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Backward Induction in the Wild: Evidence from the U.S. Senate*

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Abstract

Backward induction is a cornerstone of modern game theory. Yet, laboratory experiments consistently show that subjects fail to properly backward induct. Whether these findings generalize to other, real-world settings remains an open question. This paper develops a simple model of sequential voting in the U.S. Senate that allows for a straightforward test of the null hypothesis of myopic play. Exploiting quasi-random variation in the alphabetical composition of the Senate and, therefore, the order in which Senators get to cast their votes, the evidence suggests that agents do rely on backward reasoning. At the same time, Senators' backward induction prowess appears to be quite limited. In particular, there is no evidence of Senators reasoning backwards on the first several hundred roll call votes in which they participate.

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1. Introduction

Over the last half-century, the concepts and techniques of noncooperative game theory have become central to economics and the social sciences more generally (Kreps 1990). At the same time, game-theoretic analyses are often criticized for relying on stark assumptions about the rationality of agents (e.g., Elster 2007; Green and Shapiro 1994; Simon 1955). If game theory is to be a positive theory of actual human behavior—as opposed to a normative one of how people should behave—then understanding how closely game-theoretic assumptions are reflected in real-world conduct is a matter of fundamental importance.

At its core, game theory posits that in order to maximize their own payoffs, agents try to anticipate the actions of others. Nowhere else is this idea as purely embodied as in the principle of backward induction in dynamic games of perfect information (Kuhn 1953; Selten 1965; von Neumann and Morgenstern 1944). 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, there remains one nagging issue: when tested in the laboratory, its predictions have often not held up to empirical scrutiny.

Starting with the pioneering work of McKelvey and Palfrey (1992), scores of laboratory experiments document behavior that departs radically from equilibrium play—especially in Rosenthal's (1981) centipede game (see, e.g., Bornstein et al. 2004; Fey et al. 1996; Nagel and Tang 1998; Rapoport et al. 2003; Zauner 1999, among many others).¹ 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 (see 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 (e.g., Binmore et al. 2002; Johnson et al. 2002).² Instead, failures of backward induction are, at least in part, attributed to cognitive limitations—though subjects can be taught to backward induct (Dufwenberg et al. 2010; Gneezy et al. 2010; Johnson et al. 2002). In sum, the available experimental evidence suggests that individuals are much less forward looking than one might hope.

While much has been learned in the laboratory, there are inherent methodological limitations (see Levitt and List 2007). The artificial experimental setting need not resemble any

¹For theoretical analyses of the centipede game, see Binmore (1987), Aumann (1992), or Asheim and Dufwenberg (2003).

²An 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. For the opposite finding, see Levitt et al. (2011).

real-life situation, and, despite the games' usual simplicity, subjects may not be able to hone their behavioral rules in the narrow time frame of the experiment. Even if individuals do display consistent biases in the laboratory, market forces and repeated interactions may limit such behavior in the real world.

Unfortunately, tests of fundamental game-theoretical concepts in real-world data are very scarce.³ As pointed out by Chiappori et al. (2002), games played in nonexperimental settings are often intractable, with large strategy spaces that need not be specified ex ante or even be known to all the players. In addition, theoretical predictions generally hinge on the properties of utility functions, the subtleties of incentive structures, as well as individuals' beliefs, all of which are commonly unobserved by the econometrician. It remains, therefore, unknown whether the documented failures of backward induction generalize to other, real-world contexts.

In order to speak to this question, the present paper turns to roll call voting in the U.S. Senate. In many ways, the Senate provides an almost-ideal environment to study backward reasoning. First, conditional on voting, Senators have only two choices: "yea" or "nay." Second, Senators interact with each other repeatedly, participating in hundreds of roll calls per term. Third, the stakes are truly large. Fourth, data on roll call votes are readily available and routinely scrutinized by the public. Fifth, Senators' views on most issues are well known to their colleagues and easily predictable from past behavior. Finally, the order in which Senators' are first allowed to cast their vote depends on their alphabetical rank. Hence, exogenous variation in the alphabetical composition of the Senate produces quasi-random variation in the incentives arising from backward induction.

As in many other real-world environments, the cognitive demands imposed by backward induction are extremely high. Optimal strategies, however, take on a very simple and intuitive form. Even if Senators are not literally solving the game backwards, one may still expect their choices to mimic these strategies. Arguably, this gives the backward induction outcome (or ones close to it) the best chance of emerging amid realistic circumstances.

³The 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.

Less relevant to the present paper is a large number of studies that assume backward induction as part of the identification strategy. List and Sturm (2006), for instance, explore to which extent secondary policy issues are influenced by electoral incentives. In their model, forward-looking politicians distort policy away from their own preferences due to the desire to be reelected, but only when they are not constrained by term limits.

The analysis begins by specifying a general theory of sequential voting in the Senate. The model is tractable yet rich enough to allow for a straightforward test of the null hypothesis of no backward reasoning, i.e. myopic play. In the model, Senators are position takers who, all else equal, would like to vote for the alternative preferred by themselves or by their constituents (Levitt 1996; Mayhew 1974). However, Senators also care about the party line—perhaps because they are concerned about their party’s reputation (Downs 1957; Snyder and Ting 2002), or because party elites exert pressure to vote one way or another (Rhode 1991; Snyder and Groseclose 2000). For the subset of individuals whose own preferences are not aligned with that of their party, a conflict of interest arises. If their vote was pivotal and determined the outcome of the roll call, then some of these Senators would be willing to abandon their own stance and support the party instead. Yet, conditional on the outcome of the call, they would vote according to their own preferences. In the unique subgame-perfect equilibrium of the game, conflicted Senators count the number of agents who have yet to vote and who would choose their party’s preferred outcome if their vote was decisive. If there are enough others who would go along with the party line (or too few), they defect.

Hence, being allowed to vote early confers an advantage. The first Senator to vote may be able to defect without rendering the roll call lost because there are many others who would follow the party line if need be. Subsequent Senators, however, can count on fewer and fewer of their colleagues, which, on average, makes it less likely that they will defect. Intuitively, being the first vote is valuable because it allows forward-looking Senators to preempt each other.

If, however, Senators are unable to properly backward induct even a few rounds, then there ought to be no systematic relationship between their choices and the order in which they get to vote. That is, one would not expect the probability of defection to be correlated with alphabetical rank.⁴

Figure 1 demonstrates that the opposite is true in the data. Restricting attention to Democratic and Republican Senators who served in the 35th to 112th Congresses (i.e. from 1857 to 2013), the figure shows a semiparametric estimate of the relationship between a Senator’s alphabetical rank and the probability of him deviating from the party line. Although the magnitude of the effect is imprecisely estimated, the evidence suggests that those who are allowed to vote earlier are more likely to abandon their respective parties. This finding runs

⁴The theory abstracts from issues arising due to the repeated nature of Senators’ interactions, such as reputation building, limited commitment, and punishment strategies. Yet, the model is flexible enough to incorporate these and related matters by letting them affect (in a reduced form way) the payoffs in the stage game. The basic prediction about a negative relationship between alphabetical rank and defection, therefore, continues to hold as long as there are some agents who would rather abandon their own views than their party.

contrary to what one would expect if Senators were myopic.

By controlling for Senator fixed effects, all results in this paper account for individuals' inherent tendencies to deviate from the party line. Identification comes from two sources of quasi-random 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 of identification leads to qualitatively identical conclusions.

Broadly summarizing, the results below are more favorable to the idea that agents reason backwards than one might have expected based on the extant literature. Although Senators do seem to make mistakes, as evidenced by the fact that they strategically defect on roll calls that, as a result, are narrowly lost, a model with myopic Senators would not be able to rationalize several important features of the data.

At the same time, Senators' backward induction prowess is clearly limited. For instance, the evidence suggests that Senators anticipate and act upon the choices of others who get to vote almost directly after them, but they fail to capitalize on the behavior of colleagues who are more than fifteen positions removed. This finding echoes earlier results from student subjects in the laboratory who are rarely able to backward induct more than a few rounds (see, e.g., Camerer 2003 for a review).

In addition to rejecting the null hypothesis of no backward reasoning, the paper studies how individuals' sophistication varies with prior experience and other observable characteristics. Interestingly, there are large gender differences. While males' tendency to deviate from the party line depends strongly on the order in which they cast their vote, alphabetical rank has practically no impact on the choices of females. Moreover, there is no evidence of forward-looking play on the first several hundred votes in which Senators participate. Only for those with more than a thousand roll calls under their belt is it possible to reject the null.

This result complements findings from the laboratory according to which the behavior of experienced players and 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; but see also Wooders 2010 and Levitt et al. 2010). Of course, since Senators are not necessarily selected based on their ability to backward induct, one might not have expected them to immediately act on incentives as subtle as the ones created by variation in alphabetical rank. Yet, Senators' very low speed of learning underscores the importance of studying real-world settings in which individuals had sufficient time to accumulate experience when drawing inferences about the extent of behavioral biases.⁵

The remainder of the paper proceeds as follows. Section 2 provides background information on voting procedures in the U.S. Senate, while Section 3 formalizes the intuition about

⁵For a survey of the behavioral literature providing evidence from the field, see DellaVigna (2009).

alphabetical rank and observed behavior in a simple model of sequential voting. Section 4 presents the main results, and the last section concludes.⁶

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.”⁷ 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 care often intensely about their track record, means that the Senate decides virtually all contested issues by roll call votes.⁸

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 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 95% of calls.

⁶There are two appendices. Appendix A contains a formal proof omitted from the body of the paper, while Appendix B provides concise definitions of all variables used throughout the analysis.

⁷In describing the voting procedures in the Senate, this section borrows heavily from Rybicki (2013).

⁸Neither 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.

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 his decision before a colleague whose last name starts with a “Z.”

Intuitively, one might suspect that it would be valuable to vote *after* others have already revealed their choices and that Senators should not want to vote early. The next section, however, shows that the exact opposite is often true—at least when others’ choices are predictable. By voting as early as possible, Senators who consider abandoning the party line can do so at a lower risk of upsetting party elites by casting the vote that renders the roll call lost. Being the first in the alphabet and, therefore, the first to defect is valuable because it allows Senators to preempt their colleagues.

3. A Simple Model of Sequential Voting

The following model formalizes this argument and demonstrates how changes in the Senate’s alphabetical makeup can be exploited to construct a test of the null hypothesis that individuals fail to reason backwards.

3.1. *Basic Building Blocks*

Let there be a finite set of Senators, who are indexed by the exogenously specified order in which they submit their votes, $i = 1, 2, \dots, S$. Senators 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 bill requires strictly more “yeas” than “nays.”

Members of both parties derive utility directly from how they vote—perhaps because Senators are ideological (Levitt 1996), or because they are being held accountable by their constituents (Mayhew 1974). That is, Senator i receives $\alpha_i \in \mathbb{R}$ if he votes “yea,” and zero otherwise. All α_i are independently distributed according to some continuous cumulative distribution function F_p with $p = D, R$. By allowing for F to differ across parties, Senators’ preferences may (but need not) be correlated with party membership. Specifically, one might expect that on many issues $E[\alpha_i] > 0$ if and only if i is a Democrat. At the same time, one would also expect that some Democrats oppose the bill, i.e. $\alpha_i < 0$, especially if the measure is controversial.

In addition to their position-taking utility, agents also value the overall outcome of the roll call, i.e. whether or not the bill passes. This is because Senators might be concerned about their party’s reputation or “brand” (Downs 1957; Snyder and Ting 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 voted himself, all Democrats receive $\beta_D > 0$ if the bill passes, whereas Republicans are penalized with $\beta_R < 0$.

The following matrix summarizes agents’ payoffs.

	bill passes	bill rejected
vote “yea”	$\alpha_i + \beta_p$	α_i
vote “nay”	β_p	0

The important (and quite general) point to note is that, conditional on the overall outcome, all Senators would like to follow their own preferences, i.e. vote “yea” if and only if $\alpha_i > 0$. However, if their vote is known to be pivotal, there may be situations in which some Senators would be better off by voting against their preferences and with the party line.

Before the roll call begins, the draws for all α_i are realized and observed by all agents. Thus, when Senator i submits his vote, he not only observes the choices of all $i' < i$, i.e. those who have already voted, but he can also anticipate that of those who have yet to do so. The assumption that payoffs are common knowledge reflects the fact that Senators interact frequently and that parties often hold straw polls in advance of important votes. One would, therefore, expect Senators to be rather well informed about each other’s preferences.

3.2. *Equilibrium Strategies*

For agents whose own preferences are aligned with those of their party, i.e. agents for whom $\text{sgn}(\alpha_i) = \text{sgn}(\beta_p)$, equilibrium strategies are very straightforward: Democrats vote “yea,” and Republican choose “nay,” irrespective of their colleagues’ choices and the order in which votes are being cast.

Similarly, Senators whose own preferences dominate the influence of their party always vote according to the former. Formally, individuals for whom $|\alpha_i| > |\beta_p|$ choose “yea” if and only if $\alpha_i > 0$.

The most interesting (and only remaining) case to consider is when Senators face a mild conflict of interest, i.e. when $\text{sgn}(\alpha_i) \neq \text{sgn}(\beta_p)$ and $|\alpha_i| < |\beta_p|$. These agents would like to defect, but only if their vote does not end up being pivotal. If their vote does change the outcome of the roll call, then they would rather abandon their own views than their party. Crucially, by relying on backward induction, agents can anticipate the consequences of their

choice.

As one would expect, in equilibrium these Senators abandon the party line whenever their own vote is not going to be decisive. More formally, let \widetilde{D} (\widetilde{R}) denote the set of all agents who will vote “yea” (“nay”) for sure or who would do so if their vote was known to be pivotal, and let $|\widetilde{D}|_{i'>i}$ and $|\widetilde{R}|_{i'>i}$ be the number of agents from each of these sets who get to vote after Senator i .⁹ In addition, y_i (n_i) is the number of “yeas” (“nays”) that are still required for the bill to pass (fail) when it is i ’s turn to vote. As agents can observe the choices of those who voted before them, and since preferences are mutually known, all of these objects are part of Senators’ information sets. The following proposition then characterizes the optimal strategy of agents who face a mild conflict of interest, i.e. for whom $|\alpha_i| < |\beta_p|$ and $\text{sgn}(\alpha_i) \neq \text{sgn}(\beta_p)$.

PROPOSITION: *In the unique generic subgame-perfect equilibrium of the game, Democratic Senators who face a mild conflict of interest abandon the party line if and only if $|\widetilde{D}|_{i'>i} + 1 \neq y_i$, whereas their Republican counterparts defect whenever $|\widetilde{R}|_{i'>i} + 1 \neq n_i$.*

PROOF: See Appendix A.

In words, Senator i , who faces a mild conflict of interest, will count the number of agents who have not yet voted and who would choose his party’s preferred outcome if their vote was pivotal. He then defects whenever his own vote is not needed for his party to win the roll call—either because there are enough others who would go along with the party line if need be or because there are too few. Thus, if Senators rely on backward induction, then the choices of those who are conflicted will generally depend on the order in which they get to submit their vote.

3.3. Backward Induction and Alphabetical Rank

Intuitively, alphabetical rank confers an advantage because being allowed to vote early lets forward-looking Senators preempt each other. The first conflicted Senator may be able to defect without rendering the roll call lost because there are many others who would follow the party line if need be. Subsequent Senators, however, can count on fewer and fewer of their fellow party members, which, on average, makes it less likely that they will defect.

For a concrete example, consider the game depicted in Figure 2. Party D still requires two “yea” votes for the bill to pass, but all of its remaining three members are conflicted. That is, they receive utility $\alpha = -1$ from saying “yea,” while obtaining $\beta = 2$ if the measure ends up being approved anyway. If the Senator who gets to vote first (i.e. $D1$) is forward looking, he realizes that his fellow party members (i.e. $D2$ and $D3$) would rather abandon

⁹Note that \widetilde{D} (\widetilde{R}) might include Republicans (Democrats) for whom $|\alpha_i| > |\beta_p|$.

their own positions than be responsible for letting the bill fail. In the unique subgame-perfect equilibrium of the game, he, therefore, votes “nay,” while his colleagues are forced to say “yea.”

Though highly stylized, the basic nature of the example coincides with the situation predicted by simple agenda-setter models in political science (e.g., Romer and Rosenthal 1978): a bill that is unpopular with all members of the minority party as well as some of the majority. Since $\alpha_i < 0$ for all $i \in R$ and $\beta_R < 0$, all Republicans choose “nay”—irrespective of the order in which they vote. Similarly, all Democrats for whom $\alpha_i > 0$ choose “yea.” As the behavior of these Senators does not depend on the history of the game, one can take it as given and focus on the set of Democrats who are conflicted. There are two cases to distinguish: (i) The bill passes even if every Democrat for whom $\alpha_i < 0$ votes “nay,” in which case all conflicted Senators follow their personal preferences. (ii) The bill fails unless some number of conflicted Democrats, say s out of N , end up supporting it. In this case, it is clearly valuable to be the first to vote. Since the bill requires the support of some, but not all, conflicted majority party members, the first $N - s$ of them will be able to defect, while those who come later have to follow the party line or else the roll call will be lost.

In general, whether a given Senator is able to defect without affecting the overall outcome of the roll call depends on the history of the game and the exact order in which he and his colleagues vote. In particular, if there are members of the minority who also abandon their party, then defection among conflicted members of the majority need not be monotonic in rank (see Appendix Figure A.1 for a concrete example). Nonetheless, the simulation results in Figures 3A and 3B demonstrate that the intuition about rank and defection continues to hold *on average*.

Each panel is based on 10 million roll calls in which 100 Senators follow their equilibrium strategies. For each call, the order in which Senators vote is randomly determined. The thick black line depicts the *average* frequency with which an agent in a given position abandons his party. Figure 3A varies the size of the majority and whether there are also members of the minority party who are conflicted (i.e. for whom $\text{sgn}(\alpha_i) \neq \text{sgn}(\beta_p)$).¹⁰ In equilibrium, all conflicted minority party members defect because they anticipate that the majority party will win regardless of their own choice. This lessens the need for members of the majority to stick with the party line. Figure 3B shows that when both parties are split and the margin

¹⁰In the panels on the left (right), 30% of the majority party’s (both parties’) members are conflicted in the sense above, while there are no Senators who would always vote against the party line. Other parameter values deliver qualitatively very similar results (available from the author upon request). In particular, different choices for $F(\beta_p)$ result in a “vertical stretching” of the curves.

It is easy to see that if only the minority is split, then rank does not correlate with defection. Since members of the majority have no incentive to abandon the party line, the majority party will always win. Realizing this, all conflicted members of the minority defect.

of majority is very small, then the average probability of defection may at first fall and then rise again.¹¹ Nevertheless, even in these settings, voting very early confers an advantage.

Critical for the purposes of this paper is the following observation: Senators who are not forward looking will not realize that their alphabetical rank may benefit them. Thus, under the null hypothesis that Senators are myopic, one would not expect a systematic relationship between their choice to abandon the party line and the order in which they get to vote. Seeing a negative relationship, however, would lead one to reject the null.

Before turning to the data, it ought to be pointed out that the intuition for this test does not depend on the assumption that preferences are common knowledge. Agents who are able to backward induct at least a few rounds will realize that they can preempt their colleagues as long as others' choices are at least partially predictable. Thus, risk-neutral Senators should take advantage of being allowed to vote early, even when preferences are not perfectly observable.¹²

In fact, the crucial condition for the test to go through is that there are some issues on which a sufficiently large set of Senators would like to vote against the party line, but only if that did not change the overall outcome. If this assumption failed, one would not see a negative relationship between alphabetical rank and defection, and (based on the logic of the test) one would not be able to reject the null hypothesis of no backward reasoning.

There are thus at least two forces working against rejection of the null. First, Senators vote on many issues that are fairly uncontroversial and that would be approved even if all of them followed their preferences. For such “lopsided” roll calls there should not be any relationship between agents' alphabetical rank and the probability of defection. Including them will, therefore, understate the impact of their position in the alphabet. Second, on any given issue, most Senators' preferences are likely aligned with those of their party. For this set of agents, voting early confers no advantage, and one would not expect them to backward induct.

Given that their choice is invariant to the history of the game and the position in which they get to vote, these Senators have no incentive to even be on the floor when the clerk first calls their name. While this explains why many Senators arrive late, and thus forfeit

¹¹This observation may be surprising. It is due to the fact that defection by a conflicted member of the minority decreases y_i without lowering $\left| \tilde{D} \right|_{i' > i}$. Thus, in any particular game, defection by majority party members need not be monotonic in rank (see Appendix Figure A.1). When the seat advantage of the majority is small enough, this need not even be true on average. However, given the typical margin of majority in the U.S. Senate (cf. Appendix Figure A.2), such scenarios are unlikely to be empirically important.

¹²If Senators are risk averse and the seat advantage of the majority is small, then those who vote first may prefer to “play it safe” rather than risk the roll call being lost. Under these circumstances one might expect to see a *positive* relationship between alphabetical rank and defection. For evidence in line with this prediction, see Section 4.3.

any edge of being allowed to vote early, it also makes it more difficult to detect strategic defection by those who do reason backwards.

The clear advantage of studying backward induction in this setting is that agents have no control over when they are first allowed to cast their vote, i.e. the order in which the clerk calls their name. Exploiting quasi-random variation in the alphabetical composition of the Senate over time, it is, therefore, possible to rule out that something other than changes in the opportunity to vote early caused Senators to alter their behavior.

4. Backward Reasoning in the Wild: Empirical Evidence

4.1. *Data Sources and Descriptive Statistics*

In order to test for backward reasoning, this paper 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). These data have been collected and manually cleaned by Keith Poole and coauthors, and are publically available on the former’s website.¹³

The data contain Senators’ names, party affiliation, and final choices. They neither indicate the actual order in which votes were submitted, nor do they contain any information on whether a given Senator changed or withdrew his initial vote. This, however, is less of a problem than it may seem. The theory predicts that conflicted Senators will often want to vote as early as possible, and the order in which they are allowed to do so depends on their last names.¹⁴ Knowledge of Senators’ names and final votes is, therefore, all that is required to construct a reduced form test along the lines sketched out above.

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, almost half of the almost 40,000 roll calls in the data end up being “lopsided” in the sense that more than 65% or fewer than 35% of Senators vote “yea.”¹⁵ The remaining half is said to be contested, or “close.” About 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.

¹³For precise definitions well as additional information on the sources of all variables used throughout the analysis, see Appendix B.

¹⁴Moreover, according to the model, the votes of conflicted Senators do not depend on whether some of those whose preferences are aligned with the party line come to the floor late. This is because the choice of agents who are not conflicted is independent of the history of the game. Hence, Senators who do face a conflict of interest take them as given, irrespective of whether the vote has already been submitted.

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

In total, the data consist of slightly more than three million individual roll call votes, of which about 18.5% go against the party line. That is, in slightly less than one out of five cases does a Senator’s vote differ from that of the majority of his fellow party members.

4.2. *Econometric Approach*

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 (i.e. not counting i himself). Of course, this definition of defection represents merely one of potentially many solutions to the problem of inferring the (unobserved) party line. Its intuitive appeal is based on the idea that, on average, Senators’ positions should be aligned with those of their party. That is, their own preferences and their 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 his party, while avoiding endogeneity issues arising from i ’s choice itself. The downside of this definition is that it will misinfer the true party line on a particular roll call when more than half of all party members defect.¹⁶ Fortunately, there is little reason to suspect that this sort of misclassification would be systematically correlated with changes in Senators’ alphabetical rank. 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 conclusions (see Appendix Table A.1).¹⁷

To investigate whether the order in which Senators get to submit their votes does affect their behavior, consider the following econometric model:

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

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 rank among those who participated in the vote. To account for the fact that the total number of Senators varies by Congress as well as across roll calls within a given Congress, $o_{i,r,c}$ has been “standardized” by being set equal to i ’s percentile rank among his 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 last name puts him behind all of his colleagues. By construction, $o_{i,r,c}$

¹⁶Another downside is that the party line 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.

¹⁷One disadvantage of defining the party line by how the party leadership votes is that, for procedural reasons, the majority 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 makes earlier data unusable.

is uncorrelated with the characteristics of a given roll call as well as with any other variable that varies only across calls.¹⁸

The coefficient of interest is λ . It indicates whether alphabetical rank has any effect on Senators' choices. Identification comes from two sources of quasi-random 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 some 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 might be allowed to vote earlier on some roll calls than on others because a colleague who ranked ahead of him in the alphabet was replaced by someone whose last name comes after his alphabetically, or because another colleague happened to be absent on a particular day. As shown below, estimating λ from either source of variation leads to qualitatively identical results.

Roughly speaking, if Senators are forward looking and take the behavior of others who have not yet voted into account, then one would expect λ to be negative and statistically significant. If, however, λ was statistically indistinguishable from zero, then one would not be able to reject the null hypothesis of no backward reasoning.

4.3. Main Results

Focusing on members of the Democratic and Republican Parties, Table 2 presents the main empirical results. The numbers therein correspond to $\hat{\lambda}$, obtained from estimating equation (1) by ordinary least squares. Results in the first two columns are based on alphabetical rank among Senators who participated in a particular roll call, whereas the ones in the remaining two columns use the order of all Senators who officially served in Congress at the time when roll call r was conducted. Odd-numbered columns control for Senator fixed effects, while even-numbered ones include Senator \times Congress fixed effects. The estimate in column (1), therefore, exploits both within- and across-Congress variation in roll call-specific alphabetical rank, while the one in column (2) relies solely on the former. By contrast, the results in columns (3) and (4) discard any variation arising from Senators not participating in some roll

¹⁸Formally, $o_{i,r,c} \equiv \frac{s_i - 1}{S - 1}$, where S denotes the number of Senators and s_i is i 's raw alphabetical rank. To see that $o_{i,r,c}$ is uncorrelated with any variable that does not exhibit within-roll call variation, let x be some variable that varies only across calls, and recall the definition of the sample correlation, i.e. $\rho_{o,x} \equiv \frac{\sum_n (o_n - \bar{o})(x_n - \bar{x})}{\sqrt{\sum_n (o_n - \bar{o})^2 \sum_{n=1}^N (x_n - \bar{x})^2}}$ with n indexing individual observations. Rewriting the numerator as $\sum_c \sum_r \sum_i (o_{i,r,c} - \bar{o})(x_{r,c} - \bar{x})$ and noting that $\sum_i (o_{i,r,c} - \bar{o}) = 0$ for all r and c shows that $\rho_{o,x} = 0$, as desired.

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 column (4) uses only the latter (i.e. variation due to deaths, expulsions, or sudden departures for other reasons). To allow for almost arbitrary forms of correlation in the residuals across Senators and roll calls, standard errors are clustered by Congress.

Critically, all point estimates in Table 2 are negative and statistically significant at conventional levels. Interestingly, the estimate based on the least amount of potentially suspect variation, i.e. the one in column (4), 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 very large nor very small effects of Senators' alphabetical ranking on the probability of defection. It *is* possible, however, to reject the null hypothesis of no effect and, therefore, that of myopic play.

Tables 3 and 4 provide further tests of the model. The estimates therein are based on Senators' roll call-specific order. Results that discard variation arising from Senators not participating in some roll call votes are qualitatively very similar but less precise. As discussed in Section 3.3, one would only expect to see a negative relationship between Senators' alphabetical rank and the probability of defection when the outcome of the roll call is going to be "close," i.e. when the votes of conflicted Senators' are needed for their party's preferred outcome to be realized. For "lopsided" roll calls, however, i.e. roll calls that would be won even if all Senators voted according to their preferences, there should be no systematic relationship between rank and the decision to abandon the party line. In order to test this prediction, the upper panel of Table 3 splits the data into ex post "close" and "lopsided" calls according to the cutoffs in Snyder and Groseclose (2000).¹⁹ While there is no evidence of a systematic relationship between rank and defection on lopsided calls, there is a large negative and statistically significant correlation for roll calls that end up being close, as predicted by the comparative statics of the model.

The lower panel of Table 3 presents results from a placebo test. If the observed correlation between alphabetical rank and defection was, indeed, driven by the fact that being allowed to vote early confers an advantage because it allows Senators to preempt their colleagues, then one would not expect to see a similar relationship in the House of Representatives. In the modern House, roll calls have become practically obsolete, as the House introduced electronic voting at the beginning of the 93rd Congress. In electronic "roll calls" there exists no predetermined order in which Representatives get to cast their vote. Any Representative is allowed to submit his choice as soon as the vote has been opened. Before the introduction

¹⁹Recall, Snyder and Groseclose (2000) define a roll call to be "lopsided" whenever the final number of "yeas" differs by more than 15 percentage points from the threshold required for passage.

of voting machines, 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 ordinarily operates to debate and vote on amendments. Consequently, Representatives voted on many crucial issues in anonymity and without a prespecified order (cf. Congressional Quarterly 1971; Koempel et al. 2008).²⁰ It is, therefore, not surprising that the results in the lower panel of Table 3 suggest little to no correlation between defection in the House and Congressmen’s alphabetical rank. In fact, two of the six estimates even have the “wrong” sign, and none of them is close to being significant, despite a much larger sample size.²¹

Table 4 examines some more-subtle predictions. According to the simulation results in Figures 3A and 3B, rank and defection should be strongly correlated when the minority party is united and when the seat advantage of the majority is sizeable but not large enough for the roll call to be lopsided. By contrast, when the majority party has only a one- or two-seat advantage, then, in equilibrium, almost all of its conflicted members must stick with the party line or else the roll call will be lost. Under these circumstances one would not expect to see a large negative point estimate—especially not when Senators have only imperfect knowledge of their colleagues’ preferences and when they are risk averse. Similarly, for calls on which the minority is split, the correlation between rank and defection should only be modestly negative, if at all. This is because, in equilibrium, minority party members should realize that the majority will win the roll call irrespective of their own choice. Defection by members of the minority then lessens the need of conflicted majority party Senators to stick with the party line.

By and large, these predictions are borne out in the data. Dividing roll calls by the median defection rate among members of the minority party (i.e. 15.5%) and estimating λ on the sample of calls on which the minority was “split” shows that rank and defection are practically uncorrelated under these circumstances. The same is true when the majority party enjoys a very large or a very small seat advantage, but not in an intermediate range—as predicted.

Interestingly, $\hat{\lambda}$ is estimated to be positive (but statistically insignificant) for cases in which the majority party owns only one or two seats more than the minority. Though a small positive point estimate would be consistent with the simulation results in Figure 3B, it may also arise from uncertainty in preferences coupled with Senators being risk averse.

²⁰In 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 (Congressional Quarterly 1971).

²¹In the data, roll calls held after the introduction of electronic voting outnumber those before by about two to one. Interestingly, point estimates for the period before the 93rd Congress are lower than those afterwards. Large standard errors, however, make direct comparisons highly speculative.

If agents cannot predict the choices of their colleagues with certainty, then those who vote early may prefer to “play it safe” rather than risk losing the roll call. Once seat margins become large enough, however, the incentive to preempt dominates.

The model’s comparative statics with respect to the party-influence parameter, β_p , are probed in Figure 4. The results therein correspond to $\hat{\lambda}$ estimated decade by decade. Although political scientists disagree about how best to measure party influence, they generally concur that partisanship was minimal in the 1960s and 1970s, but much stronger before and thereafter (see, e.g., Rhode 1991; Snyder and Groseclose 2000). Viewed through the lens of the model in Section 3, one would not expect to see much of a relationship between alphabetical rank and defection during the period in which party pressure was practically nonexistent. After all, when $\beta_p \approx 0$, Senators have little incentive to backward induct. Point estimates before 1960 and after 1980, however, should be negative and large.

This is exactly what we observe in Figure 4. Although none of the estimates is very precise, it is nonetheless possible to reject that they are all equal ($p < .001$). Moreover, one can reject that the point estimate for the 1960s is as large as or even larger than that for the 2000s ($p < .001$). The evidence in Figure 4 is, therefore, consistent with the predictions of the theoretical model.

The model also predicts that the majority party wins all controversial calls, but only by a small margin.²² While the prediction that the majority party always wins is clearly false, Figure 5 uses McCrary’s (2008) discontinuity test to show that there is, indeed, a “jump” around a margin of zero. More precisely, there are more than twice as many roll calls that the majority narrowly wins than it narrowly loses, and the difference is statistically highly significant ($p < .001$).²³

At the same time, Senators do seem to make mistakes. Restricting attention to roll calls on which the majority party was defeated by less than five votes and estimating $\hat{\lambda}$ only on this set of calls yields an estimate of $-.258$ (with a standard error of $.102$). Taking the point estimate at face value, at least some of these roll calls could have been won had it not been for the strategic defection.

²²To see that the winning margin need not be exactly one vote, consider the following example. One agent from each party has yet to vote. Both are conflicted in the sense that $\text{sgn}(\alpha_i) \neq \text{sgn}(\beta_p)$ and $|\alpha_i| < |\beta_p|$. The bill requires one more “yea” to pass. If the Senator from the majority party gets to vote first, he has to say “yea” or else the roll call will be lost. The minority party Senator is then able to defect (i.e. vote “yea”) without affecting outcome; and the bill passes with more than the minimal majority.

²³King and Zeckhauser (2003) observe a similar pattern in the House of Representatives, which they attribute to vote buying. Section 4.4 argues that vote-buying theories are consistent with the evidence in Figure 5, but that they fail to predict other moments of the data.

4.4. *Alternative Explanations?*

Although the data are broadly consistent with the predictions of the model, it is important to address alternative theories. A priori, however, there are not many candidate explanations for why Senators who fail to be forward looking are less likely to support the party line when they are allowed to vote earlier.

Traditional “vote-buying” theories, for instance, are consistent with the evidence in Figure 5, but they fail to predict the relationship between alphabetical position and defection. In this class of models, party leaders who are trying to ensure the passage of a bill approach Senators who are close to indifferent, as buying off these agents is cheaper than garnering the support of those who feel strongly about a particular issue (see, e.g., Groseclose and Snyder 1996; Snyder 1990). Thus, for vote-buying theories to explain the patterns in the data, it would have to be the case that Senators become more likely to intrinsically support a measure when their alphabetical rank increases.²⁴

Perhaps the best way to rule out explanations that do not involve forward-looking agents is to present evidence suggesting that Senators do anticipate the choices of opponents who get to vote after them and that they change their own behavior in response. To this end, consider the following econometric model:

$$(2) \quad d_{i,p,r,c} = \mu_i + \sum_{t=1}^{30} \delta_t E[d_{i+t,p,r,c}] \times 1[p \neq p_{i+t}] + \sum_{t=1}^{30} \gamma_t 1[p \neq p_{i+t}] + \phi \bar{d}_{p,r,c} + \varepsilon_{i,p,r,c},$$

where $E[d_{i+t,p,r,c}]$ denotes i 's expectation about whether Senator $i+t$ (i.e. the one who is supposed to vote t positions after i) will defect, p and p_{i+t} respectively denote i 's and $i+t$'s party affiliation, and $\bar{d}_{p,r,c}$ is the mean defection rate among other Senators of party p (i.e. excluding i). All other symbols are as defined above.

The coefficients of interest are δ_t . They indicate whether Senators react to the expected choices of their opponents. In particular, if Senator i reasons that the roll call is less likely to fail when his own defection and that of $i+t$ offset each other, then one should observe that $\hat{\delta}_t > 0$.

²⁴Even “if you need me” theories of vote buying are subject to this limitation. In these models, party leaders buy rank and file members’ support conditional on the roll call being very close (e.g., King and Zeckhauser 2003). That is, leaders call in vote options only if they are needed for the bill to pass. At first, it may seem that it would be more valuable to buy off members who get to vote later and that leaders calling on the support of these Senators might produce a negative correlation between alphabetical rank and defection. Yet, this conjecture is actually inconsistent with the theory. Since Senators can delay their vote at no cost by coming to the floor after the clerk has already called their name, even “if you need me” models of vote buying predict that it is cheaper for party leaders to target members who are intrinsically close to being indifferent (i.e. for whom $\alpha_i \approx 0$). Again, for vote-buying models to rationalize the data, one would have to believe that changes in Senators’ own preferences are systematically correlated with changes in their alphabetical rank.

By including $\bar{d}_{p,r,c}$, the model in equation (2) controls for unobserved heterogeneity across roll calls, i.e. for the possibility that some calls might be intrinsically more controversial than others. Identification then comes from situations in which Senators i and $i + s$ face some of the same opponents, but each of them is s positions further removed from the former than from the latter.

The main issue with equation (2) is that Senators' expectations, i.e. $E[d_{i+t,p,r,c}]$, are not observed. It is, therefore, necessary to find an appropriate proxy variable. One possibility would be to use the actual choices of other Senators, i.e. $d_{i+t,p,r,c}$. The concern with such an approach, however, is reverse causality. That is, Senator $i + t$ might decide to deviate from the party line *because* i lowered the expected cost of doing so by having defected before him. In order to avoid this problem, the results below proxy for agents' expectations with the defection probabilities implied by Senators' DW-Nominate scores (Poole 2005; Poole and Rosenthal 1997).

DW-Nominate is a scaling technique to estimate Congressmen's ideological ideal points based on their history of roll call voting. It is widely used by scholars in the field of American Politics. Given that, on average, Senators participate in more than a thousand roll calls, the effect of any particular choice on the resulting estimate, and thus the degree of endogeneity, is likely very small. Moreover, DW-Nominate has an intuitively appealing structure. Poole and Rosenthal's estimates are based on a probabilistic, two-dimensional spatial voting model. The primary dimension measures a Senator's position in the liberal-conservative domain. Results correlate very highly with party affiliation as well as "expert judgements" and interest group ratings. The second dimension picks up ancillary issues that divide the parties internally. DW-Nominate scores are fairly stable over time, and they predict about 85% of roll call votes correctly. Since Senators' political leanings are easily observable by their colleagues, it seems plausible that defection probabilities implied by their (estimated) ideological ideal points might be a good proxy for others' expectations thereof.²⁵

Restricting attention to Senators who get to vote ahead of at least thirty others, the upper panel of Figure 6A presents the results. As should be the case if Senators are forward looking, it appears that they react quite strongly to the expected choice of an opponent whose name directly follows their own. With a point estimate of 1.79% and a standard error of .35%, $\hat{\delta}_1$ is not only statistically highly significant, but compared to an average rate of defection of 18.5%, it is also economically large.

Interestingly, all other estimates of δ_t are smaller than the first one, and with one exception it is possible to reject the null hypothesis (on the 95%-confidence level) that they are at least as large. This raises the question: How forward looking are Senators?

²⁵DW-Nominate scores as well as the implied choice probabilities were generously provided by Keith Poole.

As point estimates for $t \geq 11$ are very close to zero, one might be tempted to answer “not very much.” At the same time, it is worth noting that one *can* reject the null that $\widehat{\delta}_2 - \widehat{\delta}_{10}$ ($\widehat{\delta}_5 - \widehat{\delta}_{10}$) are jointly equal to zero ($p < .001$ and $p = .003$, respectively). In order to test for the extent of agents’ foresight, the lower panel of Figure 6A presents p -values for the null hypotheses that $\delta_{t'} > 0$ for all $t' \leq t$. That is, it tests whether the data are consistent with Senators reacting to the expected choices of *all* opponents who are no more than t positions removed, with successive null hypotheses becoming more stringent.²⁶ Based on these results, the data appear highly consistent with Senators reacting to the expected choices of others who are 3 or fewer positions removed; the corresponding p -values all exceed 90%. Even for $t = 7$ is the respective p -value greater than 40%. Only for $t = 13$ and $t = 15$ would one be willing to reject the null at the 90%- and 95%-confidence levels, respectively. The evidence from both panels implies that Senators react to the behavior of opponents who get to vote shortly after them, but not to that of those who are far removed. It, therefore, seems that Senators *are* forward looking, but not perfectly so.

Importantly, the results in Figure 6A suggest that Senators are not literally solving the game backwards. If they were, then one would expect the votes of agents who choose closer to the end of the game to be at least as salient as the votes of Senators who are only a few positions removed. The results in Figure 6A, however, are at odds with this prediction. Instead, Senators seem to reason backward a few rounds, starting from a position close to their own.

Since the estimates above are based on Senators’ position in the alphabet as opposed to the actual order in which votes were submitted, one might be worried that the results could be driven by the set of agents who submitted their votes late. That is, i might have arrived on the floor after the clerk had first called his name and thus submitted his choice after observing the decisions of all $i' > i$. While this may lead to an upward bias in $\widehat{\delta}_t$, it would not automatically cause the point estimates to decline with t . In such a scenario i already knows how t and $t + 1$ have voted. Hence, there is no clear reason for why t ’s vote should have a bigger impact than that of Senator $t + 1$.

Another way to rule out this concern is to estimate δ_t conditional on the *actual* choices of others. If it was truly the case that $\widehat{\delta}_t$ is positive because some Senators submit their vote late, then it should be the case that opponents’ actual behavior has predictive power for the choice of i , even after controlling for $E[d_{i+t,p,r,c}]$.

Figure 6B demonstrates that this is not the case. The estimates therein are based on the

²⁶ p -values are based on the block bootstrap, i.e. on randomly sampling from the observed data set (with replacement, and at the Congress level) and counting the number of instances in which the results from estimating equation (2) are consistent with the null.

following specification:

$$(3) \quad d_{i,p,r,c} = \mu_i + \sum_{t=1}^{30} \delta_t \mathbf{E}[d_{i+t,p,r,c}] \times 1[p \neq p_{i+t}] \\ + \sum_{t=1}^{30} \theta_t d_{i+t,p,r,c} \times 1[p \neq p_{i+t}] + \sum_{t=1}^{30} \gamma_t 1[p \neq p_{i+t}] + \phi \bar{d}_{p,r,c} + \varepsilon_{i,p,r,c},$$

where all symbols are defined as above. Clearly, estimates of δ_t are very similar to those in the previous figure. $\hat{\theta}_t$, however, is remarkably close to zero for all t , and small standard errors rule out meaningfully large effects.²⁷ That is, conditional on predictions of their behavior, opponents’ realized choices have virtually no effect. This suggests that Senators react to the *expected*, not the actual, behavior of their colleagues.

In sum, the findings in Figures 6A and 6B imply that Senators are imperfectly forward looking. Taking the evidence at face value, Senators’ behavior is better described by “limited lookahead” (Johnson et al. 2002) than by backward induction.

4.5. Sources of Heterogeneity

Given that Senators’ ability to reason backwards appears to be limited, one might be interested in the effect of experience. Figure 7 addresses this question. The results therein 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.

Interestingly, when Senators have fewer than a thousand votes under their belt, there is no evidence that they react to the subtle advantage associated with being allowed to vote earlier. Not only are the respective point estimates jointly insignificant ($p = .817$), but each of them is close to zero. By contrast, estimates for agents who have participated in more than a thousand previous calls are economically large and (individually as well as jointly) statistically significant. Moreover, one can reject 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 those who have voted more than 5,000 times before ($p = .035$). 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 ($p = .041$).

Splitting the data by Senator experience at the time a given roll call was conducted (i.e. more vs fewer than 1,000 previous votes), Appendix Figure A.3 replicates the analysis in Figure 6B. “Inexperienced” Senators show little to no signs of anticipating the behavior of opponents who have yet to vote. Neither for $\hat{\delta}_1$ alone nor for $\hat{\delta}_1 - \hat{\delta}_{10}$ jointly is it possible to

²⁷By contrast, without controlling for $\mathbf{E}[d_{i+t,p,r,c}]$, estimates of θ_t are very similar to those in Figure 6A.

reject the null of no effect ($p = .124$ and $p = .264$, respectively). “Experienced” Senators, however, do seem to react to the expected behavior of their opponents, even of those who are 10–15 positions removed ($p = .055$). Based on the evidence in Figures 7 and A.3 one would conclude that experience plays an important role in whether Senators rely on backward reasoning. At least in this setting, agents learn very slowly.

Table 5 explores additional sources of heterogeneity. There is little evidence that Senators’ response to their alphabetical rank differs by age, formal education, or veteran status.²⁸ There are, however, large gender differences. While males’ tendency to deviate from the party line depends strongly on the order in which they cast their votes, alphabetical rank has practically no impact on the choices of females.

4.6. Discussion

Broadly summarizing, the empirical evidence suggest that Senators *are* forward looking, but imperfectly so. Moreover, there is evidence of substantial heterogeneity in the extent to which Senators reason backwards. An important issue then becomes: Is backward induction still a useful concept for understanding real-world behavior?

Although the cognitive demands imposed by backward induction are extremely high, it would be premature to dismiss the equilibrium outcome as *a priori* unrealistic. As shown in Section 3, Senators’ optimal strategies are very simple and intuitive. After a bit of introspection, or with enough experience, agents may well adopt these or very similar behavioral rules. Yet, as in many laboratory experiments, agents’ behavior is best described as “limited lookahead” (Johnson et al. 2002). Based on this observation, one might favor other, more realistic assumptions.

By contrast, when judged by the standard of Friedman (1953), backward induction would be regarded as “useful.” A model with boundedly rational agents would be far less tractable, whereas one with myopic Senators would not be able to rationalize why their choice to deviate from the party line depends on the order in which they get to vote as well as the expected (but not the actual) behavior of others.

To the extent that we are interested in how policies are enacted, it is important to understand why politicians act the way they do. A model with backward induction predicts strategic voting and moral hazard—both of which are borne out in the results above. Though

²⁸Although the difference is not statistically significant at conventional levels, the point estimates suggest that Senators without a college education may actually be more likely to exploit the opportunity to preempt their colleagues than those without one. One admittedly speculative explanation is that the few individuals making it to the Senate without being formally educated might possess higher-than-average innate intelligence, which could be especially conducive to recognizing the advantages conferred by being allowed to vote early.

backward induction is not a literal description of Senators' behavior, it can help us make sense of the data.

5. Concluding Remarks

The application in this paper represents one of the first attempts to explicitly test for backward reasoning using data generated outside of the laboratory. Although there are clear advantages to well-conducted experiments, testing game theory in the real world has the potential to generate insights that are unique to observational data. One example is Senators' very low speed of learning, which underscores the importance of studying real-world settings when drawing conclusions about the extent of behavioral biases.

In many ways the results above corroborate the basic tenets of game theory more closely than one might have expected based on the extant experimental literature. For instance, experienced Senators appear to be quite forward looking, and they condition their own behavior on the expected choices of others. At the same time, and despite the fact that the backward induction outcome calls for strategies that are very simple and intuitive, the data are at odds with the idea that agents' conduct can be characterized "as if" they were unboundedly rational.

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APPENDIX MATERIALS

A. Proofs

This appendix contains the proof omitted from Section 3.

LEMMA: *Generically, the sequential voting game has a unique subgame-perfect equilibrium, which is in pure strategies.*

PROOF: Generically, it will be the case that $\alpha_i \neq 0$ and $\alpha_i \neq \beta_p$ 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 $\alpha_i \neq \beta_p$, 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. *Q.E.D.*

PROPOSITION: *In the unique generic subgame-perfect equilibrium of the game, Democratic Senators who face a mild conflict of interest abandon the party line if and only if*

$$(*) \quad \left| \tilde{D} \right|_{i' > i} + 1 \neq y_i,$$

whereas their Republican counterparts defect whenever

$$(**) \quad \left| \tilde{R} \right|_{i' > i} + 1 \neq n_i.$$

PROOF: The lemma above proves uniqueness for the generic case. It, therefore, remains to be shown that the proposed strategy is subgame-perfect. To see this consider any node at which a conflicted Democrat chooses, and suppose that all others continue to play their equilibrium strategies outlined above and in Section 3.2.

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

If $\left| \tilde{D} \right|_{i' > i} + 1 < y_i$, however, the Democrats cannot win the roll call, even if i votes "yea." This is because $\left| \tilde{D} \right|_{i' > i} + 1 < y_i$ implies $\left| \tilde{R} \right|_{i' > i} + 1 \geq n_i$, 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 $\left| \tilde{D} \right|_{i' > i} + 1 < y_i$.

If $\left|\tilde{D}\right|_{i'>i} + 1 = y_i$, 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 Democrat voting after i , i.e. if $\left|\tilde{D}\right|_{i'>i} = 0$, then defecting will immediately cause the roll call to be lost. If there is another Democrat following i , say i' , it will be the case that $\left|\tilde{D}\right|_{i'>i'} + 1 < y_i$ and $\left|\tilde{R}\right|_{i'>i'} + 1 \geq n_i$, 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 \tilde{D} with \tilde{R} and y_i with n_i , the same arguments apply for conflicted Republicans. This shows that (*) and (**) are subgame-perfect, as desired. *Q.E.D.*

B. Data Appendix

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

B.1. Roll Call Data

Data on all roll call votes in the United States Senate were kindly provided by Keith Poole.²⁹ They are based on careful codings of the Congressional Record. The data contain Senators’ names, home states, party affiliation, and final votes. They neither indicate the actual order in which votes were submitted, nor do they contain any information on whether a given Senator changed or withdrew his initial vote. Unfortunately, this sort of information is not part of the Congressional Record. The analysis in this paper restricts attention to the votes of Democratic and Republican Senators since the emergence of the two-party system, i.e. from the 35th to the 112th Congress (1857–2013). The following variables are being used:

Party Line is defined for each roll call vote that a Senator submits. It equals the vote choice of the simple majority of *other* Senators from the same party (not including the Senator for whose vote it is calculated).

Deviate is an indicator variable equal to one if a Senator’s vote differs from the party line, as defined above. It is zero otherwise and undefined for Senators who did not participate in a given roll call.

Alphabetical Order is defined as $\frac{s_i-1}{S-1}$, where S denotes the number of Senators who participate in a given roll call, and s_i is Senator i ’s raw alphabetical rank among participants. s_i is constructed based on Senators’ last names, as contained in the raw data. Roughly speaking, the variable Order corresponds to Senators’ alphabetical percentile ranking among their colleagues (divided by 100).

“Close” vs “Lopsided” Roll Calls are categorized as in Snyder and Groseclose (2000). That is, a roll call is said to be “lopsided” whenever more than 65% or less than 35% of Senators voted “yea.” For votes that require a supermajority, e.g., treaties and cloture votes, the corresponding cutoffs

²⁹They are publically accessible at <http://www.voteview.com>.

are 51.7% and 81.7% (i.e. $66.7\% \pm 15\%$). Data on supermajority requirements come from Snyder and Groseclose (2000) and have been manually extended through the 112th Congress.

Divisive is an indicator variable equal to one if the majority of one party votes in the opposite direction of the majority of the other party. It is zero otherwise.

“Split” Minority is an indicator variable equal to one if fewer than the median percentage of minority party Senators (i.e. 15.5%) deviate from the party line on a particular roll call. It is zero otherwise.

Seat Advantage is defined as the difference in the number of Senators between the majority and minority parties who participate in a given roll call.

Expected Deviation is the probability of deviating from the party line (as defined above) implied by Senators’ two-dimensional DW-Nominate scores. For a description of the DW-Nominate estimation procedure, see Poole (2005). DW-Nominate scores as well as the implied choice probabilities were provided directly by Keith Poole.

Experience is defined as the total number of roll call votes that a Senator had ever submitted before a particular roll call was conducted.

B.2. *Senator Characteristics*

Raw data on Senators’ characteristics come from the Database of Congressional Historical Statistics and were obtained through the Inter-University Consortium for Political and Social Research (ICPSR 3371). The data were manually checked for errors and extended to cover all Senators who served before the end of the 112th Congress. Whenever the information in the Biographical Directory of the U.S. Congress differed from the raw data, the latter was changed to conform to the former.³⁰ Throughout the analysis, the following variables are used:

Age is defined as a Senator’s age (in years) at the beginning of a particular Congress.

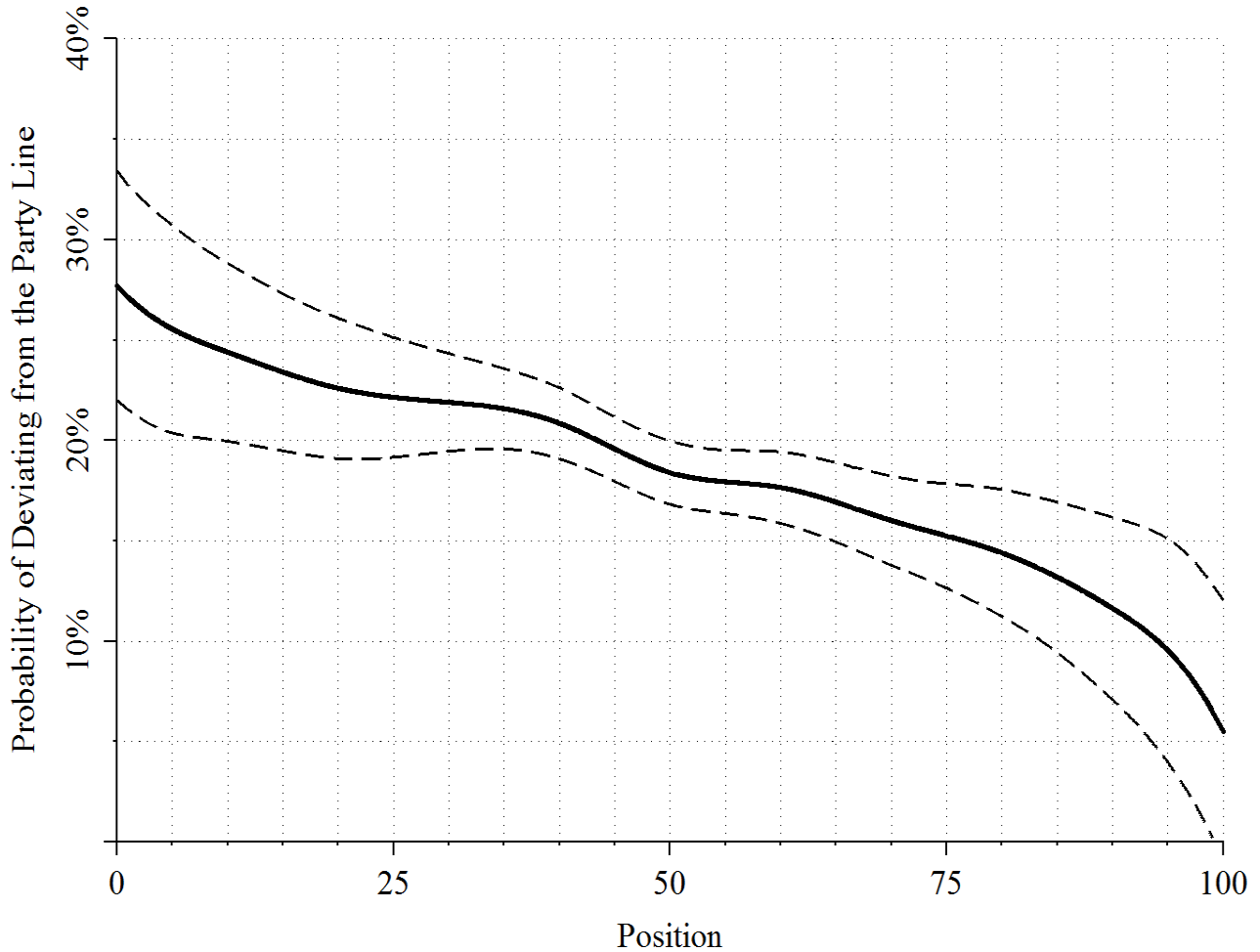
Gender is defined as the Senators biological sex.

College Educated is an indicator variable equal to one if the Biographical Directory of the U.S. Congress indicates that the Senator graduated from college. It is zero otherwise.

Veteran Status is an indicator variable equal to one if the Biographical Directory of the U.S. Congress indicates that the Senator ever served in the military. It is zero otherwise.

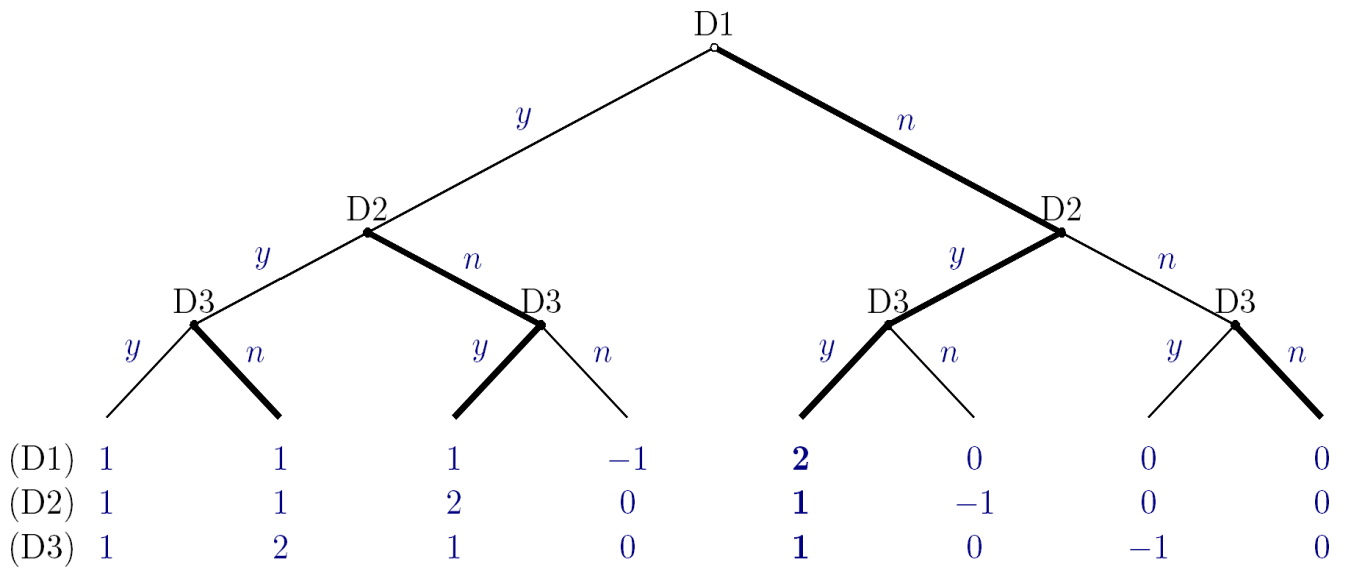
³⁰The Biographical Directory of the U.S. Congress is available at <http://bioguide.congress.gov/>.

Figure 1: Probability of Deviating from the Party Line as a Function of Alphabetical Order, U.S. Senate



Notes: Figure shows a semiparametric estimate of the relationship between Senators' alphabetical rank and the probability of deviating from the party line, i.e. $f(\cdot)$ in the following empirical model: $d_{i,p,r,c} = \mu_i + f(o_{i,r,c}) + \epsilon_{i,p,r,c}$, where $d_{i,p,r,c}$ is an indicator variable equal to one if and only 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 rank among those who participated in r . $f(\cdot)$ is approximated by cubic B-splines with knots at every 10 positions. The associated 95%-confidence intervals account for clustering at the Congress level. For precise definitions of all variables, see the Data Appendix.

Figure 2: Example of Sequential Voting Game with $\beta = 2$ and $\alpha = -1$



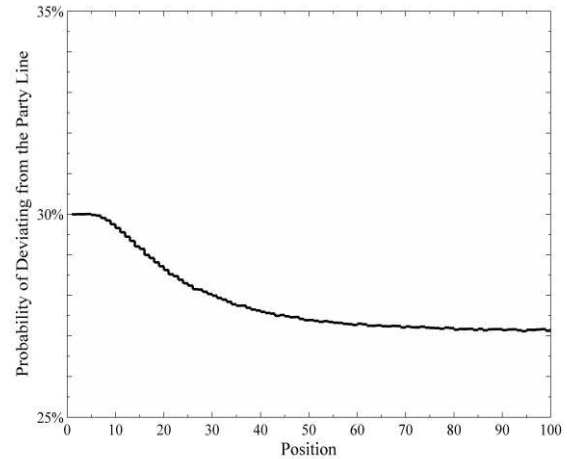
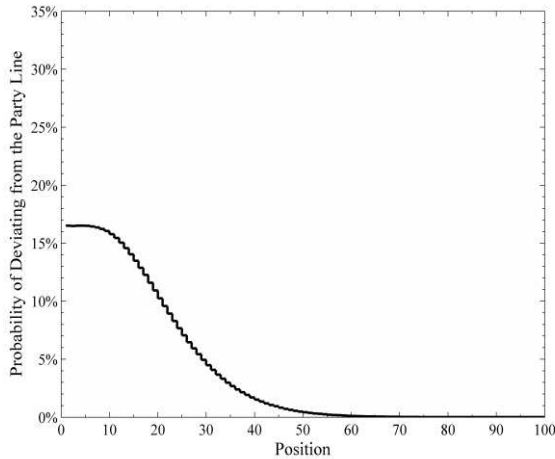
Notes: Figure shows an example of the sequential voting game in Section 3 with one party and three players, all of whom receive payoff $\alpha = -1$ if they vote "yea" and $\beta = 2$ if the bill ends up being approved. Two "yea" votes are needed for passage. The thick lines indicate each player's optimal action at a particular node in the game tree.

Figure 3A: Simulated Mean Frequency of Deviations from the Party Line

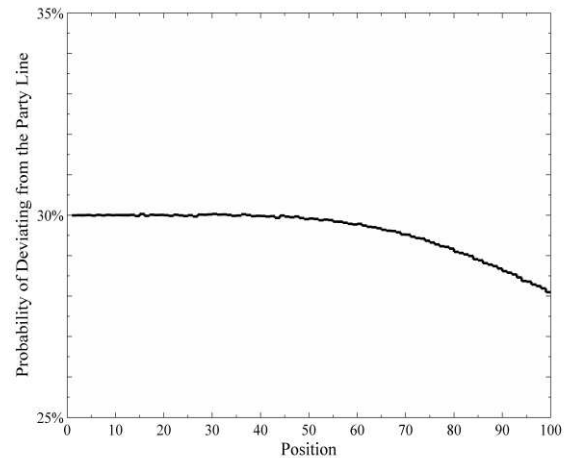
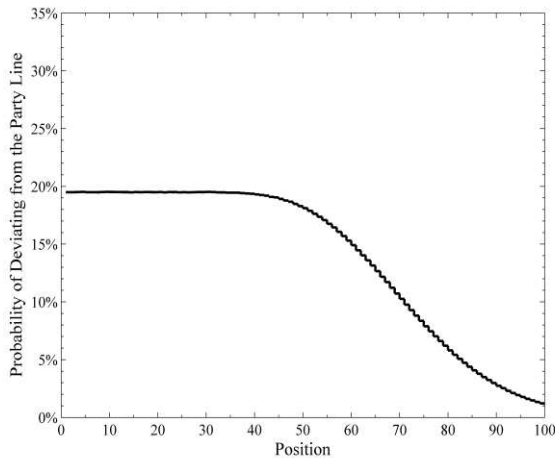
A. Majority Party Split

B. Both Parties Split

I. 55 Majority Party Members

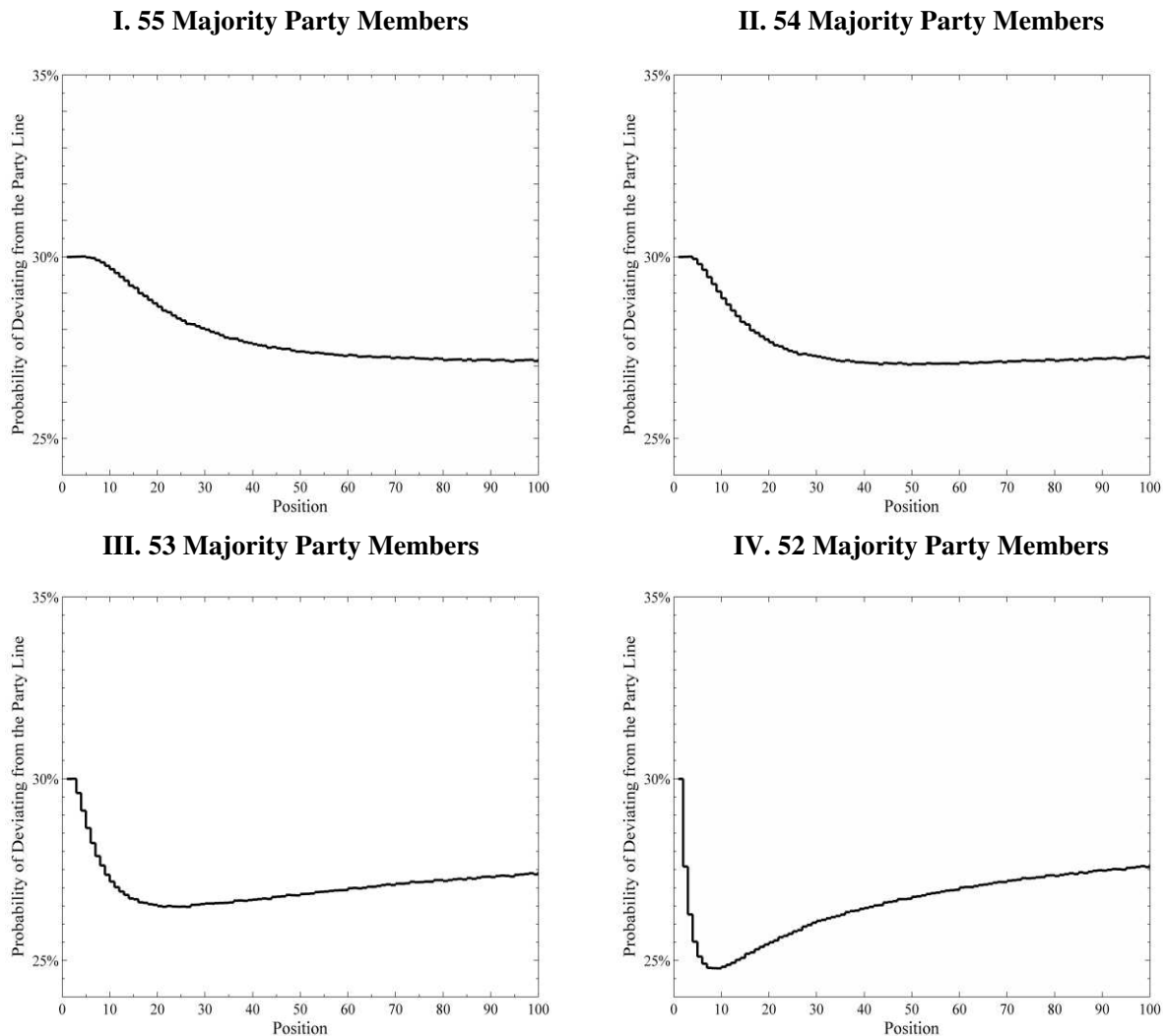


II. 65 Majority Party Members



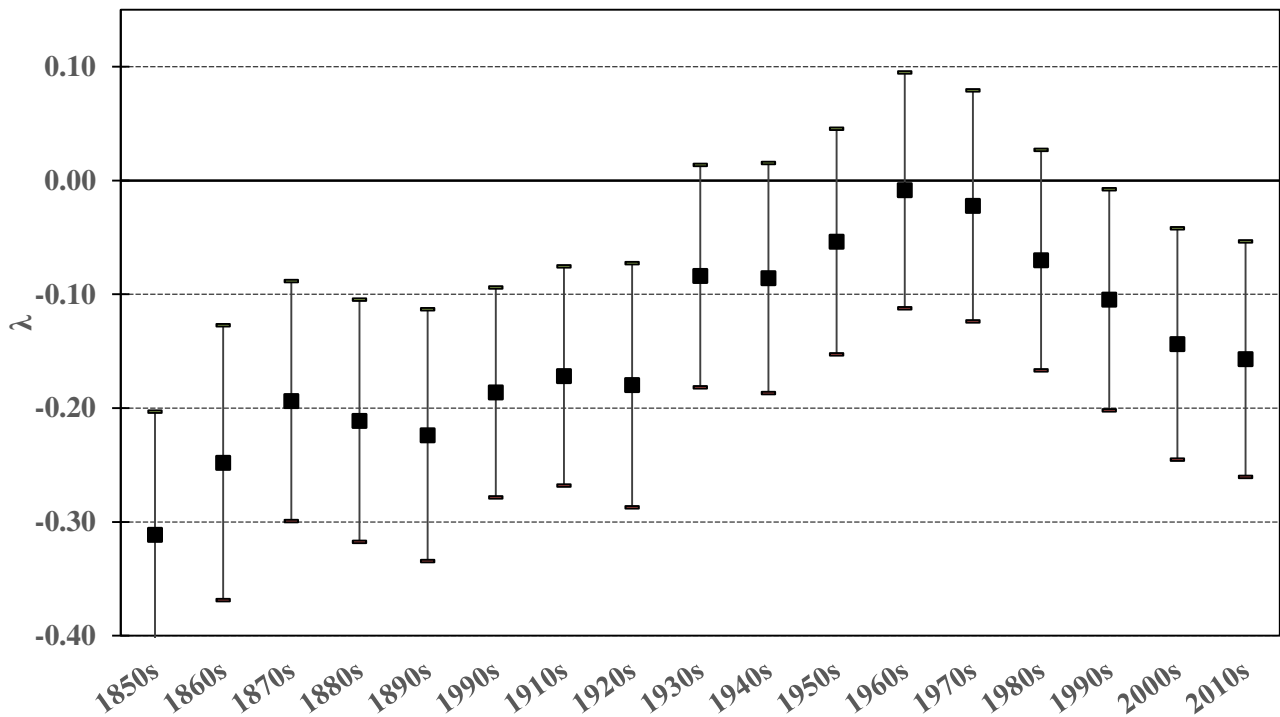
Notes: Figure depicts the expected average rate of defection as a function of when a Senator gets to cast his vote. The results in each panel are based on 10 million simulated roll call votes in which 100 Senators follow the equilibrium strategies described in Section 3.2. For each roll call, the order in which agents vote is determined randomly. The majority party's preferred outcome obtains whenever a simple majority votes "yea." In the upper two panels, 55 Senators belong to the majority party. In the lower two panels, that number increases to 65. In the panels on the left, there is a 30% chance that a Senator of the majority party is conflicted in the sense that he would want to vote against his own party if and only if his vote did not change the overall outcome of the roll call. In the panels on the right, that probability applies to Senators of both parties. The preferences of all other agents are aligned with their parties' opposing stances. Simulations varying the shares of conflicted Senators show qualitatively identical patterns and are available from the author upon request.

Figure 3B: Simulated Mean Frequency of Deviations from the Party Line Given a Narrow Margin of Majority



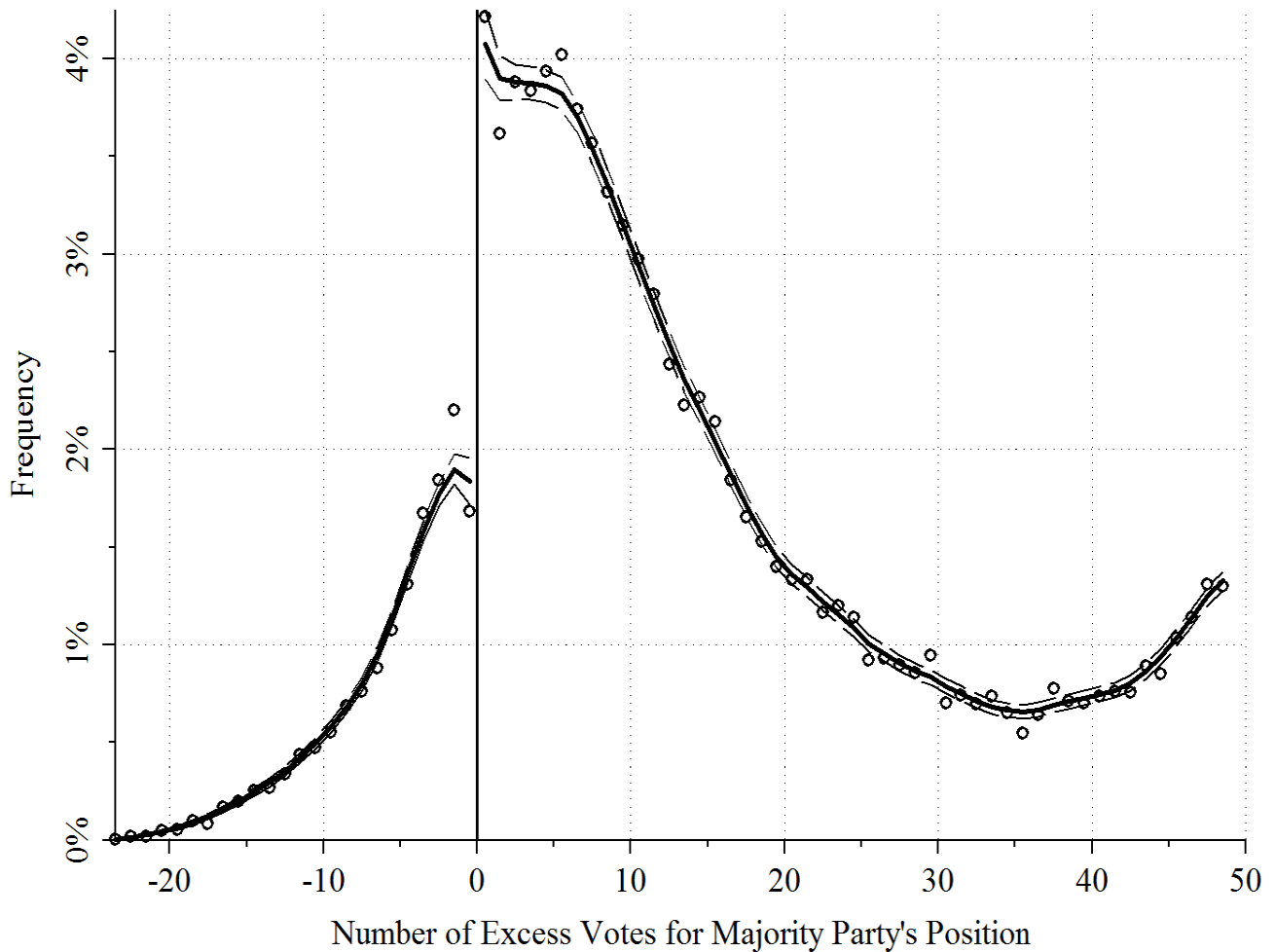
Notes: Figure depicts the expected average rate of defection as a function of when a Senator gets to cast his vote. The results in each panel are based on 10 million simulated roll call votes in which 100 Senators follow the equilibrium strategies described in Section 3.2. For each roll call, the order in which agents vote is determined randomly. The majority party's preferred outcome obtains whenever a simple majority votes "yea." In all simulations, there is a 30% probability that any given Senator is conflicted in the sense that he would want to vote against his own party if and only if his vote did not change the overall outcome of the roll call. Panels I–IV lower the number of Senators who belong to the majority party from 55 to 52. The preferences of all other agents are aligned with their parties' opposing stances. Simulations varying the shares of conflicted Senators show qualitatively similar patterns and are available from the author upon request.

Figure 4: Estimated Order Effects, by Decade



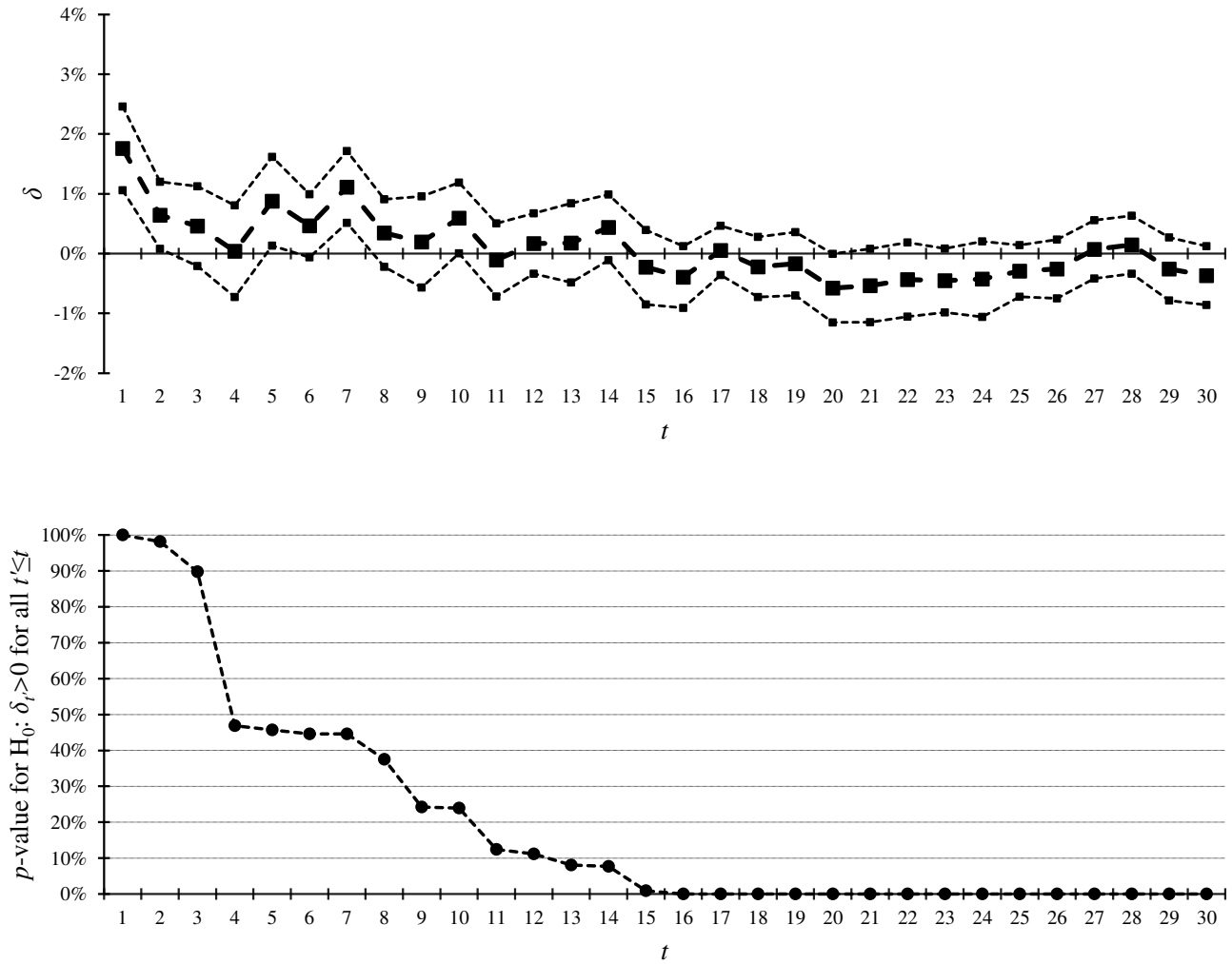
Notes: Figure shows point estimates and the associated 95%-confidence intervals for λ , estimated decade by decade. Estimates are based on equation (1) and Senators' roll call-specific rank. Confidence intervals account for heteroskedasticity and clustering of the residuals at the Congress level. See the Data Appendix for the precise definition and source of each variable.

Figure 5: Distribution of Excess Votes in Favor of Majority Party's Position, U.S. Senate 1857–2013



Notes: Figure depicts a histogram of the excess number of votes (relative to the threshold required for passage) in favor of the position held by the Senate's majority party, as well as the estimated density function and the associated 95%-confidence intervals. The underlying data come from roll calls in the U.S. Senate that required a simple majority and were held during the 35th–112th Congresses. The histogram's binsize is set to 1, and the stance of the majority party is determined as explained in Section 4.2. Density estimates are based on local linear regressions with a bandwidth of 4, applied separately on each side of the cutoff at 0. The estimated log-discontinuity equals 133% of the value just left to the cutoff and has a standard error of 5%. See McCrary (2008) for details on the estimation procedure.

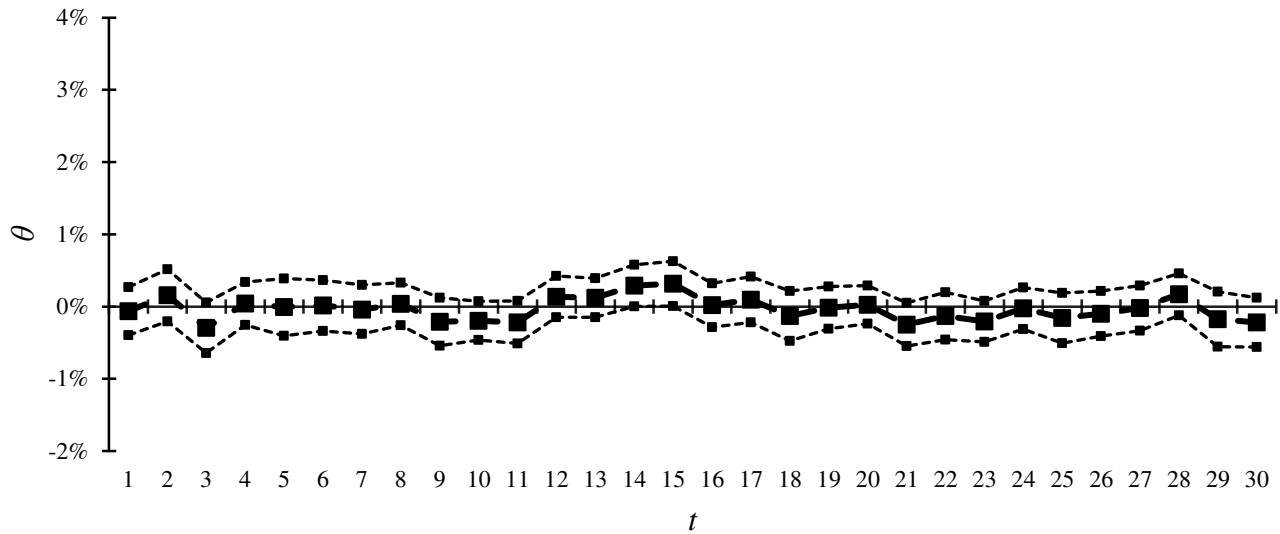
Figure 6A: Change in the Likelihood of Deviating from the Party Line as a Function of Opponents' Predicted Behavior



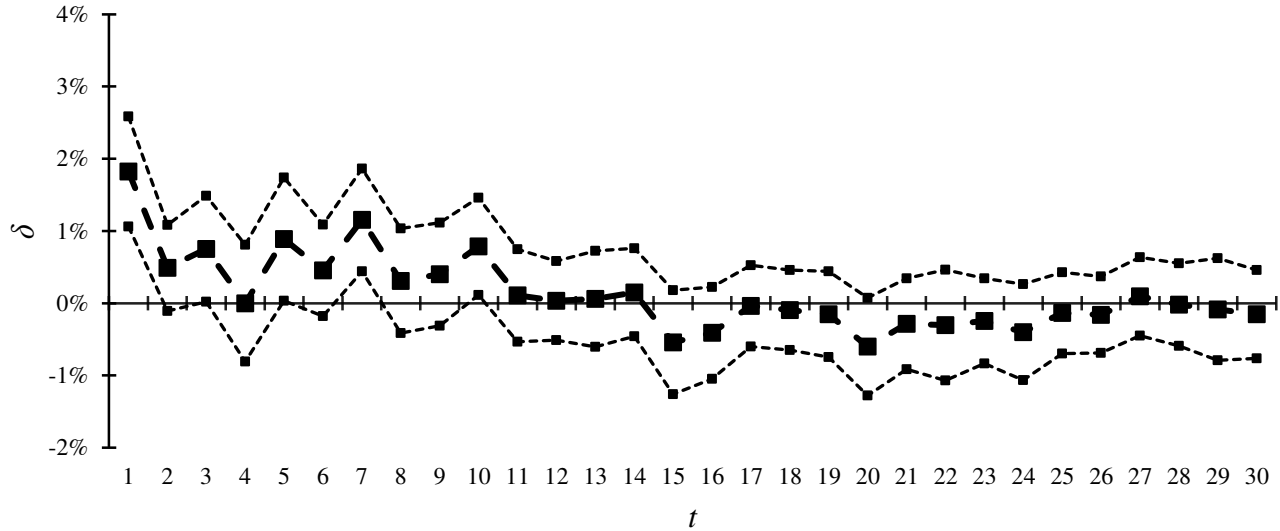
Notes: The upper panel shows the estimated change in Senators' probability of deviating from the party line in response to anticipated deviations from agents of the opposing party who get to vote t positions afterwards, i.e. δ_t in equation (2). The associated 95%-confidence intervals account for heteroskedasticity and clustering at the Congress level. Defection probabilities implied by DW-Nominate scores proxy for Senators' expectations, as explained in Section 4.4. The lower panel depicts p -values from testing the null hypotheses that Senators react to all opponents who are t or fewer positions removed, i.e. that $\delta_{t'} > 0$ for all $t' \leq t$. p -values account for clustering at the Congress level and are based on the block bootstrap with 10,000 iterations.

Figure 6B: Reactions to Opponents' Predicted vs Actual Behavior

I. Reaction to Opponents' Actual Behavior (controlling for Predicted Choice)

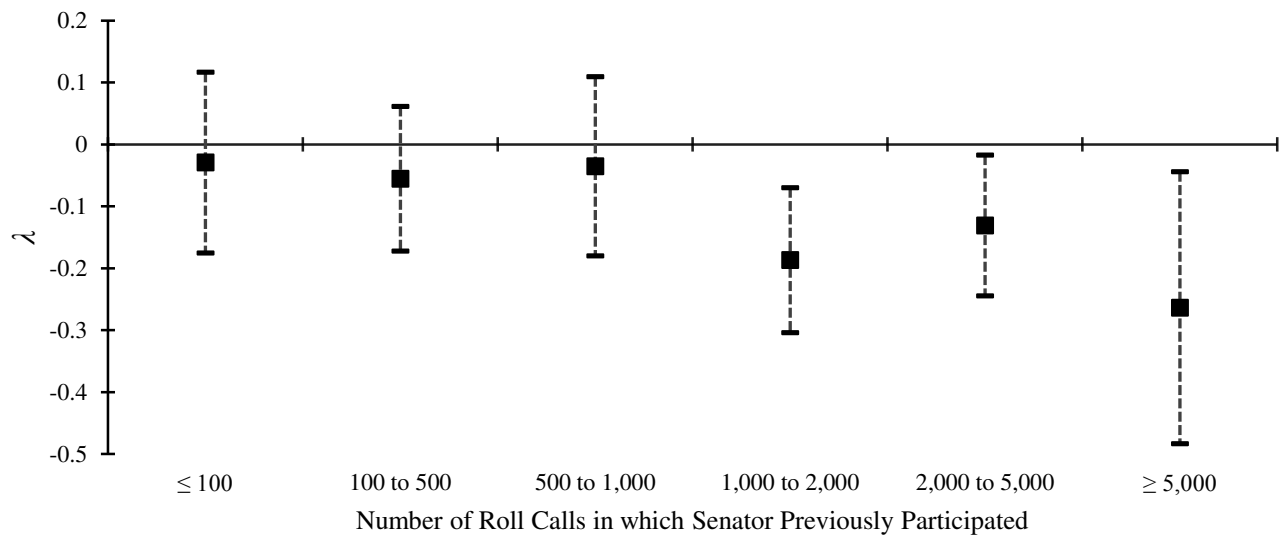


II. Reaction to Opponents' Predicted Behavior (controlling for Actual Choice)



Notes: Figure shows the estimated change in Senators' probability of deviating from the party line in response to actual (upper panel) and anticipated (lower panel) deviations from Senators of the opposing party who get to vote t positions afterwards, i.e. θ_t and δ_t in equation (3). The associated 95%-confidence intervals account for heteroskedasticity and clustering at the Congress level. Defection probabilities implied by DW-Nominate scores proxy for Senators' expectations, as explained in Section 4.4.

Figure 7: Estimated Order Effect, by Senators' Prior Experience



Notes: Figure shows point estimates and the associated 95%-confidence intervals for λ among different sets of roll call votes. Groups are defined according to the number of roll calls in which Senators had previously participated. Estimates are based on equation (1) and Senators' roll call-specific rank. Confidence intervals account for heteroskedasticity and clustering of the residuals at the Congress level. See the Data Appendix for the precise definition and source of each variable.

Table 1: Summary Statistics for Roll Call Votes in the U.S. Senate, 1857–2013

Variable	Mean	Median	SD	Min	Max
Congress Level ($N = 78$):					
Number of Roll Calls	511.9	492	272.2	84	1,311
Number of Distinct Senators	95.46	101	12.18	54	111
Number of Distinct Democrats	47.81	48	15.24	10	82
Number of Distinct Republicans	46.41	47	10.33	16	67
Roll Call Level ($N = 39,929$):					
Number of Valid Votes	76.10	85	21.85	14	100
Outcome "Close"	.498	0	.500	0	1
Outcome "Lopsided"	.502	1	.500	0	1
Divisive	.563	1	.496	0	1
Vote Level ($N = 3,009,507$):					
Alphabetical Position	.500	.500	.292	0	1
Deviation from Party Line	.185	0	.388	0	1

Notes: Entries are descriptive statistics for the most important variables used throughout the analysis. For precise definitions of all variables, see the Data Appendix.

Table 2: Likelihood of Deviating from the Party Line as a Function of Alphabetical Order, U.S. Senate

	<i>A. Roll Call Specific Order</i>		<i>B. Order Among All Senators</i>	
	(1)	(2)	(3)	(4)
Alphabetical Order	-.166 (.054)	-.118 (.048)	-.212 (.072)	-.522 (.257)
Senator Fixed Effects	Yes	No	Yes	No
Senator × Congress Fixed Effects	No	Yes	No	Yes
R-Squared	.055	.074	.055	.074
Number of Observations	3,009,507	3,009,507	3,009,507	3,009,507

Notes: Entries are coefficients and standard errors from estimating equation (1) by ordinary least squares. Heteroskedasticity robust standard errors are clustered by Congress and reported in parentheses. As explained in the main text, Alphabetical Order has been "standardized" to cover the unit interval. The two left-most columns are based on Senators' alphabetical rank among those who participated in a given roll call, whereas the two right-most columns construct order based on the entire set of Senators who served in Congress at the time a given roll call was held. See the Data Appendix for the precise definition and source of each variable.

Table 3: Deviations from the Party Line as a Function of Alphabetical Order, U.S. Senate & House of Representatives

<i>A. Senate</i>						
	Deviate					
	(1)	(2)	(3)	(4)	(5)	(6)
Roll Call-Specific Order	-.166 (.054)	-.118 (.048)	-.057 (.038)	.002 (.051)	-.298 (.088)	-.244 (.063)
Sample	All Roll Calls	All Roll Calls	Lopsided Roll Calls	Lopsided Roll Calls	Close Roll Calls	Close Roll Calls
Senator Fixed Effects	Yes	No	Yes	No	Yes	No
Senator × Congress Fixed Effects	No	Yes	No	Yes	No	Yes
R-Squared	.055	.074	.036	.056	.114	.151
Number of Observations	3,009,507	3,009,507	1,557,319	1,557,319	1,452,188	1,452,188
<i>B. House of Representatives</i>						
	Deviate					
	(7)	(8)	(9)	(10)	(11)	(12)
Roll Call-Specific Order	-.042 (.077)	.161 (.101)	-.060 (.091)	.157 (.097)	-.092 (.107)	-.047 (.110)
Sample	All Roll Calls	All Roll Calls	Lopsided Roll Calls	Lopsided Roll Calls	Close Roll Calls	Close Roll Calls
Senator Fixed Effects	Yes	No	Yes	No	Yes	No
Senator × Congress Fixed Effects	No	Yes	No	Yes	No	Yes
R-Squared	.052	.068	.036	.061	.131	.158
Number of Observations	14,229,434	14,229,434	7,537,202	7,537,202	6,692,232	6,692,232

Notes: Entries are coefficients and standard errors from estimating equation (1) by ordinary least squares. The upper panel does so for the U.S. Senate, while the entries in the lower panel refer to the House of Representatives. Heteroskedasticity robust standard errors are clustered by Congress and reported in parentheses. As explained in the main text, roll calls are classified as "close" or "lopsided" according to the cutoffs in Snyder and Groseclose (2000). See the Data Appendix for the precise definition and source of each variable.

Table 4: Comparative Statics

	λ	N
Baseline	-.166 (.054)	3,009,507
Split Minority	.019 (.044)	1,493,962
By Majority Party's Seat Advantage:		
1 or 2 Seats	.070 (.080)	261,856
3 to 5 Seats	-.128 (.109)	207,880
6 to 10 Seats	-.191 (.109)	889,653
11 to 20 Seats	-.175 (.115)	756,724
> 20 Seats	.015 (.074)	816,748

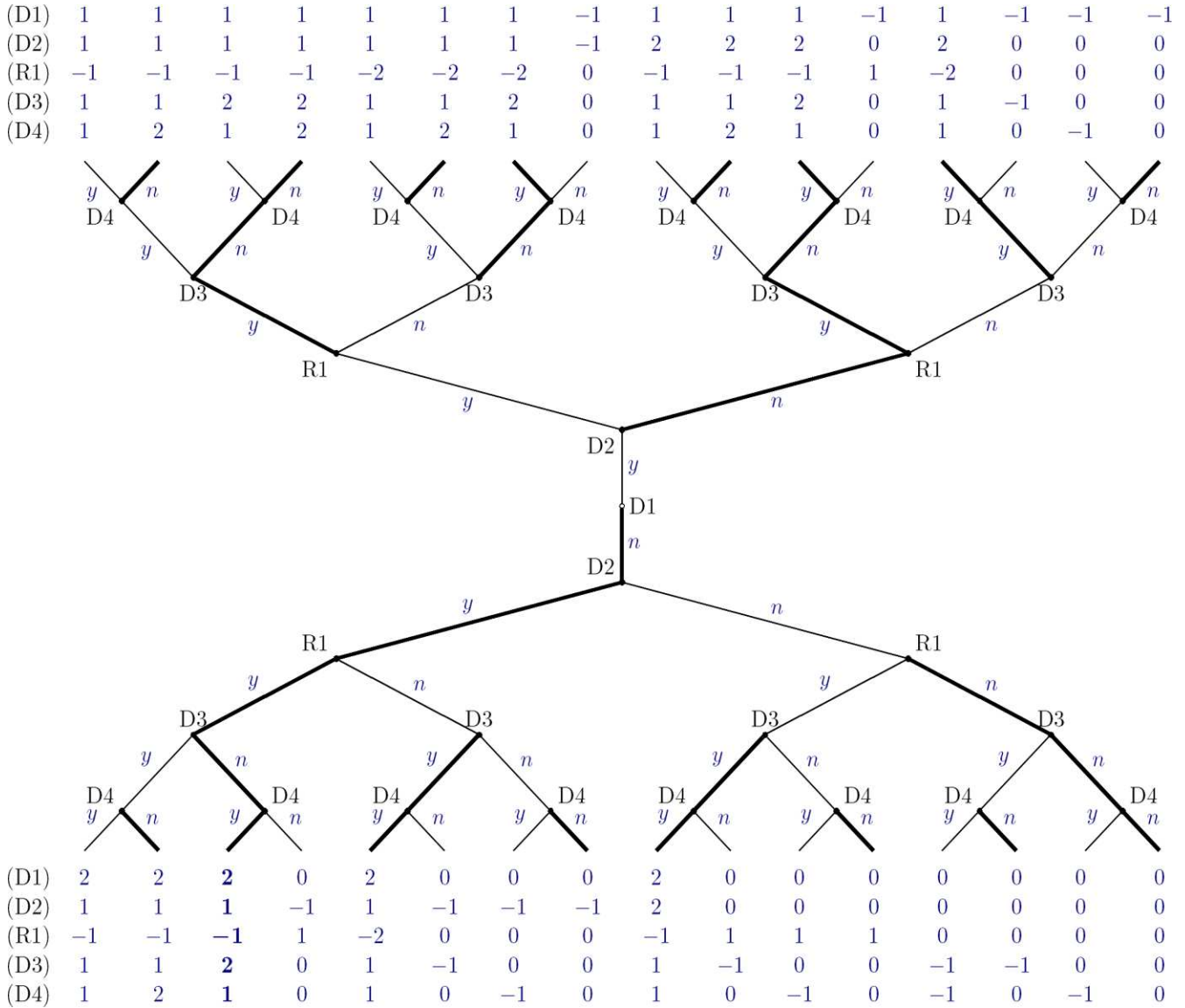
Notes: Entries in the center column are point estimates and standard errors for λ in different subsamples of the data. The respective restriction is indicated on the left of each row. Estimates are based on equation (1) and Senators' roll call-specific rank. Heteroskedasticity robust standard errors are clustered by Congress and reported in parentheses. The column on the right contains the number of observations in each subsample. See the Data Appendix for the precise definition and source of each variable.

Table 5: Order Effects, by Senators' Characteristics

Observable Characteristic	λ	F-Test
Baseline	-.166 (.054)	--
By Age:		
< 50 Years	-.151 (.052)	
50 to 65 Years	-.159 (.052)	.290
> 65 Years	-.168 (.055)	
By Gender:		
Male	-.165 (.054)	
Female	-.027 (.030)	.012
By Educational Achievement:		
Less than College	-.245 (.076)	
College Educated	-.138 (.058)	.149
By Veteran Status:		
Veteran	-.188 (.058)	
No Military Experience	-.141 (.066)	.487

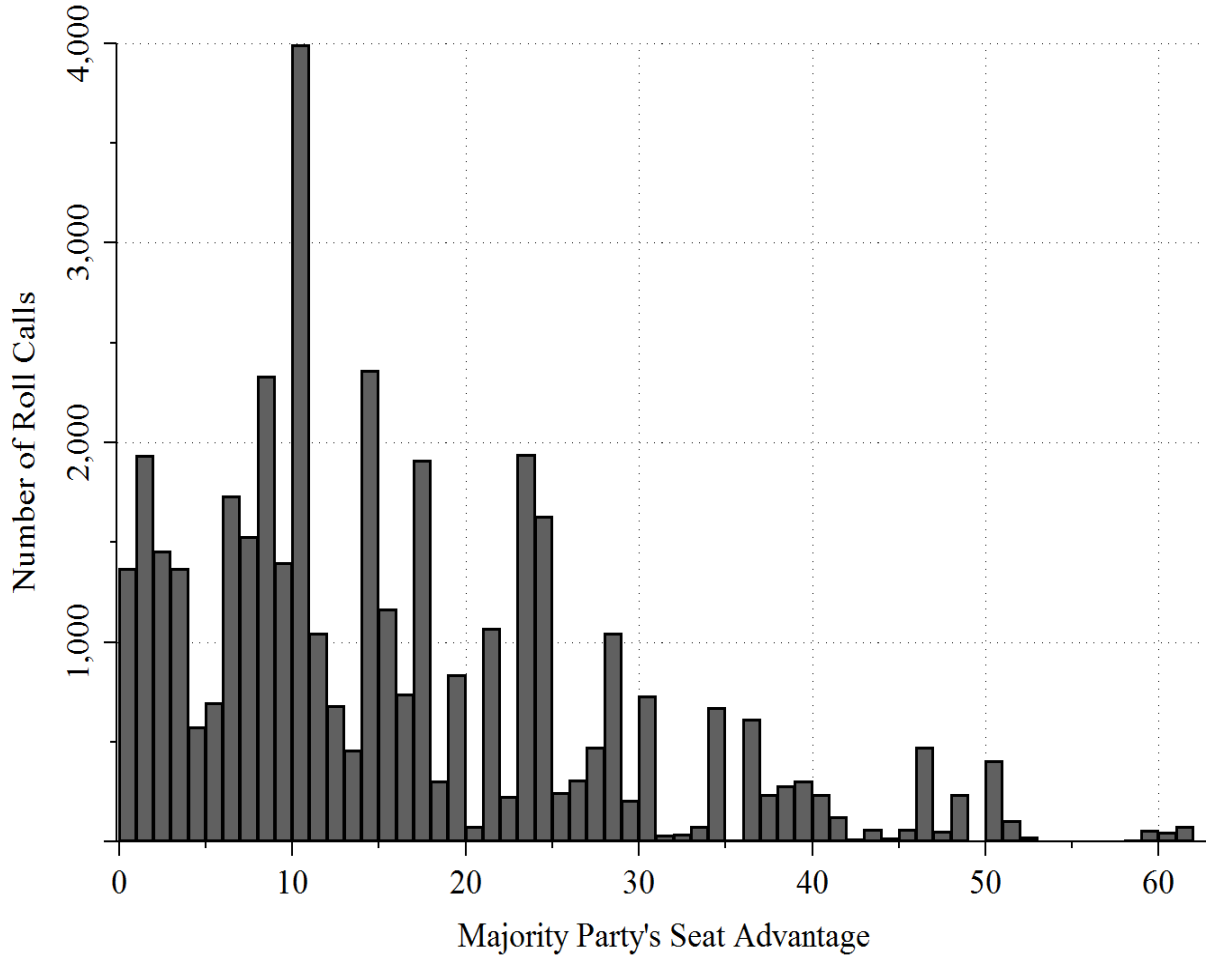
Notes: Entries in the center column are point estimates and standard errors for λ in different subsamples of the data. The respective restriction is indicated on the left of each row. Estimates are based on equation (1) and Senators' roll call-specific rank. Heteroskedasticity robust standard errors are clustered by Congress and reported in parentheses. The column on the right displays p -values from an F-test for equality of coefficients. See the Data Appendix for the precise definition and source of each variable.

Figure A.1: Sequential Voting Game with Conflicted Members of Both Parties



Notes: Figure shows an example of the sequential voting game in Section 3 with two parties and five Senators. All Democrats receive payoff $\alpha = -1$ if they vote "yea" and $\beta = 2$ if the bill ends up being approved, whereas Republicans receive $\alpha = 1$ and $\beta = -2$. Three "yea" votes are needed for passage. The thick lines indicate each player's optimal action at a particular node in the game tree.

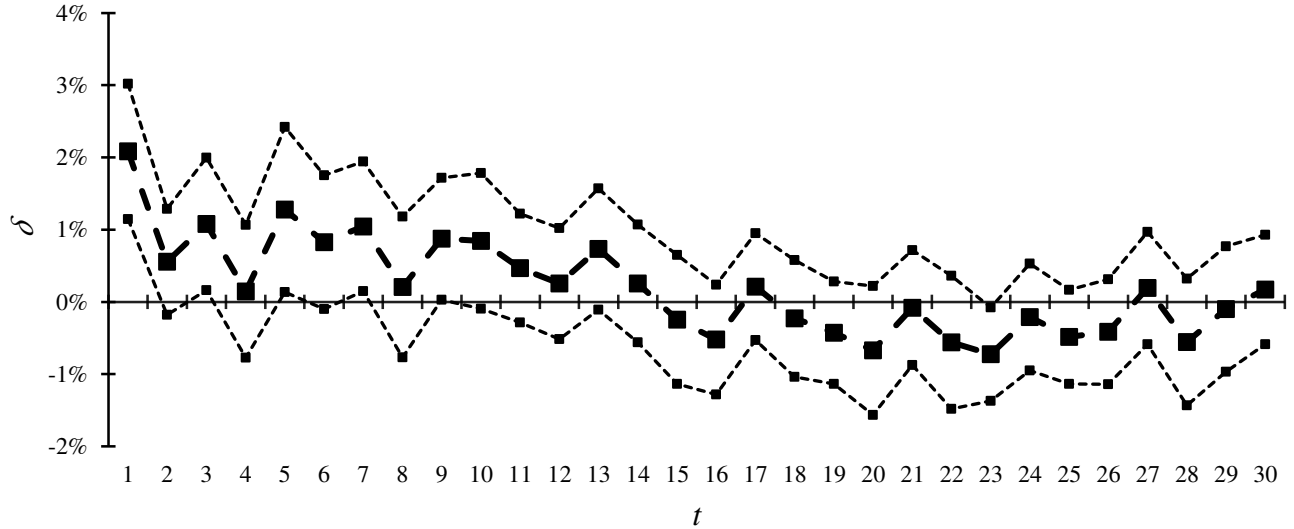
Figure A.2: Distribution of the Majority Party's Roll Call-Specific Seat Advantage, U.S. Senate 1857–2013



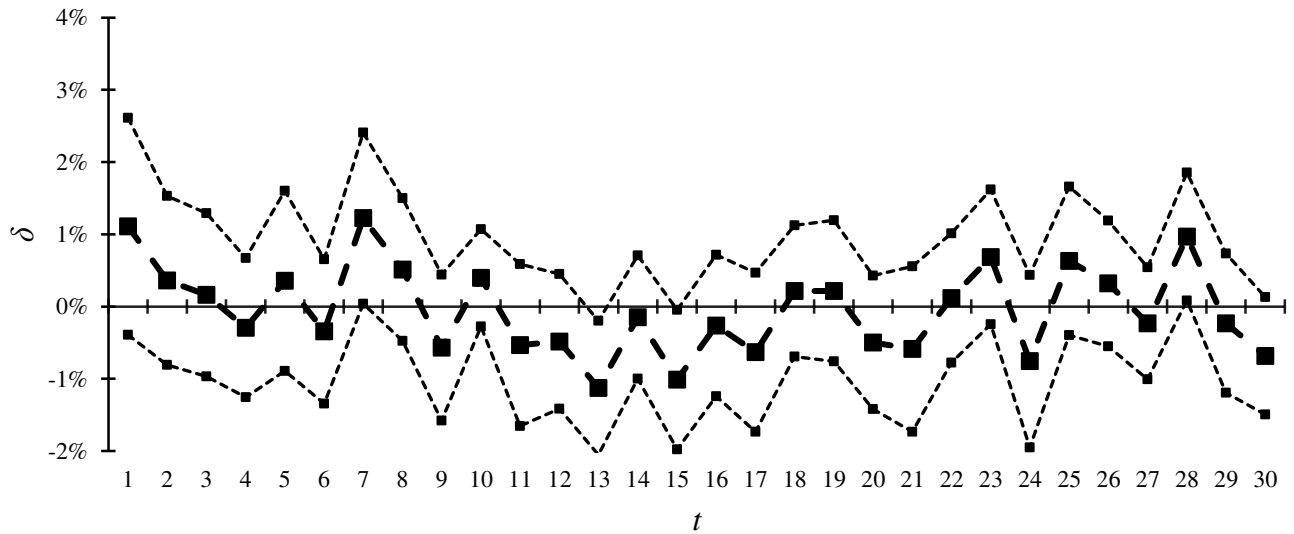
Notes: Figure shows the distribution of the majority party's seat advantage during the 35th–112th Congresses, restricting attention to Senators who participated in a given roll call. The majority party is defined by roll call, i.e. the party with the most Senators participating.

Figure A.3: Reactions to Opponents' Predicted Behavior, by Senators' Experience

I. Experienced Senators ($\geq 1,000$ roll call votes)



II. Inexperienced Senators ($< 1,000$ roll call votes)



Notes: Figure shows the estimated change in Senators' probability of deviating from the party line in response to anticipated deviations from agents of the opposing party who get to vote t positions afterwards, i.e. δ_t in equation (3). The upper (lower) panel restricts attention to the choices of Senators who had participated in at least (less than) 1,000 previous roll calls. Estimates control for opponents' actual choices. The associated 95%-confidence intervals account for heteroskedasticity and clustering at the Congress level. Defection probabilities implied by DW-Nominate score proxy for Senators' expectations, as explained in Section 4.4.

Table A.1: Estimated Order Effects given Alternative Definitions of the Party Line

	λ	N
Based on Majority of Fellow Party Members	-.166 (.054)	3,009,507
Based on Vote of Party Leader	-.375 (.090)	2,182,028
Based on Vote of Party Whip	-.239 (.099)	2,256,939

Notes: Entries in the center column are coefficients and standard errors for λ , given different definitions of the party line. The respective definition is indicated on the left of each row. Estimates are based on equation (1). Heteroskedasticity robust standard errors are clustered by Congress and reported in parentheses. The column on the right shows the number of valid observations associated with each definition. Sample sizes vary because parties did not adopt today's leadership system until the early twentieth century. See the Data Appendix for the precise definition and source of each variable.