Power Tool

Measuring Power in Political Science: A New Method with Application to the Senate

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Abstract

The measurement of power, even in structured settings like legislatures, has proved elusive. We discuss the problems with traditional, *a priori* voting indices approaches and suggest a data-driven, actor-based, (logistic regression) method that is straightforward to implement. This treatment is consistent with systematic theoretical models and discussions of power, and formally allows the separation of 'power' from its causes. To illustrate the strengths of this new technique, we apply the model to the 108th United States Senate. We find that institutional, ideological, personal and geographic variables all influence senators' power.

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1 Introduction

Scholars have long conceptualized politics as a process of conflict over resources. To determine "who gets what, when and how" (Lasswell, 1936), political scientists have invoked notions of 'power' (Dowding, 1996, 1–8). Early positive political theory made the case that median voters—be they in the electorate or in parliaments—were particularly decisive and hence 'powerful' (Black, 1948; Downs, 1987; Riker, 1962). Later theorists—particularly those associated with the 'Rochester school' (Amadae and Bueno de Mesquita, 1999)—have focused on the role of institutional rules and norms in giving 'players' advantages over one another in settings like Congress. This literature is, by now, enormous, and includes foundational work by Riker (1982, 1986) and others (e.g. Shepsle (1979), Shepsle and Weingast (1987), Krehbiel (1991)). Despite this theoretical work, the *empirical* investigation and measurement of power—even in structured settings like parliaments, committees and courts—has proved difficult and contentious, concentrating on *a priori* metrics that are removed from the data that we have regarding agents' actual actions and decisions (Felsenthal and Machover, 1998, 2004).

This paper is an attempt to address this problem and to bridge a gap between the theoretical treatments of power familiar to positive political theorists and the empirical work of political methodologists. Following Dowding (1996), we suggest an *actor-based*, *data driven* approach. Thus, we treat 'power' as a latent variable or 'ability' possessed to varying extents by actors like Congressmen (Senators in particular). We demonstrate that this trait is straightforwardly uncovered by studying easily available voting records. A strength of this approach is that the definition of power is theoretically removed from factors that influence *how* powerful individuals actually are. Methodologically, our contribution to the discipline is the introduction of a new version of the Bradley-Terry (Bradley and Terry, 1952) model for pairwise comparisons, which includes regressors that are thought to covary with actors' power. We show the utility of both the conceptual and empirical suggestions by studying 'power' in the 108th United States Senate where we show the role that ideology, institutional arrangements, geography and personal factors play in determining the power of its members. To wit, in Section 2 we discuss the problems with traditional voting

index measures of power; in Section 3 we suggest, derive and discuss a new data driven model; in Section 4 we apply the model to the 108th Congress and produce a 'power list' of Senators therein; in Section 5 we show how the power can be predicted by its proposed 'causes,' and we discuss the impact of, *inter alia*, party, committee assignment, geographic and personal factors. In Section 6 we conclude and suggest future avenues for research.

2 Problems with Traditional Approaches to Measuring Power

Scholars have been interested in measuring the power of actors in structured settings for over half a century.[1] Beginning with Shapley and Shubik's seminal 1954 contribution, with extensions most famously by Banzhaf (1965), this branch of positive theory has failed to find widespread acceptance in political science for at least three reasons. First, when voters have different weights, different indices yield different results for the same data and, generally, the resulting ambiguity cannot be resolved because there is no objective evidence on the actual distribution of power (Leech, 2002*a*,*b*). Second, for institutions with large numbers of actors, there are computational difficulties with performing the requisite calculations (Leech, 2002*a*,*b*). Third, and of central importance for political scientists, there is much sceptism on the question of whether the indices actually measure 'power' at all (Barry, 1991; Dowding, 1996; Riker, 1964).

The third criticism is the central issue here. Barry (1991) argues that, since power indices are based on the probability that an actor is pivotal, they measure something akin to 'luck' or 'decisiveness' rather than power.[2] The point is that any definition or measurement of power must incorporate the notion of getting one's preference in the face of resistance from other actors. Moving on from this notion, Dowding (1996) considers pivotality as a *resource* among many.[3] The

[1] Social scientists have discussed 'power' in various ways for well over a century: at least since, for example, Marx and *Das Kapital*. The American Political Science Association felt it was sufficiently important and unresolved even in 2006 to devote their annual meeting to "Power Reconsidered."

[2] A natural defence is that power indices are intended for *a priori* analysis; that is, power indices tell us about the distribution of power *before* we consider the preferences of actors or their ability to set an agenda (see Felsenthal and Machover (1998) for a comprehensive review. See also: Lane and Berg (1999) and Holler and Widgren (1999) in their response to Garrett and Tsebelis (1999)).

[3] See also Krehbiel (1998) for a development of 'pivotality' with respect to US legislatures.

implication is that one's power index score is simply one of several independent variables explaining or 'causing'—but theoretically distinct from—an individual's 'power' (which might be thought of as a latent variable). Thinking *this* way enables political scientists to break away from some nonsensical statements such that the power of the Chief Justice in the Supreme Court is ($\frac{1}{9}$), or that the Chairman of the Finance Committee in the United States Senate is is equal in power terms to a freshman senator who has never held a committee post ($\frac{1}{100}$).

In sum: power indices whatever their hue, are not ideal tools for studying what political scientists conventionally think of as 'power.' A new method is needed which, *inter alia*,

1. defines power as the capacity to get what an actor wants in the face of resistance...
2. treats power as a (latent) capability...
3. estimates an actor's power as a function of independent variables...
4. incorporates commensurate statements of uncertainty and...
5. allows for explicit comparison of the effects of different predictors.

In the next section, we show one way to achieve these aims.

3 Statistical Theory and Model

'Power,' as considered here, is a *latent* variable. Since we cannot measure it directly, we need a statistical model that takes *observable* data, estimates an unobservable trait, and outputs a metric. We made the case above that, in the broadest sense, power is an actor's ability to obtain his preferred outcome. In the case of legislatures, which are our concern here, members require majorities to pass bills and an actor's power in these settings will turn on his capability to form legislative coalitions for the issues he cares most about. There is resistance, in the form of actors who vote against the bill, precisely because they stand to lose from its passage. After introducing a little notation, we now provide a way to systematically measure actors —in fact, senators'—capabilities to achieve their preferences in such settings

Let $i = 1, \ldots, I$ index the senators and $j = 1, \ldots, J$ index the bills on which they vote. For any particular j, there exists a senator who proposes the bill, denoted i^p_j. In any session of the Senate, there will be not more than J such individuals, since all bills are proposed by someone, but not all senators propose. The proposer of bill j, i^p_j, is assumed to seek a coalition to vote for the bill and we denote that coalition $c_{i^p_j}$ which has $|c_{i^p_j}|$ members (one of whom is the proposer). It is natural to assume that i^p_j prefers a coalition that is a majority of all senators voting on j, but this is not strictly required here.[4] For now, we suppose that the benefits of passing j—be they pork, credit, news headlines—will accrue only to i^p_j and that other legislators pay some cost in supporting the bill, perhaps because the total size of the pork or publicity 'pie' available is now decreased for them and their home districts. Else, there is some simple opportunity cost of the time they take to vote. In attempting to form the coalition, we say that i^p_j 'convinces' a senator to join $c_{i^p_j}$ if she subsequently votes in favor of the bill (and hence in favor of i^p_j's ideal point relative to the status quo). The nature of the convincing could take many forms: the proposer may attempt to reason, argue, threaten or bargain with his colleagues explicitly, or else the inducement may be implicit. In subsequent votes, say $j+1$, the situation may well be reversed with the previous proposer now joining a coalition $c_{i+1^p_{j+1}}$ backing a senator $i+1$ who had been a member of $c_{i^p_j}$. We say that two senators 'interact' in a particular session of Congress if one proposes a bill and the other joins its backing coalition. Notice that for any particular bill j proposed by i, there are $c_{i^p_j} - 1$ interactions.

For each senator, the statistical model we discuss below will determine a score λ_i such that if we know only that Senator A and Senator B are involved in an interaction, the probability that it is A convincing B (i.e. B is backing A's proposal) rather than B convincing A, is the difference of the scores $\lambda_A - \lambda_B$:

$$\text{logodds}(A \text{ convinces } B | A \text{ and } B \text{ interact }) = \lambda_A - \lambda_B. \tag{1}$$

[4] We assume rather that a proposer is coalition size maximizing: his utility is increasing in $|c_{i^p_j}|$. We could think of this as increasing the *probability* that j is passed.

The interpretation is then straightforward: the greater the value of λ_i relative to other senators, the more powerful we hold that senator to be.

The derivation of the estimator begins by assuming that there exists a latent and hence unobservable power for each senator denoted α_i. For any given interaction (any particular bill) between a pair of senators, let $\pi_{AB} \in (0,1)$ be the probability that the interaction involves Senator A convincing Senator B. Since an interaction must involve either A convincing B or B convincing A it must be true that $\pi_{AB} + \pi_{BA} = 1$.[5] Write the odds that A convinces B as a function of their latent powers, such that

$$\frac{\pi_{AB}}{\pi_{BA}} = \frac{\pi_{AB}}{1 - \pi_{AB}} = \frac{\alpha_A}{\alpha_B}. \tag{2}$$

This formulation has the obvious consequence that, if $\alpha_A > \alpha_B$, *in any given interaction*, $\pi_{AB} > \pi_{BA}$. That is, for any given interaction between A and B, A is more likely to be *forming* the coalition (and gaining his preferred outcome) than B is.

The problem of *estimating* α_i can be approached via a logistic regression. To see how, first let $\alpha_i = \exp(\lambda_i)$. Then, some rearrangement yields[6]

$$\pi_{AB} = \frac{\exp(\lambda_A)}{\exp(\lambda_A) + \exp(\lambda_B)}. \tag{3}$$

Suppose that A and B interact a total of N_{AB} times. Of these interactions, let n_{AB}—where $n_{AB} \leq N_{AB}$— be the number of times that A convinces B. Then, so long as the N_{AB} interactions are independent of one another, and the same probability π_{AB} applies to each interaction, n_{AB} has a binomial (N_{AB}, π_{AB}) distribution. If we are also willing to assume that all the other interactions between the other senators are also independent, we have a logit model that can be estimated via

[5] An objection may be that party or some other factor compels senators to vote one way or the other, in which case this equality will not hold. By studying *personal amendments* in Section 4 we ameliorate these concerns somewhat but see also our 'order effect' specification below.

[6] From Equation (2), it is obvious that $\pi_{AB}(1 + \frac{\alpha_A}{\alpha_B}) = \frac{\alpha_A}{\alpha_B}$; substitute $\frac{\alpha_B}{\alpha_B}$ for 1 and note that $\alpha_i = \exp(\lambda_i)$ to obtain (3).

maximum likelihood:

$$\text{logit}[\Pr(A \text{ convinces } B)] = \lambda_A - \lambda_B. \tag{4}$$

We can then compare the relative size of λ_A and λ_B to see which senator is more powerful.[7]

A concern with this formulation might be that, in fact, party pressures and thus *a priori* similar preferences between senators, obviates the need to 'convince' other legislators in any real sense. Otherwise put, some senators are disposed to supporting others like them, whatever the proposers power. We will tackle this issue head-on by estimating a version of our logistic regression as

$$\text{logit}[\Pr(A \text{ convinces } B)] = \lambda_A - \lambda_B + \delta w \tag{5}$$

where w is an indicator taking the value 1 if the proposer's party is the same as that of an individual he convinces and -1 otherwise. Hence, δ will capture the 'natural advantage' of proposing to someone in a senator's party, and the λ_i will reflect the ability *absent* this advantage.

Notice that our method here is very different to that of previous endeavors to measure power. Unlike index methods, it is an *a posteriori* in the sense that we infer 'power' *after* observing actor's *actual* decisions—rather than before. Hence the terms 'data driven' and 'actor based.' Second, unlike subjective rankings it is objective and relies on a clearly defined definition of power. This means, in contrast to 'panel of expert' surveys, that our findings (below) are exactly replicable by any other political scientist who chooses so to do. Moreover, it is much cheaper and faster to calculate.

This estimator is not new to this paper; it is the Bradley-Terry (Bradley and Terry, 1952) pairwise comparison (with equation 5 representing an 'order effect' specification) method in a novel setting. This approach is well known and well studied by statisticians working in fields as diverse as sport

[7]Importantly, the model does not require that the matrix of interactions is 'complete' in the sense that every senator interacts at some point with every other. The model implicitly assumes transitivity: if Senator A is more powerful than B, and B is more powerful than C, then A is also more powerful than C.

team rankings (Agresti, 2002), journal citation patterns (Stigler, 1994) and competition for mates in the biological sciences (Stuart-Fox et al., 2006).[8] This is not the first paper in the discipline to suggest thinking of some political phenomena as pairwise interactions: for example, Groseclose and Stewart (1998) study the value of Congressional committee assignments using (dyadic) transfers of representatives.[9] The paper is perhaps closest in spirit (though not in execution) to work by Wawro (2000) who studies legislative entrepreneurship in the House. Designing a novel "entrepreneurship scales score" based on five observables of behavior, Wawro shows that party-based career prospects are strongly linked to a representative's records of actively introducing legislation. Below, we build on this work by presenting congruent findings—though with a different causal direction: in particular, that party and committee advancement aids senators in their quest to pass (potentially controversial) legislation. Also, like Wawro we provide scholars with a metric that may be used for further research.

4 Application: 108th Senate

We use data from the 108th Senate, that met between January 2003 and December 2004. The universe of cases for the present analysis is the 255 amendments, by 74 different senators, proposed and voted upon during this time. Amendments are preferred to bills as a whole since they "tend to reflect more specific changes to a bill that are less susceptible to deviations from the sponsor's original intent" (Fowler, 2006, 9). That is, they are more amenable to the notion of *personal* coalitions formed to achieve an individual's goals. Studying the Senate in particular has the further benefit that, subject to some constraints negotiated via Unanimous Consent Agreements, its members may propose amendments at essentially any time, in any order, without permission from a Committee of the Whole. This means that, unlike the House, the status quo is afforded less protection—an ongoing concern for those studying power (see Bachrach and Baratz, 1962, for example). There are 101 actors in the current data set: 74 proposing senators, 26 non-proposing but voting senators

[8] Such models can be fitted with many standard statistical packages. For this paper, `R` (R Development Core Team, 2006) was the environment of choice in conjunction with the `BradleyTerry` library (Firth, 2005).

[9] See also King (2001) who discusses some possible extensions of standard international relations models that assume dyadic interactions, and Fowler (2006) who studies the 'connectedness' of legislators in both chambers—though not in an explicitly pairwise way.

and the President (where his views on the amendments are known). Of the amendments, 112 were winning, 139 were losing, and four were tied votes. Recall that the number of observations is the number of interactions, and is thus well in excess of the number of amendments: otherwise put, each amendment corresponds to multiple interactions and hence multiple observations.

One concern might be that senators vote *strategically*: against their first preferences for an alternative that is *a priori* less preferred. They might also *propose* strategically, to ensure their preferred alternative is selected by majority rule (Riker, 1982, 1986). However, it is not immediately apparent that strategic (let alone 'killer') amendments are common. Second, strategic voting on *amendments*, as opposed to bills, should be relatively rare: we can generally assume that those voting for an amendment *want* it to pass. Third, strategic voting is presumably a product of the organizational structure—like the timetabling procedures—of the Senate: but this is precisely the sort of consideration that ought to be *included* in the calculation of our metric. Lastly, votes in the Senate are part of the public record, so we expect senators to treat their vote seriously and think through its consequences.[10]

In Table 1, we report a selection of the power estimates for this specification. Recall that there is no sense in which the power measure is absolute, and all the coefficients are scaled relative to zero which is assigned to President Bush.

Examining the table, we note that the long serving (since 1979) John Warner of Virginia (senior senator) is ranked first. Second is Mitch McConnell of Kentucky (senior senator). In the 108th Senate he was elected as the majority whip by the Republicans and, at the time of writing, was the leader of Republicans in the Senate. Judd Gregg, the senior (Republican) senator from New Hampshire is at third. Gregg chaired the Health, Education, Labor and Pensions Committee in the 108th Congress, and became chair of the Budget Committee in the 109th. Robert Byrd, the

[10]Notice that simply proposing (and forming coalitions) for more amendments cannot in and of itself increase a senator's power in this model: see Appendix A and Appendix C.

	Senator	Power (λ_i)
1	Warner, John	22.10
2	McConnell, Mitch	22.09
3	Gregg, Judd	21.84
4	Byrd, Robert	21.63
5	McCain, John	21.58
6	Frist, Bill	21.57
7	Cochran, Thad	21.44
8	Grassley, Charles	21.44
9	Boxer, Barbara	21.39
10	Graham, Lindsey	21.36
⋮	⋮	⋮
22	Kennedy, Edward	20.79
23	Daschle, Tom	20.79
⋮	⋮	⋮
29	Kerry, John	20.58
⋮	⋮	⋮
33	Lott, Trent	20.48
⋮	⋮	⋮
45	Clinton, Hillary	20.13
⋮	⋮	⋮
54	Feingold, Russ	19.85
57	Lieberman, Joe	19.74
⋮	⋮	⋮
93	Santorum, Rick	-0.34
⋮	⋮	⋮
99	Inouye, Daniel	-0.73
100	Jeffords, Jim	-0.74
101	Akaka, Daniel	-0.82

Table 1: Baseline results for model of power for US Senators in the 108th Senate.

longest serving senator in history is the first Democrat on this power list. From West Virginia, Byrd is, at the time of writing, the President *Pro Tempore*—a role he had previously held in the 1980s and 1990s. John McCain of Arizona, then chair of the Commerce committee, is followed by Bill Frist of Tennessee, the Senate Majority leader for the Congress in question. Thad Cochran and Charles Grassley, chairs of the Appropriations and Finance Committees respectively (in the 109th Congress) hold the 7th and 8th spots. Barbara Boxer, the junior senator from California is the first woman to feature on the list. At the bottom of the ranking, we see both senators from Hawaii (Daniel Akaka and Daniel Inouye) along with Jim Jeffords (Republican to 2001, Indepen-

dent thereafter).[11] Fitting an 'order effect' model such that the 'natural advantage' of proposing to like-minded partisans is controlled for—as specified in equation 5—makes little appreciable difference to this rank order: see Appendix B for more details.

Subjective rankings—published in magazines such as *Time* and by consultancy groups like *Knowlegis*—reach very similar conclusions to ours. The *Knowlegis* power list for 2005 for example, one session after the 108th, places Thad Cochran at 1 (7 in our ranking), Mitch McConnell at 4 (2), Charles Grassley at 7 (8), John McCain at 8 (5), Bill Frist at 10 (6), Arlen Spector at 9 (15) and Orrin Hatch at 2 (19). This similarity to our ranking is remarkable given that (a) they are discussing a different Congress and that (b) our approach is based on a simple, model-based voting metric that is relatively straightforward to compute. The *Knowlegis* list, by contrast, is based upon a vast and expensive survey incorporating what is theoretically much more information.[12]

As noted above, a pleasing feature of the current estimator is that the power estimates λ_i have meaning outside of a simple rank ordering. Recall that $\lambda_A - \lambda_B$ is the (anti-logged) probability that, conditioned on two senators interacting, it is A that convinces B to back his amendment rather than the other way round. Consider, for example, John McCain and Russ Feingold (Wisconsin), coauthors of the Bipartisan Campaign Reform Act of 2002. The probability that, in any interaction between these two, it is McCain proposing the bill and Feingold backing it is

$$\frac{\exp(\lambda_{\text{McCain}})}{\exp(\lambda_{\text{McCain}}) + \exp(\lambda_{\text{Feingold}})} = \frac{\exp(21.58)}{(\exp 21.58) + \exp(19.85)} \approx 0.85.$$

By contrast, the same calculation for McCain and Rick Santorum yields a probability of (very close to) 1. This is hardly surprising given that the senator from Pennsylvania did not offer an

[11] Importantly, the rank ordering is very different to that which might be garnered from looking solely at the number of amendments proposed by each senator. See Appendix C for *this* rank ordering.

[12] According to their website, "*Knowlegis* staff carefully researched, sorted and considered thousands of data points to determine ... power... reviewed thousands of media articles, hundreds of bills that passed out of committee ... over a thousand amendments... We collected data on the leadership, committee, and caucus positions of each Member ... researched relevant campaign contributions, and considered any characteristic or action that could contribute to their Sizzle-Fizzle factor... there are more than 10,000 data points and variables that were considered in the 2006 Knowlegis Power Rankings" source:`http://www.congress.org/congressorg/power_rankings/backgrounder.tt`

amendment in the 108th Congress, but it lends some validity to the estimator.

A further factor in favor of the new approach concerns the goodness of fit: in contrast to standard methods this is at least meaningful (what is the goodness of fit for a subjective survey?) and, in fact, respectable, at some 85% of interactions correctly predicted. This figure is within the ballpark of similar statistics for industry standards like `NOMINATE` (see Poole and Rosenthal, 1997), though given the structure of the underlying statistical model it is calculated somewhat differently. Appendix D reports more details.

In sum, Table 1 seems to be a reasonable 'influence list' both in terms of its underlying statistical model and its actual contents; it tells us little, however, about the *causes* of power, a subject to which we now turn.

5 Structured Modeling

We usually have theories about what explains the power of different individuals; indeed, sometimes we treat characteristics that are causes of power as if they were synonymous with power itself: consider, for example, the notion that 'the rich are powerful.' A pleasing feature of the current approach and estimator is that we can *separate* these notions and explicitly incorporate individual specific explanatory variables as predictors of power. We estimate

$$\lambda_i = \sum_{r=1}^{p} \beta_r x_{ir} \tag{6}$$

and thus we predict the power of each senator as a (linear) function of explanatory variables $x_{i1}, x_{i2}, \ldots x_{ip}$ with coefficients $\beta_1, \beta_2 \ldots, \beta_p$ (see Firth (2005) and Springall (1973) for details). Since the approach here is essentially a logistic regression, we can interpret coefficient estimates as positive or negative, in terms of their marginal effects on power, and we have commensurate standard errors. We can thus make uncertainty statements about our predictors.

We used institutional and personal information to explain power in the Senate. Collecting such data is straightforward: the Senate itself, the Government Printing Office and the United States Census Bureau provided all the relevant variables below in electronic form. We break the findings into four subsections dealing with 'Party and Ideology,' 'Committees and Agenda Control,' 'Geographic Factors' and 'Career Factors.' The intention here is not to provide an exhaustive account of power, but to demonstrate the strength of the approach and possible avenues for future research. Before describing the results, notice that the nature of 'power' now being considered is altered somewhat. In the previous section, power was an ability to be ascribed to individual senators—it was a 'personal' characteristic. Now though, power is a function of variables and is being treated in an 'institutional' sense, separate from the individuals who wield it. Otherwise put, it is now a maintained assumption that institutional (and other) characteristics *make* individuals powerful.[13]

5.1 Party and Ideology

In contrast to the 'textbook Congress' of Fenno (1973), there is increasing evidence that Congressional voting is ideological and party driven (McCarty, Poole and Rosenthal, 2006).[14] This is more true of the House than the Senate, but nonetheless it suggests some testable hypotheses. As noted above, senators must assemble majorities to obtain their own preferences. If a majority party exists (the Republicans for the 108th Congress) we might expect those from the majority party to be more powerful than those from the minority (Democrats). A refinement on this theme is that we expect *leaders* of Congressional parties to be especially powerful: the Senate Majority Leader (Bill Frist for the 108th Congress), for example, has the ability to schedule debate. Other officials—which we refer to as 'junior leaders'—such as Policy Committee Chairs have powers to design and execute policy ideas. In Table 2 we give the results of the model for a `Majority` dummy variable and `SeniorLeadership`, a dummy that denotes either the senior Senator for each party, or the whips for each party. We also interact these variables. The positive and significant effects of being a Republican and being part of the Senate's senior leadership are evident from Table 2.

[13]Notice that a potential endogeneity concern—that individuals *already* endowed with latent power *ipso facto* obtain important institutional advantages—is being avoided by construction.

[14]See also Huitt (1957) who discusses cross cutting tensions of ideology and party as it applies to senators.

	Estimate	Std. Error
`Majority`	0.286^{***}	0.034
`SeniorLeadership`	0.205^{***}	0.072
`Majority`×`SeniorLeadership`	0.754^{***}	0.104

Table 2: Effect of majority party and senior leadership status on power in the Senate. Asterisked coefficients (***) imply $p < 0.01$. AIC: 11052.

From the interaction term it is evident that being a Republican *and* a leader adds an extra fillip to one's power. To be clearer here and recalling equation (6), consider the power of some senator A who is a member the majority party and also a senior leader. By Table 2,

$$\lambda_A = 0.286 \times 1 + 0.205 \times 1 + 0.754 \times 1 = 1.245.$$

The power of Senator B who is a rank-and-file Republican is

$$\lambda_B = 0.286 \times 1 + 0.205 \times 0 + 0.754 \times 0 = 0.286.$$

The probability that, if these two interact, it is the Republican leader proposing and B supporting is

$$\frac{\exp(1.245)}{\exp(1.245) + \exp(0.286)} = 0.72.$$

If B is a rank-and-file Democrat, then this probability rises to

$$\frac{\exp(1.245)}{\exp(1.245) + \exp(0)} = 0.78.$$

In Table 3 we estimate the same model with `AllLeadership`, a dummy that includes all senior leaders (as in `Leadership`) in addition several other categories: Conference Chairs, Party Committee Chairs, Conference Secretaries and Senatorial Campaign Chairs. This model fits the data as well as the previous model (note the similar values of the Akaike Information Criterion (AIC)). Interestingly though, general leadership status does not confer the power that senior leadership

	Estimate	Std. Error
`Majority`	0.304^{***}	0.035
`AllLeadership`	0.118^{**}	0.047
`Majority`×`AllLeadership`	0.373^{***}	0.073

Table 3: Effect of majority party membership and any leadership status on power in the Senate. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 11152.

does—notice that the coefficients for `AllLeadership` and the interaction are now smaller than the commensurate ones in Table 2.

To demonstrate how American politics has become increasingly polarized, McCarty, Poole and Rosenthal show that legislators' ideological positions, and the median positions for parties, have become increasingly disparate along a liberal-conservative dimension. As politics becomes more polarized, we might have several conflicting expectations. On the one hand, senators who occupy the center ground—are close to the legislative median— may find it easier to broker deals with others to their left and right, and hence will be more powerful. On the other hand, if voting is strongly party based, then perhaps the most ideologically extreme in each party will be able to motivate their 'core' supporters into backing their preferred positions. This will be *a fortiori* true for relatively radical senators from the *majority* party. At base, this is one version of the 'party versus floor median' debate well discussed in literature elsewhere (Cox and McCubbins, 1993; Rohde, 1991, *cf.* Krehbiel, 1998).

We can measure ideological extremism via senators' `NOMINATE` scores (Poole and Rosenthal, 1997).[15] In particular, the score for the senator in one dimension is treated as their 'conservatism' (we label this '`Conservatism`' and the higher the score, the more conservative and less liberal they are). 'Extremism' is a different concept and can be ascertained by taking the absolute value of this score (`Extremism`): a very high score now implies a senator very far to the left *or* to the right, while

[15] In particular, `DW-NOMINATE` scores, available from `http://voteview.com/dwnomin.htm`

a low score reflects a senator in the center of the chamber. We add `Distance from Median` that records the absolute value of senators' distances from their party median in terms of `NOMINATE` scores. In Table 4 we report the effects of conservatism (controlling for majority party membership and distance from the median) and in Table 5 we report the effects of extremism.

	Estimate	Std. Error
`Conservatism`	-0.591^{***}	0.080
`Majority`	0.844^{***}	0.073
`Distance from Median`	-0.722^{***}	0.122

Table 4: Effect of conservatism, distance from median and majority status on power in the Senate. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 11169.

	Estimate	Std. Error
`Extremism`	1.14^{***}	0.107
`Majority`	0.783^{***}	0.075
`Majority`×`Extremism`	-0.9636^{***}	0.168
`Distance from Median`	-0.702^{***}	0.123

Table 5: Effect of extremism, distance from median and majority status on power in the Senate. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 11136.

The lessons from Tables 4and 5 are interesting. Once we control for majority party membership, conservatism and distance from the median have a negative impact on power. Consider, for example, Senator A who is a moderate Republican with a `NOMINATE` score of 0.2 (the scale runs -1 through 1). By contrast Senator B is deeply conservative with a `NOMINATE` score of 0.8. Their powers are

$$\lambda_A = -0.591 \times 0.2 + 0.844 \times 1 + \times - 0.702 \times |0.2 - 0.441| = 0.557$$

and

$$\lambda_B = -0.591 \times 0.8 + 0.844 \times 1 + -0.702 \times |0.8 - 0.441| = 0.119.$$

In any interaction, the probability that A proposes some coalition, while B joins it, is around 0.61. To see more of the interplay between ideology and power, consider Figure 1: here, we plot the Senator's power estimates against their `NOMINATE` scores, and then impose a solid loess curve. The top graphic displays the plot for all senators, and the one below is the same graphic for senators who proposed amendments in the 108th Senate. Notice that, in the top panel of Figure 1, the extremes of the Senate are rewarded in power terms: the loess dips slightly as it crosses the middle of the ideological spectrum. But, interestingly, in the lower panel (which represents the most powerful senators), we see two things: first, majority party status boosts one's power—notice that the loess rises as it moves right. *Within* the majority party (the Republicans) though, the most powerful senators are not drawn from the far right wing: notice the high λ_i recorded for those with a `NOMINATE` score around 0.4. In Table 5, the positive coefficient on `Extremism` suggests once again that senators towards the middle of the chamber lack power. Interestingly, it is also evident while being in the majority party is beneficial, it does not pay to be a right wing Republican: rather, the powerful are from the median of the party. Figure 2 confirms this idea: in the first panel, the power ratings for all senators are shown, and in the bottom panel, the analysis is restricted to the proposers only. Notice that the bulk of the mass occurs around 0.4 for both parties, with the most powerful senators of both parties occurring just above and below this scaling. Otherwise put, it does not pay to be the median of the chamber, but it does pay to be the median of your party.

5.2 Committee and Agenda Control

Positive political theorists, especially those of the 'Rochester school' (Amadae and Bueno de Mesquita, 1999), have suggested that it is the organization of Congress in terms of its *committees* that confers power on actors. Indeed, in a series of articles Shepsle and Weingast (1987) and Krehbiel (1991) discussed precisely *why* committees are powerful. Of course, not all committees are created equal, and they attract different memberships with different motivations (Fenno, 1973). Nonetheless, there is general agreement that financial committee positions—those that have 'power

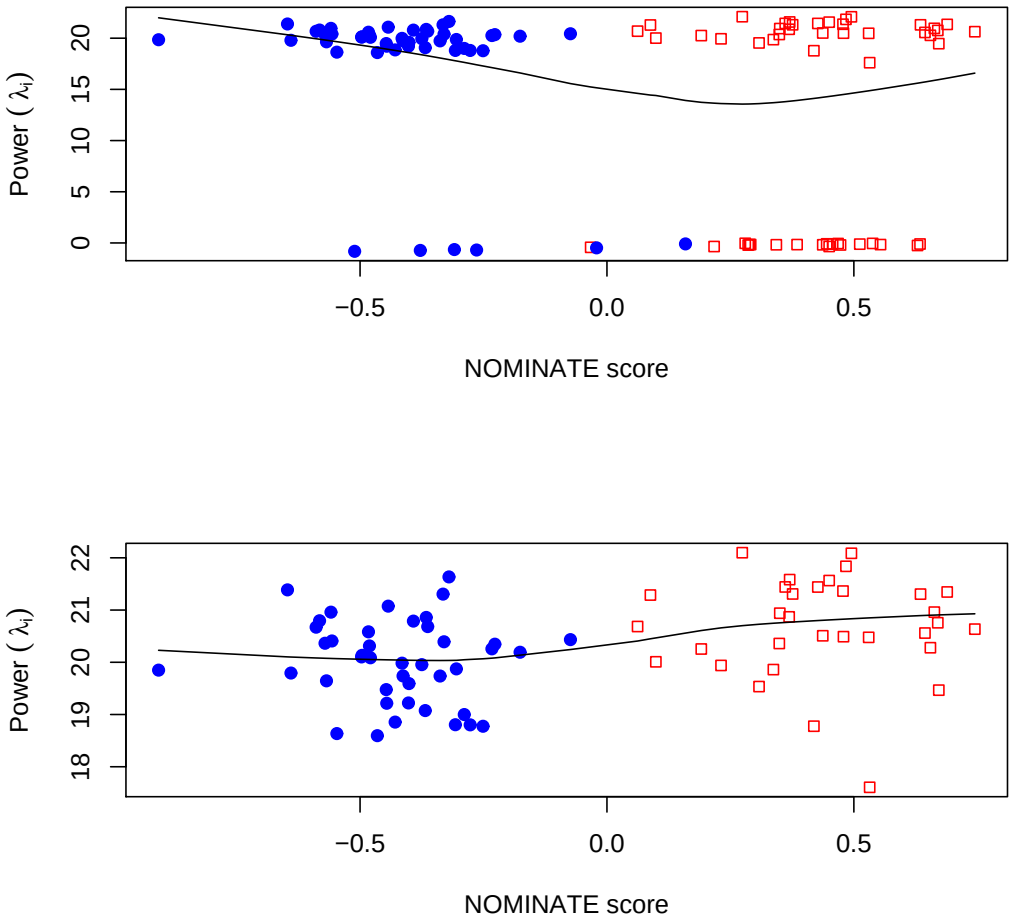

Figure 1: NOMINATE score versus power (λ_i); open squares are Republicans, closed circles are Democrats; solid line is loess. Top figure is for *all* senators; bottom figure is for all *proposing* senators.

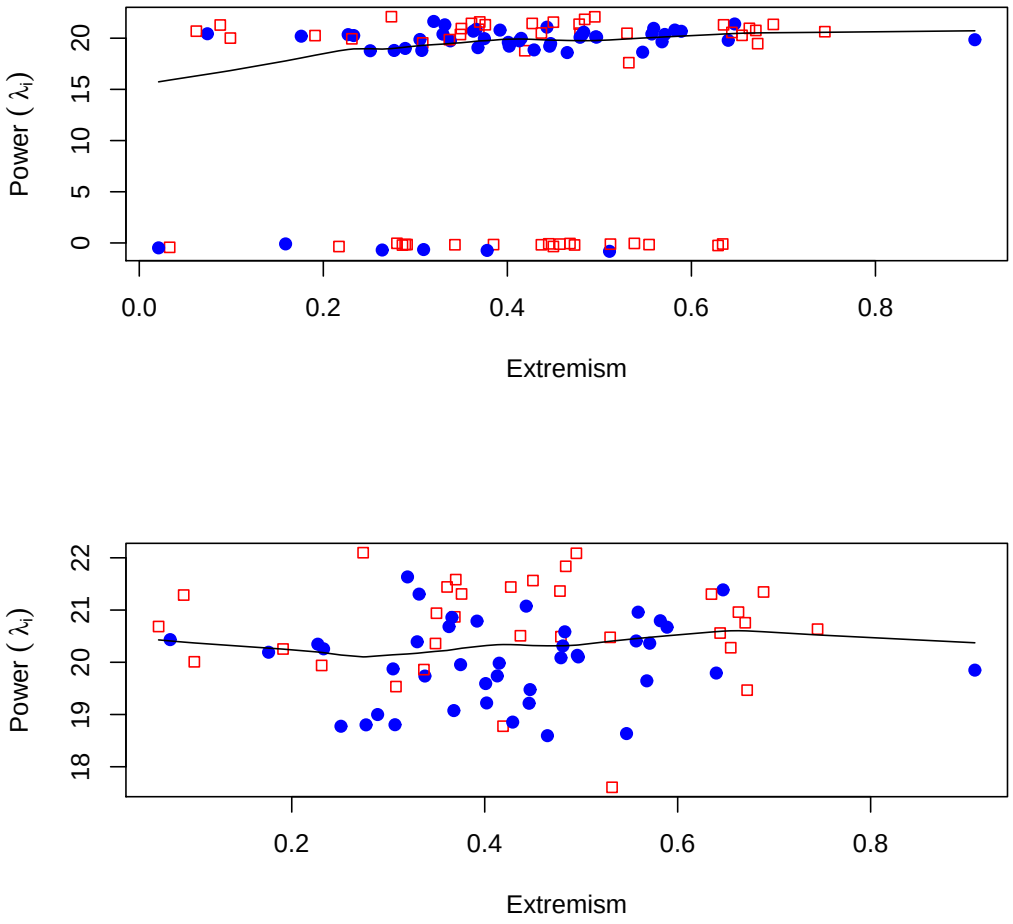

Figure 2: Extremism versus power (λ_i); open squares are Republicans, closed circles are Democrats; solid line is loess. Top figure is for *all* senators; bottom figure is for all *proposing* senators.

of the purse' tend to be the most coveted spots for ambitious senators. This is not least because such positions enable members to channel substantial pork to their home states. For example, Charles Grassley, Chairman of the Senate's Appropriations Committee, used the 2004 appropriations bill to steer some $50m to Iowa's visionary complex of biomes, *Earthpark* (*The Economist*, 2006).

Committees themselves are, of course, hierarchical structures. As mentioned above, Grassley was the *Chair* of Appropriations, not simply a member. Chairs have several *de jure* responsibilities and rights pertaining to timetabling, hearings and the selection of bills to be considered. Other than the Chair, who must be a member of the majority party, committees are constructed of minority and majority party members. Above, we discussed reasons why majority party senators might be powerful, and presumably this goes *mutandis mutatis* for majority party committee members.

Since space is limited, we only discuss some of the committees and their members here. In particular, in Table 6 we report regression coefficients for the Appropriations, Armed Services, Commerce, Finance and Rules and Administration committee all denoted with these names. We also include a majority party interaction term, and a term for Chairs (of any committee) denoted `Chair`. Where Table (6) reports positive coefficients, the Committee assignment increases the power of a senator relative to one *not* on the that committee. Majority party members get an extra boost in power on the Armed Services, Appropriations and Finance committees, but not on the Rules and Administration or Commerce committees. From the perspective of a senator, the most powerful position is a role on the Finance committee (notice that the addition of the `Finance` coefficient and that for `Majority`×`Finance` is a larger number than for any other committee). Perhaps unsurprisingly, Chairs are more powerful than rank-and-file members; in Figure 3 we compare chairs to Democrats and non-chairing Republicans who propose amendments. Notice that the median power of chairs clearly exceeds that of the other groups and, in fact, their entire inter-quartile range is more powerful than that of Democrats.

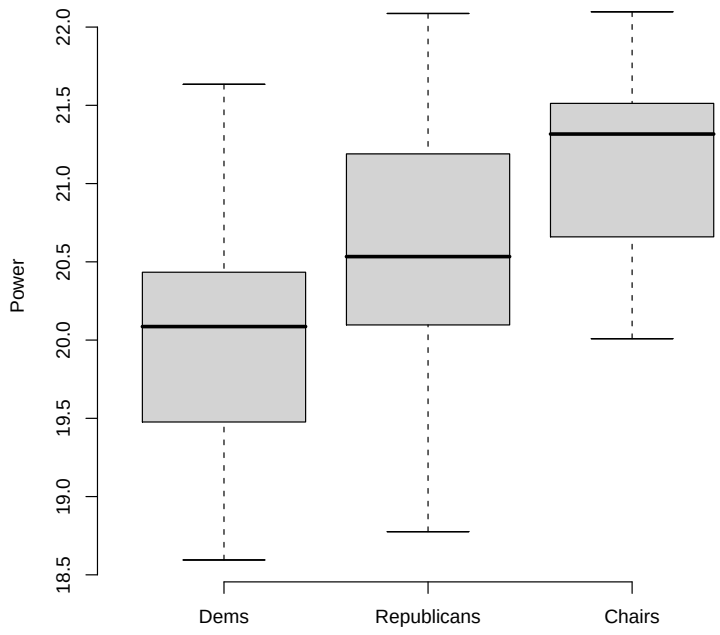

Figure 3: Boxplot showing relative power of committee chairs, non-chairing Republicans and Democrats who propose amendments.

	Estimate	Std. Error
Chair	0.596^{***}	0.042
Majority	-1.055^{***}	0.089
Appropriations	0.245^{***}	0.040
Majority×Appropriations	1.376^{***}	0.100
Armed Services	0.189^{***}	0.042
Majority×Armed Services	1.353^{***}	0.102
Commerce	0.264^{***}	0.040
Majority×Commerce	-0.737^{***}	0.068
Finance	0.482^{***}	0.046
Majority×Finance	1.445^{***}	0.104
Rules Admin	0.440^{***}	0.039
Majority×Rules Admin	0.312^{***}	0.068

Table 6: Effect of committee membership, majority party membership and chair status on power in the Senate. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 9434.9.

5.3 Geographic Factors

One of the results of the Constitutional Convention of 1787 was the so called 'Connecticut Compromise.' Dealing with the creation of the United States' legislative bodies, the Compromise proposed two houses: a lower house elected in proportion to population, and a senate, in which each state would have two representatives, regardless of its population. The fear of large state tyranny, though admonished as unlikely and illogical by the likes of Madison and Hamilton, motivated small states—like Delaware, Maryland, New Jersey and Connecticut—to seek institutional protection.

Of course, as argued with respect to the power indices approach above, the fact that voting resources are *de jure* equal across states should not imply that all senators are equally powerful. One way to examine this notion more formally is to use the present model with geographic factors as explanatory variables. We do not have particularly strong priors about the effect of geographic factors on a senator's power, but some vague ideas might be as follows.

Historically, representatives from the South were very powerful actors. Up until the 1960s, Southern states were solidly Democratic, and possibly dissenting voices—from blacks and poor whites—were excluded from voting (Key, 1949). As a result, Southern senators faced few challenges in their home states and could use the committee seniority system—that rewarded long service irrespective of party affiliation—to obtain powerful chairmanships. In the 'post-reform' period, this systematic concentration of power in Southern hands was much reduced Rohde (1991). Moreover, the South is no longer under hegemonic Democratic control as demonstrated by George Bush with victory in every Southern state in his 2004 Presidential reelection. Nonetheless, we might still expect, for historical or other reasons, that senators from the South—Texas, Louisiana, Arkansas, Mississippi, Alabama, Florida, Georgia, North Carolina, South Carolina, Virginia and Tennessee—wield disproportionate power. We use a `South` dummy taking the value of 1 for senators from these states.

The expected effect of a state's wealth on a senator's power is arguably ambiguous. On the one hand, senators from rich states may be able to procure greater 'home-grown' funding for their campaigns and causes, rendering them more influential. On the other hand, senators from poorer places may have more sway in Washington because they can point to underfunded public services and crumbling infrastructures in their home states as evidence that they have a more urgent claim to the nation's resources. Combined with suitably deployed rhetorical skill, we could imagine poverty may boost a state's representative's powers. We measure wealth use the Census Bureau's Median Household Income statistics for each state in dollars (`Median Income`).

We have similarly vague priors *viz* the effect of population density on power. On the one hand, small, primarily urban, densely populated states have senators who literally represent 'more' citizens (we measure this with Census Bureau's population estimate for 2003, `Population`), which may aid rhetorical appeals. On the other, sparsely inhabited, primarily agricultural states may increase the power of senators who represent them, in part because, for historical reasons, farm-based financial aid—an important component of rural states' federal funding—is easier to deliver than other types of support. We use the land area of the states and denote this variable `Land Area`.

The significant, negative coefficients in Table 7 suggest that poorer, smaller, more densely popu-

	Estimate	Std. Error
`Median Income`	$-2.199 \times 10^{-5***}$	2.003×10^{-6}
`South`	-0.256^{***}	3.390×10^{-2}
`Land Area`	$-1.668 \times 10^{-6***}$	2.135×10^{-7}
`Population`	$2.488 \times 10^{-8***}$	1.723×10^{-9}

Table 7: Effect of incomes, southern state representation, land area (state size) and state population on senator's power. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 10954.

lated, non-Southern states will yield senators with more power. Of course, this might not correspond to any particular state. To help interpretation, in Figure 4, we color a map of the contiguous United States according to the predicted λ_i that a senator from that state based on the coefficients of Table 7. Based only on geographical factors, the most powerful state—in terms of its Senators—is California and it is shaded lightest. New York and West Virginia are similarly light colored. 'Weaker' states are dark colored. There are no particular regional patterns discernable from Figure 4, except perhaps a band of states from New York west through Missouri which appear disproportionately light (and thus powerful) relative to their neighbors.

5.4 Career Factors

For most politicians, a position in the Senate is a career ambition (Brace, 1984; Rohde, 1979). But, once attained, senators have strong incentives to seek reelection (Mayhew, 1974). As implied above, this is in part because long service is linked to promotion in terms of committee and other assignments. Here we calculated the years of service since first entering the Senate through 2004 and denoted this variable `Service`. Though not formally associated with greater rights or responsibilities, longevity of service *for a particular state* makes a senator the 'senior' representative of his constituency. We use a `Senior` dummy to check for any extra power effect that such status confers.

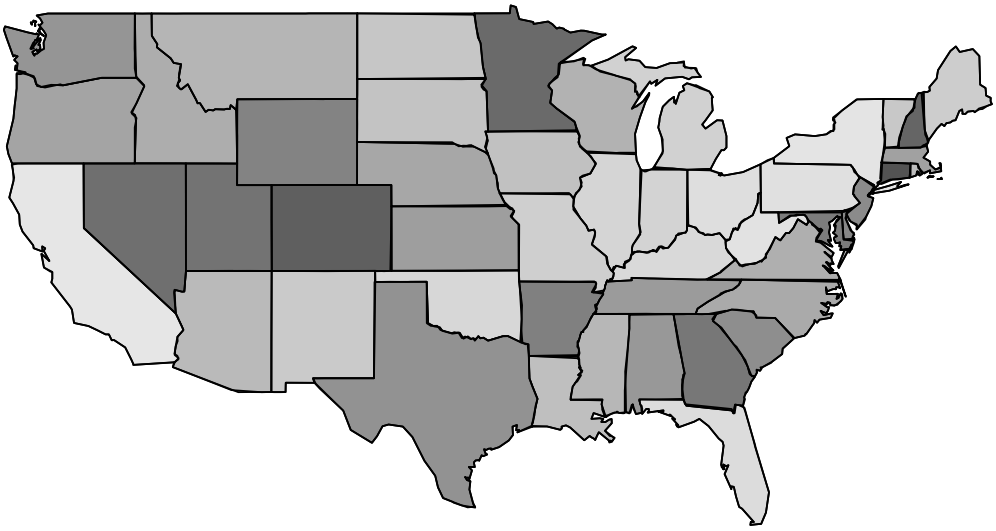

Figure 4: Map of contiguous United States with shading proportional to 'power' given by coefficients in Table 7: lighter states are associated with more powerful senators.

From a career perspective, sociologists have long argued that being male strengthens advantages one in the work place, and this is no less true in politics. Consider, for example, the comment and excitement drawn by Nancy Pelosi's ascension to the Speakership of the House in 2006.[16] For this reason, we add a dummy variable for `Male` here.

The coefficients for `Service` and `Senior` status are much as we might anticipate in Table 8:

	Estimate	Std. Error
`Service`	0.029^{***}	0.001
`Senior`	0.543^{***}	0.029
`Male`	-0.521^{***}	0.035

Table 8: Effect of incomes, southern state representation, land area (state size) and state population on senator's power. Asterisked coefficients imply $p < 0.01$ (***), $p < 0.05$ (**). AIC: 10205.

longer time served in the Senate, as well as seniority makes for a more powerful senator. The coefficient for sex though is perhaps not as expected. Being male is actually associated with a *lower* power than being a female. In Figure 5 we report a boxplot for males and females, in terms of their power. Interestingly, though the median power of the sexes is approximately equivalent, the distributions are very different: while male senators are counted among the most powerful, they are also some of the weaker members of the Senate. Females, by contrast, are heavily concentrated in the upper power ranges.

5.5 Summary of Findings

In summary, a senator is more powerful if the senator is:

- a member of the majority party, and has a leadership position within the party;

[16] Pelosi herself seemed well aware of her exceptionism and, in her acceptance speech noted that "[i]t is an historic moment for the Congress, and an historic moment for the women of this country... For our daughters and granddaughters, today we have broken the marble ceiling. For our daughters and our granddaughters, the sky is the limit, anything is possible for them."

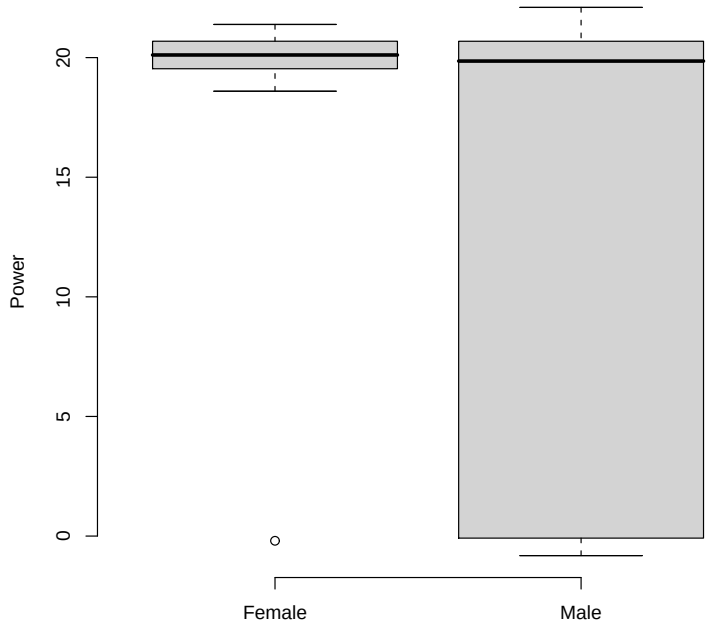

Figure 5: Boxplot showing relative power of male and female senators.

- from the center of the ideological distribution of her party;

- a majority party member of the Finance and Appropriations committees;

- chair of a committee;

- is from a relatively poor, densely populated non-Southern state;

- is female, long serving and is the Senior Senator from her state.

6 Discussion

This paper proposed a new way to measure power in structured settings. Rather than relying on *a priori* metrics that arguably measure something akin to 'luck' or 'pivotality' rather than power, we suggested an approach that assumes the powerful have a greater capability to form coalitions in order to pass bills that they care about. This method is straightforward to implement, and allows the separation of 'power' from its 'causes' in a standard generalized linear model framework. Thus, we can talk of predicted probabilities and make statements of uncertainty regarding the 'effects' of certain variables. We applied the statistical model to the 108th Senate, using (personal) amendments as the bills around which Senators attempt to form coalitions and we found that *inter alia* majority party membership, moderation within a party, chairing of committees, long service records and seniority all make for more powerful senators. These findings in and of themselves are perhaps not shocking, but they do demonstrate the strength and flexibility of the approach, along with establishing some validity of the method.

In terms of future avenues of research, there are obvious 'cross section' and 'time series' extensions to this work. Here, we choose to study the Senate: its 100 members are a manageable number of observations for which to ascertain biographical and other data. There is no reason why, with more time, political scientists could not execute a similar model for the House of Representatives. Temporally, we studied one Congress and thus the results here are something of a 'snapshot.' Studying actors' power over time may allow a more complete picture: certainly we could imagine

that changing rules in Congress, along with the prevailing political climate, might alter the power of say, chairs and party leaders.

Taking the model outside of the United States Congress is a possibility too, though any such extension requires knowledge of actors' preferences in interactions. The United Kingdom House of Commons, for example, may provide another test ground for the model via private members bills. Unfortunately, due to strong party whipping and strategic voting, deciding actors' preference in this circumstance is not always straightforward. There is a similar caveat for the US Supreme Court, though in that case it is simply unclear who 'leads' a coalition. Outside of American and Comparative politics, International Relations with its concentration on specifically dyadic interactions may be amenable to such an approach. We leave this for future work.

A The "Busy" Senator Problem

The concern is that a senator could increase his influence score by simply proposing *more* amendments. That is, by being 'busy' in a legislative sense, he would appear more powerful. Here we show this to be untrue.

First, consider three proposing senators A, B and C. Suppose that A and B decide to somehow combine their efforts such that only *one* of them will propose and form coalitions for all amendments jointly that they formerly worked on separately. Whether A will have B do all the proposing and coalition forming, or whether B will delegate his work to A, write the senator who does the proposing and forming as S_{AB}.

Clearly, S_{AB} is busier—in that he now proposes more amendments—than either A or B. Importantly, though, the probability that any randomly drawn interaction involving S_{AB} and C has C convincing S_{AB}, will be simply the weighted average of the former probability that C convinces A and C convinces B: there is no fillip from proposing more amendments. Hence, 'business' alone cannot yield a higher power rating. To show this, let "$C\text{con}S_{AB}$" be the event that C convinces S_{AB}. The probabilities for the constituent senators are:

$$\overset{A}{\Pr} = \frac{\Pr(A\text{con}C)}{\Pr(C\text{con}A)}$$

and

$$\overset{B}{\Pr} = \frac{\Pr(B\text{con}C)}{\Pr(C\text{con}B)}.$$

The probability for the joint, 'busy' senator is:

$$\begin{aligned}
\overset{S_{AB}}{\Pr} &= \frac{\Pr(S_{AB}\text{con}C)}{\Pr(C\text{con}S_{AB})} \\
&= \frac{\Pr(A\text{con}C) + \Pr(B\text{con}C)}{\Pr(C\text{con}S_{AB})} \\
&= \frac{\Pr(C\text{con}A)\frac{\Pr(A\text{con}C)}{\Pr(C\text{con}A)} + \Pr(C\text{con}B)\frac{\Pr(B\text{con}C)}{\Pr(C\text{con}B)}}{\Pr(C\text{con}S_{AB})} \\
&= \gamma \overset{A}{\Pr} + (1-\gamma)\overset{B}{\Pr}.
\end{aligned}$$

where $\gamma = \frac{\Pr(C\text{con}A)}{\Pr(C\text{con}S_{AB})}$.

Thus, business cannot itself increase a senator's influence.

B Logit Model with Order Effect

We estimate the 'order effect' model as described in equation 5 and present the results in Table 9. Inspection suggests that the rank order is closely similar to that of the model without an order effect. In fact, performing a Spearman rank correlation test between the sorted lists yields a $\rho = 0.144$ with a p-value (on the null hypothesis that $\rho \leq 0$) of 0.08. We estimate δ—the advantage of proposing to someone in one's own party—at 0.52 (and is significant at the 1% level). That is, there is a 'home advantage', but it does not disturb our earlier findings greatly when accounted for.

C Amendment Proposers

Table 10 gives the rank ordering of senators in accordance with the number of amendments they proposed. Clearly, simply *proposing* more amendments does not make you more powerful: for example, Grassley proposes only 3 times yet is ranked in the top 10. For completeness, Figure 6 displays the frequency information from Table 10.

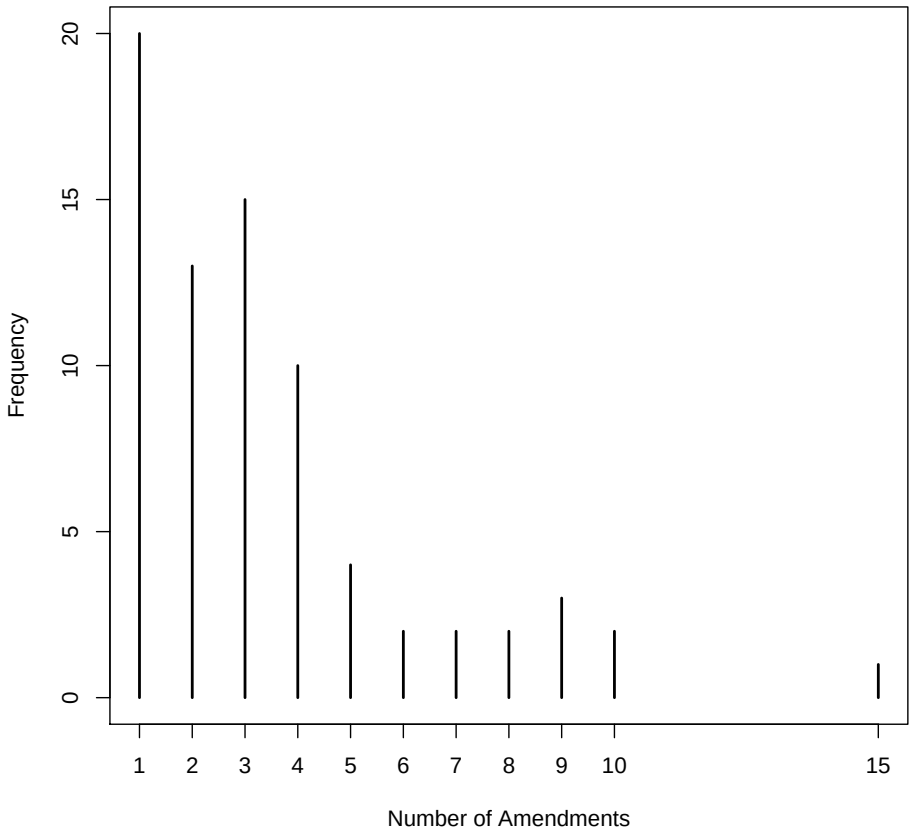

Figure 6: Amendment numbers: distribution.

D Goodness-of-Fit

Recall that the method calculates a (maximum likelihood) value of λ_A and λ_B for all senator pairs who interact. Above, we defined an 'interaction' as an amendment in which either A proposed and B supported or B proposed and A supported. Then, as in 3, the λ_i have the interpretation that

$$\Pr(A \text{ convinces } B | A \text{ and } B \text{ interact}) = \frac{\exp(\lambda_A)}{\exp(\lambda_A) + \exp(\lambda_B)}. \tag{7}$$

The conditioning of the probability in (3) implies that we need not consider the counterfactual of non-proposing senators as proposers. Hence, the matrix of votes to be predicted denoted $\mathbf{Y_{act}}$, is of dimension $I^p \times I$ where $|I^p|$ is the number of proposing senators (74 for this case) and $|I|$ is the number of senators in total (here, 101, since we included President Bush to aid interpretation). $\mathbf{Y_{act}}$ then, is the actual interactions, and is of the following form:

	Akaka	Alexander	Allard	...
Allard	1	1	0	...
Baucus	3	0	0	...
Bayh	1	0	0	...
Biden	4	2	1	...
Bingamen	9	4	2	...
⋮	⋮	⋮	⋮	⋱

where the proposers lie to the left and all the voting senators form the columns. So, for example, Joe Biden proposed and was backed four times by Daniel Akaka, twice by Lamar Alexander and once by Wayne Allard. Notice also that senators voting for their own amendments are not, in and of themselves, counted as backers.

For any particular cell of $\mathbf{Y_{act}}$, there exists an associated total number of *possible* interactions (in either direction) for the senators. For example, Joe Biden and Wayne Allard interacted a total of 3 times: once when Allard was the proposer and Biden backed him, twice when Biden was the

proposer and Allard backed him. This matrix has symmetric form when proposers as compared to voting senators who were also proposers, but not otherwise. We denote this matrix $\mathbf{Y_{poss}}$ and a similar segment to that above appears as:

	Akaka	Alexander	Allard	...
Allard	1	1	0	...
Baucus	3	0	1	...
Bayh	1	0	0	...
Biden	4	2	2	...
Bingamen	9	4	3	...
⋮	⋮	⋮	⋮	⋱

From the estimates of Table 1 via Equation (3), we can obtain predicted probabilities of 'convincing' for any particular pair of senators A and B. For example, consider the following subset of the matrix:

	Akaka	Alexander	Allard	...
Allard	1.00	1.00	0.50	...
Baucus	1.00	1.00	0.48	...
Bayh	1.00	1.00	0.21	...
Biden	1.00	1.00	0.52	...
Bingamen	1.00	1.00	0.74	...
⋮	⋮	⋮	⋮	⋱

where the incidence of 1 implies that the proposer on the left is the one convincing the voter in the column to back the amendment (rather than the other way round) essentially with certainty. We denote this matrix $\mathbf{O_{pred}}$. Since we have direct estimates of the underlying latent abilities, we do not dichotomize this matrix to zeros and ones as may be seen in standard logistic (and probit) regression predicted probability contexts.

The expected votes matrix is the element-by-element multiplication $\mathbf{Y_{poss}} \times \mathbf{O_{pred}}$ yielding an-

other matrix of dimensions $I^p \times I$. Note that every element of $\mathbf{Y_{poss}} \times \mathbf{O_{pred}}$ is non-zero valued. Subtracting this matrix from $\mathbf{Y_{act}}$ yields a matrix of both positive (the model over predicts) and negative entries (the model under predicts). The absolute sum of these columns yields the total number of misclassifications which is (when rounded) 2062 of some 13,869 total interactions. Hence, the percentage of interactions correctly predicted is $1 - \frac{2062}{13{,}869} = 0.85$.

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	Senator	Power (λ_i)
1	McConnell, Mitch	19.63
2	Warner, John	19.59
3	Gregg, Judd	19.36
4	Frist, Bill	19.10
5	McCain, John	19.09
6	Cochran, Thad	18.98
7	Byrd, Robert	18.97
8	Graham, Lindsey	18.97
9	Grassley, Charles	18.96
10	Nickels, Don	18.87
11	Boxer, Barbara	18.84
⋮	⋮	⋮
21	Kennedy, Edward	18.30
⋮	⋮	⋮
25	Daschle, Tom	18.19
⋮	⋮	⋮
30	Kerry, John	18.10
⋮	⋮	⋮
33	Lott, Trent	17.97
⋮	⋮	⋮
46	Clinton, Hillary	17.49
⋮	⋮	⋮
52	Feingold, Russ	17.30
53	Lieberman, Joe	17.25
⋮	⋮	⋮
94	Santorum, Rick	-0.89
⋮	⋮	⋮
98	Akaka, Daniel	-1.20
99	Jeffords, Jim	-1.34
100	Inouye, Daniel	-1.51
101	Johnson, Tim	-1.53

Table 9: Baseline results for model of power for US Senators in the 108th Senate, logit with 'order effect' (party advantage) estimated.

Byrd 15	Bingaman 10	Boxer 10	Dodd 9	Feinstein 9	Lautenberg 9	Kennedy 8
McCain 8	Daschle 7	Warner 7	Dorgan 6	Harkin 6	Durbin 5	Gregg 5
Leahy 5	McConnell 5	Biden 4	Breaux 4	Cantwell 4	Clinton 4	Frist 4
Hutchison 4	Levin 4	Mikulski 4	Reed 4	Specter 4	Baucus 3	Cochran 3
Conrad 3	Corzine 3	Edwards 3	Feingold 3	Graham (FL) 3	Graham (SC) 3	Grassley 3
Kerry 3	Kyl 3	Lincoln 3	Nickles 3	Schumer 3	Thomas 3	Bond 2
Bunning 2	Dayton 2	Hatch 2	Hollings 2	Inhofe 2	Landrieu 2	Lieberman 2
Lott 2	Murray 2	Reid 2	Rockefeller 2	Snowe 2	Allard 1	Bayh 1
Brownback 1	Campbell 1	Carper 1	Collins 1	DeWine 1	Ensign 1	Enzi 1
Hagel 1	Kohl 1	Murkowski 1	Nelson (FL) 1	Roberts 1	Sarbanes 1	Sessions 1
Smith 1	Stabenow 1	Voinovich 1	Wyden 1			

Table 10: Number of amendments per senator.