, thus allowing for a different baseline propensity to vote tactically in each bin, and we also include an indicator for each election year and interact these with the τ bins to allow baseline responsiveness to τ to vary across years as well.[38] (All models are estimated by pooling the 2005, 2010 and 2015 BES samples.)

For each of the five voter characteristics of interest, Table 1 reports the estimated main effects of group membership and the interaction between group membership and the $I\{\tau > 0\}$ indicators (i.e. β_1 and β_3 from Equation 3). (Standard errors are robust to heteroskedasticity.) The main effects of the group membership indicators are all substantively small (the maximum absolute main effect is 0.6 percentage points) and all but one are statistically non-significant, indicating that (in line with our graphical analysis) the propensity to cast a tactical vote when $\tau \leq 0$ does not differ much across groups. Turning to the interaction terms (which are the main coefficients of interest), model 1 provides no strong evidence that moderately educated or highly educated voters are more or less responsive to tactical incentives than voters in the lowest education group. In contrast, the interaction terms in model 2 provide evidence that strategic responsiveness does vary by age-group, with voters in the 30-59 and 60+ age groups being, respectively, 8 and 10 percentage points more responsive to tactical incentives than voters under 30. Model 3 indicates that there is no significant difference in strategic responsiveness between medium-income voter and lower-income voters, but high-income voters are 7 percentage points more responsive to tactical incentives than low income voters. In model 4, the interaction between the female indicator and $I(\tau_i > 0)$ is small and non-significant, providing little evidence

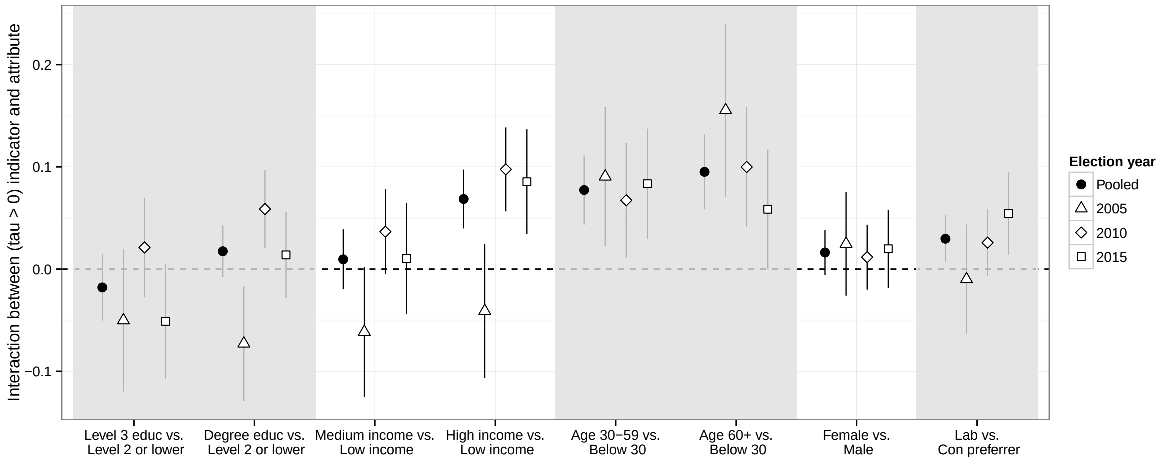
[38] Because of the way the bins are designed, the $\beta_2 I\{\tau_i > 0\}$ term drops out of the regression.

Table 1: Tactical voting and heterogeneity in strategic responsiveness

	(1)	(2)	(3)	(4)	(5)
Level 3 education	0.0004				
	(0.004)				
Degree-level+ education	0.003				
	(0.004)				
Age 30-59		−0.005			
		(0.005)			
Age 60+		−0.009			
		(0.005)			
Medium income			−0.006		
			(0.004)		
High income			−0.002		
			(0.004)		
Female				0.001	
				(0.003)	
Lab preferrer					0.006*
					(0.003)
$I(\tau > 0)\times$ Lev 3 educ	−0.018				
	(0.017)				
$I(\tau > 0)\times$ Degree educ	0.017				
	(0.013)				
$I(\tau > 0)\times$ Age 30-59		0.077***			
		(0.017)			
$I(\tau > 0)\times$ Age 60+		0.095***			
		(0.019)			
$I(\tau > 0)\times$ Med income			0.010		
			(0.015)		
$I(\tau > 0)\times$ High income			0.069***		
			(0.015)		
$I(\tau > 0)\times$ Female				0.016	
				(0.011)	
$I(\tau > 0)\times$ Lab preferrer					0.030*
					(0.012)
Constant	0.034***	0.040***	0.041***	0.034***	0.032***
	(0.008)	(0.009)	(0.009)	(0.008)	(0.008)
Control for (binned) τ?	Yes	Yes	Yes	Yes	Yes
Control for election year?	Yes	Yes	Yes	Yes	Yes
Control for (binned) τ × election year?	Yes	Yes	Yes	Yes	Yes
Observations	23,177	24,985	20,783	24,985	23,357
R^2	0.222	0.221	0.223	0.219	0.229
Adjusted R^2	0.221	0.220	0.221	0.218	0.228

Note: *p<0.05; **p<0.01; ***p<0.001

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



that females are more or less strategic than males. Finally, the interaction in model 5 indicates that voters who prefer Labour to the Conservatives are 3 percentage points more responsive to strategic incentives than those who prefer the Conservatives to Labour.

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 run the analysis separately by election year (2005, 2010, and 2015) and in all years pooled together.[39] Each point estimate in this figure comes from a separate regression; the pooled estimates (filled black dots) are the interaction estimates presented in Table 1. 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

[39] 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.

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.

5.3 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 conduct an initial examination of a number of different plausible explanations. Each of the explanations we consider involves a third *omitted variable* Z_i, which is itself associated with responsiveness to measured tactical incentives and may also be correlated with the social characteristic of interest conditional on τ. Therefore, our strategy for testing each explanation is to assess whether the interactions reported in each regression model of Table 1 are attenuated when we re-estimate the model and add a control for Z_i and for 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.[40]

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

[40]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 positive and significant (though still relatively small).

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 claim to have an expressive or instrumental approach to voting. (Specifically, our measure is based on respondents' level of agreement with the 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".) 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 more skilled at strategic voting. 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 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.

6 Discussion and conclusion

In their article "In Praise of Manipulation", Dowding and Van Hees (2008) consider strategic voting from a normative standpoint, concluding that strategic voting is not as problematic as many democratic theorists think. They recognize that there may be cause for worry 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 it is good for democracy for voters to seek the information and understanding that would make them better strategic voters (p. 10). Dowding and Van Hees discuss inequality in strategic voting as a hypothetical problem, but their sanguine view may be more difficult to sustain once we take into account this paper's findings about which types of voters actually vote more strategically than others. In particular, 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 may 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. We are eager to see how similar the results are in other elections in the UK, in plurality elections in other countries, and in elections carried out under different electoral rules. Second, additional research could improve our understanding of why differences in strategic voting arise. We took a first step by checking whether observed differences in strategic responsiveness disappear when we control for factors that might differ across groups, such as levels of information or general attitudes toward vote choice. Future studies might address the question 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: A new method for calculating the probability of various events given a model of election outcomes

We begin with a Dirichlet model of election outcomes. The goal is to measure the relative probabilities of ties between different pairs of parties. Fisher and Myatt (2017) show that there is an analytical solution in the case of three parties. To calculate pivotal probabilities for a larger number of parties, one can adopt the brute-force solution of simulating a large number of elections and counting the number of simulations in which a given pair of parties is tied for first. This approach seems to work well in cases where beliefs have low precision and/or the parties are all fairly competitive. It becomes unwieldy, however, when beliefs are more precise and/or parties vary widely in expected vote share; in these cases, some pairs of parties may be very unlikely to be nearly tied for first, such that even in a large number of simulations they are nearly tied in zero cases or one case – and with such small numbers of near ties, the random variation of the simulation process can matter quite a lot.[41] Ultimately this is a computational problem, of course, as with an infinite number of simulations the results should match the correct analytical solution. To avoid this computational problem, we develop an analytical approximation that closely mirrors the much more time-intensive simulation results.

Suppose there are K parties. We can denote the pivotal probability for parties 1 and 2 as

$$\int_{1/K}^{1/2} \Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y)dy, \tag{4}$$

where $x_1, x_2, \ldots x_K$ are realized vote shares for parties $1, 2, \ldots K$. The question is how to compute this given a distribution over election outcomes (e.g. the Dirichlet distribution we described above). To make progress, we transform the joint probability into a conditional probability and make an independence assumption:

$$\begin{aligned}\Pr(x_1 = x_2 = y, x_3 < y, \ldots, x_K < y) &= \Pr(x_1 = x_2 = y)\Pr(x_3 < y, \ldots, x_K < y | x_1 = x_2 = y) \\ &\approx \Pr(x_1 = x_2 = y)\prod_{i=3}^{K}\Pr(x_i < y | x_1 = x_2 = y) \end{aligned} \tag{5}$$

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 can apply the "aggregate property" of Dirichlet distributions to compute this object given 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

$$\Pr(x_1 = x_2 = y) = \text{Dir}\big(sv_1, sv_2, s(1 - v_1 - v_2); y, y, 1 - 2y\big). \tag{6}$$

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

[41] For example, in a case where party A has a huge lead over both parties B and C (or a smaller lead with high precision of beliefs), in one set of simulations there may be no ties; in another A and B may get 1 "tie" while A and C get 0; in another, the results may be reversed, completely reversing the conclusion about how a voter should vote strategically.

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

$$\Pr(x_3 = z | x_1 = x_2 = y) = \text{Beta}\big(\alpha_3, \sum_{i=4}^{K} \alpha_i; \frac{z}{1-2y}\big). \tag{7}$$

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 equal to

$$\text{Dir}\big(sv_1, sv_2, s(1 - v_1 - v_2); y, y, 1 - 2y\big) \prod_{i=3}^{K} \int_0^y \text{Beta}\big(sv_i, s\sum_{j=3}^{K} v_j - sv_i; \frac{z}{1-2y}\big) dz \tag{8}$$

To calculate the probability that parties 1 and 2 are tied for first, we compute this for values of y between $1/K$ and $1/2$ and numerically integrate.

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.

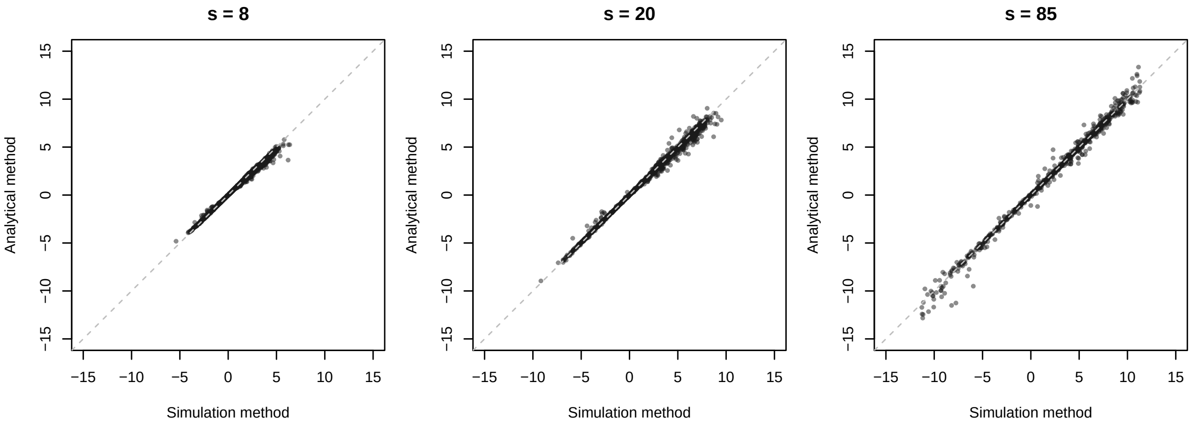
As a first validation, we compute the following for every election race using both the simulation approach and our approach:

$$\ln \frac{\pi_{Lab-Con}}{\pi_{LD-Con}} \tag{9}$$

where π_{A-B} is the probability of a tie for first between party A and party B. Figure 9 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 9: 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 9: 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 Table 1 (in the main text) 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.[42] 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 $I(\tau > 0)$.[43]

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 $I(\tau > 0)$.[44]

[42] 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.

[43] 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.

[44] 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.[45]

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.[46] 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".

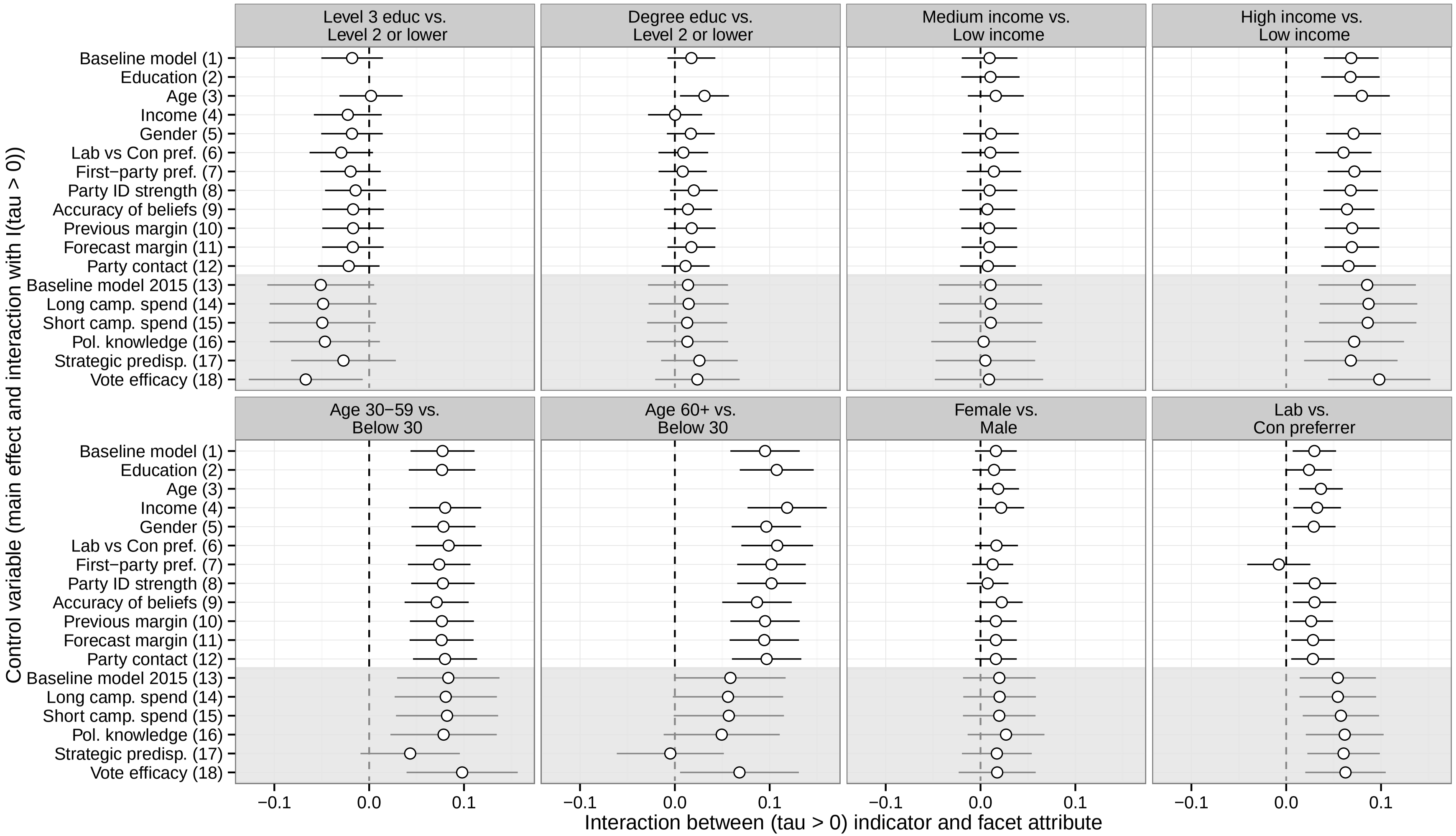
Figure 10 reports the results of this exercise. Each panel corresponds to a particular $I\{\tau_i > 0\}\times$ group membership interaction. In each panel, row 1 plots our 'baseline' estimate of this interaction, as well as the corresponding 95% confidence interval, based on the model specifications reported in Table 1 above. 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

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

[45] 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.

[46] 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 10: Sensitivity of estimated interactions to inclusion of controls



is only measured 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.[47]

The stability of estimates in rows 1-6 of each panel of Figure 10 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 detected in Table 1 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

$$E[Y_i] \quad = \quad g(\tau_i, \text{Year}_i) + \beta_1 Z_i + \beta_2 I\{\tau_i > 0\} + \beta_3 Z_i \times I\{\tau_i > 0\}. \qquad (10)$$

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 10 is β_3, which measures the change in responsiveness to $I(\tau > 0)$ when Z_i increases by one unit.

Table 2 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 3 shows coefficient estimates for other Z_i variables discussed in the main text. Column

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

Table 2: 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	0.008	
	(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	−0.006	
	(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	0.209***	
	(0.049)	
$I(\tau > 0)\times$ PID weak		−0.057*
		(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	

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.

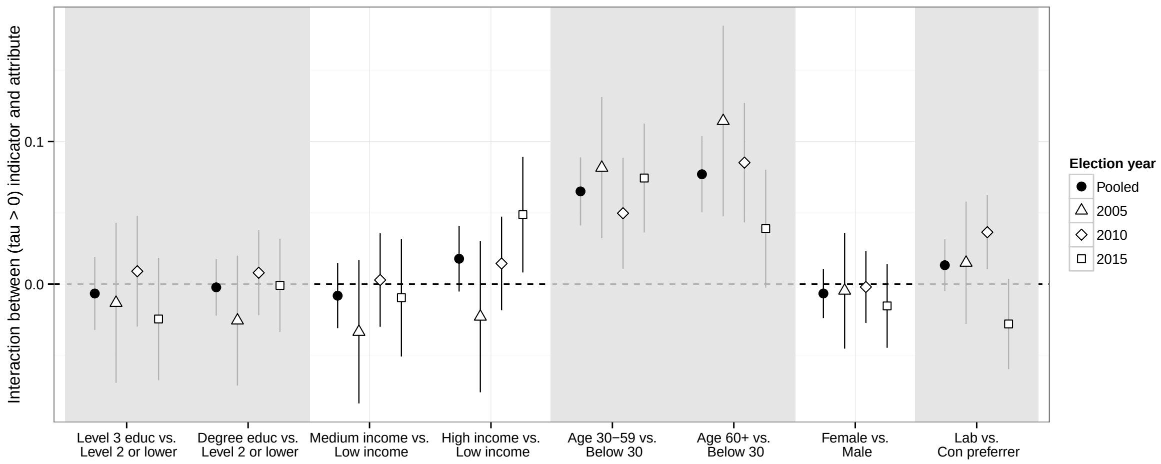
Turning to voter attributes, column 7 shows that voters who score higher in the BES political knowledge test are no more responsive to τ than voters who score lower. In line with expectations, however, column 8 shows that a voter's self-reported strategic predisposition is strongly associated with strategic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

Table 3: 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	−0.026***	−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: $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Figure 11: **Fisher (2004) measure of definition of tactical voting**: Heterogeneity in strategic responsiveness across election years



Appendix C: Robustness checks

Results are similar when we use Fisher's (2004) measure of tactical voting

Figure 11 reports the same sensitivity analysis as 8 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 of best non-sincere vote that maximises outcome-dependent expected utility.

Results hold when we use different definitions of "good information"

In the analysis in the paper and in the sensitivity analysis above, we assumed throughout that "good information" was information that correctly anticipated the actual results (although with different amounts of imprecision). Suppose that good information is information which matches poll-based forecasts of election results in the constituency, corrected for known poll biases. Figure 12 reports the same sensitivity analysis as 8, but using forecasts as the source of expected election results.

Results hold when we make different assumptions about precision of information

In the analysis in the paper and in the sensitivity analysis above, we assumed throughout that "good information" was information that correctly anticipated the actual results with a level of precision corresponding to $s = 85$. Suppose that we judge voter decision-making while assuming lower levels of precision in electoral expectations. Figure 13 reports the same sensitivity analysis as 8, but repeated for two additional 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 triple and double (respectively) that at $s = 85$.)

Figure 12: **Information based on forecast results**: Heterogeneity in strategic responsiveness across election years

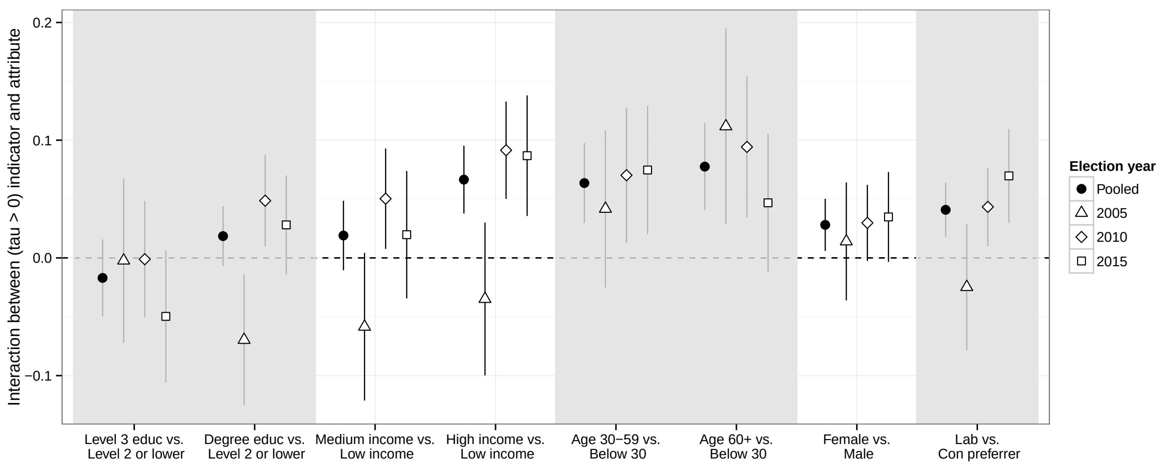


Figure 13: **Less precise beliefs about election outcomes**: Heterogeneity in strategic responsiveness across election years