Voting in the Bicameral Congress: Large Majorities as a Signal of Quality.*

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Abstract

We estimate a model of voting in Congress that allows for dispersed information about the quality of proposals in an equilibrium context. The results highlight the effects of bicameralism on policy outcomes. In equilibrium, the Senate imposes an endogenous supermajority rule on members of the House. We estimate this supermajority rule to be about four-fifths on average across policy areas. Moreover, our results indicate that the value of the information dispersed among legislators is significant, and that in equilibrium a large fraction of House members (40-50 %) vote in accordance with their private information. Taken together, our results imply a highly conservative Senate, in the sense that proposals are enacted into law only when it is extremely likely that their quality is high.

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1 Introduction

One of the main arguments for bicameralism is that a bicameral legislature can improve the quality of public policy vis-à-vis a unicameral system (see Tsebelis and Money (1997) and references therein). Evaluating the quality of proposals is indeed a key consideration in legislative settings. As numerous examples and a vast literature show (see Krehbiel (1991)), two key points seem to be largely uncontroversial. First, most issues decided in Congress have a common value dimension, be it the technical merit of the proposal or its appropriateness for the given state of the environment. Second, the information about these common value components is dispersed throughout the members of Congress: no individual knows the whole truth, but each individual has some valuable information to improve the quality of legislation (see also Gilligan and Krehbiel (1987), Epstein and O'Halloran (1999), Londregan (1999, 2000), and Hirsch and Shotts (2008)).

Given elements of common values and dispersed information, legislators will generally be able to use the information contained in the voting decisions of other members of Congress to shape their own decision of how to vote. A natural question then emerges: does bicameralism affect the voting behavior of members of Congress? And if so, what are the implications for policy outcomes of adopting a bicameral legislature? This paper addresses these questions by analyzing roll call voting data in the US Congress.

Doing so demands a fundamental change in the way we approach roll call voting data. Beginning with the seminal contributions of Poole and Rosenthal (1985, 1991) a large empirical literature made considerable progress in understanding the voting behavior of members of the US Congress.[1] This progress relied on a fully micro-founded (i.e., structural) approach, based on the sincere (non-strategic) spatial voting model of decision-making in committees (SSV). In other words, these analyses take the SSV model as given, and then recover the parameters of the model as those that best fit the data.

[1]Within this framework, the literature tackled a diverse array of issues, including stability and polarization in Congress (Poole and Rosenthal (1991), Poole and Rosenthal (1997), McCarty, Poole, and Rosenthal (2001)), the role of Committees (Poole and Rosenthal (1997), Londregan and Snyder (1994)), and the influence of political parties (Snyder and Groseclose (2000), McCarty, Poole, and Rosenthal (2001), Cox and Poole (2002)).

While the SSV model has several appealing properties, it also makes strong implicit and explicit assumptions which shape the analysis and interpretation of roll call data. In particular, a key limitation of applying the SSV model to Congress is that it assumes that the legislative setting is entirely about conflict resolution, precluding legislators from considering the technical merit or appropriateness of proposals for the given state of the environment. As a result, the SSV model rules out by hypothesis the possibility that bicameralism can shape the quality of public policy.[2]

For the same reasons, the SSV model led to a disconnection in the analysis of voting in the two chambers of Congress. In this private values model, a legislator votes in favor of a proposal if and only if the proposal is closer to her ideal policy than the status quo: the votes of other members do not contain information that would help a legislator improve her decision. In particular, legislators in one chamber cannot gain any relevant information by observing (or conditioning on) the outcome of the vote in the other chamber. As a result, the empirical analysis of voting in Congress treated the consideration of the same bill in the two separate chambers as statistically (and theoretically) independent.

But with dispersed information about the quality of the proposal, a bicameral legislature can amount to more than a sequence of separate chambers. If at least some members of the originating chamber use their information to guide their voting decision, the outcome of their vote will become a public signal for members of the receiving chamber. In fact, this is consistent with anecdotal evidence from comparable political institutions with two-tier committee systems. In universities, for example, votes for tenured appointments with divided support in the faculty often fail at the administration level, or are not even presented for consideration. A similar phenomenon seems to hold in committee-floor considerations in legislatures.[3] The model of common values and dispersed information suggests that

[2]The SSV can be extended to include a *publicly known* valence differential between alternatives. In fact, as pointed out by Londregan (1999), the two models are equivalent: a valence advantage for the proposal against the status quo is indistinguishilble from a more extreme status quo (and no valence). Thus we cannot separately identify the midpoint between two alternatives and the valence differential. Extending the spatial model to incorporate common values and dispersed information is a different matter. This is the focus of this paper (see also Iaryczower and Shum (2009)).

[3]As Oleszek (2004) points out, bills " voted out of committee unanimously stand a good chance on the floor . . . [while a] sharply divided committee vote presages an equally sharp dispute on the floor" (pg. 102).

this is due to the fact that the voting outcome in the originating committee aggregates information about the quality of the proposal vis-a-vis the status quo. A divided vote in an academic committee is problematic because it sends the administration a *signal* of low quality; similarly, a divided vote in a standing committee signals to the full membership that the proposal might be a poor response for the current state of affairs.[4] Does the bicameral Congress lead to the same kind of filtering of flawed proposals as in the above examples?

We begin by establishing some basic key facts about the impact of bicameralism on legislative outcomes. To do so, we link the votes of bills originated in the House to their continuation in the Senate (we consider all bills that originated in the House, and whose passage in the House was decided by a roll call vote in the 102nd to 109th Congresses; i.e., 1991-2006). A basic analysis of the data makes two facts apparent. First, a large number of bills approved by the House *die* in the Senate. In fact, 45 % of all bills passed by the House are never taken up for consideration on final passage by the Senate, and almost one quarter of all bills approved in the House reach consideration on final passage in the Senate only after being heavily amended by that body.[5] Second, the analysis illustrates a previously unknown fact. As in standing committees and universities, also in the US Congress proposals with a larger support in the originating chamber tend to be more successful in the receiving chamber.

The correlation between voting outcomes does not necessarily rule out the SSV model: any data with this property can be explained within the SSV model *if* the preferences of members of both chambers are properly aligned. However, we show they are not: the estimates of the SSV model that are consistent with the individual voting data generate large errors in passage rates of the same bill across chambers.

We then characterize the equilibrium voting behavior in a theoretical framework that

[4] One might argue that it is not relevant whether the entire committee is divided, but instead whether some particular subset of the membership tends to agree or be divided about the issue. This argument, as we explain in more detail below, is not only correct but also consistent with our analysis, and simplified here only for simplicity of exposition.

[5] Congressional scholars have provided anecdotal evidence suggesting that many bills passed by the House die in the Senate. A systematic and quantitative documentation of this phenomenon, however, does not appear to exist in the previous literature.

is consistent with common values and dispersed information. In the model, a bicameral legislature considers a proposal against the status quo. The proposal is considered sequentially, first by the House and then (if it was approved by House) by the Senate, and has to be approved by both chambers to be enacted into law. The proposal can be of good or bad quality, and individuals only have imperfect private signals about its quality. All individuals prefer a good proposal, but individuals differ in the amount of evidence in favor of the proposal that would induce them to vote for it. We argue that the data is consistent with a particular class of equilibria of the theoretical model in which the Senate only approves House bills that were passed by the vote of more than an (endogenous) R-majority of the members of the House that vote informatively.

We estimate the model within the Bayesian framework via MCMC methods. The statistical model comprises two steps. In the first step, we implement a finite mixture model to estimate legislators' types and the proposal's common value component in six different policy areas. In this step we also estimate the precision of legislators' private information. In a second step, we estimate the equilibrium cutpoint in the Senate based on the assignment of legislators into types in the first stage and on the realized vote outcome for each bill that passed the House.

The results highlight the effects of bicameralism on policy outcomes. First, our estimates imply that private information (information dispersed in the system that has not been made public and incorporated in the prior) is quite important. For one, a large fraction of the House votes according to their private information in each case (from 40% in the case of Appropriations bills, to a 50% in Judiciary bills). Moreover, the results show that the informativeness or precision of the signals is relatively large across all issue areas. Thus, large majorities are indeed informative about the quality of proposals. Second, in order to induce this degree of informative voting, the Senate imposes an endogenous supermajority rule on members of the House. We estimate this supermajority rule to be about four-fifths on average across policy areas. In other words, in equilibrium bicameralism is transformed into a unicameral system with a four-fifths supermajority rule. This endogenous majority rule has significant variation across areas: close to two thirds for Foreign Relations, and larger for Economic issues (0.87) and Appropriations (0.89). Third, the result of combining relatively informative signals and relatively large cutpoints in the Senate imply a very conservative blocking coalition in the Senate, in the sense that proposals are enacted into law only when it is extremely likely that their quality is high (or that they constitute an appropriate response for the current state of the environment). The results give credit to the genius of the Founding Fathers in establishing the Senate as a *counter-majoritarian* device restraining the impulse of "sudden and violent passions" that can prevail in the House (Hamilton, Jay, and Madison (1788)).

The remaining of the paper is organized as follows. Section 2 highlights the related literature. Section 3 describes the main features of the data, and considers the implications of the SSV model for the passage or proposals across chambers. Section 4 introduces the theoretical model and summarizes its empirical implications. Section 5 presents the specification of the model and estimation methodology. Section 6 presents the results. Section 7 concludes and discusses possible directions for future research.

2 Related Literature

This paper builds on an extensive literature studying the policy implications of bicameral legislatures (see Dahl (1956), Riker (1982), Lijphart (1984) Tsebelis (1995), Tsebelis and Money (1997), and Diermeier and Myerson (1999) among many others; see also the classical analysis of Montesquieu (1748), and Hamilton, Jay, and Madison (1788)).[6]

Our paper focuses on what Tsebelis and Money (1997) call the efficiency rationale for bicameralism, emphasizing the importance of common values in the legislative setting (see Rogers (1998, 2001)). Different than previous contributions, our argument emphasizes the importance of dispersed information about the quality of proposals. As such, our analysis is connected with the literature on strategic transmission of information from specialized committees to the full chamber pioneered by Gilligan and Krehbiel (1987) and Krehbiel (1991).[7] Differently than in the Gilligan and Krehbiel (1987) (and Crawford and Sobel

[6]For a comprehensive review of this literature, see Tsebelis and Money (1997), Longley and Oleszek (1989), Cutrone and McCarty (2006), and references therein.

[7]To be clear, in Gilligan and Krehbiel (1987)'s theoretical framework legislators are uncertain about the

(1982)) *cheap talk* models, the focus here is on communication through voting. Moreover, an important innovation of our analysis is that we focus on the strategic considerations among members in different chambers, each of them a (multimember) committee. To do so, we build on the theoretical literature on strategic voting with common values and incomplete information (Austen-Smith and Banks (1996), Feddersen and Pesendorfer (1997, 1998)), and in particular on the analysis dealing with strategic interactions among members of different committees (Piketty (2000), Maug and Yilmaz (2002), Razin (2003), and in particular Iaryczower (2008)).

On the methodological side, our paper is related to the various contributions analyzing the voting behavior of members of Congress starting from an underlying model of behavior. The seminal paper here is Poole and Rosenthal (1985), where - starting from the assumption that the data is generated according to the sincere voting spatial model - Poole and Rosenthal develop NOMINATE, a method to estimate the parameters of the spatial model: legislators' ideal points and separating hyperplanes for each roll call.[8] Londregan (1999) allows a (publicly known) valence advantage in the spatial voting model, and proposes to incorporate features of the process of agenda formation to deal with the incidental parameters problem present in the agnostic SSV (see also Londregan (2000), and Clinton and Meirowitz (2003, 2004)). Our paper joins these efforts to incorporate strategic considerations into the analysis of voting in legislatures. To our knowledge, our paper represents the first study to estimate a model of voting in legislatures that allows for common values with dispersed information in an equilibrium context (see also Iaryczower and Shum (2009)).

precise mapping from policy to outcomes. However, as Hirsch and Shotts (2008) point out, "many of the examples of information and expertise in Krehbiel (1991) are better described by a model of information as policy-specific valence than by the $x = p + \omega$ model." See also Epstein and O'Halloran (1999). Moreover, with risk averse legislators, and under some conditions, reducing the uncertainty about the policy implications of a proposal is equivalent to improving its quality.

[8]Still based on the spatial model with sincere voting, Heckman and Snyder (1997), Jackman (2001), and Clinton, Jackman, and Rivers (2004) propose alternatives estimation methods. Heckman and Snyder build on the random utility model with unobservable attributes for the characteristics of the bill and the status quo. Clinton, Jackman, and Rivers (2004) develops a Bayesian procedure for the estimation and inference of spatial models of roll call voting (see also Jackman (2001)).

3 Bicameralism and Legislative Outcomes

In this section we describe the data and document how the sequential organization of the U.S. Congress affects legislative outcomes. In Section 3.1 we use these data to evaluate the performance of the SSV in terms of aggregate voting outcomes.

Our data consists of all *bills* that were *originated* in the House, and whose *passage* in the House was decided by a *roll call* vote over the period 1991-2006 (Congresses 102 through 109).[9] By *bills*, we refer loosely to both bills (say H.R. 100) and Joint Resolutions (say H.J.Res.100) - which have the same effect as bills unless they are used to propose amendments to the Constitution.We say that a bill was *originated* in the House if the bill was voted on final passage in the House before being voted on final passage in the Senate. We consider here only votes on final passage, thus ignoring votes on procedure or amendments. Moreover, we consider only bills that passed the House by a roll call vote, in which members' votes are recorded individually, and that record made publicly available prior to consideration of the bill in the Senate.

Under the House rules, bills are considered for approval by a simple majority vote of Representatives in a vote *on passage* (OP). Bills can also be approved in the House by an alternative streamlined procedure, called *suspend the rules and pass* (SRP). In a SRP vote, debate is restricted, amendments are not allowed, and the bill has to be approved by a two-thirds majority of the votes. Our data consists of bills considered on final passage either by a standard on passage vote, or by the SRP procedure. Between 1991 and 2006, 950 House bills had a roll call on passage, and 861 had a roll call vote on SRP.[10]

To be considered approved by Congress, bills need to be passed in identical form by the House and the Senate.[11] Once a bill is passed by House, its fate in the Senate can

[9]In principle, it would be desirable to also include bills originated in the Senate. Unfortunately, during the period under study only a very small number of the bills originated in the Senate passed in the Senate by a roll call vote. Due to this data availability restriction, in this paper we limit our analysis to bills that originated in the House. We leave a more comprehensive analysis for future research.

[10]It is worth noting that "most" bills put up for a vote on final passage in the House do in fact pass the House. Specifically, this amounted to more than 90 % of the 1811 votes on final passage in our database.

[11]If the House and the Senate pass different versions of a bill, their disagreements are often resolved through a conference committee, an *ad hoc* joint committee composed of delegations of both chambers. Conferees usually draft a modified version of the bill in question, which is subsequently considered sequen-

be classified in three categories. We consider that a bill **passes** (P) if it is approved by the Senate without any amendments during the same Congressional session in which it is initiated in the House. An original bill is considered to be **passed amended** (A) if it is approved by the Senate with amendments during the same Congressional session in which it is initiated in the House. We also consider that a bill is passed amended if it fails in the Senate by inaction, but a related bill (as classified by the Library of Congress, in *Thomas*) that reached the chamber's floor passed the Senate. Finally a bill **fails** (F) if it reaches the Senate floor and is voted down, or if it is never taken up for consideration. The latter case occurs when: (a) no action whatsoever is taken in the Senate during the Congress in which the House passed the bill; (b) a bill is never reported to the Floor by the Senate committee to which it was referred; (c) the bill does not progress after being placed on the Senate's legislative calendar; or (d) the bill fails on a vote on cloture on the motion to proceed. Regardless of the particular way in which it takes place, Senatorial inaction is akin to killing a bill. Figure 1 presents the fate of House bills in the Senate.

[Figure 1 about here]

The figure illustrates two key points. First, a fairly significant fraction of bills that reach the Senate (38 percent) do get voted in the Senate as is. Moreover, once put up for a vote, almost all of these bills in fact pass the vote in the Senate (only one in seventy seven bills voted by roll call, and one in four hundred and thirty two bills voted by voice vote failed to pass). However, being up for consideration in the Senate is hardly a synonym of success. In fact, a staggering 37 percent (718) of the House bills that reached the Senate in the period under study were not taken up for consideration on final passage: 75 were ignored, 481 never made it out of committee, 200 were reported out of committee and put on calendar but were never voted, and 10 failed a vote to pass a filibuster. In addition, almost a quarter of the bills (475) only reached consideration for final passage after being heavily amended by the body. Thus, a second fact is that - even before considering amendments - a large number of bills that passed the House die in the Senate. It follows that if legislators are

tially under a closed rule by the House and the Senate. Our sample includes 237 bills that were considered by the House for a final passage roll call vote after a conference committee.

outcome oriented and strategic, analyzing voting outcomes independently across chambers, without linking votes and outcomes to its continuation in the receiving chamber, can be problematic.

The figure has two additional implications. First, the selection of bills into OP or SRP considerations is not random or innocuous. Pieces of legislation that were approved in the House using the SRP procedure (and thus received the support of at least two-thirds of its members) were more likely to be approved without amendments by the Senate than bills approved by a simple majority (OP). The opposite is true with regard to those bills that were approved after being heavily amended in the Senate. House bills that were approved in the House using simple majority (OP) are more likely to be approved with amendments by the Senate than bills approved using a SRP procedure. Note also that bills approved in the House using simple majority (OP) are more likely to fail than those passed under SRP.

Second, the figure also suggests that after a bill is voted by the two chambers, and a compromise is reached within the conference committee, all private information is made public, and no uncertainty about the quality of the bill remains. In fact, there is almost no variation in outcomes after a bill is reported from the conference committee: approximately 95 percent of these bills (225) were passed (without amendments) once they reached the Senate. We henceforth exclude these bills from our analyses.

Support for the Bill in the House: Does it Matter? As we mentioned in the introduction, a stylized fact from bicameral systems in various political institutions is that proposals that pass the originating committee without significant objections tend to be more successful in the receiving committee than those proposals that clear the first committee with a contested vote. Does the bicameral system in Congress lead to similar outcomes?

To tackle this question, we begin by considering whether the outcome of the bill in the Senate is "correlated" with the fraction of members of the House supporting the bill. To measure this aggregate support, we compute the net tally of votes in favor of the proposal in the House (number of "aye" votes minus number of "nay" votes) for each bill in the sample. The upper panel of Figure 2 shows the distribution (kernel density estimates) of the net tally of votes in favor of the proposal in the House conditional on two possible outcomes in the Senate: the bill passes (P) and the bill fails (F).

[Figure 2 about here]

The figure shows a significant difference in the Pass and Fail conditional distributions, especially for bills considered On Passage. The distribution of the tally in the House conditional on a Senate Fail (a Senate Pass) puts a relatively large probability mass on low (high) values of the tally. In other words, bills that are approved by the Senate tend to have higher tallies in the House than bills that fail in the Senate.[12]

The same conclusion holds if we separate bills by different policy areas. To do this, we use the committee/s to which the bill was referred to classify each roll call as pertaining to one of six policy areas: Appropriations, Foreign Relations, Economic Activity, Judiciary, Government Operations, and Others.[13] The lower panel of Figure 2 shows the "Senate Fail" and "Senate Pass" conditional distributions of the net tally of votes in favor of the proposal in the House for votes On Passage in Appropriations and Judiciary. Once again, the evidence indicates that pieces of legislation that were approved in the House with a larger net number of favorable votes are more likely to be approved by the Senate than bills approved with less legislative support.

3.1 The Sincere Voting Spatial Model in Bicameral Perspective

The findings in the previous section are consistent with, but do not necessarily imply, that the tally of votes in the House is transmitting relevant information to members of the Senate. In particular, the correlation between the tally of favorable votes in the House and

[12] In fact, we can say more. Bills that passed the Senate typically have higher tallies in the House than bills that pass amended in the Senate, and these in turn have higher tallies than bills that fail in the Senate.

[13] We obtained the basic referral information from the Library of Congress, in *Thomas*. We classify a bill in "Appropriations" if it was referred to the Appropriations committee, and to "Other" if it was referred to multiple committees. If a bill was referred to a single committee other than appropriations, we classify it in one of the remaining four classes: Foreign Relations (includes Foreign Affairs, Armed Services, National Security, Veterans' Affairs, Homeland Security and Intelligence), Economic Activity (includes Agriculture, Science, Education and Labor, Energy and Commerce, Financial Services, Natural Resources, Small Business, Transportation and Infrastructure, and Merchant Marine and Fisheries), Judiciary (includes Judiciary), and Government Operations (includes Budget, Government Reform, and Ways and Means).

the outcomes in the Senate could also be consistent with the sincere voting spatial model. If the preferences of members of both houses are highly correlated, then proposals that only receive the support of a small number of House members should also receive the support of a small number of Senators, while proposals that are overwhelmingly preferred to the status quo in the House should also be preferred to the status quo by a winning coalition in the Senate.

It should be clear, however, that the estimates of the SSV model that are consistent with the individual voting data will not necessarily be consistent with the responsiveness of the outcome in the Senate to the tally of votes in favor of the proposal in the House. For example, if preferences are perfectly aligned across chambers and both committees decide by simple majority rule, then all proposals that clear the first committee will clear the second committee as well. This, however, would be inconsistent with the passage rates described in the previous section. As a result, while not necessarily ruling out the SSV model, the correlation in voting outcomes suggest that the match between the data and the model should be reconsidered.

In this section we evaluate this alternative hypothesis using Poole and Rosenthal's Optimal Classification (OC) common-space estimates. OC is a non-parametric scaling method that maximizes the number of correctly classified choices (individual votes), assuming that legislators have euclidean preferences and vote sincerely. In the common-space procedure, OC is used to simultaneously scale every session of both houses of Congress, using legislators who served in both chambers to place the House and Senate in the same space. Hence, the estimates of the ideal points/roll call cutpoints are directly comparable across both chambers.

The sincere-voting spatial model is characterized by two sets of parameters. The first is the set of legislators' ideal points in the House and the Senate. Second, for each roll call, there is an associated separating line L, that partitions the space into two half spaces. Legislators with ideal points to either side of L are predicted to vote "aye" and "nay", respectively. The basic idea is to use the separating line estimated for each roll call in the House, together with the estimates of the ideal points of Senators to obtain a predicted outcome in the Senate. Having done this, we can then compare the predicted and actual outcomes in the Senate.

Specifically, we proceed as follows. We take Keith Poole's OC estimates for the spatial voting model as given.[14] The set of estimates includes the following elements: for each legislator, *(i)* his/her ideal point; and for each roll call of a bill originated in the House, *(ii)* the normal vector $N = (n_1, n_2)$ (perpendicular to L), *(iii)* the projected midpoint on the normal vector, ℓ, and *(iv)* the polarity (where the "ayes" and "nays" fell relative to the projected midpoint on the normal vector). Points on the normal vector $N = (n_1, n_2)$ are points (x_1, x_2) such that $x_2 = x_1 \frac{n_2}{n_1}$. A line perpendicular to N (parallel to L) passing through the point $z = (z_1, z_2)$ - call it $L(z_1, z_2)$ - is then given by

$$L(z_1, z_2) \equiv \{(x_1, x_2) : n_1(z_1 - x_1) + (z_2 - x_2)n_2 = 0\}.$$

Thus the projection onto N of an ideal point (z_1, z_2) is given by the intersection of N and $L(z_1, z_2)$,

$$(\hat{z}_1, \hat{z}_2) = \left(\frac{n_1}{n_1^2 + n_2^2}(n_1 z_1 + n_2 z_2), \frac{n_2}{n_1^2 + n_2^2}(n_1 z_1 + n_2 z_2) \right),$$

and its relative location on the normal vector is then given by $d(\hat{z}, 0) \times sign(\hat{z}_1 \times n_1)$. Combining the projection of Senators' ideal points to the normal vector with the projected midpoint on the normal vector for a given roll call, ℓ, and its polarity, we then obtain a predicted vote for each Senator for each (scaled) roll call in our sample. Finally, using these predictions, we calculate – for each bill originated in the House – a predicted (counterfactual) pass/fail outcome in the Senate.

Figure 3 presents the comparison between the predicted outcomes generated using the OC estimates and the actual Senate outcomes. The top panel shows the results assuming that a simple majority rule is used to determine a bill's passage in the Senate. The bottom panel presents a similar exercise using a three-fifths majority rule, as required for cloture.

[Figure 3 about here]

[14] These estimates are publicly available at http://voteview.com/oc.htm.

The evidence in Figure 3 clearly indicates that the standard (private-values) spatial model with sincere voting generates predictions that are at odds with the data. Consider, for example, the 106th Congress' predictions assuming that a simple majority voting rule is used. According to the sincere voting spatial model, 156 bills should have been approved by the Senate (and only 1 should have failed). Instead, 43 were approved after being heavily amended, and 68 actually failed. A similar pattern holds for the other sessions of Congress. The predicted power of the spatial model improves if we assume that a three-fifths majority decision rule is employed. Nonetheless, as Figure 3 demonstrates, the spatial model still generates large errors when it is used to predict bills' passage rates across chambers.

4 Dispersed Information in Bicameral Legislatures: A Theoretical Framework

The analysis of the previous section suggests that the standard spatial model with sincere voting generates large errors in passage rates of the same bill across chambers. In this section, we develop the implications of a theoretical framework that is consistent with common values and dispersed information. We consider here the model of strategic voting with common value components introduced in Iaryczower (2008). The model develops formally a simple intuition: if legislators have private information about the relative value of the alternatives under consideration, voting outcomes in the originating chamber can aggregate and transmit relevant information to members of the receiving chamber. The model builds on the contributions of Austen-Smith and Banks (1996), and Feddersen and Pesendorfer (1997, 1998). Here, however, voting does not occur in single-committee systems, but instead a proposal can prevail only by defeating the status quo by (possibly qualified) majority voting first in one and, provided it is successful there, then in a second chamber.

The possibility of observing the outcome of the vote in the originating chamber introduces two main differences in the incentives of members of both chambers vis a vis the single-committee framework. First, the tally of the votes in favor of the alternative becomes an informative public signal for members of the receiving chamber, whose members can condition their behavior on the voting outcome in the originating chamber. Second, members of the originating chamber can influence the outcome both in the traditional sense of killing or passing the proposal in their chamber (a *standard-pivotal* voting motive), and/or by influencing the beliefs of members of the receiving chamber regarding the relative value of the two alternatives (a *signal-pivotal* voting motive).

The Model. A group of legislators arranged in two chambers, C_0 and C_1, choose between a proposal A and a status quo Q, both lying in an arbitrary policy space X. Chamber C_j is populated by an odd number n_j of individuals, and the collective choice of each chamber j is determined by voting under a R_j-majority rule. Formally, letting $v_i \in \{-1, 1\}$ denote i's vote against (-1) or in favor (1) of the proposal, $t(\mathbf{v}_j) \equiv \sum_{i \in C_j} v_i$ the net tally of votes in favor of the proposal in C_j, and $z_j \in \{Q, A\}$ the policy choice in C_j, $z_j = A$ if and only if $t(\mathbf{v}_j) \geq r_j$, for an odd integer r_j such that $1 \leq r_j \leq n_j$ (thus $R_j = \frac{n_j + r_j}{2}$).

Voting is simultaneous within each chamber, but sequential between chambers.[15] The alternatives are first voted on in the *originating chamber* C_0, or the House. If the proposal defeats the status quo in the originating chamber, the alternatives are then voted on in the *receiving chamber* C_1, or the Senate. The proposal is adopted if and only if it defeats the status quo in both committees, $t_j(\mathbf{v}_j) \geq r_j$ for $j = 0, 1$, otherwise the status quo remains.

The proposal can be of high or low quality, and this is unobservable to all legislators. We represent this state by an unobservable random variable $\omega \in \{\omega_A, \omega_Q\}$, where ω_A denotes high quality. We denote the prior probability of the proposal being of high quality by $\Pr(\omega = \omega_A) = p$. Each individual $i \in C_j$ receives a private, imperfectly informative signal $s_i \in \{-1, 1\}$, distributed independently conditional on the quality of the proposal, such that $\Pr(s_i = 1 | \omega_A) = \Pr(s_i = -1 | \omega_Q) = q > 1/2$.

Individuals' preferences have an ideological and a common value component. Each individual $i \in C_j$ has a publicly known ideology bias either for or against the proposal, and we say that i is either a *liberal* or a *conservative*, respectively. Liberals and conservatives differ in their ranking of alternatives *conditional* on observing the same information $\mathcal{I}$.

[15] The result of Proposition 1 below is unchanged if voting within each chamber is done sequentially.

In particular, liberals prefer the proposal to the status quo whenever $\Pr(\omega_A|\mathcal{I}) \geq \pi_A$ for some $\pi_A < 1/2$, while conservatives prefer the proposal to the status quo whenever $\Pr(\omega_A|\mathcal{I}) \geq \pi_Q$ for some $\pi_Q > 1/2$. More formally, we normalize the payoff for both types if the proposal is not passed to zero, and denote the payoff of an individual of type $b \in \{Q, A\}$ if the proposal passes in state ω by U_b^ω, with $U_b^A = 1 - \pi_b > 0$ and $U_b^Q = -\pi_b < 0$. Thus the individual wants the proposal passed given $\mathcal{I}$ if $\Pr(\omega_A|\mathcal{I})[1 - \pi_b] + [1 - \Pr(\omega_A|\mathcal{I})](-\pi_b) \geq 0 \Leftrightarrow \Pr(\omega_A|\mathcal{I}) \geq \pi_b$. We denote the number of individuals of type b in chamber j by n_j^b. The equilibrium concept is Perfect Bayesian equilibria in pure strategies, with a refinement: with probability $1 - \upsilon$, a committee member i is a *moderate*, and has the preferences described above; with probability $\upsilon > 0$, she is a *partisan* and always votes her bias. We focus on equilibria of the game for small υ.

The model admits multiple voting equilibria. For our purposes, it is useful to separate these in two classes. In a first class, the proposal can fail and succeed on a vote in the receiving chamber with positive probability. In a second class, it cannot. The fact that in the US Congress data House bills are never killed on a vote on the Senate floor rules out the first class of voting equilibria as possible data generating processes in this particular application. The remaining voting equilibria is the class of *endogenous majority rule* (EMR) voting equilibria. In an EMR voting equilibrium, the second chamber acts only to raise the hurdle that the alternative has to surpass in the first chamber to defeat the status quo, killing the proposal following low vote tallies in the originating chamber, and unconditionally approving the proposal otherwise. It follows that in a EMR voting equilibrium it is common knowledge for members of the receiving chamber whether the proposal will pass the senate or not after observing the outcome of the vote in the house. Thus while passing the proposal requires its approval in a vote on the floor, it is immaterial whether the proposal is killed in a vote, by scheduling, or by burying it in a Committee.[16]

[16]The other possible class of equilibria in which members of the originating chamber vote informatively is that *two-sided informative* (TSI) voting equilibria. In TSI voting equilibria, members of both committees vote informatively. In particular, in any equilibrium of this class the probability of the proposal being accepted increases (strictly) with the tally of votes in favor of the proposal in the originating committee. To achieve this, the number of individuals voting informatively in the receiving committee must vary following different vote tallies in the originating committee. Implicit in the construction of equilibria of this kind is therefore the requirement that the proposal can fail and succeed on a vote in the receiving

In order to characterize EMR equilibria, it will be convenient to measure agents' biases in terms of the least net number of positive (negative) signals that a conservative (liberal) member would need to observe to vote for (against) the proposal. We call these signal thresholds ρ_Q (for conservatives) and ρ_A (for liberals). Note that given information $\mathcal{I}$, an individual with bias π prefers the proposal to the status quo if and only if $\frac{\Pr(\mathcal{I}|\omega_A)}{\Pr(\mathcal{I}|\omega_Q)} \geq \frac{\pi}{1-\pi}\frac{1-p}{p}$. Note moreover that $\frac{\Pr(s:\sum_i s_i=\tau|\omega_A)}{\Pr(s:\sum_i s_i=\tau|\omega_Q)} = \left(\frac{q}{1-q}\right)^{\tau}$. Thus, focusing on ρ_Q for example,

$$\rho_Q \equiv min\left\{\tau : \left(\frac{q}{1-q}\right)^{\tau} \geq \frac{\pi}{1-\pi}\frac{1-p}{p}\right\}. \tag{1}$$

The following proposition fully characterizes EMR voting equilibria.

Proposition 1 *(1) If conservatives can block the proposal in the receiving chamber, there exists an EMR voting equilibrium if and only if the number of conservative members in the originating chamber is at least ρ_Q. In an equilibrium of this class, $\rho_Q \leq k \leq \min\{n_0^Q, \rho_Q+n_0-(r_0-1)\}$ conservatives in the originating chamber vote informatively, and the Senate passes the bill if and only if the net tally of votes of individuals voting informatively is above ρ_Q.*

(2) If conservatives cannot block the proposal in the receiving chamber, then there exists an EMR voting equilibrium if and only if the majority surplus of liberals in the originating chamber, $\frac{n_0^A-n_0^Q-r_0}{2}$ is at least ρ_A. In an equilibrium of this class, $\rho_A \leq k \leq n_0^A - n_0^Q - r_0 - \rho_A$ liberals vote informatively in the originating chamber and the proposal fails in the receiving chamber if and only if the net tally of votes of individuals voting informatively in the house is below $-\rho_A$.

Proof. See Theorem 1 in Iaryczower (2008). ■

Proposition 1 provides the theoretical foundations of the econometric specification that we describe in the next section.

committee with positive probability. This is inconsistent with the bicameral data, for which proposals are killed in Committee or scheduling, but not on votes on the floor.

5 Estimation

5.1 Econometric Specification

In EMR voting equilibria, only members of the originating chamber vote informatively, the second committee acts only to raise the hurdle that the alternative has to surpass in the first chamber to defeat the status quo in equilibrium. As a result, the votes of individual members of the receiving chamber (here the Senate) do not provide relevant information for the econometrician. In the originating chamber instead (here the House), all votes contain useful information to recover the structure of the model: *(i)* the prior probability of the quality of the proposal being high, *(ii)* the type of each individual, and *(iii)* the precision of their private information. The data therefore consists of an $n \times T$ matrix v of voting data in the House, and a $1 \times (T - T_F)$ vector z of outcomes of House bills in the Senate. Here T is the number of votes in which the House is the originating committee, T_F is the number of votes in the House in which the proposal failed in the House, and n is the number of legislators in the house. Column t is therefore the voting record for all legislators in the house in roll call t, v_t, with ith entry $v_{it} \in \{-1, 1, \emptyset\}$.

To control for the effect that the heterogeneity in policy areas might have on equilibrium behavior, we allow preferences, information technology and equilibrium strategies to vary between policy issues. In particular, we assume that the prior probability of the state being favorable for the proposal, the precision of private information and the voting strategy of each individual are invariant within issues but can differ between issues. Let α denote the assignment of roll calls $t = 1, \ldots, T$ to classes $g = 1, \ldots, G$ according to the classification in issue areas of Section 3.

Within each class g, therefore, the preferences and voting strategy of each member of the House are fixed, and can be summarized by a type $\theta_{ig} \in \{Y, I, N\}$. Here $\theta_{ig} = Y$ denotes i is a *partisan-liberal* in class g, who supports proposals independently of her private information. Similarly, $\theta_{ig} = N$ means i opposes the proposals in class g independently of her private information (i is a *partisan-conservative*). Finally, $\theta_{ig} = I$ if i votes informatively in class g, supporting the proposal when $s_i = 1$ but voting against it when $s_i = -1$.

The type of an individual i is therefore a $1 \times G$ vector $\theta_i \equiv (\theta_{i1}, \ldots, \theta_{iG})$. The precision of signals is also allowed to vary per class, so that $q \equiv (q_1, \ldots, q_G)$. The common prior of the state being favorable to the proposal is also issue-specific. Given independence of states between roll calls, which we assume throughout, then $\Pr(\omega_t = \omega_A) = p_{\alpha(t)}$, and $p \equiv (p_1, \ldots, p_G)$. For each class g there is also an EMR voting equilibrium cutpoint ζ_g in the Senate. The vector of Senate equilibrium cutpoints is then $\zeta \equiv (\zeta_1, \ldots, \zeta_G)$. Finally, we assume that there is a probability of error μ at the individual level, so that whenever equilibrium behavior dictates a vote $v \in \{-1, 1\}$, the observed value is v with probability $1 - \mu$ and $-v$ with probability μ. We can then write down an expression for the likelihood of data $y = (v, z)$ given (q, p, θ, ζ). First,

$$\Pr(y|q,p,\theta,\zeta) = \prod_{g=1}^{G} \prod_{t:\alpha(t)=g} \Pr(y_t|p_g, q_g, \theta_g, \zeta_g), \tag{2}$$

Next, given $\alpha(t) = g$, since the outcome in the Senate depends only on the relevant cutpoint ζ_g and on the informative tally, itself a function only of v_t and θ_g, then

$$\Pr(y_t|p_g, q_g, \theta_g, \zeta_g) = \Pr(v_t|p_g, q_g, \theta_g) \Pr(z_t|v_t, \theta_g, \zeta_g).$$

Next we obtain an expression for $\Pr(v_t|p_g, q_g, \theta_g)$. For $a = N, I, Y$, let $m_a(t,g) \equiv |\{i \in C_1 : \theta_i = a, v_{it} = 1\}|$ and $\ell_a(t,g) \equiv |\{i \in C_1 : \theta_i = a, v_{it} = -1\}|$ denote the number of individuals of type a in group g voting in favor and against the bill, respectively. Now, let $\kappa_g \equiv [q_g(1-\mu) + (1-q_g)\mu]$ denote the probability that an individual i such that $\theta_{ig} = I$ votes in favor (against) of the proposal in roll call t if $\omega_t = 1$ (if $\omega_t = 0$). Then

$$\Pr(\{v_{it}\}_{i:\theta_{ig}=I}|q_g, p_g) = \left[p_g \kappa_g^{m_I(t,g)} (1-\kappa_g)^{\ell_I(t,g)} + (1-p_g)(1-\kappa_g)^{m_I(t,g)} \kappa_g^{\ell_I(t,g)}\right].$$

Moreover, since $\Pr(v_{it} = 1|\theta_{ig} = N) = \mu$, and $\Pr(v_{it} = 1|\theta_{ig} = Y) = 1 - \mu$, then $\Pr(\{v_{it}\}_{i:\theta_{ig}=N}) = \mu^{m_N(t,g)}(1-\mu)^{\ell_N(t,g)}$ and $\Pr(\{v_{it}\}_{i:\theta_{ig}=Y}) = (1-\mu)^{m_Y(t,g)} \mu^{\ell_Y(t,g)}$, so that

$$\begin{aligned} \Pr(v_t|q_g, p_g, \theta_g) = {} & \mu^{m_N(t,g)}(1-\mu)^{\ell_N(t,g)} \times (1-\mu)^{m_Y(t,g)} \mu^{\ell_Y(t,g)} \\ & \times \left[p_g \kappa_g^{m_I(t,g)} (1-\kappa_g)^{\ell_I(t,g)} + (1-p_g)(1-\kappa_g)^{m_I(t,g)} \kappa_g^{\ell_I(t,g)}\right]. \end{aligned} \tag{3}$$

Consider now $\Pr(z_t|v_t, \theta_g, \zeta_g)$. Assume first that in the data we observe a binary Pass/Fail outcome in the Senate $z_t \in \{0, 1\}$, as it is in the theory. Let $\tau_t(g, v_t) \equiv \sum_{i:\theta_{ig}=I} v_i$ denote the informative tally in roll call t. We introduce noise ε_t in the class g cutpoint ζ_g so that $z_t = 1$ if and only if $\tau_t(g, v_t) \geq \zeta_g + \epsilon_t$, or equivalently if $\varepsilon_t \leq \tau_t(g, v_t) - \zeta_g$. Assuming that ϵ_t is i.i.d. with c.d.f. $F(\cdot)$, then (again, for $\alpha(t) = g$)

$$\Pr(z_t|v_t, \theta_g, \zeta_g) = [F(\tau_t(g, v_t) - \zeta_g)]^{z_t}[1 - F(\tau_t(g, v_t) - \zeta_g)]^{1-z_t}.$$

In the data, however, we observe not two but three outcomes in the Senate: bills that Fail, bills that Pass without being amended, and bills that Pass after being amended in the Senate. We proceed as follows. We assume that bills either Pass or Fail, but that this final outcome $z_t \in \{0, 1\}$ is unobservable. What we observe is an imperfect signal of this final outcome, $\hat{z} \in \{P, A, F\}$. In particular, we assume that $\Pr(\hat{z}_t = A|z_t = 0) = 1 - \eta$, $\Pr(\hat{z}_t = F|z_t = 0) = \eta$, $\Pr(\hat{z}_t = A|z_t = 1) = 1 - \gamma$, and $\Pr(\hat{z}_t = P|z_t = 0) = \gamma$. Given these we have:

$$\begin{aligned}\Pr(\hat{z}_t|\tau_t(g, v_t), \zeta_g) = {} & [\gamma F(\tau_t(g, v_t) - \zeta_g)]^{I(\hat{z}_t=P)} \times [\eta(1 - F(\tau_t(g, v_t) - \zeta_g))]^{I(\hat{z}_t=F)} \\ & \times [(1 - \gamma)F(\tau_t(g, v_t) - \zeta_g) + (1 - \eta)(1 - F(\tau_t(g, v_t) - \zeta_g))]^{I(\hat{z}_t=A)}.\end{aligned} \tag{4}$$

5.2 Estimation Methodology

To estimate the model, we adopt a Bayesian approach. In this setting, the objects of analysis are the distributions of the parameters $(q, p, \zeta, \{\theta_i\})$. We follow a two-step estimation procedure. In the first step, we use the observed votes of each legislator in each issue class g to estimate class-specific posterior distributions of the signal precision q_g, the assignment of legislators into types $\theta_{i,g} \in \{N, I, Y\}$, and the assignment of roll calls t into the set of possible realizations of the unobservable state $\{\omega_Q, \omega_A\}$. In the second step, we compute the average informative tally for each bill in class g based on the *a posteriori* assignment of legislators into types, and estimate the EMR equilibrium cutpoint ζ_g. Both steps rely on Markov chain Monte Carlo (MCMC) methods (Gilks, Richardson, and Spiegelhalter (1996), Gelman, Carlin, Stern, and Rubin (2004)).[17]

[17]It is in fact possible to integrate both steps in a single estimation procedure. Given the complexity of the problem, however, the computational burden of a single-step estimation approach renders it very

First Stage. The main idea underlying the estimation of the model is that the vote of legislator i in a roll call t depends only on her type θ_i and the realization of the state ω_t (we drop for convenience the dependence on the issue class g when there is no room for confusion). From (2) and (3), estimating q would be straightforward if we knew the type of each legislator and the realization of the state in each roll call. The problem of course is that θ and ω are not observable. To address this complication, the first step of our estimation strategy implements a latent class or finite mixture model.

Latent class analysis is useful to explain heterogeneity in observed categorical variables (e.g., votes) in terms of a small number of underlying latent classes or groups (e.g., legislators' types and state realizations). The observations in the sample are assumed to arise from mutually exclusive classes characterized by intra-group homogeneity and inter-group differences in behavioral or attitudinal patterns, with the association between the observed indicators assumed to be entirely explained by their relationship to a latent categorical variable (see for example McLachlan and Peel (2000)). In our model, these latent variables are the types θ and the state ω. We then adopt an *ex post* specification for the state, where the state parameter is given by ω (as opposed to p in an *ex ante* formulation). Since ω_t is independent across t, we can then estimate p from the hyperparameter describing the distribution of ω_t (more on this below).

Compared to similar latent trait models and to traditional cluster, factor and discriminant analysis techniques, latent class models provide a clearer and more robust way of summarizing patterns of categorical responses while imposing less restrictive distributional assumptions (Hagenaars and Halman (1989), Huang and Bandeen Roche (2004)). As a result, they have recently found a growing number of uses in political science (Blaydes and Linzer (2008), Jackman (2008), Treier and Jackman (2008)). Virtually all applications in the political science literature, though, assume a single relevant classification dimension.

In our setting, however, we need to classify both legislators into types and roll calls into states. To implement this, we draw on recent developments on two-sided clustering

impractical for dealing with multiple large datasets, as in our case. Nonetheless, it is worth mentioning that, using small simulated datasets, we found little difference in the main substantive conclusions drawn from models estimated under the two procedures.

methods used in collaborative filtering (Ungar and Foster (1998), Hoffman and Puzicha (1999)), implementing a fully Bayesian approach based on the Gibbs sampling algorithm that allows for the (probabilistic) classification of legislators into types and roll calls into states while simultaneously estimating q.[18] The unknown types and states are treated as random variables with missing values, which in the Bayesian framework are essentially indistinguishable from other model parameters. Inference thus requires defining a prior for the indicators of type/state and the remaining model parameters and sampling from their joint posterior distribution.

Specifically, we proceed as follows. First, we specify a prior distribution for the parameters θ, ω, q.[19] In particular, we assume that *(i)* $q \sim U[1/2, 1]$, that *(ii)* for each $i \in N$, $\Pr(\theta_i = j) = \lambda_j$ for $j = N, I, Y$, and that *(iii)* for each roll call $t \in T$, $\Pr(\omega_t = \omega_A) = p$. We give the hyperparameters λ_j and p diffuse prior distributions f_λ and f_p. We can then write a joint posterior distribution for the vector $(\theta, \omega, q; \lambda, p)$,

$$f(\theta, \omega, q; \lambda, p|v) \propto \Pr(v|\theta, \omega, q) f(\theta, \omega, q|\lambda, p) f_\lambda(\lambda) f_p(p).$$

Note that given $\{\theta_i\}$ and $\{\omega_t\}$, the mixture model essentially reduces to a standard binary choice model, and it is thus quite straightforward to sample from the conditional distribution of the remaining parameters. Hence, the sampling algorithm implemented alternates two major steps (Gelman, Carlin, Stern, and Rubin (2004)): (i) obtaining draws from the distribution of θ_i and ω_t given p, λ, and q; and (ii) obtaining draws from q and the hyperparameters p, λ given the type/state realizations. This leads to an iterative scheme whereby, starting from an arbitrary set of initial values, we obtain a sample of the parameters $\psi^m = (p^m, \lambda^m, q^m, \theta^m, \omega^m)$ for each step m of the sampling algorithm, $m = 1, \ldots, M$. Under mild regularity conditions, the sampled parameters ψ^m asymptoti-

[18] The standard expectation-maximization (EM) algorithm typically used to fitting latent class models cannot be efficiently formulated for this problem, since untractably many sufficient statistics are required for the EM formulation (Ungar and Foster (1998)).

[19] Note that this treats the voting error μ as given. In the results that we report in Section 6, we fix this at $\mu = 0.10$. All major conclusions remain unchanged if we set $\mu = 0.05$. Moreover, we also repeated the analysis including μ as an additional parameter to be estimated with the remaining parameters of the model. Again, the results are fundamentally unchanged. Furthermore, the estimated μ ranges between values of 0.10 and 0.15 in all policy areas. These results are reproduced in Figures 2,3 and 4 in the Supplementary Materials Appendix.

cally satisfy $\psi^m \sim P(\psi|v_g)$ (Gilks, Richardson, and Spiegelhalter (1996), Gelman, Carlin, Stern, and Rubin (2004)).[20]

Given the convergent samples of types θ, we assign each legislator to a type and each roll call to a state based on their maximum a-posteriori probabilities (MAP). Given this assignment, we compute the net informative tally $\tau_t(v_t) \equiv \sum_{i:\theta_i=I} v_i$ for all bills that passed the House. Together with the outcome of the bill in the Senate, the net informative tallies computed in this way become the data in the second stage.

Second Stage. In the second step of the procedure, we estimated the EMR equilibrium cutpoints ζ_g for $g = 1, \ldots, G$. Consistent with (4), we assumed that the observed outcomes $\hat{z}_t$ are conditionally distributed $\hat{z}_t \sim Multinomial(1, \varphi_t)$, with $\varphi_t = (\varphi_t^P, \varphi_t^A, \varphi_t^F)'$ and, for $j = P, A, F$:

$$\varphi_t^j = \gamma_j P(z_t = 1|\tau_t(g, v_t), \zeta_g) + \eta_j P(z_t = 0|\tau_t(g, v_t), \zeta_g) \tag{5}$$

$$P\big(z_t = 1|\tau_t(g, v_t), \zeta_g\big) = \Phi\big(\tau_t(g, v_t) - \zeta_g\big) \tag{6}$$

where $\gamma_F = \eta_P = 0$, $\gamma_A = 1 - \gamma_P$, $\eta_A = 1 - \eta_F$, and where Φ is the cdf of a standard normal variable. Given the relatively small number of roll calls assigned to some of the classes, we used a hierarchical specification to "borrow strength" across them (Gelman, Carlin, Stern, and Rubin (2004), Gelman and Hill (2007)), assigning a $N(\mu_\zeta, \sigma_\zeta)$ distribution to ζ_g.

For each step of the estimation procedure, three parallel chains with dispersed initial values and varying lengths were run after an initial burn-in period, with convergence assessed based on Gelman and Rubin's potential scale reduction factors $\widehat{R}$ (Gelman and Rubin (1992)). We used independent priors for the parameters in ψ: we assumed that λ has a uniform Dirichlet distribution, that $p \sim U[0, 1]$, and that $q \sim U[1/2, 1]$. For the parameters of the second stage, we assumed $\mu_{\varsigma_g} \sim \mathcal{N}(0, 100)$, $\sigma_{\varsigma_g} \sim InverseGamma(0.1, 0.1)$,

[20] A well known difficulty with MCMC estimation of posterior distributions in latent class models is the "label switching" problem stemming from the fact that permutations of the class assignments are not necessarily identifiable since the likelihood may be unchanged under these permutations (Redner and Walker (1984)). Label switching is less of an issue in our model, given the constraints on legislators's voting behavior derived from the theoretical model. In fact, visual inspection of the MCMC chains showed no evidence of label switching, and application of the decision-theoretic post-processing approach described by Stephens (2000) did not result in changes in the class assignments.

$\gamma, \eta \sim Dirichlet(1, 1)$.

Routine sensitivity checks were performed to assess the robustness of the estimates to the prior distributions. In all cases, the average overlap the between prior and posterior distribution for the parameters governing the latent class membership probabilities was quite small, and the (empirical) Kullback-Leibler divergences were extremely high.[21] This indicates that there is enough data to distinguish between the different types and states, suggesting that the model is well identified, and thus relatively insensitive to prior assumptions (Garrett and Zeger (2000), Elliot, Gallo, Ten, Bogner, and Katz (2005)). Posterior predictive simulations based on the subject-level statistic $S = \sum_t v_{i,t}$ indicated that the (conditionally) independent Bernoulli distribution for legislators' votes is reasonable (Gelman, Carlin, Stern, and Rubin (2004)). The posterior predictive p-value $\sum_{rep} I\left(\sum_t v_{i,t}^{rep} > \sum_t v_{i,t}\right) / \sum_{rep} I$ based on 1,000 replications ranged between 0.13 to 0.82 across legislators. In addition, in order to check the ability of our estimation strategy to recover the "true" model parameters and class memberships, we used "fake-data simulations" (Gelman and Hill (2007)) with several alternative datasets. Classifying legislators and rollcalls acording to the MAP led to very high rates of success in terms of agreement between actual and estimated class membership, and the central 95% credible intervals for the parameters of interest covered in all cases the true values, with point estimates reasonably close to them.[22]

6 Results

In this section we present the main results. For presentation purposes, we focus here on non-unanimous votes On Passage.[23] The main results are summarized in Figure 4.

[21] Figure 5 in the Supplementary Materials Appendix plots the prior and posterior probability distributions of a legislator being informative, λ_I and of the proposal being of high quality p for three issue areas (Economic, Judiciary, and Government). The figure shows that the average overlap between prior and posterior distributions is quite small. Similar patterns are verified across parameters and issue areas.

[22] Details from different simulation exercises and robustness checks are available from the authors upon request. See also the Supplementary Materials accompanying this paper.

[23] Figure 1 in the Supplementary Materials Appendix summarizes the results for SRP votes. While there are interesting differences in the details between these and bills considered On Passage, the main results remain unchanged.

[Figure 4 about here]

The top left panel presents the estimate of the signal precision $q_g \equiv \Pr(s_{it} = \omega_t | \omega_t, \alpha(t) = g)$ for state ω_t and issue g. The chart presents the median value, and the 5 and 95 percentiles of (a sample of 1000 observations drawn from) the posterior distribution of the parameters of the model. Note that the estimates in all issue areas are very precise, as 90 percent of the mass of the posterior is concentrated in a small interval around the median. In terms of the value of the estimates, note that the precision of the signals is relatively large, close to 0.9 in all issue areas. This suggests that private information - information dispersed in the system that has not been made public and incorporated in the prior - is quite important. The moderate heterogeneity across issue areas suggests that this conclusion holds independently of issue class, at least within our relatively broad issue classification.

The top right panel presents the estimate of the common prior probability that the proposal is of high quality, $p_g \equiv \Pr(\omega_t = 1 | \alpha(t) = g)$. To calculate this, we first compute for each point in the sample the proportion of roll calls with $\omega_t = 1$, and then compute the median and 5-95 percentiles of this variable in the sample. The results suggest relatively moderate beliefs about the quality or appropriateness of proposals being brought to a vote in the House (possibly with the exception of the more favorable expectations in Foreign Relations). This is consistent with our previous finding in terms of the value of private information in the system.

The middle panels show the proportion of members of the House voting informatively (left) and the proportion of members of the House voting uninformatively in favor of the proposal (right). Recall that each point in the sample from the posterior distribution includes a type for each legislator. Thus for each point in the sample we can compute the proportion of legislators of each type. The chart presents the median, and 5-95 percentiles of this variable in the sample. The results show that, according to our estimates, a large fraction of the House votes according to their private information in each case. With the exception of Foreign Relations, the proportion of legislators voting informatively ranges from a relatively low 40% in the case of Appropriations bills, to a 50% in Judiciary bills. In Foreign Relations the proportion is higher still: about 70% of the total members vote informatively. That this is large relative to the EMR cutpoint (lower left panel) means that the public signal generated by the informative tally of votes in favor of the proposal in the House can in fact sway the outcome in the Senate one way or the other. Moreover, most individuals that do not vote informatively vote in favor of the proposal; i.e., the fraction of members voting uninformatively against the proposal (the partisan-conservatives) is relatively low across the different issue areas (as high as 6-7% for Foreign Relations and Government Operations, substantially lower in all other issues).[24]

The bottom left panel shows the EMR voting equilibrium cutpoint in the receiving committee. This is the smallest net number of favorable votes among individuals voting informatively in the House for which the Senate passes the bill in equilibrium. The results show that these EMR cutpoints are relatively large in all areas, with a smallest value of 23 in Judiciary, and a largest value of 108 in Appropriations.

The large EMR equilibrium cutpoints have two important implications. First, as it is implied by the name, the EMR equilibrium cutpoint effectively imposes a supermajority rule on the House, which can be computed given our estimates. Note that a cutpoint ζ means that in order for the bill to pass the Senate, we need at least ζ net votes of the members of the House voting informatively. This in turn means that if there are n_Y partisan liberals and n_N partisan conservatives, we need at least $\zeta + n_Y - n_N$ net votes out of all votes in total for the bill to pass the Senate ($n_Y - n_N$ is the net uninformative tally). But this in turn means that in order for the bill to pass the Senate we need at least $\frac{\zeta + n_Y - n_N + n}{2}$ positive votes in total to pass the Senate. Thus the rule for the entire chamber is $R = \frac{\zeta + n_Y - n_N + n}{2}$, or as a fraction of the membership,

$$\frac{R}{n} = \frac{1}{2} + \frac{\zeta + n_Y - n_N}{2n}$$

Similarly, we can compute the hurdle imposed on the set of individuals voting informatively. This effective rule for the informative voters follows quite directly from the EMR equilibrium cutpoint. Again, a cutpoint ζ means that in order for the bill to pass the

[24]This is consistent with the most informative EMR voting equilibrium, in which conservatives are a blocking coalition in the receiving committee and all conservatives in the originating committee vote informatively. We return to this below, where we examine the relationship between type allocation and party label.

Senate, we need at least $R_I = \frac{\zeta + n_I}{2}$ positive votes among the n_I members of the House voting informatively. Thus, in terms of the fraction of the total number of individuals voting informatively,

$$\frac{R_I}{n_I} = \frac{1}{2} + \frac{\zeta}{2n_I}$$

The bottom right panel shows R/n and R_I/n_I for each issue area. The implied supermajority on the entire chamber is $R/n \simeq 4/5$ on average across areas. In other words, bicameralism is transformed in equilibrium into a unicameral system with a 4/5 supermajority rule. On the other hand, the threshold imposed on the members voting informatively is about $R_I/n_I \simeq 2/3$ on average across areas. Both R/n and R_I/n_I have significant variation across issue areas. In particular, the EMR R/n is relatively low for Foreign Relations (0.62) and largest for Economic issues (0.87) and Appropriations (0.89). Similarly, the hurdle for members voting informatively is relatively lower for Foreign Relations (0.56) and Judiciary (0.55), and largest for Economic issues (0.72) and Appropriations (0.80).

The large EMR cutpoints have a second important implication. The EMR cutpoints are not only large in nominal terms, but also in relation with the value of private information implicit in the estimates of q. Note that with q taking values above 0.85, the public signal induced by the tally of votes in the House is very informative indeed: votes that are not close (among informative voters) have a dramatic effect on the posterior inference about the quality of the proposal. In fact, since Proposition 1 implies that $\zeta = \rho$, we can use (1), together with our estimates of q, p, and ζ to recover the bias π such that a (conservative) member would prefer the proposal to the status quo only if $\Pr(\omega_A|E) \geq \pi_Q$. The result of combining relatively informative signals and relatively large cutpoints leave no room for ambiguity, implying $\pi_Q \approx 1$. In other words, the results imply a very conservative blocking coalition in the Senate, in the sense that proposals are enacted into law only when it is extremely likely that they are "good".

Endogenous Classification of Amendments. Recall that we assumed that the final outcome in the Senate is a binary up or down decision on the passage of a bill $z_t \in \{0, 1\}$. We treated $z_t \in \{0, 1\}$ as an unobservable variable from the perspective of the econometrician, who can only observe an imperfect signal $\hat{z} \in \{P, A, F\}$ of $z_t \in \{0,1\}$, such that $\hat{z}_t = F$ when $z_t = 0$ with some probability η (otherwise we observe it as amended), and that $\hat{z}_t = P$ when $z_t = 1$ with some probability γ (otherwise we observe it as amended). The lower left panel shows the estimates of γ and η: $\eta \approx 0.59$ while $\gamma \approx 0.36$. Note that by Bayes' rule, the posterior probability of the bill having failed given that we observe an ammendment is

$$\Pr(z_t = 0|\hat{z}_t = A) = \frac{(1-\eta)\Pr(z_t = 0)}{(1-\eta)\Pr(z_t = 0) + (1-\gamma)\Pr(z_t = 1)}$$

We can estimate $\Pr(z_t = 1)$ by the proportion of bills with an informative tally above the equilibrium cutpoint. Doing this gives 0.48 for Appropriations, 0.65 for Economic issues, 0.80 for Foreign Relations, 0.34 for Government Operations, $\simeq 0.40$ for Judiciary, and 0.69 for Other issues. We then find that $\Pr(z_t = 0|\hat{z}_t = A) = 0.41$ for Appropriations, 0.26 for Economic issues, 0.13 for Foreign Relations, 0.55 for Government Operations, 0.49 for Judiciary, and 0.22 for Other issues. Thus we are classifying amended bills as relatively likely to have passed in all areas. This is particularly so in Foreign Relations, Other and Economic issues.

Passage of Bills in the Senate. In Section 3.1 (Figure 3) we presented the comparison between the predicted passage of bills in the Senate implied by the spatial voting model (OC estimates) and the actual Senate outcomes. We can now extend this comparison to include our results.

[Figure 5 about here]

Figure 5 plots the actual and predicted passage rates for the sequential committees model, and the SSV model assuming both a simple majority rule and a three-fifths majority rule in the Senate. The sequential committee model clearly outperforms the SSV model under either voting rule in this comparison.

6.1 Do Party Labels Explain Behavior?

In this paper, we have been completely agnostic about whether party labels might be informative about the preferences or the behavior of members of Congress. In particular, we chose not to identify members of the majority party as being predisposed in favor of the proposal and members of the minority party as being predisposed against the proposal. Doing so would have been unduly restrictive.

Having said this, it is reasonable to expect that at the very least, parties will tend to bundle like-minded individuals. Thus it is interesting to see whether there is a correlation between the types we identify in the analysis and their partisan affiliation. A particular hypothesis of interest is that members of the majority party are typically biased in favor of the proposal (and thus are partisan-liberal behavioral types, typically voting in favor of the proposal independently of their private information), and that members of the minority party are typically biased against the proposal, and then either vote informatively or vote against the proposal independently of their private information (partisan-conservative behavioral types). Is this hypothesis consistent with our results?

[Figure 6 about here]

The top panel in Figure 6 plots the proportion of members of the majority party classified as partisan liberals (bar) and the proportion of members of the minority party classified as informative voters (line) per congress and issue area for Appropriations, Economic, and Other issues. Clearly enough, this fit the pattern. Although there are some notable exceptions, in most periods and issues the individuals we classify as liberals are (mostly) members of the majority, and the individuals that we classify as informative are (mostly) members of the minority.

On the other hand, party labels are far from explaining all relevant behavior. The lower panel in Figure 6 mimics the upper panel but for Foreign Relations, Government Operations, and Judiciary. Here the story is altogether different. While in these areas there are some periods and issues for which we observe the same pattern as in the previous case, this is not the norm. Instead, in several issue/Congress observations, a majority of members of both parties vote informatively. Still in other instances, a significant fraction of the minority party is classified as partisan-conservative. We conclude that while party labels do explain some behavior - in particular within Appropriations and Economic areas

- party labels are generically a poor estimate for behavioral types in our model. A more detailed analysis of the role of parties in this context is left for future research.

7 Conclusion

This paper makes a significant contribution to the debate about the policy consequences of adopting a bicameral legislative body. One set of consequences is well understood. Since at least Montesquieu (Montesquieu (1748)), bicameralism has been seen and used as a tool to represent and protect the interests of special minorities (the aristocracy, the states). Tsebelis and Money (1997) call this the *political* aspect of bicameralism. There is a second, equally important argument in the debate, championed by Madison in the Federalist papers (Hamilton, Jay, and Madison (1788)). This second aspect, which Tsebelis and Money call the "efficiency" aspect of bicameralism, sees bicameralism as a tool to improve the quality of political decisions. How this happens, and to what extent does bicameralism actually enhance the quality of public policy is less understood.

In this paper, we explored the "efficiency" motivation of bicameralism. We showed, first, that voting outcomes in both Houses are consistent with a model that incorporates both ideology and common values into legislative decision-making, but not with the simple purely ideological spatial model commonly used in the literature. We presented a model consistent with common values and dispersed information, and argued that the data are consistent with an equilibrium of the theoretical model in which the Senate only approves House bills that pass an endogenous R-majority rule, determined in equilibrium. We then estimated the parameters of the model using the votes of members of the House and the Senate. We obtained three major conclusions:

(i) First, our estimates imply that private information (information dispersed in the system that has not been made public and incorporated in the prior) is quite important. For one, a large fraction of the House votes according to their private information in each case (from 40% in the case of Appropriations bills, to a 50% in Judiciary bills). Moreover, the results show that the informativeness or precision of the signals is relatively large, above 0.85 in all issue areas.

(ii) Second, we showed that the implied supermajority on the entire chamber is $R/n \simeq 4/5$ on average across areas. In other words, bicameralism is transformed in equilibrium into a unicameral system with a four-fifths supermajority rule. This endogenous majority rule has significant variation across areas: close to two thirds for Foreign Relations, and larger for Economic issues (0.87) and Appropriations (0.89).

(iii) Third, we used the estimates to recover the bias π_Q such that a (conservative) member would prefer the proposal to the status quo only if $\Pr(\omega_A|E) \geq \pi_Q$. The combination of relatively precise signals and large cutpoints imply $\pi_Q \approx 1$. In other words, the results imply a very conservative blocking coalition in the Senate, in the sense that proposals are enacted into law only when it is extremely likely that their quality is high.

This paper also provides a significant methodological contribution to the analysis of voting in legislatures. To our knowledge, our paper represents the first study to estimate a model of voting in legislatures that allows for common values with dispersed information in an equilibrium context. This complements recent efforts in the literature to incorporate strategic considerations to the analysis of voting in legislatures.

In spite of the advances, much work is left for future research. Three directions are noteworthy. First, we see this paper as a first step towards achieving a more general framework that can fully integrate the spatial model alongside with common value components and dispersed information. In particular, it would be desirable to allow broader heterogeneity in the biases of different individuals, as well as in the precision of their information (see Iaryczower and Shum (2009) for a step in this direction within a single-committee setting). Second, it is also key to refine this family of models by testing their empirical implications, and comparing their success against other possible explanations for the patterns we uncover here. Finally, we hope that this paper will engage other researchers to expand the application of the framework to other legislatures and institutions around the world.

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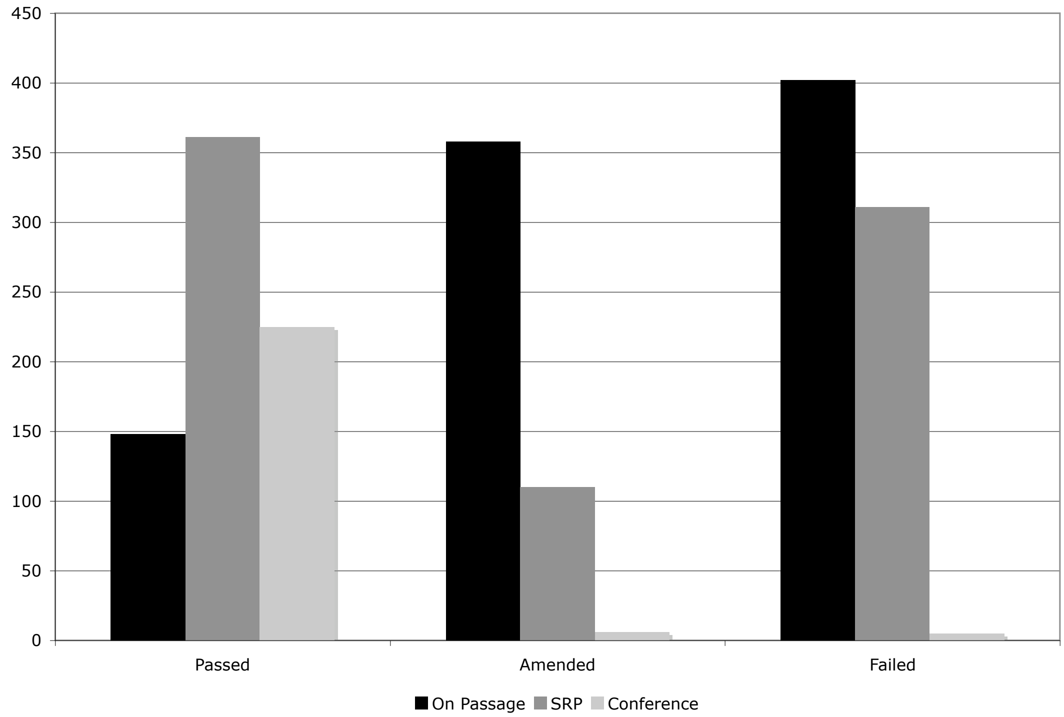


Figure 1: The Fate of House Bills in the Senate

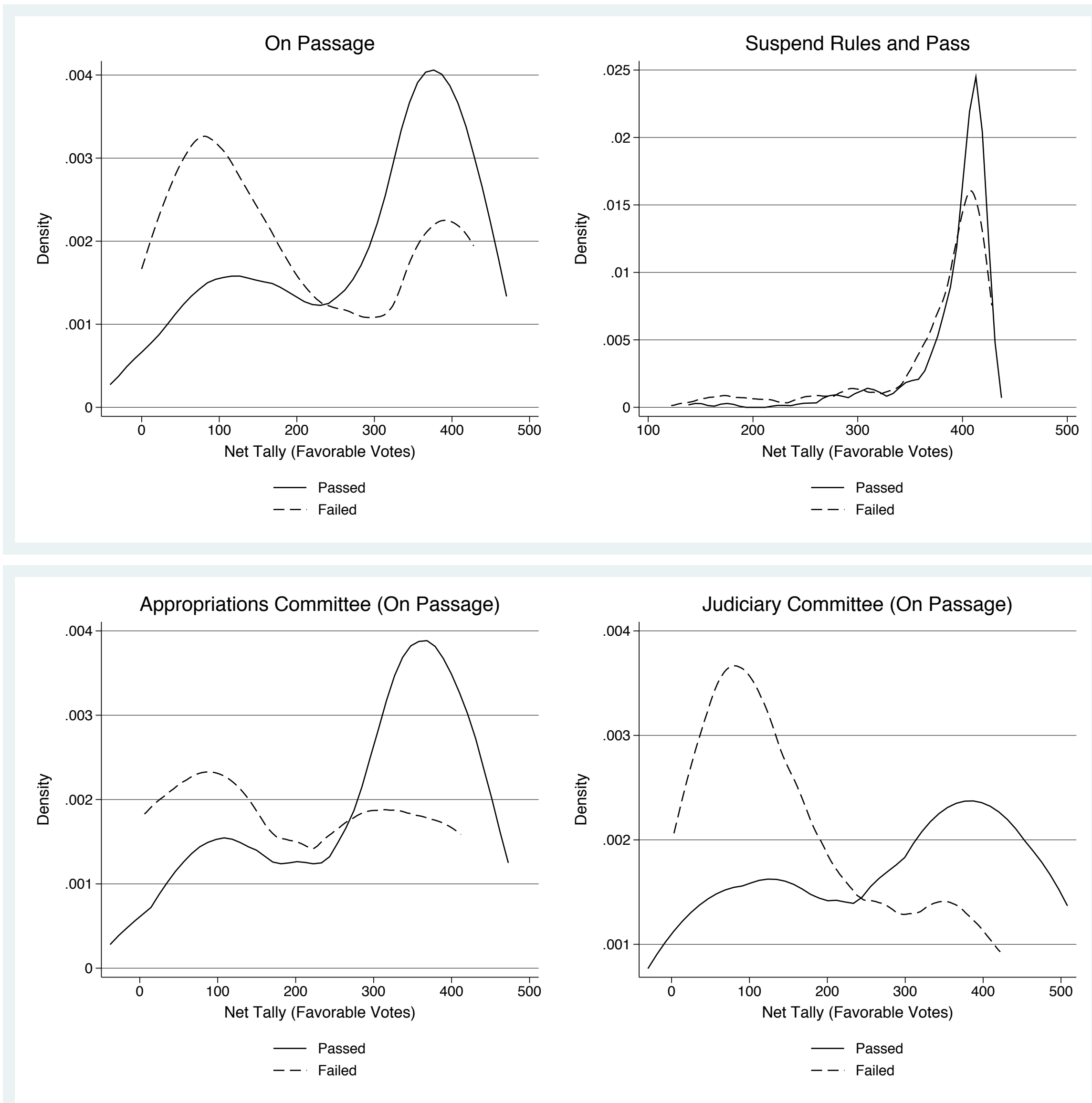
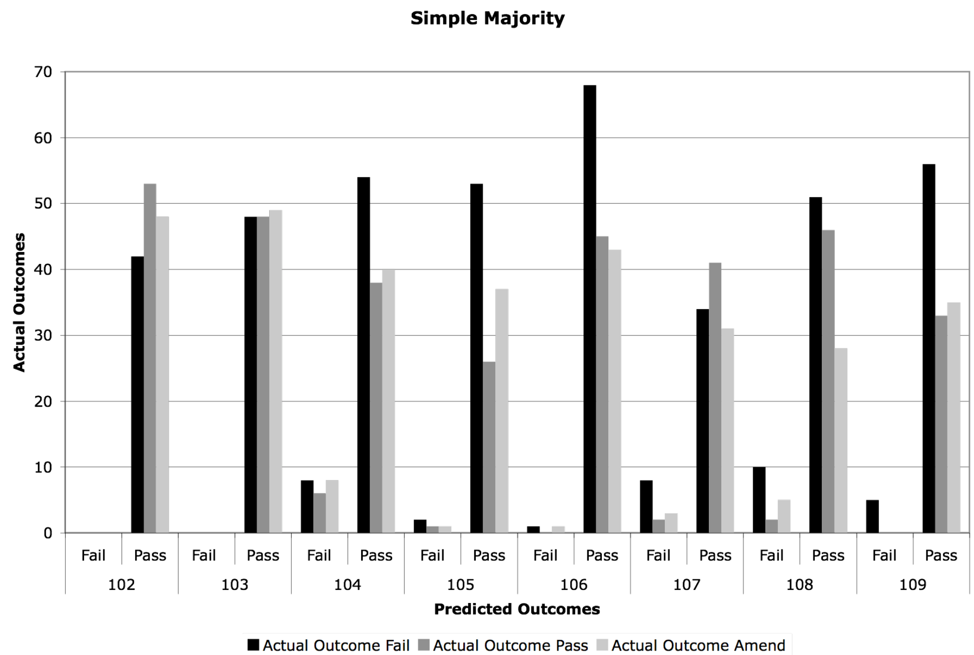


Figure 2: Tally of Votes in the House and Outcomes in the Senate

Simple Majority



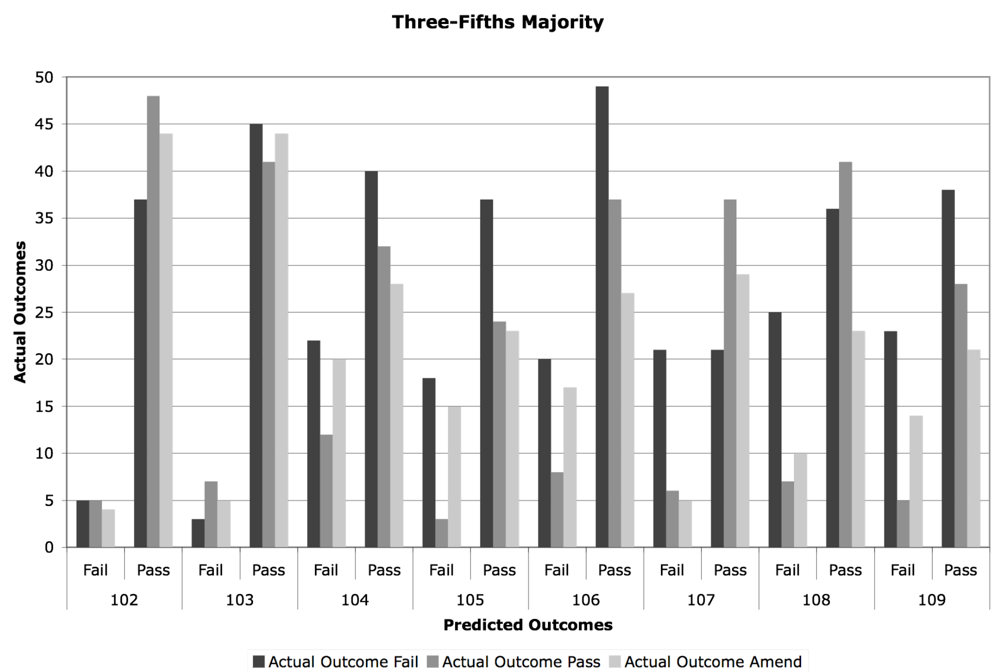
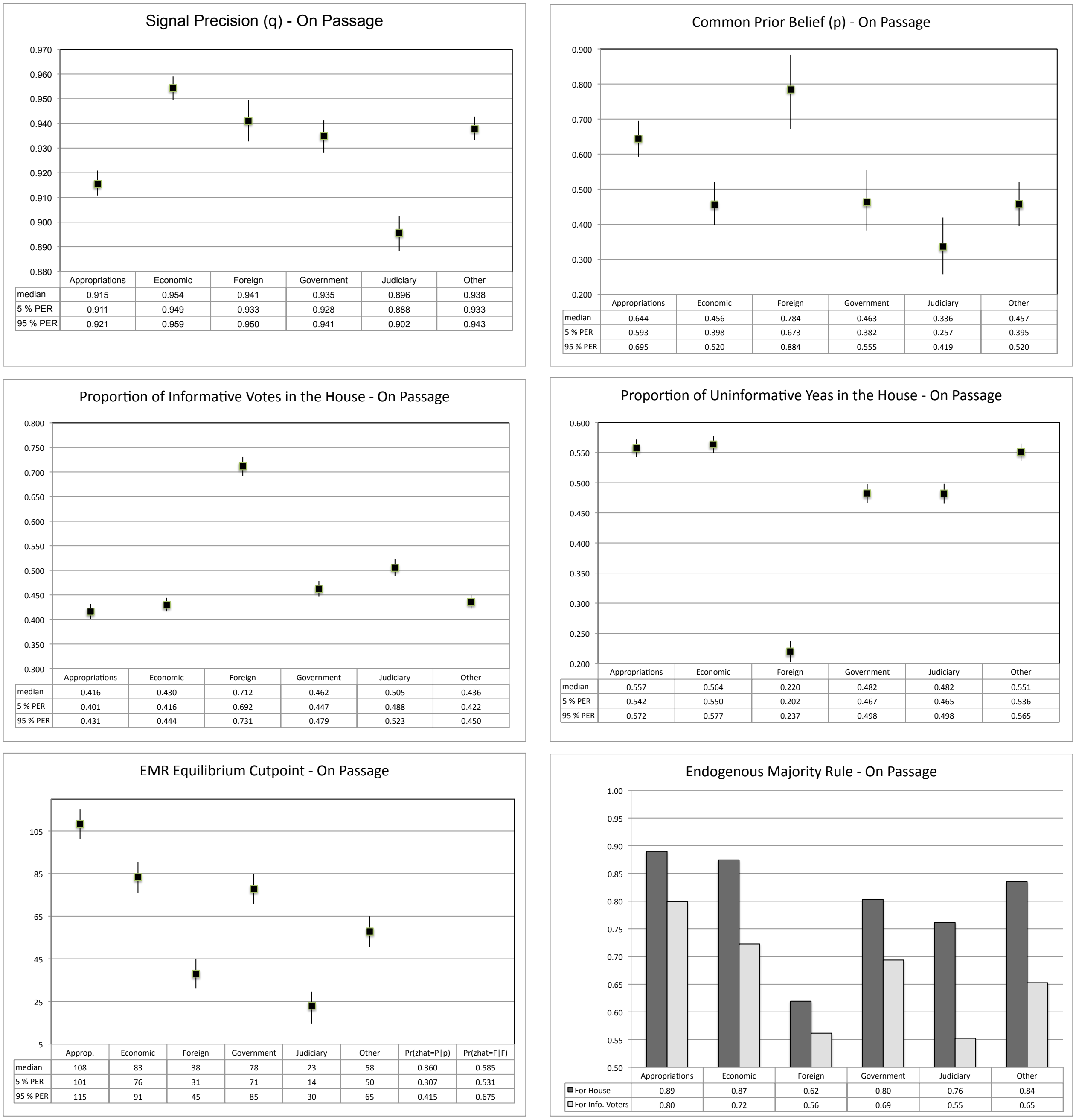


Figure 3: Actual and Predicted Outcomes in the Senate according to the SSV Model



Signal Precision (q) - On Passage

	Appropriations	Economic	Foreign	Government	Judiciary	Other
median	0.915	0.954	0.941	0.935	0.896	0.938
5 % PER	0.911	0.949	0.933	0.928	0.888	0.933
95 % PER	0.921	0.959	0.950	0.941	0.902	0.943

Common Prior Belief (p) - On Passage

	Appropriations	Economic	Foreign	Government	Judiciary	Other
median	0.644	0.456	0.784	0.463	0.336	0.457
5 % PER	0.593	0.398	0.673	0.382	0.257	0.395
95 % PER	0.695	0.520	0.884	0.555	0.419	0.520

Proportion of Informative Votes in the House - On Passage

	Appropriations	Economic	Foreign	Government	Judiciary	Other
median	0.416	0.430	0.712	0.462	0.505	0.436
5 % PER	0.401	0.416	0.692	0.447	0.488	0.422
95 % PER	0.431	0.444	0.731	0.479	0.523	0.450

Proportion of Uninformative Yeas in the House - On Passage

	Appropriations	Economic	Foreign	Government	Judiciary	Other
median	0.557	0.564	0.220	0.482	0.482	0.551
5 % PER	0.542	0.550	0.202	0.467	0.465	0.536
95 % PER	0.572	0.577	0.237	0.498	0.498	0.565

EMR Equilibrium Cutpoint - On Passage

	Approp.	Economic	Foreign	Government	Judiciary	Other	Pr(zhat=P|p)	Pr(zhat=F|F)
median	108	83	38	78	23	58	0.360	0.585
5 % PER	101	76	31	71	14	50	0.307	0.531
95 % PER	115	91	45	85	30	65	0.415	0.675

Endogenous Majority Rule - On Passage

	Appropriations	Economic	Foreign	Government	Judiciary	Other
For House	0.89	0.87	0.62	0.80	0.76	0.84
For Info. Voters	0.80	0.72	0.56	0.69	0.55	0.65

Figure 4: Precision, Prior, Distribution of Types, and Endogenous Majority Rule in votes On Passage ($\mu = 0.10$)

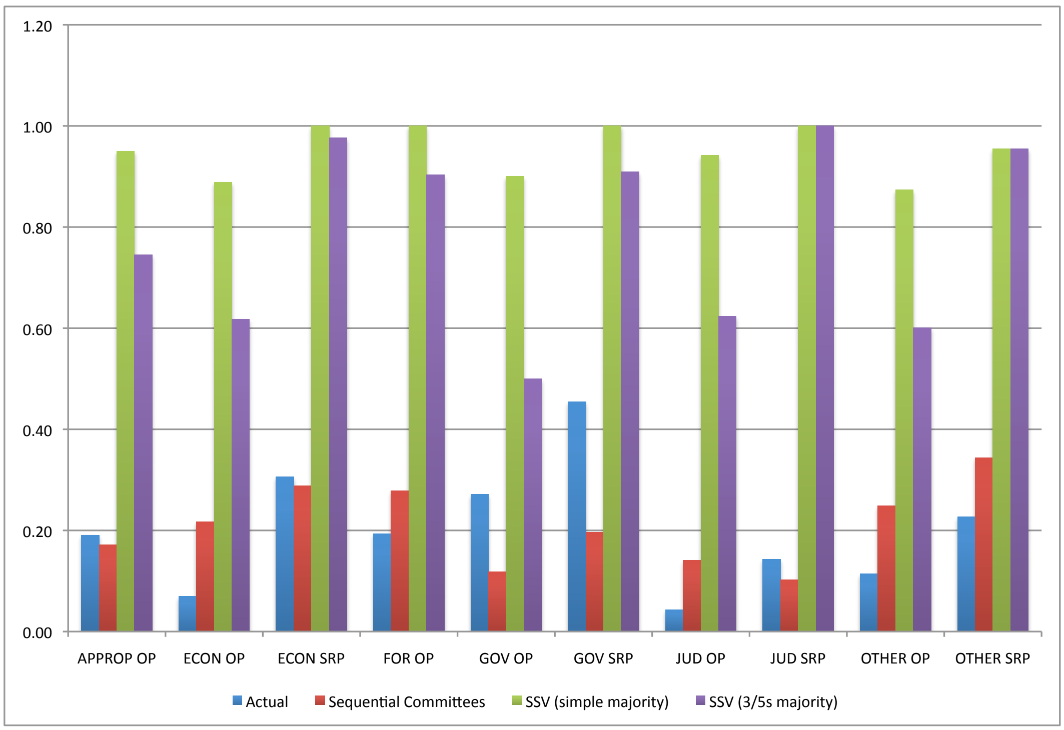
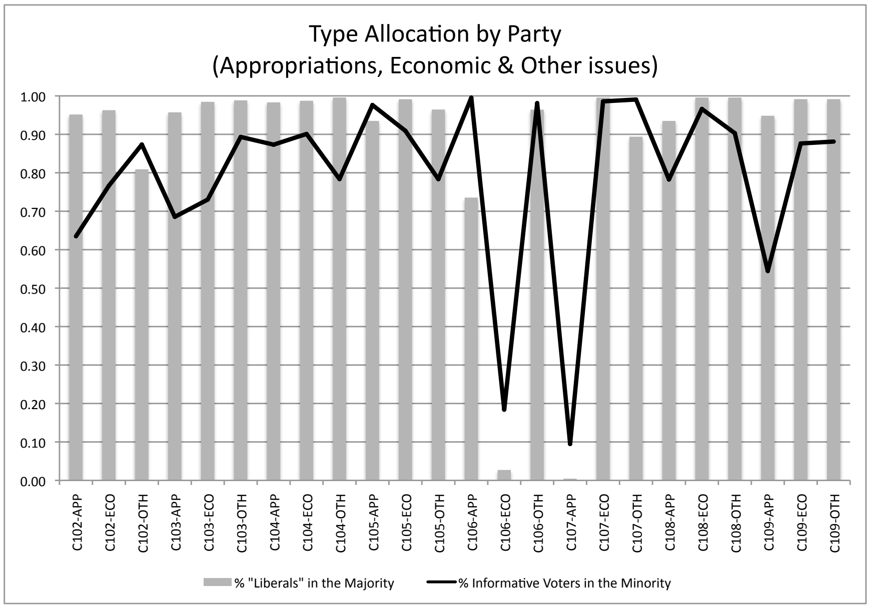


Figure 5: Actual and Predicted Passage Rates in the Senate for the Sequential Committees model and the Spatial Voting model.



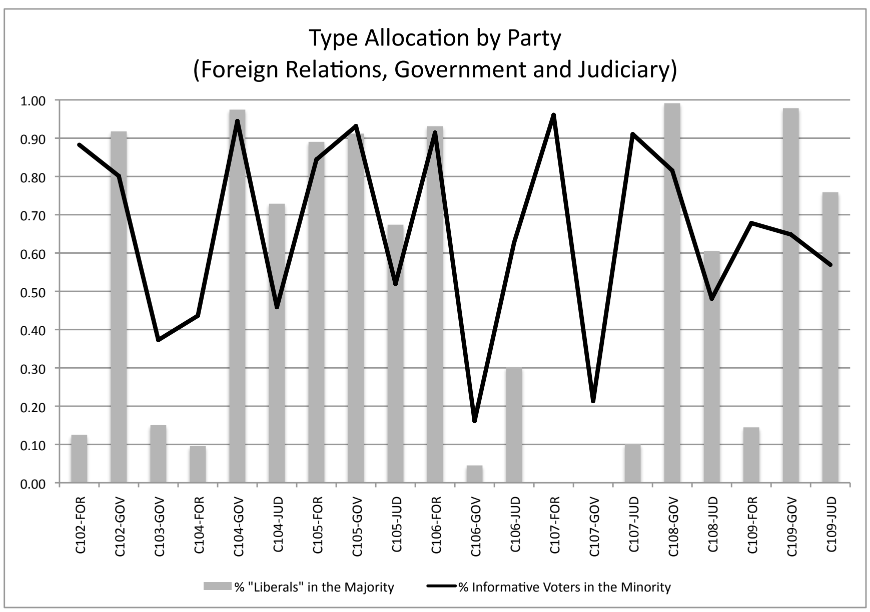


Figure 6: Proportion of "Liberal" Types in the Majority Party and "Informative" Types in the Minority Party, by Issue Area and Congress