Backward Induction in the Wild? Evidence from Sequential Voting in the U.S. Senate*

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Abstract

In the U.S. Senate, roll calls are held in alphabetical order. We document that senators early in the order are less likely to vote with the majority of their own party than those whose last name places them at the end of the alphabet. To speak to the mechanism behind this result, we develop a simple model of sequential voting, in which forward-looking senators rely on backward induction in order to free ride on their colleagues. Estimating our model structurally, we find that this form of strategic behavior is an important part of equilibrium play. At the same time, there appears to be a great amount of heterogeneity in senators' use of backward reasoning. We also consider, but ultimately dismiss, alternative explanations related to learning about common values and vote buying.

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1. Introduction

Economic theory often assumes that strategic agents try to anticipate the actions of others in order to maximize their own payoffs. Nowhere else is this idea as purely embodied as in the principle of backward induction in dynamic games of perfect information. Although backward induction provides each player with an impeccable way to arrive at an optimal strategy, and despite the fact that it is widely used to analyze games' subgame-perfect equilibria, when tested in the laboratory its predictions have often not held up to empirical scrutiny (see, e.g., McKelvey and Palfrey 1992, or the review in Camerer 2003).

In this paper, we examine the behavior of U.S. Senators during legislative roll-call votes. On theoretical grounds, "strategic voting is an ineradicable possibility in all voting systems" that should "almost always [be] present in legislatures" (Riker 1982, p. 167). Empirical evidence of strategic behavior by legislators, however, is extremely scarce. Groseclose and Milyo (2010), for instance, "only find ten roll call votes—in the entire history of Congress—on which a researcher has claimed that sophisticated voting occurred" (p. 65). Our analysis exploits the fact that the Senate holds roll calls in alphabetical order. This does not only allow us to learn about senators' calculus of voting, but it also affords us a unique opportunity to study backward reasoning outside the laboratory.

In the first part of the paper, we document two empirical regularities. First, the majority party in the Senate is considerably more likely to narrowly win a roll-call vote than to narrowly lose it. Second, senators who, by virtue of their last name, get to vote earlier in the order are more likely to deviate from the party line than those who get to vote late.

Figure 1 illustrates this pattern in the raw data. Importantly, we only find vote-order effects on roll calls that end up being close. We further demonstrate that there are no comparable order effects in the modern House of Representatives, where roll calls are *not* held according to the alphabet.

To account for senators' inherent tendencies to deviate from the party line, our preferred estimates control for senator fixed effects. We, therefore, do not assume that preferences are as good as randomly assigned. Identification in our setup comes from two sources of plausibly exogenous variation: *(i)* changes in the alphabetical composition of the Senate over time, and *(ii)* within-Congress variation in the set of senators who participate in a given roll call. Focusing on either source produces qualitatively equivalent results.

In the second part of the paper, we develop a simple game-theoretic model of "parties as teams," which, by appealing to backward induction, has the potential to explain the previously unknown set of facts. In our model, senators have both instrumental preferences over policy outcomes and expressive preferences over their recorded votes. We assume that senators from the same party have similar instrumental interests, i.e., they prefer the same set of bills to pass. Yet, at least some of them have conflicting expressive preferences. That is, conditional on the outcome of the vote, some senators prefer not to be on the record supporting the bill—even if they would rather see it pass than fail. Such situations may, for instance, arise if constituent interests conflict with the official party position, or when senators' personal preferences are misaligned with those of their party.

In equilibrium, a conflicted senator's behavior depends on how likely her vote is to be pivotal. At first blush it may appear that conflicted agents would benefit from voting after the choices of all others have been revealed. The model, however, shows that when preferences are common knowledge, the exact opposite is often the case. If a measure is known to have more supporters than needed, then early voters are able to reject it without affecting the ultimate outcome of the roll call. This is because voters later in the order will, if necessary, adhere to the party line in order to carry the bill to passage. As a result, forward-looking senators can free ride on their colleagues, which gives rise to a negative relationship between alphabetical rank and defection.

Example. For a simple example of this logic, consider the extensive-form game depicted in Figure 2. Party D still requires two "yea" votes for the bill to pass. All of its three remaining members, however, are conflicted. That is, they prefer to say "nay," but only if the measure ends up being approved anyway. If the senator who gets to vote first (i.e., $D1$) is forward-looking, she realizes that her fellow party members (i.e., $D2$ and $D3$) would rather abandon their own positions than be responsible for letting the bill fail. She, therefore, votes "nay," while her colleagues are forced to vote "yea."

At its core, our theory builds on the game-theoretic idea that agents backward induct in order to anticipate the actions of others (Kuhn 1953; Selten 1965; von Neumann and Morgenstern 1944). To learn more about backward reasoning in this important real-world setting, in the third part of the paper we structurally estimate our model. Our findings are two-fold: First, the data clearly favor the null hypothesis of backward induction over the alternative of nonstrategic play. Second, there is a great amount of heterogeneity in senators' reliance on backward reasoning. Taking our results at face value, about 32% of senators appear to explicitly account for the expected behavior of those who have not yet voted, while the behavior of another 16% is best described by a heuristic that crudely resembles the backward induction strategy. The remaining senators do not engage in forward-looking, strategic play. Interestingly, ancillary results suggest that senators become more likely to preempt their colleagues after having participated in a few hundred roll calls.

In the fourth part of the paper, we explicitly discuss two alternative mechanisms that might also give rise to negative vote-order effects. The first alternative is based on theories of herding and learning about common values (e.g., Ali and Kartik 2012; Banerjee 1992; Bikhchandani et al. 1992; Callander 2007; Welch 1992). According to this explanation, senators exercise hindsight rather than foresight. Intuitively, senators might be uncertain as to the best position to take on a particular bill, which is why they may look to the votes of others to inform their own decision. If legislators interpret the choices of copartisans who voted before them as cues, then agents toward the end of the alphabet have received a greater number of signals. They should thus be more likely to ignore their private information and vote with the majority of their own party.

We empirically test for herding and learning about common values by asking whether a senator's choice is more strongly correlated with the preceding votes of her colleagues than one would expect under the null hypothesis of no cue taking. The answer turns out to be "no." That is, we find no evidence of herding.

The second alternative mechanism we consider is vote buying (Dal Bo 2007; Dekel et al. 2008, 2009; Groseclose and Snyder 1996; Snyder 1990). Vote buying by the party leadership can explain why the majority party is more likely to narrowly win a roll-call vote than to narrowly lose it—although it may also give rise to supermajorities. A vote-buying mechanism may also be consistent with senators' observed choices being a function of pivot probabilities. However, for such a theory to explain why legislators later in the vote order are more likely to support the party line than those with last names closer to the beginning of the alphabet, it would have to be the case that the party leadership is more likely to "buy off" the former.

To better understand whether rational party leaders should target senators who vote late, we extend the model of Dekel et al. (2009) to settings in which legislators vote sequentially. We show that the basic insights gleaned from their static theory carry over to the dynamic case. In particular, party leaders should target legislators who are close to indifferent, independent of the vote order. We further argue that models that emphasize decisions by the party leadership cannot easily explain why we find substantial individual-level heterogeneity in how senators respond to the possibility that their vote might be decisive, and why vote order effects only emerge after senators have participated in sufficiently many roll calls.

Our findings contribute to two separate literatures. An important body of work in behavioral economics documents that individuals in the laboratory do not properly backward induct, e.g., in ultimatum games (see Camerer 2003 for review). Most relevant for our paper are the results of McKelvey and Palfrey (1992) on the centipede game (see also Fey et al. 1996; Nagel and Tang 1998; Rapoport et al. 2003; Zauner 1999). In order to understand why observed outcomes coincide so rarely with those prescribed by backward induction, recent research has tested a host of potential explanations, ranging from cognitive limitations and failures of common knowledge of rationality to preferences for fairness and altruism (Binmore et al. 2002; Dufwenberg et al. 2010; Gneezy et al. 2010; Johnson et al. 2002; Levitt et al. 2011; Palacios-Huerta and Volij 2009). This strand of the literature typically concludes that social preferences or departures from rationality cannot fully explain the observed violations of Nash equilibrium (Binmore et al. 2002; Johnson et al. 2002).[1] Instead, failures of backward induction are, at least in part, attributed to cognitive limitations—though subjects can be taught to reason backwards (Dufwenberg et al. 2010; Gneezy et al. 2010).

While studies conducted in the laboratory have provided important insights into human decision-making, there remain inherent methodological limitations (see Levitt and List 2007). Tests of fundamental game-theoretical concepts outside of the laboratory, however, are scant.[2] It remains, therefore, unknown to which extent failures of backward reasoning generalize to other, real-world contexts.

Although our results corroborate the basic tenets of game theory more closely than one might have expected based on the extant literature, certain results from the laboratory appear to travel very well. In particular, our finding that experience makes senators more likely to engage in strategic preemption complements existing evidence according to which the behavior of professionals is often more consistent with the predictions of standard theory than that of novices (e.g., List 2003, 2004; Palacios-Huerta and Volij 2008). At the same time, legislators' low speed of learning underscores the importance of studying real-world settings in which individuals had sufficient time to accumulate experience.

We also contribute to a large literature on voting in legislatures (e.g., Levitt 1996; Londregan 2000; Krehbiel 1998; McCarty et al. 2016; Poole 2005; Poole and Rosenthal 1997; Rhode 1991; Snyder and Groseclose 2000, among many others). Theory and a variety of anecdotes suggest that politicians might act strategically in roll-call settings (see Enelow 1981; Jenkins and Munger 2003; Riker 1986; Volden 1998). Yet, thorough empirical evidence of tactical voting in Congress is almost nonexistent (see Landha 1994; Poole and Rosenthal 1997; Wilkerson 1999). To rationalize the surprising absence of evidence, Groseclose and Milyo (2010) provide a formal model in which agents vote simultaneously and strategic voting does not arise in any pure-strategy equilibrium.[3] To the best of our knowledge, our finding

[1] An important exception are the results of Palacios-Huerta and Volij (2009), who argue that failure of backward induction is due to a lack of common knowledge of rationality, and Baghestanian and Frey (2016), who replicate the findings in the former paper with GO instead of chess players.

[2] The most important exception is a growing literature on the use of mixed strategies in professional sports. While earlier work studying settings as wide-ranging as tennis serves in Wimbledon and penalty kicks in soccer cannot reject minimax play (Chiappori et al. 2002; Hsu et al. 2007; Palacios-Huerta 2003; Walker and Wooders 2001), Kovash and Levitt (2009) show that pitches in Major League Baseball and play choices in the National Football League exhibit too much serial correlation to be consistent with players using mixed strategies. They suggest that earlier studies' inability to reject the null hypothesis may be due to a lack of statistical power.

[3] As in our model of "parties as teams," Groseclose and Milyo (2010) assume that at least some legislators

that senators' choices depend on the probability of casting a pivotal vote is one of the first systematic pieces of evidence to suggest that tactical voting is, in fact, widespread.[4] Our work, therefore, helps to better understand legislators' calculus of voting and, as a result, the genesis of public policy.

2. Roll-Call Votes in the U.S. Senate

Article I of the Constitution states that "each House shall keep a Journal of its Proceedings, and [...] the Yeas and Nays of the Members of either House on any question shall, at the Desire of one fifth of those Present, be entered on the Journal."[5] According to the Rules of the Senate, a senator who has the floor may, at any time, ask for the Yeas and Nays on the bill, motion, amendment, etc. that is currently pending. If at least 11 senators (i.e., one fifth of the minimal quorum) raise their hands in support of the request, then the eventual vote on the issue will be conducted by calling the roll, with each senator's vote being recorded. Although a roll-call request has no effect on when the issue will be voted upon, the low requirement for ordering the Yeas and Nays, coupled with the fact that senators often care intensely about their track record, means that the Senate decides most controversial issues by roll-call votes.[6]

Regarding the manner in which roll calls are to be conducted, Rule XII of the Senate requires that

> "when the yeas and nays are ordered, the names of Senators shall be called alphabetically; and each Senator shall, without debate, declare his assent or dissent to the question, unless excused by the Senate; and no Senator shall be permitted to vote after the decision shall have been announced by the Presiding Officer, but may for sufficient reasons, with unanimous consent, change or withdraw his vote."

In practice, when the time to vote has come, the presiding officer announces that "the Yeas and Nays have been ordered and the clerk will call the roll." The clerk then calls senators in alphabetical order. Senators who are present declare their choice. Following the initial call of the roll, the clerk recapitulates the vote by respectively identifying those who voted "yea" and "nay." Senators who were absent when their name was first called, but have since

have "position taking" (i.e., expressive) concerns that differ from their policy preferences. In subsequent work, Groseclose and Milyo (2013) allow legislators to vote sequentially, which leads them to conclude that, in such settings, strategic voting may be part of equilibrium play.

[4]For recent studies attempting to estimate the extent of strategic voting among ordinary citizens, see Kawai and Watanabe (2013) and Spenkuch (2015). For evidence on voter rationality and strategic sophistcation in the laboratory, see, e.g., Dal Bo et al. (2017).

[5]In describing the voting procedures in the Senate, this section borrows heavily from Rybicki (2013).

[6]Neither voice nor division votes are recognized by the Rules of the Senate. They are permitted by precedent. In practice, division votes are very rare and voice votes are almost exclusively used on uncontested questions. Sometimes these are even decided "without objection" and without a formal vote.

arrived on the floor, are allowed to go to the rostrum and still cast their vote. The clerk calls their name, and repeats the senator's choice. Usually, the presiding officer announces the decision fifteen minutes after the beginning of the roll call—though votes are sometimes kept open longer for more senators to hurry to the floor. On average, senators participate in about 85% of calls.

It is important to note that, on the majority of roll calls, a nonnegligible number of senators arrive on the floor late, i.e., after the clerk first called their name. Consequently, the actual order in which votes are submitted is not strictly alphabetical. Nevertheless, changes in the alphabetical composition of the chamber do provide quasi-random variation in the order in which senators were first allowed to cast their votes. That is, a senator whose last name starts with the letter "A" can always announce her decision before a colleague whose last name starts with a "Z."

3. A First Look at the Data

3.1. *Data Sources and Summary Statistics*

Our analysis uses data on all roll-call votes in the U.S. Senate since the emergence of the two-party system, i.e., from the beginning of the 35th until the end of the 112th Congress (1857–2013). The data contain senators' names, party affiliation, and final votes. They come from the Congressional Record and have been transcribed by Keith Poole and coauthors.[7]

Table 1 presents descriptive statistics. On average, about 95.5 distinct senators serve in a given Congress, participating in almost 512 roll calls per two-year period—though the latter number varies widely over time. According to the definition in Snyder and Groseclose's (2000) seminal work on party influence, about half of the almost 40,000 roll calls in the data end up being "lopsided" in the sense that more than 65% or less than 35% of senators vote "yea."[8] The remaining half is said to be contested, or "close." Approximately 56% of roll calls are divisive. That is, the majority of senators from one party takes a position opposite from that of the majority of the other party.

In total, the data consist of almost 2.9 million individual votes, of which about 18.4% go against the party line. More precisely, senator i's vote is said to deviate from the party line whenever it does not coincide with the majority of others from the same party (not counting i herself). The intuitive appeal of this definition is based on the idea that, on average, the positions of copartisans should be aligned. That is, senators' own preferences and their

[7] For defintions as well as additional information on the sources of all variables used throughout the analysis, see Appendix XXX.

[8] For votes that require a supermajority, e.g., treaties and cloture votes, the corresponding cutoffs are 51.7% and 81.7% (i.e., 66.7% ± 15%). Data on supermajority requirements come from Snyder and Groseclose (2000) and have been manually extended through the 112th Congress.

party's stance are likely highly correlated. Thus, looking at i's colleagues provides a way to gauge whether a given bill, amendment, etc. is popular within her party, while avoiding endogeneity issues arising from i's choice itself.[9] Alternative definitions of the party line might, for instance, be based on the votes of party leaders or the parties' whips. Reassuringly, they lead to qualitatively similar results.[10]

3.2. *Descriptive Analysis*

Focusing on members of the Democratic and Republican Parties, Table 2 presents our main empirical finding. The numbers therein are based on the following econometric model:

$$d_{i,p,r,c} = \mu_i + \lambda o_{i,r,c} + \varepsilon_{i,p,r,c}. \tag{1}$$

Here, $d_{i,p,r,c}$ is an indicator variable equal to one if senator i deviated from the party line on roll call r during Congress c, μ_i marks a senator fixed effect, and $o_{i,r,c}$ denotes i's alphabetical percentile ranking among her colleagues. That is, $o_{i,r,c}$ takes on a value of zero for the senator whom the clerk calls first, whereas it is one for the agent whose surname ranks her last.[11]

The coefficient of interest is λ. It measures by how much the opportunity of voting earlier affects the probability that senators adhere to the party line. By including μ_i, all of our specifications control for agents' idiosyncratic tendencies to deviate from the majority position of their own party. Put differently, senator fixed effects account for the fact that surnames themselves are unlikely to be as good as randomly assigned. For instance, names are known to be indicative of ethnicity and social class (see, e.g., Bertrand and Mullainathan 2004; Fryer and Levitt 2004). In fact, names even contain information about partisanship. Looking only at the first letters of senators' last names, a χ^2-test rejects the null hypothesis that their distribution is the same for Democrats and Republicans ($p < .01$). We, therefore, control for senators' intrinsic disposition.

Identification in our setup comes from two sources of plausibly exogenous variation: *(i)* changes in the alphabetical composition of the Senate over time (most of which is due to the replacement of retiring senators or those who fail to get reelected), and *(ii)* within-Congress variation in the set of senators who participate in a given roll call (e.g., because

[9] The most important downside of this method of inferring the party line is that it is undefined whenever there are exactly as many "yeas" as there are "nays" among a senator's colleagues. This is the case for about 1.4% of observations, which are consequently discarded.

[10] Appendix Table A.2 replicates the papers' main descriptive finding for alternative definitions of the party line. An important disadvantage of defining the party line by how the party leadership votes is that, for procedural reasons, the majorty-party leader sometimes votes *against* a bill that he in actuality supports. Another disadvantage is that parties did not adopt today's leadership system until the late 1910s, which renders earlier data unusable.

[11] Formally, $o_i \equiv \frac{s_i - 1}{S - 1}$, where S denotes the number of senators and s_i is i's raw alphabetical rank.

other senators were not on Capitol Hill when roll call r was held, or because they abstained due to a conflict of interest). That is, conditional on having a particular last name, senator i is allowed to vote earlier on some roll calls than on others because a colleague who ranked ahead of her in the alphabet was replaced by someone whose last name comes after hers, or because another colleague happened to be absent on a particular day.

The results in the first three columns of Table 2 are based on alphabetical rank among senators who participated in a particular roll call, whereas the ones in the remaining three columns use the order of all senators who officially served in Congress at the time when roll call r was conducted. Within each set of regressions, the leftmost estimates control for senator fixed effects, while the ones in the middle and rightmost columns include senator-by-Congress fixed effects. The estimate in column (1), therefore, exploits both within- and across-Congress variation in roll call–specific alphabetical rank, while the ones in columns (2) and (3) rely solely on the former. By contrast, the results in columns (4)–(6) discard any variation arising from senators not participating in some roll-call votes. Instead, identification comes from changes in the alphabetical composition of the chamber over time. Column (3) allows for both across- and within-Congress changes, whereas columns (5) and (6) use only the latter (i.e., variation due to deaths, expulsions, or sudden departures for other reasons).

Our specifications in columns (3) and (6) also control for the fraction of copartisans who deviate from the party line during the same roll call. If there are no strategic interactions between senators, then controlling for the choices of others from the same party yields more precise estimates by implicitly accounting for roll call–specific unobservables that might affect how controversial a given measure is. If there are strategic interactions, however, then the specifications in columns (3) and (6) include an endogenous control variable, which will generally bias the coefficient of interest (cf. Cameron and Trivedi 2005, ch. 4). In Appendix XXX, we derive an analytical expression for the bias. Assuming that preference shocks are conditionally independent of the voter order, our derivations imply that if the true average vote order effect is negative, and if, on average, defection by one senator crowds out defections among her copartisans, then the point estimates in columns (3) and (6) are upward biased (see the appendix for technical details). In the next section, we develop a model of "parties as teams" in which senators strategically preempt each other. The theory is consistent with these conditions and, therefore, with the observed changes in the coefficients. By contrast, for the estimates in the remaining columns to be biased, one would have to believe that changes in senators' views on a bill are systematically correlated with whether they get to vote earlier or later than usual.[12]

[12]Technically, strict exogeneity, i.e., $E\left[d_{i,p,r,c}|o_{i,1,c}, o_{i,2,c}, ..., o_{i,R,c}, \mu_i\right] = E\left[d_{i,p,r,c}|o_{i,r,c}, \mu_i\right] = \mu_i + \lambda o_{i,r,c}$, ensures consistency of the estimator with senator fixed effects (cf. Wooldridge 2002, ch. 10). This requires that the position in which a senator gets to vote in *other* roll calls does not partially correlate with his

Importantly, all point estimates in Table 2 are negative and statistically significant at conventional levels. In fact, the estimate based on the least amount of potentially suspect variation, i.e., the one in column (5), is the most negative of all. At the same time, it is also the least precisely estimated. Taking the 95%-confidence intervals implied by the standard errors in Table 2 at face value, one can reject neither large nor small effects of senators' alphabetical ranking on the probability of defection. Nevertheless, the evidence in Table 2 does imply that the opportunity to vote early causes senators to deviate from the party line.[13]

Figure 3 presents results from a placebo test. Specifically, we randomly reassign senators' names and reestimate equation (1) based on the newly induced ordering. Repeating this process sufficiently many times, we compare our preferred point estimate from column (1) in Table 2 to the distribution of placebo coefficients. As one might expect, we find that the median placebo estimate is approximately zero. More importantly, 98.4% of them are larger than the true coefficient, which suggests that our finding in the previous table is unlikely to be due to chance.[14]

In Table 3, we show that vote-order effects in the Senate are driven by "close" rather than "lopsided" roll calls. We also establish that there are no corresponding effects in the modern House of Representatives, where, after the introduction of electronic voting machines, alphabetical roll calls have become obsolete. In electronic "roll calls," there exists no predetermined order in which legislators get to cast their vote. Any congressman is allowed to submit his choice as soon as the vote has been opened. Reassuringly, the point estimates for the House show no systematic correlation between defection and alphabetical rank. In fact, two of the six coefficients even have the "wrong" sign, and none of them are statistically significant.[15]

contemporaneous choice.

[13]There exists the possibility that the results in columns (1)–(3) are affected by selective abstention. For the point estimates in the these columns to be biased, it would have to be the case that abstention is concentrated in certain parts of the vote order and correlated with *other* senators' propensity to deviate from the party line. To assuage concerns about selective abstention driving our results, we show in Appendix Table A.3 that the point estimates become, if anything, more negative when we restrict attention to roll calls with greater levels of participation.

[14]Appendix Figure A.1 replicates this placebo test based on the specification in colum (3) of Table 2. The results are qualitatively identical.

[15]For additional context, when a recorded vote is held in the House, congressmen typically have fifteen minutes to cast their votes by inserting an identification card into one of forty voting stations distributed throughout the House floor and pushing a button corresponding to "yes," "no," or "present." There is no prespecified order. If a member votes yes (no) on the issue under consideration a green (red) light is illuminated next to her name on a large "scoreboard" mounted above the Speaker's chair. If she votes "present," a yellow light goes off instead.

Before the introduction of voting machines during the 93rd Congress, recorded votes were held by orally calling the roll, but they were not permitted in the Committee of the Whole, the form in which the House

Next, we examine the frequency with which the majority party in the Senate wins close roll calls. Using McCrary's (2008) discontinuity test, Figure 4 shows that there exists a large discontinuity around a winning margin of zero, which is statistically significant ($p < .001$).[16]

In sum, our analysis of sequential roll-call votes in the U.S. Senate documents three empirical regularities. First, the majority party is considerably more likely to barely win a roll-call vote than to just lose it. Second, senators who, by virtue of their last name, get to vote earlier in the order are more likely to deviate from the party line than their colleagues who get to vote late. Third, the vote order affects the choices of senators only on roll calls that end up being close.

4. Parties as Teams

In this section, we present a simple model of sequential voting that, by appealing to backward induction, has the potential to rationalize these findings. The theory is closely related to that of Groseclose and Milyo (2013) and to the dynamic free-riding problem in Iaryczower and Oliveros (2015).

Primitives. Let there be a finite set of senators, $i = 1, 2, \ldots, S$, who can either vote "yea" or "nay." Each of them belongs to one of two parties, Democrats (D) or Republicans (R). The Democratic Party is in the majority, i.e., $|D| > |R|$. It supports the bill that is currently under consideration. The Republican Party, on the other hand, would like to see it fail. Passage of the measure requires strictly more "yeas" than "nays."

Members of both parties derive expressive utility directly from how they vote. In line with the standard, spatial model of voting, we let $\overline{x}$ and $\underline{x}$ denote the "yea"- and "nay"-positions on the bill, with $\overline{x} < \underline{x}$. It is useful to think about $\overline{x}$ and $\underline{x}$ as the conservativeness of the policy proposed in the bill and the policy that would obtain if the measure fails, respectively. We further assume that senators evaluate both positions according to the distance from their personal ideal point x_i. These ideal points might arise because senators themselves are ideological (Levitt 1996), or because they are being held accountable by their constituents (Mayhew 1974). Specifically, we assume that $U_i(\overline{x}) = -(x_i - \overline{x})^2$ and $U_i(\underline{x}) = -(x_i - \underline{x})^2$.

In addition to their position-taking utility, agents also have instrumental preferences. That is, they value whether or not the bill ultimately passes. Such instrumental preferences might be due to concerns about their party's reputation or "brand" (Downs 1957; Snyder and Ting

ordinarily operates to debate and vote on amendments. As a consequence, congressmen voted on many issues in anonymity and not in alphabetical order (cf. Koempel et al. 2008). In 1970, for instance, the House used voice, division, or teller votes on issues ranging from a measure to exempt potatoes from federal marketing orders to American troops in Cambodia, the antiballistic missile system, and school desegregation (cf. Congressional Quarterly 1971).

[16] This result holds regardless of whether the Vice President belongs to the majority party, although the estimated discontinuity is smaller when he does not (cf. Appendix Figure A.2).

2002), or because party elites exert pressure on rank and file members (Rhode 1991; Snyder and Groseclose 2000). Thus, irrespective of how a given senator votes herself, all Democrats receive utility $\delta_D > 0$ if the bill passes, whereas Republicans incur a penalty of $\delta_R < 0$.

Without loss of generality, define $\alpha_i \equiv U_i(\overline{x}) - U_i(\underline{x})$ and normalize each agent's utility from voting "nay" when the bill is rejected to zero. The following 2×2 matrix summarizes senators' payoffs, depending on their party affiliation $p \in \{D, R\}$.

	bill passes	bill rejected
vote "yea"	$\alpha_i + \delta_p$	α_i
vote "nay"	δ_p	0

The important point to note is that, conditional on the overall outcome of the roll call, all senators would like to follow their position-taking preferences, i.e., vote "yea" whenever $\alpha_i > 0$. If their vote ended up being pivotal, however, then senators for whom $\alpha_i\delta_p < 0$ and $|\alpha_i| < |\delta_p|$ would be better off by voting against their expressive preferences and with the party line instead.[17] We say that these agents are "conflicted."

Timing & Information. Senators publicly announce their choice in the order of their exogenously determined index. The vote order as well as individual senators' payoffs are common knowledge. Although the latter assumption is unlikely to be literally correct, senators do interact frequently and parties often hold straw polls in advance of important votes. We would, therefore, expect agents to be rather well-informed about each other's preferences.

The substantive implication of the common knowledge assumption is that forward-looking senators do not only know the current vote count, but by using backward induction they can perfectly predict the choices of their colleagues who have not yet voted. In our structural estimation in Section 5, we relax this assumption. For now, however, we abstract from uncertainty, as analyzing a finite extensive-form game with perfect information significantly simplifies the exposition.[18]

Equilibrium. We focus on subgame-perfect Nash equilibria (SPNE). Generically, the game above admits a unique SPNE, which is in pure strategies. To see this, consider the senator who votes last. Having observed all previous votes, she knows whether or not her vote will be pivotal. Generically, $\alpha_i \neq 0$ and $|\alpha_i| \neq |\delta_p|$, which implies that it is not optimal

[17] Consistent with Ali and Kartik (2012), our notion of pivotality is dynamic in that senators evaluate the possibility that their choice affects the outcome of the vote, taking into account the best responses by later players. Thus, roll calls that are *ex post* decided by more than one vote—and hence would be unaffected by an *ex post* vote change—might nevertheless have had many dynamically pivotal moments.

[18] Another reason to abstract from uncertainty is that it would work *against* finding negative vote-order effects in the data. That is, if uncertainty about preferences was quantitatively important, then senators early in the order might prefer to "play it safe" rather than preempt their colleagues. In Appendix XXX, we show that if uncertainty is low enough, senators' optimal strategies coincide with those in Proposition 1.

for her to play a mixed strategy. As a consequence, the second-to-last senator also knows whether her choice changes the outcome of the roll call, which, again, results in a strictly preferred choice. Proceeding along the same lines, no player is indifferent at any node of the game tree.

For senators whose position-taking preferences are either aligned with the party line (i.e., $\alpha_i \delta_p > 0$) or dominate it (i.e., $|\alpha_i| > |\delta_p|$), equilibrium strategies are straightforward. These individuals choose "yea" if and only if $\alpha_i > 0$.

A more interesting situation arises when senators are conflicted, i.e., when $\alpha_i \delta_p < 0$ and $|\alpha_i| < |\delta_p|$. As in the example in Figure 2, these agents reason backwards to determine whether their vote will be decisive.

To formally characterize conflicted senators' strategy, we introduce the following notation. Let $Y \equiv \{i : \alpha_i > 0 \wedge (\alpha_i \delta_p > 0 \vee |\alpha_i| > |\delta_p|)\}$ and $N \equiv \{i : \alpha_i < 0 \wedge (\alpha_i \delta_p > 0 \vee |\alpha_i| > |\delta_p|)\}$ denote the sets of agents who will always vote "yea" and "nay", respectively. Further, let $\widetilde{Y} \equiv \{i : \alpha_i < 0 \wedge \alpha_i \delta_p < 0 \wedge |\alpha_i| < |\delta_p|\}$ and $\widetilde{N} \equiv \{i : \alpha_i > 0 \wedge \alpha_i \delta_p < 0 \wedge |\alpha_i| < |\delta_p|\}$ be the group of senators who would do so if (and only if) their vote was known to be pivotal. $|\cdot|_{i'>i}$ denotes the number of agents from a particular set who submit their choice after i. In addition, define $\underline{y}$ ($\underline{n}$) as the minimal number of "yeas" ("nays") required for the bill to pass (fail), and let $(\overline{y}_i, \overline{n}_i)$ be the current vote count when it is i's turn to submit his choice. All of these objects are part of senators' information set. To see this, note that previous votes are publicly observable, and that membership in Y, N, $\widetilde{Y}$, or $\widetilde{N}$ only depends on preferences, which are common knowledge. With this notation in hand, the following proposition characterizes conflicted senators' equilibrium strategy.

PROPOSITION 1: *In the unique generic subgame-perfect equilibrium of the game, Democratic senators for whom $\alpha_i \delta_p < 0$ and $|\alpha_i| < |\delta_p|$ abandon the party line if and only if $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 \neq \underline{y} - \overline{y}_i$, whereas their Republican counterparts defect whenever $|N|_{i'>i} + \left|\widetilde{N}\right|_{i'>i} + 1 \neq \underline{n} - \overline{n}_i$.*

In words, a conflicted senator counts the number of agents who have not yet voted and who would choose her party's preferred outcome, either for sure or if their vote was pivotal. If there are enough others who would go along with the party line if need be, or too few, she defects.

Empirical Implications. Proposition 1 suggests that being allowed to vote early confers an advantage because it lets forward-looking senators preempt each other. The first conflicted agent may be able to defect without rendering the roll call lost because there are enough others who can be counted on to carry the bill to passage. Subsequent senators, however, can rely on fewer and fewer of their colleagues, making it, on average, less likely that they defect.

A sufficient (but not necessary) condition for this intuition to go through and for negative vote-order effects to arise in equilibrium is that the ideal points of legislators from either party do not overlap. Under this assumption, we can prove the following propositions.

PROPOSITION 2: *Suppose that* $\max_{i \in D} x_i < \min_{i \in R} x_i$. *There exists some* $\bar{\imath} \in \{0, 1, \ldots, S\}$ *such that conflicted senators defect if and only if* $i \leq \bar{\imath}$.
Further,
(a) $1 \leq \bar{\imath} < S$ *if* $|Y| < \underline{y} < |Y| + \left|\widetilde{Y}\right|$ *or* $|N| < \underline{n} < |N| + \left|\widetilde{N}\right|$;
(b) $\bar{\imath} = 0$ *if* $|Y| < |Y| + \left|\widetilde{Y}\right| = \underline{y}$ *or* $|N| < |N| + \left|\widetilde{N}\right| = \underline{n}$;
(c) $\bar{\imath} = S$ *if* $|Y| \geq \underline{y}$ *or* $|N| \geq \underline{n}$.

IMPLICATION: *Deviations from the party line should be more common early in the vote order than at the end.*

Substantively, the first part of the proposition states that, along the equilibrium path, conflicted senators deviate from the party line if and only if they appear "early enough" in the order. The second part delineates the situations in which the vote order does and does not impose any limits on defection. Intuitively, vote order effects arise only when one side needs some but not all of its conflicted members to go along with the party line. Together with the next proposition, this implies that order effects do not occur on roll calls that end up being "lopsided."

PROPOSITION 3: *In equilibrium, the majority party wins a roll call vote if and only if* $|Y| + \left|\widetilde{Y}\right| \geq \underline{y}$. *If, in addition,* $\max_{i \in D} x_i < \min_{i \in R} x_i$ *and* $|Y| < \underline{y}$, *then the bill receives exactly as many "yea" votes as required for passage. By contrast, if* $\max_{i \in D} x_i < \min_{i \in R} x_i$ *and* $|Y| + \left|\widetilde{Y}\right| < \underline{y}$, *then, in equilibrium, the majority party falls at least* $\left|\widetilde{Y}\right|$ *votes short of winning.*

IMPLICATION: *The majority party should be more likely to barely win a roll-call vote than to just lose it.*

IMPLICATION: *Vote-order effects should only be observed on roll calls that are ex post close.*

The first implication follows from the fact that strategic defection might turn a comfortable majority into a narrow victory, i.e., it makes wins endogenously close. Its effect on losses, however, is the opposite. If a party is going to lose, then, in equilibrium, its conflicted members exacerbate the defeat by defecting.

To see the second implication, note that if the roll call does not end up being close, i.e., if the "yea" position obtains with more than the minimal majority, then it must have been the case that $|Y| \geq \underline{y}$. If a majority of senators intrinsically supports the bill, then *all* others are free to deviate from the party line, irrespective of their position in the vote order. There are, therefore, no vote-order effects on roll calls that are not endogenously close.

Our proofs of Propositions 2 and 3 depend on the assumption of nonoverlapping preferences to avoid intractable combinatorics with an arbitrary number of senators. While this restriction may appear to be very strong, a large literature in political science has produced considerable evidence to suggest that it is approximately satisfied for most of the period since the emergence of the two-party system (see Barber and McCarty 2015; Poole and Rosenthal 1997; Theriault 2008). In fact, McCarty et al. (2016) report estimates of senators' ideal points for recent Congresses that are perfectly consistent with our assumption.

Only during the middle of the twentieth century, when, by historical standards, polarization was unusually low and party labels contained less information about legislators' ideology, are nonoverlapping preferences unreasonable. At the same time, we stress that this assumption is not necessary for the model to rationalize our empirical findings. In the Online Appendix, we study all possible preference profiles in the case of five senators. We show that if all preference profiles are *a priori* equally likely, then vote order effects are on average negative. We also present simulation results for the case of one hundred players, who vote in random order. Restricting only the expected number of senators who are conflicted, we again obtain similar comparative statics. We also provide additional reduced-form evidence that supports our model.

Broadly summarizing, by appealing to backward induction our theory of "parties as teams" explains *(i)* why the majority party is much more likely to barely win a roll-call vote than to just lose it, *(ii)* why senators who appear early in the vote order are more likely to deviate from the party line than their colleagues who get to vote late, and *(iii)* why vote-order effects only arise on roll calls that end up being close.

Common Knowledge of (Ir)rationality. To arrive at these predictions, we implicitly assume that senators' rationality is common knowledge. In many games, common knowledge of rationality (CKR) is unlikely to be exactly satisfied; and even small deviations from CKR may give rise to equilibrium strategies that are dramatically different from the one prescribed by backward induction (see, e.g., Kreps et al. 1982; Reny 1992). It is, therefore, important to consider whether plausible deviations from CKR would affect the empirical implications above.

By way of example, suppose that senator $i \in D$ was conflicted but myopic. That is, she always deviates from the party line, even in situations in which her vote is necessary for the bill to pass. If this is known to all of her colleagues, then Propositions 1–3 continue to go through, only the "accounting" changes. That is, instead of being counted as part of $\widetilde{Y}$, i would now belong to N. Similarly, if senator i was conflicted but would nonetheless always vote *with* the party line, then $i \in Y$. In general, the predictions of our theory would remain unaffected by deviations from CKR as long as agents know about others' irrationality, and provided that the deviant behavior can be rationalized by an alternative set of payoffs over a senator's recorded vote and the ultimate outcome of the bill.

Instead of it being known for sure that some agents do not play the backward-induction strategy, it could also be the case that CKR fails because there is a small probability that agents make a mistake. In Appendix XXX, we consider situations in which there is uncertainty about whether conflicted senators stick with the party line. We show that when the probability of mistakes is low enough, then the backward-induction strategy in Proposition 1 remains optimal. As a consequence, the theory's empirical predictions would continue to go through.

5. A Closer Look at the 112th Congress

At its core, our model builds on the game-theoretic idea that forward-looking agents try to anticipate the behavior of others in order to maximize their own payoffs. After all, systematic preemption is predicated upon agents being forward-looking, or on behavioral rules that are ultimately based on backward-induction logic. In order to learn more about strategic foresight in this important real-world setting, we now turn to the 112th Congress (01/2011–01/2013).

5.1. *Data and Reduced-Form Evidence*

A significant limitation of existing roll-call data is that they only contain senators' final choices. While knowledge of senators' names is sufficient to reconstruct the order in which they were first allowed to submit their votes, the Congressional Record does not indicate whether a senator submitted her choice after the initial, alphabetical call of the roll, nor does it contain any information on whether a given vote was ever changed or withdrawn. In Appendix XXX, we show that allowing for vote changes in our model of "parties as teams" would not affect equilibrium behavior. Nonetheless, whether senators do, in fact, flip-flop is ultimately an emprical question.

To overcome these limitations and provide evidence that senators are not playing a game that is altogether different from the one in the previous section, we contacted the C-SPAN network and requested video recordings of all 486 roll calls conducted during the 112th Congress. Human coders watched each recording and transcribed every senator's vote, whether it was submitted during the alphabetical call of the roll, as well as any subsequent changes.

They also recorded the exact order in which votes were submitted by latecomers, i.e., after the clerk had stopped calling senators' names. A second coder rewatched the video to check the transcription for errors, ensuring that senators' final choices match the Congressional Record.[19]

To the extent that the newly collected information is generalizable, it is possible to establish the following three facts: *(i)* As only 0.5% of initial votes are ever changed or withdrawn, "flip-flopping" is quantitatively negligible. *(ii)* Consistent with the idea that senators use the opportunity to cast their vote as early as possible in order to preempt their colleagues, senators at the beginning of the alphabet are more likely to vote during the initial call of the roll than those towards the end. *(iii)* Alphabetical rank and actual vote order covary closely. Regressing the position in which a senator ended up voting on her alphabetical rank and a set of senator fixed effects produces a point estimate of 1.066 (with a standard error of .088).

Next, we provide suggestive evidence in support of the assumption that senators are more likely to support the party line when their vote might be pivotal. Relying on the actual order in which votes were cast, we group the data by the number of "yeas" and "nays" that were still required when a given senator voted (i.e., $\underline{y} - \overline{y}_i$ and $\underline{n} - \overline{n}_i$) as well as the number of copartisans who had yet to do so ($|D|_{i'>i}$ or $|R|_{i'>i}$). We then define the empirical frequency of a pivotal vote as the share of instances in which a different choice by agents who voted in the same "state of the world" would have changed the overall outcome of the roll call.

Figure 5 shows the average defection rate for each value of this crude indicator of *ex post* pivotality. Although our measure has few unique values, the data indicate a strongly negative relationship—consistent with our theory's core assumption.

5.2. *Structural Estimation*

To more rigorously assess the prevalence and importance of backward reasoning among senators, we now structurally estimate our model of "parties as teams." In doing so, we relax the assumption that payoffs are common knowledge.

Setup. Specifically, in order to accommodate the possibility that senators' views on a given bill may only be partially known to their colleagues, we let player i's position-taking utility from voting "yea" on roll call r be given by $U_{i,r}(\overline{x}_r) = -(x_i - \overline{x}_r)^2 + \epsilon^+_{i,r}$, while that from choosing "nay" is $U_{i,r}(\underline{x}_r) = -(x_i - \underline{x}_r)^2 + \epsilon^-_{i,r}$. Intuitively, the preference shocks $\epsilon^+_{i,r}$ and $\epsilon^-_{i,r}$ indicate how much senator i's valuation of a particular position differs from what would be expected based on her ideology. We posit that these differences are i.i.d. random

[19]For additional information on the coding process, see Appendix XXX.

variables that are only observed by i herself. All other elements of the game remain common knowledge.[20]

Since senators can no longer perfectly anticipate whether others will support the party line, the overall outcome of the vote is generally uncertain. Let δ be the instrumental utility associated with achieving the party's goal, and let $q_{i,r}(\overline{y}_{i,r} + y_{i,r})$ denote senator i's belief that her party's preferred position obtains. In equilibrium, this belief depends on how many "yeas" she has already observed ($\overline{y}_{i,r}$), her own vote ($y_{i,r}$), as well as the roll call specific parameters (β_r and γ_r), the ideal points of all senators voting after her ($x_{i'>i}$), and how deeply her colleagues care about winning (δ). For ease of notation, we suppress the dependence of $q_{i,r}$ on $(x_{i'>i}, \beta, \gamma, \delta)$, but note that our estimates explicitly account for it.

By individual optimization, a senator votes "yea" if and only if $U_{i\,r}\left(\overline{x}_r\right) + \delta q_{i,r}(\overline{y}_{i,r} + 1) \geq U_{i,r}\left(\underline{x}_r\right) + \delta q_{i,r}(\overline{y}_{i,r})$. Assuming that $\epsilon^+_{i,r}$ and $\epsilon^-_{i,r}$ are normally distributed with $\mathbb{E}\left[\varepsilon^+_{i,r}\right] = \mathbb{E}\left[\varepsilon^-_{i,r}\right]$ and $\operatorname{Var}\left[\varepsilon^+_{i,r} - \varepsilon^-_{i,r}\right] = \sigma^2$, the probability that i assents to the bill when $\overline{y}_{i,r}$ others have already done so is equal to

$$\text{(2)} \qquad \begin{aligned} \Pr\left(y_{i,r} = 1 | \overline{y}_{i,r}\right) &= \Pr\left(\varepsilon^-_{i,r} - \varepsilon^+_{i,r} \leq \begin{array}{c} -\left(x_i - \overline{x}_r\right)^2 + \left(x_i - \underline{x}_r\right)^2 \\ +\delta\left[q_{i,r}(\overline{y}_{i,r} + 1) - q_{i,r}(\overline{y}_{i,r})\right] \end{array}\right) \\ &= \Phi\left(\beta_r x_i + \gamma_r + \delta \Delta q_{i,r}\right), \end{aligned}$$

where $\beta_r \equiv \frac{2}{\sigma}\left(\overline{x}_r - \underline{x}_r\right)$, $\gamma_r \equiv \frac{1}{\sigma}\left(\underline{x}^2_r - \overline{x}^2_r\right)$, $\Delta q_{i,r} \equiv \frac{1}{\sigma}\left[q_{i,r}(\overline{y}_{i,r} + 1) - q_{i,r}(\overline{y}_{i,r})\right]$, and Φ denotes the standard normal CDF. Note, equation (2) parameterizes the choice probability in terms of β_r and γ_r rather than $\overline{x}_r$ and $\underline{x}_r$. Doing so is not only computationally advantageous, but β_r and γ_r also have intuitive real-world interpretations. As explained in more detail below, γ_r denotes the bill's valence (i.e., how popular the measure is regardless of senators' idiosyncratic preferences), while β_r measures its divisiveness (i.e., disagreement between senators along ideological lines).

For now, we maintain that *all* agents form beliefs about the outcome of the roll call by reasoning backwards. Thus, in equilibrium, $\Delta q_{i,r}$ is uniquely determined by $(x_{i'>i}, \beta, \gamma, \delta)$.[21]

[20] In particular, we continue to assume that agents know the order in which votes end up being cast, or, equivalently, that they can predict the outcome of whichever game determines the order of votes that are submitted after the initial, alphabetical call of the roll.

[21] To construct $q_{i,r}\left(\cdot\right)$, let $\widetilde{\delta}_i$ equal δ if i's party supports the bill and $-\delta$ otherwise. Further, let $\widetilde{q}_{S,r}\left(y\right) = \mathbb{I}\left[y \geq \underline{y}\right]$, and proceed recursively:

$$\begin{aligned} \widetilde{q}_{i,r}\left(y\right) = {} & \widetilde{q}_{i+1,r}\left(y+1\right)\Phi\left(\beta_r x_{i+1} + \gamma_r + \widetilde{\delta}_i\left[\widetilde{q}_{i+1,r}(y+1) - \widetilde{q}_{i+1,r}(y)\right]\right) \\ & + \widetilde{q}_{i+1,r}\left(y\right)\left[1 - \Phi\left(\beta_r x_{i+1} + \gamma_r + \widetilde{\delta}_i\left[\widetilde{q}_{i+1,r}(y+1) - \widetilde{q}_{i+1,r}(y)\right]\right)\right]. \end{aligned}$$

If i's party prefers the bill to pass, then $q_{i,r}\left(y\right) = \widetilde{q}_{i,r}\left(y\right)$. Otherwise, $q_{i,r}\left(y\right) = 1 - \widetilde{q}_{i,r}\left(y\right)$.

Estimation. Given the assumptions above, the likelihood is

$$\mathcal{L}(\Psi|x,\beta,\gamma,\delta) = \prod_{r=1}^{C}\prod_{i=1}^{S}\Phi\left(\beta_r x_i + \gamma_r + \delta\Delta q_{i,r}\right)^{y_{i,r}} \times \left[1-\Phi\left(\beta_r x_i + \gamma_r + \delta\Delta q_{i,r}\right)\right]^{1-y_{i,r}}, \tag{3}$$

where $x = (x_1, \ldots, x_S)$, $\beta = (\beta_1, \ldots, \beta_C)$, $\gamma = (\gamma_1, \ldots, \gamma_C)$, and Ψ denotes the data. To estimate $(x, \beta, \gamma, \delta)$ we build on the Markov Chain Monte Carlo approach of Clinton et al. (2004), who pioneered the Bayesian analysis of roll-call data. The key difference between their setup and ours is that the former assumes legislators are pure position-takers, i.e., $\delta = 0$. Thus, compared to conventional analyses of voting in legislatures, we estimate one additional parameter, which governs whether senators behave strategically (see Appendix XXX for details on our estimation procedure).

We adopt the Bayesian approach of Clinton et al. (2004) because it allows us to engage with a large literature in political science on essentially equal footing. By nesting the standard model in this literature within ours, and by using the same estimation techniques, we can rule out that our finding that senators behave strategically is due to methodological differences. In particular, below we show that the posterior probability of $\delta > 0$ far exceeds that of $\delta \leq 0$, which lets us reject the conventional wisdom of pure position-taking in favor of our model.

In our view, the most important drawback of a Bayesian analysis is that the results might be driven by the prior. To mitigate this concern and to "let the data speak" as much as possible, we only impose vague priors. Specifically, we assume that $(x, \beta, \gamma, \delta) \sim N(0, \kappa I)$, where I denotes the identity matrix and $\kappa = 25$. As the presentation of our results makes clear, the information in the data "swamps" these priors.

Identification. Before we proceed to the results, however, it is useful to discuss which features of the data are informative about different parameters. Note, in our hand-collected data for the 112th Congress, we only observe senators' votes and the order in which they were cast.

As in virtually all random utility models, the parameters in (3) can only be recovered up to some arbitrary normalizations. To set the overall scale, we let $\sigma = 1$. A peculiarity of the spatial model of voting is that we additionally need to fix the scale and directionality of senators' ideal points. This is because, for any $\varkappa \gtrless 0$, $\beta_r x_i = (\varkappa\beta_r)\left(\frac{x_i}{\varkappa}\right)$. We resolve this indeterminacy by anchoring the ideal point of Senator John Kerry (D-MA) at -1 and that of Senator John McCain (R-AZ) at 1. Hence, an ideal point of $x_i = 0$ should be interpreted as ideologically halfway between Kerry and McCain, whereas a senator with $x_i < -1$ ($x_i > 1$) would be more liberal (conservative) than the former (latter).

In the absence of strategic behavior, i.e., with $\delta = 0$, the likelihood function above is isomorphic to that of a one-dimensional latent variable or IRT model. Identification of these models has been studied extensively in the psychometrics and, to a lesser extent, the political science literature (see, e.g., Bock et al. 1988; Bollen 1989; Jackman 2001; Rivers 2003; Thurstone 1947). Poole (2000), for instance, establishes that the ordering of legislators' ideal points can be recovered without imposing parametric assumptions on the random component in senators' utility function. Peress (2012) shows that, as long as $\epsilon^+_{i,r}$ and $\epsilon^-_{i,r}$ are i.i.d., nonparametric identification extends to the cardinal case and encompasses (x, β, γ).

To build intuition for how the parameters in our model depend on the data, first focus on a set of "lopsided" votes—as in Snyder and Groseclose (2000). Since the outcome of these roll calls is never truly in question, senators' choices are effectively determined by their position-taking preferences, i.e., $\delta \Delta q_{i,r} \approx 0$. When legislators decide on the same set of issues, then those who tend to vote alike must have similar ideal points. Given the normalizations above, senators who often vote with John Kerry will have negative ideal points, whereas senators whose choices align with those of John McCain will have positive x. A senator will be placed to the left (right) of Kerry (McCain) if she disagrees even more frequently with McCain (Kerry) than Kerry (McCain) does. Thus, even if senators are (differentially) strategic, it is still possible to infer their ideal points from the covariance of their choices on "lopsided" votes.

Next, consider the roll call–specific parameters γ and β, which denote the bill's valence and partisan divisiveness, respectively. A measure that receives many "yeas" from *both* sides of the aisle must have high valence and relatively low divisiveness. By contrast, roll calls that split neatly along partisan lines must have low γ and a high absolute value of β. Whether the latter is positive or negative depends on which of the parties supports the bill.

Lastly, δ depends on two features of the data. First, conditional on the intensity of a senator's position-taking preferences (i.e., the value of $\beta_r x_i + \gamma_r$), is she more likely to support the party line during a "close" roll call than a "lopsided" one? Second, comparing the votes of different legislators on the same bill, are senators less likely to defect when, due to the vote order, their own vote stands a higher chance of being decisive? If so, then δ is positive.

More precisely, δ depends on the covariance between $\Delta q_{i,r}$ and senators' choices, conditional on their preferences and the roll call specific parameters. Since Δq itself is a function of $(x, \beta, \gamma, \delta)$, this part of our model is highly nonlinear. These nonlinearities are a direct result of the theory, i.e., backward induction, and provide additional identification.

The preceding arguments help to clarify which patterns in the data allow us to draw inferences about different model parameters. Intuitively, our Bayesian approach treats all parameters as random variables, subject to the equilibrium constraints imposed by the game.

Using Bayes Rule, it combines our diffuse priors with the information in the data to obtain the posterior distribution of $(x, \beta, \gamma, \delta)$. By construction, the posterior summarizes all available information about these unknown quantities.

5.3. *Results*

Baseline. Figure 6 plots the posterior mean of senators' estimated ideal points against the first dimension of Poole and Rosenthal's (1997) DW-Nominate scores, the most widely used index of legislators' ideology. Although the two measures are based on different modelling assumptions, their rank-order correlation exceeds .9. This finding is consistent with the idea that senator's ideological ideal points are mainly identified from lopsided votes, for which the predictions from our theory coincide with those from standard approaches to ideal point estimation.

To speak to the question of whether senators exhibit strategic foresight, we turn to the posterior distribution of δ. According to our theory of "parties as teams," senators engage in backward induction to optimally decide between pursuing their instrumental and position-taking goals. If senators actually have instrumental preferences *and* if they are forward-looking, then δ should be positive. We, therefore, evaluate the null hypothesis $H_0 : \delta > 0$ against the alternative $H_1 : \delta \leq 0$. The latter encompasses the assumption of pure position-taking, which underlies almost all analyses of roll-call voting in the political science literature.

Figure 7 depicts the marginal posterior of δ (solid line) relative to its prior (dashed line). Reassuringly, the posterior is considerably more concentrated, suggesting that the data rather than the prior are driving our results. Most importantly, positive values account for 96.4% of probability mass. As a consequence, the posterior odds of H_0 versus H_1 are $\frac{\Pr(H_0|\Psi)}{\Pr(H_1|\Psi)} \approx 26.8$, which leads us to conclude that there is strong evidence of strategic behavior in the U.S. Senate.[22]

Extended Model. Next, we relax the assumption that all senators are equally strategic and sophisticated. In particular, we differentiate among three distinct types of players: *(i)* nonstrategic ones, *(ii)* rational ones, and *(iii)* senators who are strategic but not fully rational in the sense that they rely on a behavioral heuristic that crudely resembles the backward-induction strategy in Proposition 1.

Specifically, we assume that the third type does not explicitly contemplate the likely behavior of others. Instead, these senators use a mental shortcut that compares the number of copartisans who have yet to submit their vote with the number of "yeas" or "nays" that are still required for their party's preferred outcome to obtain. If the former falls short of

[22] Since we have no substantive interest in the roll call–specific parameters (β, γ), we relegate the presentation of these results to Appendix Figures A.18 and A.19.

the latter by exactly one, then agents who rely on this heuristic believe that their own vote is going to be decisive. Otherwise, they conclude that their choice has no effect on the ultimate outcome of the roll call.[23] By contrast, nonstrategic senators act without any regard for whether their vote might be pivotal. This may either be because they are myopic (i.e., unable or unwilling to reason backwards), or because their preferences lack the instrumental component (i.e., they always vote expressively).[24]

We constrain the irrational types to use the strategies outlined above, whereas rational senators fully internalize the presence of both behavioral types and choose optimally by using backward induction. The structure of the sequential game is otherwise the same as in our baseline model, and we continue to study the game's SPNE. Assuming that senators' types are common knowledge, and letting π_1, π_2, and π_3 denote the population share of each, the likelihood is given by

$$(4) \qquad \mathcal{L}\left(\Psi|x,\beta,\gamma,\delta\right) = \prod_{r=1}^{C}\prod_{i=1}^{S}\sum_{t=1}^{3}\pi_t\Phi\left(\beta_r x_i + \gamma_r + \delta\Delta q_{i,r,t}\right)^{y_{i,r}} \times \left[1-\Phi\left(\beta_r x_i + \gamma_r + \delta\Delta q_{i,r,t}\right)\right]^{1-y_{i,r}},$$

where $\Delta q_{i,r,t}$ refers to senator i's subjective probability of casting a pivotal vote when she reasons like type t.[25] Since we have no strong *a priori* information on the prevalence of types, we impose a symmetric Dirichlet prior with parameters $a_1 = a_2 = a_3 = 1$. That is, our prior is that (π_1, π_2, π_3) are uniformly distributed over the unit simplex. In light of the evidence from our baseline model, we restrict δ to be weakly positive and the same across senators.

Ruling out heterogeneity in δ is a very strong assumption that is unlikely to be literally correct. Its principal implication for our results is that we cannot distinguish between senators who lack the mental capacity to reason backwards and those with minimal concerns about the outcome of the roll call. Both kinds of legislators behave "as if" $\delta\Delta q = 0$, which means

[23] Put differently, agents who reason according to this heuristic expect that all senators follow the party line if need be.

[24] Our approach of addressing heterogeneity by introducing differentially sophisticated "types" is similar to that in the literature on level-k thinking (see, e.g., Gill and Prowse 2016 or the review of Crawford et al. 2013), with the important difference that the "heuristic type" in our analysis is typically not accomodated by the aforementioned framework.

[25] More specifically, let $|P|_{i'>i}$ denote the number of senators who vote after i and whose party supports the bill. For senators who rely on the heuristic described above,

$$\Delta q_{i,r,3} = \begin{cases} 1 & \text{if } |P|_{i'>i} + 1 = \underline{y} - y \\ 0 & \text{otherwise} \end{cases},$$

whereas $\Delta q_{i,r,1} = 0$ for type-1 agents. The beliefs of legislators who reason backwards, i.e., $q_{i,r,2}$, continue to be defined as in the construction in footnote 21, replacing $\Delta\widetilde{q}_{i+1,r}$ with $\Delta\widetilde{q}_{i+1,r,t}$.

that they will be both be classified as type 1, i.e., as "nonstrategic."[26]

Conditional on the other model parameters, the type shares are linked to the data directly via Bayes Rule. To see this, consider the case of a single senator voting "yea" on a particular bill. After observing this vote, the probability that senator i is of type k, i.e., $t_i = k$, is given by

$$\Pr(t_i = k | y_{i,r} = 1, x, \beta, \gamma, \delta) = \int \frac{\tilde{\pi}_k \Phi_{i,r,k}}{\sum_{s=1}^{3} \tilde{\pi}_s \Phi_{i,r,s}} dF(\tilde{\pi}), \tag{5}$$

where $F(\tilde{\pi})$ denotes the prior over the random variables (π_1, π_2, π_3). When the vote is close, it will generically be the case that $\Phi_{i,r,t} \neq \Phi_{i,r,t'}$ for some $t \neq t'$, which means that a senator's choice contains information about her type. To arrive at the posterior over population shares, we need to consider an agent's entire vote profile in equation (5) rather than a single choice, and properly aggregate over all senators.

Interestingly, senators' estimated ideal points remain virtually unaffected when we allow for heterogeneity in strategic sophistication (cf. Appendix Figure A.14). The posterior distribution of δ, however, shifts markedly to the right. As shown in Figure 8, once we account for the possibility that some agents may not be strategic, the posterior mean of δ increases to 6.15. To put this number into perspective, consider a senator who, based on her ideology, would be expected to assent to a bill with probability $\Phi(3) = .999$. A value of $\delta \approx 6$ implies that if her party opposes the measure and she knows her vote to be pivotal, then that same senator will now *reject* the bill with probability .999.[27]

At the same time, the evidence suggests that many legislators are not strategic and fully rational. Figure 9 depicts the posterior of π_1, π_2, and π_3. Taking the posterior means at face value, almost 52% of senators are nonstrategic. Another 16% are estimated to rely on the heuristic described above, while 32% of agents are strategic and actually reason backwards.

To be clear, there are potentially many types of players, and our structural model distinguishes only three of them. Nevertheless, we believe that even such a crude differentiation is useful because the estimated type shares are informative about the prevalence of broad classes of behavior.

For instance, we do not claim that nearly a third of senators engage in exact backward

[26]Note, a posterior over (π_1, π_2, π_3) and δ could, in principle, be estimated separately for each senator. However, since the behavior of agents who lack the mental capacity to reason backwards and those with no concerns about the outcome of the roll call is observationally equivalent, the only way to discriminate between myopic and purely expressive senators would be to either lean heavily on the prior, or to impose additional parametric restrictions on the population distribution of δ.

[27]The robustness checks in Appendix XXX show that the results from our extended model are not very sensitive to reasonable alternative priors.

induction. However, for Bayes Rule to assign considerable mass to π_2 rather than π_3 or π_1, it must be the case that the choices of these legislators are more consistent with explicit backward reasoning than either of the alternatives. That is, these senators are forward-looking and consider the likely behavior of at least a few others who have not yet voted—above and beyond what could be inferred based on party affiliation alone. It is this type that most closely resembles the idealized rational economic agent.

By contrast, senators whose conduct is best described by the mental shortcut above do not react to the likely actions of others, although they do behave with an eye toward the future. These types realize that the outcome of the roll call depends on who has yet to vote, but they lack the sophistication to account for uncertainty in the choices of other players.

Still, game theory provides a useful tool to understand even these senators' behavior. After all, without strategic interactions there would be no preemption and no (attempted) free riding, both of which are reflected in this type's choices. Only when it comes to nonstrategic agents would a game-theoretical model lead us astray.

Ancillary Results. To speak to the question of what predicts strategically rational behavior, we calculate the mean posterior probability that each agent enages in backward induction. We then regress these probabilities on a parsimonious set of individual-level characteristics and present the results in Table 4. Although our estimates are very noisy—in part because only 102 senators served during the 112th Congress—there is some evidence to suggest that agents with little to no prior experience in roll-call settings are less likely to reason backwards.

In Figure 10, we return to all roll-call votes since the emergence of the two-party system and study whether experience correlates with whether senators engage in preemption. The results are based on the empirical model in equation (1), but allow for the impact of alphabetical rank, i.e., λ, to vary with the number of votes in which a senator had already participated at the time a given roll call was held.

For senators who have fewer than a thousand votes under their belt, there is no evidence that they preempt their colleagues when they are allowed to vote earlier. Not only are the respective point estimates jointly insignificant ($p = .765$), but each of them is rather close to zero. By contrast, estimates for agents who have participated in more than a thousand previous calls are large and statistically significant. Furthermore, it is possible to reject the null that the least experienced senators (i.e., those who have cast fewer than a hundred roll call votes) react at least as strongly to alphabetical rank as the most experienced ones, i.e., those who have voted more than 5,000 times before ($p = .037$). Even senators with the experience of 500 to 1,000 calls appear to react less to the opportunity to vote early than their colleagues with more than 5,000 previous votes ($p = .045$). Exploiting the fact that senators vote on more bills in some Congresses than in others, Appendix Figure A.3 shows that these patterns are qualitatively robust to conditioning on the time a senator has served. This suggests that it is not seniority, but experience with the game, that leads agents to preempt each other.

6. Alternative Explanations

Although the evidence above supports the idea that strategic voting coupled with backward reasoning is an important part of equilibrium play, we now discuss two alternative mechanisms that might also give rise to our main finding of negative vote-order effects.

6.1. *Herding and Learning about Common Values*

The first alternative is based on theories of herding and learning about common values (e.g., Ali and Kartik 2012; Banerjee 1992; Bikhchandani et al. 1992; Callander 2007; Welch 1992). At its core, this explanation assumes that legislators are uncertain about whether supporting a particular bill is in their own best interest. They, therefore, resort to the choices of others to inform their decisions. The key idea in this class of models is that herding may occur because the votes of earlier senators are informative about copartisans' (common) best course of action. Intuitively, whenever senators look at fellow party members for cues, learning about common values leads to positive serial correlation in choices. Moreover, given that those who vote later in the order observe a greater number of their colleagues, they will, on average, have a more precise posterior. Later voters should thus be more likely than earlier ones to ignore their private information and go with the majority position in their own party.

Our empirical test of this mechanism probes the prediction that a senator's own choice depends causally on those of her colleagues who have already voted. In particular, we estimate

$$y_{i,p,r} = \mu_i + \theta \overline{y}_{<i,p,r} + \chi_{i,p,r} + \eta_{i,p,r}, \tag{6}$$

where $y_{i,p,r}$ is an indicator variable for whether senator i voted "yea" on roll call r, $\overline{y}_{<i,p,r}$ denotes the share of her copartisans who did so before it was i's turn, and μ_i marks a senator fixed effect. To account for the fact that senators have not only observed a different mix of potential signals, but also differentially many, we include fixed effects for i's position in the vote order, $\chi_{i,p,r}$.

The parameter of interest is θ. It measures the effect of copartisans' observable choices on those of senator i. If there is learning about common values, then, all else equal, we would expect that a senator is more likely to say "yea" the greater the share of her colleagues who have already chosen that position. That is, $\widehat{\theta}$ should be positive.

For θ to be consistently estimated, it must be the case that the error term in equation (6) is uncorrelated with the regressors. This, however, is unlikely to be the case. Even if senator i is not taking any cues, she is likely to assent to the same set of bills as her colleagues voting before her—simply because members of the same party tend to have similar preferences (Krehbiel 1993). Unobserved heterogeneity in the popularity of bills may, therefore, lead to spuriously positive estimates of θ.[28]

Thus, instead of asking whether $\widehat{\theta}$ is statistically distinguishable from zero, we ask whether it is larger than one would expect under the null hypothesis of no cue taking, conditional on bill characteristics. If not, we are forced to conclude that the data are consistent with the null.

To obtain the distribution of the estimator under the null hypothesis, we build on an idea in Scheinkman and LeBaron (1989) and resort to placebo techniques (see also Efron 1982, ch. 5). Specifically, we randomly assign senators to a particular spot in the vote order. Holding their actual choices fixed, we reestimate equation (6) after replacing the original $\overline{y}_{<i,c}$ with that induced by the placebo ordering. Repeating this procedure sufficiently many times gives rise to the null distribution. By construction, "randomly reshuffling" the vote order breaks the serial dependence in senators' choices. Under the null, nonzero values of the estimator must be due to other, omitted variables or to random noise.[29]

Figure 11 shows the CDF of the placebo estimates. The upper panel relies on senators' alphabetical ordering during all roll-call votes since the emergence of the two-party system. In the lower panel, we rely on our hand-collected data on the sequence in which votes were cast during the 112th Congress. As one might expect if copartisans' preferences are highly correlated, the median of each placebo distribution is much closer to one than to zero. Strikingly, the original point estimate (depicted by the vertical line) is actually *smaller* than the vast majority of values in the respective null distribution. The evidence provides, therefore, no support for the herding mechanism.[30]

In order to demonstrate that our placebo approach is not severely underpowered, we show in Appendix XXX that it does detect negative serial correlation in defection among copartisans—as predicted by systematic preemption in our model of "parties as teams." Further, the appendix reports results from a Monte Carlo study, which suggest that this approach can detect herding in data sets considerably smaller than ours.

[28] For instance, using the House as a placebo test, we obtain an estimate of θ in excess of .9, even though congressmen generally do *not* submit their votes in alphabetical order.

[29] Among physicists, this approach is known as the method of surrogate data. It is commonly used to test for nonlinearities in time series on superfluids, brain waves, and sunspots (see, e.g., Theiler et al. 1992).

[30] Since copartisans' choices might be differentially informative, we show in the Online Appendix that senators who get to vote after their party's leader or whip are no more likely to follow the leadership's example than senators who rank ahead of them in the vote order.

Lastly, in the appendix we show that senators react to the likely choices of opponents who directly follow them in the vote order. This finding is difficult to reconcile with a learning mechanism.

6.2. *Vote Buying*

The second alternative explanation we consider is vote buying (Dal Bo 2007; Dekel et al. 2008, 2009; Groseclose and Snyder 1996; Snyder 1990). One way to think about vote buying is as one of several potential justifications for the payoff structure in our theory of "parties as teams." Suppose, for instance, that party leaders can write outcome-dependent contracts with rank-and-file members. Rather than stipulating actual cash payments—which would be illegal—such contracts may take on the form of "pork," i.e., particularized benefits written into the actual bill. Thus, at least a subset of agents would receive some benefit δ if and only if the bill passes. Note, however, for negative vote-order effects to occur in such a setting, it would still have to be the case that agents reason backwards.

Of course, if the party leadership could, it might want to offer payments that are conditional on an individual senator's choice instead of the overall outcome. The perhaps more relevant question is, therefore, whether vote buying can explain vote-order effects *without* relying on senators to backward induct. For such a theory to rationalize why agents later in the vote order are more likely to support the party line than those with last names closer to the beginning of the alphabet, it would have to be the case that, in equilibrium, the party leadership is more likely to bribe the former.

A robust prediction of traditional vote-buying models is that the legislators who are "bought off" are closer to being indifferent than those who do not receive any payments (see, e.g., Dekel et al. 2008, 2009; Groseclose and Snyder 1996; Snyder 1990). The reason is that it is cheaper to sway someone who feels less strongly about a particular issue. Thus, for conventional vote-buying theories to explain the patterns in the data without appealing to senators employing backward induction, one would have to believe that senators become more likely to intrinsically support a measure when their alphabetical rank increases.

However, existing theories do not explicitly account for the fact that senators cast their votes sequentially. It is, therefore, unclear whether the conclusions from these models do, indeed, apply to roll calls in the Senate. In an effort to better understand whether rational party leaders should target legislators who appear later in the alphabet, we have extended the model of Dekel et al. (2009) to settings in which votes are submitted in order. In Appendix XXXX, we show that the basic insights gleaned from their static theory carry over to the dynamic case. In particular, we prove that, in equilibrium, party leaders should target legislators based on their preferences and independent of the vote order.

This leaves two salient possibilities for a vote buying mechanism to explain our findings: *(i)* party leaders may be unaware of senators' preferences (and make insufficient attempts to become informed prior to the vote); or *(ii)* party leaders could be irrational. Consider, for instance, the following decision rule. Suppose the leadership chooses to acquire little to no information about the preferences of rank-and-file members. Instead of approaching the set of senators who are the "cheapest," party leaders may simply wait for the likely outcome of the roll call to become apparent, and, if they learn that the outcome is going to be close, they may pay whatever is necessary to "convince" the agents who have yet to submit their vote.

Clearly, in settings in which it is nearly costless to acquire information about preferences, such a strategy would not be optimal. Nonetheless, if party leaders did follow this or a similar behavioral rule, then vote buying would give rise to negative order effects without any reliance on backward reasoning. Yet, models that emphasize decisions by the party leadership rather than individual senators have trouble explaining why we find substantial individual-level heterogeneity in how rank-and-file members react to the probability of casting the decisive vote. Further, if party leaders have to learn about the closeness of the vote because they are unaware of rank-and-file members' preferences, then it is not clear why senators' votes depend on the likely choices of opponents who follow them in the vote order (cf. Appendix XXX). For such a dependence to arise, it has to be the case that the decision maker is well-informed about others' preferences.

7. Concluding Remarks

Notwithstanding some important exceptions involving expert players (see, e.g., Baghestanian and Frey 2016; Palacios-Huerta and Volij 2009), a large literature in behavioral economics documents that subjects in laboratory experiments do often not properly backward induct. Whether these findings generalize to other, real-world settings remains an open question.

In this paper, we study backward reasoning in the "wild," i.e., the United States Senate. Our analysis builds on the fact that the Senate holds roll calls in alphabetical order. Exploiting quasi-random variation in the alphabetical composition of the chamber over time, we document two striking facts. First, the majority party is considerably more likely to narrowly win a roll-call vote than to narrowly lose it. Second, senators who appear early in the vote order are more likely to deviate from the party line than those towards the end.

To rationalize these findings, we propose a theory of "parties as teams." Our model assumes that senators are position takers who, all else equal, would like to vote for the alternative preferred by themselves or by their constituents. Yet, senators also care about the ultimate outcome of the roll call—either because they are concerned about their party's reputation or due to the influence of party elites. For the subset of individuals whose own preferences are not aligned with the position of their party, a conflict of interest arises. They would like to defect, but only if their vote does not end up being decisive. In equilibrium, conflicted senators are able to deviate without rendering the roll call lost if they appear early enough in the vote order. Agents towards the end of the order, however, must stick with the party line to still carry the bill to passage. Since agents only defect when their own vote is going to be inconsequential, the theory predicts the relative dearth of narrow defeats for the majority. Negative vote-order effects arise because senators backward induct in order to free ride on their colleagues.

Our structural estimates imply that many, but by no means all, senators explicitly reason backwards. Given the preponderance of failures of backward induction in the laboratory, this result may be unexpected. At the same time, certain experimental results travel very well. We find that free riding and strategic preemption increase as senators gain experience, which complements existing evidence suggesting that the behavior of trained strategic players may well approach the predictions of standard theory (Baghestanian and Frey 2016; List 2003, 2004; Palacios-Huerta and Volij 2009).

More broadly, the evidence we present supports anecdotal accounts according to which politicians engage in strategic behavior during legislative votes. Our results also speak to a long-standing debate among political scientists about the extent of party influence (e.g., Krehbiel 1993; McCarty et al. 2001; Rhode 1991; Snyder and Groseclose 2000, among many others). Our findings for the 112th Congress are consistent with the notion that parties are influential enough to induce senators to follow the party line if need be. Party discipline is not strong enough, however, to prevent legislators from opposing the party's official position if the opportunity permits.

Appendix A: Main Proofs

A.1. *Proof of Proposition 1*

Our proof of Proposition 1 proceeds in two steps. First, we show that the proposed strategy is subgame-perfect. We then show that, generically, the game admits a unique SPNE.

Subgame-Perfection. To see that the stratgey specified in Proposition 1 is a Nash equilibrium, consider any node at which a conflicted Democrat chooses, and suppose that all others continue to play their equilibrium strategies.

If $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 > \underline{y} - \overline{y}_i$, then, by construction of $\widetilde{Y}$ and Y, the Democratic party will win the roll call even if senator i deviates. This is because there are enough others in $\widetilde{Y}$ who will vote subsequently and stick with the party line if need be. Put differently, if $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 > \underline{y} - \overline{y}_i$ and everybody plays their equilibrium strategies, then it can never be the case that $|Y|_{i''>i'} + \left|\widetilde{Y}\right|_{i''>i'} + 1 < \underline{y} - \overline{y}_{i'}$ for any $i' \in D$ with $i' > i$, which means that the Democrats must win. A conflicted senator anticipates this and, therefore, defects.

If $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 < \underline{y} - \overline{y}_i$, however, then the Democratic party cannot win the roll call, even if i votes "yea." This is because $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 < \underline{y} - \overline{y}_i$ implies $|N|_{i'>i} + \left|\widetilde{N}\right|_{i'>i} + 1 \geq \underline{n} - \overline{n}_i$, which in turn means that if everybody else plays their equilibrium strategies, then the Republicans can guarantee themselves victory. Since a conflicted Democrat cannot affect the overall outcome of the roll call, it is optimal to defect whenever $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 < \underline{y} - \overline{y}_i$.

If $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 = \underline{y} - \overline{y}_i$, then conflicted Senators must vote with the party line or else the roll call will be lost. By way of contradiction, suppose a conflicted Democrat voted "nay." If there is no other (conditional) "yea"-voter after i, i.e., if $\left|\widetilde{Y}\right|_{i'>i} + |Y|_{i'>i} = 0$, then defecting will immediately cause the roll call to be lost since $|Y|_{i'>i} + \left|\widetilde{Y}\right|_{i'>i} + 1 = \underline{y} - \overline{y}_i$ implies that $\underline{y} - \overline{y}_i > 0$. If there is another (conditional) "yea"-voter following i, say i', it will be the case that $|Y|_{i''>i'} + \left|\widetilde{Y}\right|_{i''>i'} + 1 < \underline{y} - \overline{y}_{i'}$ and $|N|_{i''>i'} + \left|\widetilde{N}\right|_{i''>i'} + 1 \geq \underline{n} - \overline{n}_{i'}$, which, based on the argument above, also implies that the Republican Party would win for sure. Thus, conflicted Democrats find it optimal to stick with the party line.

After replacing Y ($\widetilde{Y}$) with N ($\widetilde{N}$) and $\underline{y}$ ($\overline{y}$) with $\underline{n}$ ($\overline{n}$), the same arguments apply for conflicted Republicans. Since we considered an arbitrary node, we can start at the end of the game and proceed by backward induction to show that the strategies in Propostion 1 are subgame-perfect, as desired.

Uniqueness. Generically, it will be the case that $\alpha_i \neq 0$ and $|\alpha_i| \neq |\delta_p|$ for all players and parties, which implies that mixing is not optimal for the last player. Thus, the second-to-last player's vote either changes the outcome for sure, or it will be inconsequential with certainty. Since, generically, $\alpha_i \neq 0$ and $|\alpha_i| \neq |\delta_p|$, the second-to-last player strictly prefers one of his actions over the other. Proceeding along the same lines, no other player will be indifferent between "yea" and "nay." This shows that any subgame-perfect equilibrium must be in pure strategies. Since the number of players is finite, backward induction terminates and it produces a unique subgame-perfect equilibrium.

A.2. *Proof of Proposition 2*

Our proof of Proposition 2 proceeds in four steps. First, we establish a lemma that clarifies the role of nonoverlapping preferences. We then prove *(a)–(c)*, which together establish that, for each roll call, there is a cutoff value for defection.

Lemma: If $\max_{i \in D} x_i < \min_{i \in R} x_i$, then it cannot be the case that members of *both* parties are conflicted with respect to the same roll call vote.

Let $s \equiv \arg\max_{i \in D} x_i$ and $t \equiv \arg\min_{i \in R} x_i$. Suppose by way of contradiction that our premise holds, but there are members of both parties that are conflicted. Having conflicted members of both parties implies there exists some $i \in D$, and $j \in R$ such that $\alpha_i < 0 < \alpha_j$. For the conflicted Democrat, $\alpha_i < 0$ implies that x_i is closer to $\underline{x}$ than $\overline{x}$. Since $\overline{x} < \underline{x}$ and $x_s \geq x_i$ then x_s is closer to $\underline{x}$ than $\overline{x}$. Similarly, for the conflicted Republican, $\alpha_j > 0$ implies that x_j is closer to $\overline{x}$ than $\underline{x}$. Since $\overline{x} < \underline{x}$ and $x_t \leq x_j$ then x_t is closer to $\overline{x}$ than $\underline{x}$. Taken together we have x_s is closer to $\underline{x}$ than $\overline{x}$ and x_t is closer to $\overline{x}$ than $\underline{x}$ and $\overline{x} < \underline{x}$ which implies $x_s > x_t$—a contradiction of our premise.

Case (a): If $|Y| < \underline{y} < |Y| + \left|\widetilde{Y}\right|$, then, by the lemma, $\widetilde{N} = \varnothing$, and at least one conflicted majority party senator must vote with the party line for the bill to pass. Let $\overline{q} = \left|\widetilde{Y}\right| + |Y| - \underline{y}$, and let $q = 1, \ldots, \left|\widetilde{Y}\right|$ index all conflicted senators according to the order in which they vote. Clearly, if all $q > \overline{q}$ adhere to the equilibrium strategies in Proposition 1, then any $q \leq \overline{q}$ will be able to defect without rendering the roll call lost. They will, therefore, do so. Since all $q \leq \overline{q}$ defect along the equlibrium path, any $q > \overline{q}$ must vote with the party line. From $1 \leq \overline{q} < \left|\widetilde{Y}\right|$, it then follows that $\overline{\imath}$, the position of $\overline{q}$ in the overall vote order, is $1 \leq \overline{\imath} < S$.

The proof for $|N| < \underline{n} < |N| + \left|\widetilde{N}\right|$ proceeds along similar lines.

Case (b): If $|Y| < |Y| + \left|\widetilde{Y}\right| = \underline{y}$, then the lemma implies that $\widetilde{N} = \varnothing$. Hence, all $i \in \widetilde{Y}$ must vote with the party line for the majority party to win. By Proposition 1 no conflicted majority party members defects along the equilibrium path, and $\overline{\imath} = 0$.

The proof for $|N| < |N| + \left|\widetilde{N}\right| = \underline{n}$ proceeds along similar lines.

Case (c): If $|Y| \geq \underline{y}$, then the majority party wins the roll call with certainty, even if all of its conflicted members defect and if all conflicted minority party senators voted with their party. Hence, along the equilibrium path, *all* senators are free to defect, which implies that $\overline{\imath} = S$.

The proof for $|N| \geq \underline{n}$ proceeds along similar lines.

A.3. *Proof of Proposition 3*

If $|Y| + \left|\widetilde{Y}\right| \geq \underline{y}$, then for $i = 1$ we have that $|Y|_{i'>1} + \left|\widetilde{Y}\right|_{i'>1} + 1 \geq \underline{y}$. If all majority-party senators play their equilibrium strategies, then $|Y|_{i''>i'} + \left|\widetilde{Y}\right|_{i''>i'} + 1 \geq \underline{y} - \overline{y}_{i'}$ for all $i' \in D$. Thus, the majority party wins.

If $|Y| + \left|\widetilde{Y}\right| < \underline{y}$, however, let $\underline{i} = \min_{i \in D} i$, then we have that $|Y|_{i'>\underline{i}} + \left|\widetilde{Y}\right|_{i'>\underline{i}} + 1 < \underline{y}$, which in turn implies that, along the equilibrium path, $|Y|_{i''>i'} + \left|\widetilde{Y}\right|_{i''>i'} + 1 < \underline{y} - \overline{y}_{i'}$ for all $i' \in D$. As a consequence, the majority party loses. This shows that the majority wins if and only if $|Y| + \left|\widetilde{Y}\right| \geq \underline{y}$, as desired.

To see that the bill will receive exactly $\underline{y}$ "yea"-votes whenever $\max_{i \in D} x_i < \min_{i \in R} x_i$ and $|Y| < \underline{y} \leq |Y| + \left|\widetilde{Y}\right|$, note that, by the lemma above, $\widetilde{N} = \varnothing$. Further, note that we are either in case *(a)* or *(b)* of Proposition 2. If the latter, then, in equilibrium all $i \in \widetilde{Y} \cup Y$ vote "yea" (i.e., they support the party line), while all $i \in N$ vote "nay." This results in $\underline{y}$ total "yeas." If we are in case *(a)* of Proposition 2, then the first $\overline{\imath} = \left|\widetilde{Y}\right| + |Y| - \underline{y}$ conflicted senators find it optimal to defect, while all remaining ones stick with the party line. By construction of $\overline{\imath}$ and given that all $i \in N$ say "nay," we, again, arrive at $\underline{y}$ total "yeas"-votes.

Now, suppose $|Y| + \left|\widetilde{Y}\right| < \underline{y}$, which implies that the majority loses. Along the equilibrium path, any $i \in \widetilde{Y}$ defects. If $\left|\widetilde{Y}\right| \geq 1$ then $\widetilde{N} = \varnothing$, and the bill will only get $|Y|$ votes. Thus, if $|Y| + \left|\widetilde{Y}\right| < \underline{y}$ the majority falls more than $\left|\widetilde{Y}\right|$ votes short. If $\left|\widetilde{Y}\right| = 0$, then, given that the majority loses, the claim that it falls at least $\left|\widetilde{Y}\right|$ votes short of $\underline{y}$ is trivially true.

Appendix B: Estimation Procedure

As stated in the main text, our structural estimation builds on the Markov Chain Monte Carlo (MCMC) approach of Clinton et al. (2004). In what follows, we detail our procedure, borrowing heavily from the description of Clinton et al. (2004).

Baseline Model. Intuitively, our MCMC algorithm "explores" the joint posterior density of $(x, \beta, \gamma, \delta)$ by successively sampling from the conditional densities that together characterize the joint distribution. Define the latent variable $y^*_{i,r} \equiv \left[U_{i,r}\left(\overline{x}_r\right) + \delta q_{i,r}(\overline{y}_{i,r} + 1)\right] - \left[U_{i,r}\left(\underline{x}_r\right) + \delta q_{i,r}(\overline{y}_{i,r})\right]$, and note that $y_{i,r} = 1$ if $y^*_{i,r} \geq 0$ and 0 otherwise. We augment the Gibbs sampler with $y^*_{i,r}$, which greatly reduces the computational complexity because it allows us to exploit standard results on the Bayesian analysis of linear regression models. In addition, we condition on senators' beliefs. That is, to further reduce the complexity of the Gibbs sampler we overparameterize the model by introducing the (redundant) parameter vector Δq, recognizing that, in the equilibrium of the game, its distribution depends on the structural parameters $(x, \beta, \gamma, \delta)$. Letting z index the iterations of the MCMC algorithm, a given iteration consists of sampling from the following conditional densities.

1. $g(y^*|y, x, \beta, \gamma, \delta, \Delta q)$: At the start of iteration z, we have $\left(x^{(z-1)}, \beta^{(z-1)}, \gamma^{(z-1)}, \delta^{(z-1)}, \Delta q^{(z-1)}\right)$. Depending on whether a given senator votes "yea" $(y_{i,r} = 1)$ or "nay" $(y_{i,r} = 0)$, we sample $y^*_{i,r}$ from one of the two following truncated normal distributions:

$$y^*_{i,r}|\left(y_{i,r} = 0, x_i^{(z-1)}, \beta_r^{(z-1)}, \gamma_r^{(z-1)}, \delta^{(z-1)}, \Delta q_{i,r}^{(z-1)}\right) \sim N\left(\mu_{i,r}^{(z-1)}, 1\right) \mathbb{I}\left(y^*_{i,r} < 0\right)$$
$$y^*_{i,r}|\left(y_{i,r} = 1, x_i^{(z-1)}, \beta_r^{(z-1)}, \gamma_r^{(z-1)}, \delta^{(z-1)}, \Delta q_{i,r}^{(z-1)}\right) \sim N\left(\mu_{i,r}^{(z-1)}, 1\right) \mathbb{I}\left(y^*_{i,r} \geq 0\right),$$

   where $\mu_{i,r}^{(z-1)} = x_i^{(z-1)}\beta_r^{(z-1)} + \gamma_r^{(z-1)} + \delta^{(z-1)}\Delta q_{i,r}^{(z-1)}$ and $\mathbb{I}(\cdot)$ is an indicator function. For abstentions we sample from $N\left(\mu_{i,r}^{(z-1)}, 1\right)$, effectively creating multiple imputations.

2. $g(\beta, \gamma|y^*, x, \delta, \Delta q)$: For every r, we run a "Bayesian regression" of $(y^* - \delta\Delta q)$ on x and a constant, and then sample from the posterior density. That is, we sample $\beta_r^{(z)}$ and $\gamma_r^{(z)}$ from a multivariate normal with mean

$$\left[X^{(z-1)\prime}X^{(z-1)} + T_0^{-1}\right]^{-1}\left[X^{(z-1)\prime}\left(y^{*(z)}_{\cdot,r} - \delta^{(z-1)}\Delta q_{\cdot,r}^{(z-1)}\right) + T_0^{-1}\tau_0\right]$$

   and covariance matrix

$$\left[X^{(z-1)\prime}X^{(z-1)} + T_0^{-1}\right]^{-1},$$

   where $X^{(z-1)}$ is an $S \times 2$ matrix with a typical row $\left(x_{i,r}^{(z-1)}, 1\right)$, $y^{*(z)}_{\cdot,r}$ and $\Delta q_{\cdot,r}^{(z-1)}$ are both of dimension $S \times 1$, and τ_0 and T_0 respectively denote the prior mean and covariance matrix of (β_r, γ_r).

3. $g(x|y^*, \beta, \gamma, \delta, \Delta q)$: For every i, we now run a "Bayesian regression" of $(y^* - \delta\Delta q - \gamma)$ on β (and no constant). More specifically, letting ν_0 and V_0 denote the prior mean and variance of x_i, we sample $x_i^{(z)}$ from a normal distribution with mean

$$\left[\beta^{(z)\prime}\beta^{(z)} + V_0^{-1}\right]^{-1}\left[\beta^{(z)\prime}\left(y^{*(z)}_{i,\cdot} - \delta^{(z-1)}\Delta q_{i,\cdot}^{(z-1)} - \gamma^{(z)}\right) + V_0^{-1}\nu_0\right]$$

   and variance

$$\left[\beta^{(z)\prime}\beta^{(z)} + V_0^{-1}\right]^{-1},$$

   where $\beta^{(z)}$, $y^{*(z)}_{i,\cdot}$ and $\Delta q_{i,\cdot}^{(z-1)}$ are all of dimension $C \times 1$. After updating all x_i, we renormalize x so that the ideal points of John Kerry and John McCain are equal to -1 and 1, respectively.

4. $g(\delta|y^*, x, \beta, \gamma, \Delta q)$: Next, we run a "Bayesian regression" of $(y^* - \beta' x - \gamma)$ on Δq (and no constant). In particular, let l_0 and L_0 denote the prior mean and variance of δ, respectively. We then sample $\delta^{(z)}$ from a normal with mean

$$\left[\Delta q^{(z-1)\prime}\Delta q^{(z-1)} + L_0^{-1}\right]^{-1}\left[\Delta q^{(z-1)\prime}\left(y^{*(z)} - \widetilde{\beta}^{(z)}\widetilde{x}^{(z)} - \widetilde{\gamma}^{(z)}\right) + L_0^{-1}l_0\right]$$

and variance

$$\left[\Delta q^{(z-1)\prime}\Delta q^{(z-1)} + L_0^{-1}\right]^{-1}.$$

Note, $\Delta q^{(z-1)}$ and $y^{*(z)}$ are $SC \times 1$ vectors, while $\widetilde{\beta}^{(z)}$, $\widetilde{\gamma}^{(z)}$, and $\widetilde{x}^{(z)}$ are comformably stacked.

5. $g\left(\Delta q|y^*, x, \beta, \gamma, \delta\right)$: Lastly, we update $\Delta q_{i,r}^{(z)}$. Note, conditional on $\left(x^{(z)}, \beta^{(z)}, \gamma^{(z)}, \delta^{(z)}\right)$, $\Delta q_{i,r}^{(z)}$ has a degenerate distribution with all mass at a single point. This is because, in equilibrium, $\Delta q_{i,r}$ is uniquely determined by backward reasoning in conjunction with $(x, \beta, \gamma, \delta)$. Letting $\Gamma(\bullet)$ denote the operator implied by the recursive construction in footnote 21, we update $\Delta q_{i,r}^{(z)}$ by setting it equal to $\Gamma\left(x^{(z)}, \beta^{(z)}, \gamma^{(z)}, \delta^{(z)}\right)$.[31] This ensures that the end of every iteration of the Gibbs sampler, $\left(x^{(z)}, \beta^{(z)}, \gamma^{(z)}, \delta^{(z)}, \Delta q_{i,r}^{(z)}\right)$ satisfies the constraints that are implied by the SPNE of the game. As a consequence, the posterior is consistent with equilibrium play / beliefs.

Extended Model. The Gibbs sampler for our extended model is very similar to the one above, with the important difference that we augment the model by introducing finite mixture components in order to represent each type. Letting t_i denote the sampled type of senator i, steps 1–5 are preceded by:

0.1. $g\left(t_i|y^*, x, \beta, \gamma, \delta, \Delta q, \pi\right)$: For each i, we sample $t_i^{(z)}$ from a multinomial distribution with parameter vector

$$\widetilde{\pi}_{i,k} = \frac{\pi_k^{(z-1)} \prod_{r=1}^{C} \Phi\left(\beta_r^{(z-1)} x_i^{(z-1)} + \gamma_r^{(z-1)} + \delta^{(z-1)} \Delta q_{i,r,k}^{(z-1)}\right)^{y_{i,r}} \left[1 - \Phi\left(\beta_r^{(z-1)} x_i^{(z-1)} + \gamma_r^{(z-1)} + \delta \Delta q_{i,r,k}^{(z-1)}\right)\right]^{1-y_{i,r}}}{\sum_{m=1}^{3} \pi_m^{(z-1)} \prod_{r=1}^{C} \Phi\left(\beta_r^{(z-1)} x_i^{(z-1)} + \gamma_r^{(z-1)} + \delta^{(z-1)} \Delta q_{i,r,m}^{(z-1)}\right)^{y_{i,r}} \left[1 - \Phi\left(\beta_r^{(z-1)} x_i^{(z-1)} + \gamma_r^{(z-1)} + \delta \Delta q_{i,r,m}^{(z-1)}\right)\right]^{1-y_{i,r}}}.$$

0.2 $g\left(\pi|y^*, x, \beta, \gamma, \delta, \Delta q, t\right)$: We update $\pi^{(z)}$ by sampling from a Dirichlet distribution with parameter vector

$$\widetilde{a}_k = n_k + a_k,$$

where $n_k = \sum_{i=1}^{S} \mathbb{I}\left(t_i^{(z)} = k\right)$ and a_k is the prior on the Dirichlet parameters.

Steps 1–5 above then proceed conditional on $t^{(z)}$ and $\pi^{(z)}$. In particular, $\Delta q_{i,r}^{(z-1)}$ becomes $\Delta q_{i,r,t_i}^{(z-1)}$, as defined in the text.

Implementation. We implement the above algorithms using compiled C++ code that we call from within MATLAB. All results we report are based on 10 parallel chains with 120,000 iterations each, of which the first 20,000 are discarded as "burn in" period. To obtain starting points for each chain we implement the nonparametric unfolding procedure of Poole (2000) and add random noise to the resulting values. We check for convergence of the Markov chain using the Potential Scale Reduction Factor (PSRF) of Gelman and Rubin (1992). In Appendix Figures A.14 and A.15, we show the iterative history of the (thinned) Markov chain for the most important parameters in our model, i.e., for δ and (π_1, π_2, π_3).

[31] In calculating $\Delta q_{i,r}^{(z)}$ we consider the exact order in which votes were cast, ignoring abstentions. For senators who abstained on a particular vote, we set $\Delta q_{i,r}^{(z)} = 0$.

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