Slicing and Bundling*

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Abstract

We develop a theory of agenda-setting in a legislature. A proposer supports a platform comprised of several policies. Policies are divisible and can be bundled — the proposer can slice each policy into parts, and she can aggregate the various policy parts into bills. The proposer chooses an agenda, which is a collection of bills. The legislature votes each bill up or down, and all the policy parts in each approved bill are implemented. We address the following questions: In equilibrium, which agenda is chosen? What are the consequences for voters? What are the implications for institutional design?

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We revisit a classic question in legislative studies: the power of an agenda setter to pass policies that are not favored by any majority of legislators.

Consider a legislature with a proposer who controls the agenda and a set of legislators who vote on the proposals. The proposer supports a platform, which is a collection of policies. Our model does not rely on a spatial interpretation of the set of policies: we regard each policy as an infinitely divisible unit mass of policy activity, and not as a point in space. The proposer can slice policies into parts, and she can bundle these parts into bills that she proposes to the legislature. Bills that gain a favorable vote from a majority of legislators pass, and the policy activity contained in any bill that passes is implemented.

The proposer's challenge is to pass policies that no majority of legislators wants. The standard tool to achieve this is to bundle unpopular policies with popular ones into an omnibus bill that can pass. We note that the proposer has a second degree of freedom: to *slice* a policy, proposing only a fraction of the total activity that constitutes the policy.[1] We call each fraction of a policy a "slice." We assume that preferences are separable across policies, and that policy preferences scale down to partial policies: if passing a policy in full gives a legislator a utility $\bar{u}$, then the utility of passing a slice of this policy of size $\lambda \in [0, 1]$ is only $\lambda\bar{u}$. For example, suppose the policy is to advance NASA's space exploration program. This policy can be sliced into parts, such as missions to Mars, Jupiter and the Moon. If a mission to Mars is twice as important as a mission to the Moon, then a Mars mission is a slice twice as big as a Moon mission. Similarly, missions can be sliced into larger or smaller pieces — e.g., sending astronauts instead of rovers.

[1]See Krutz (2001) for a comprehensive study of omnibus bills in the US Congress, and Rundquist and Strom (1987) for an account of how parts of initial proposals are dropped and others kept to craft bills.

Slicing the policy first, and only then bundling the slices into bills makes it easier for the proposer to construct bills that can pass. The following example illustrates our theory.

Example 1 *Consider a legislature with a non-voting proposer, three voters, and simple majority rule. Assume that the proposer wants to pass a platform with three policies: education, gun control, and taxes. Table 1 describes the payoff for each voter per unit of policy passed.*

		Policies		
		Education	Gun Control	Taxes
	1	**+3**	-2	-2
voters	2	-2	**+3**	-2
	3	-2	-2	**+3**

Table 1: Payoffs from implementing each policy.

If the proposer introduces each of her policies in full one by one, all three policies fail by a 1-2 vote. By bundling policies, the proposer can get two of her policies to pass. For instance, if she bundles education and gun control into a single bill, this bill would pass with the votes of voters 1 and 2.[2] But if two policies are bundled, then the third one does not pass alone, and there is nothing left to bundle it with. If all three policies are bundled into a single bill, then all voters reject the bill. Thus, the best the proposer can do by bundling is to pass two policies.

The proposer can do better by slicing policies before bundling them into bills. In our example, the proposer can get her entire platform to pass in three bills. A first bill, with half of the education policy and half of the gun control policy, yields a strictly positive payoff to voters 1 and 2, who vote to pass the bill. A second bill, with half of the education policy and half of the tax policy, passes with the votes of voters 1 and 3. Finally, a third bill, with the remaining half of the gun control and tax policies, passes with the votes of voters 2 and 3.

[2]Bundling has a similar effect as log-rolling or vote trading by voters (see, for instance, Schwartz 1977).

We generalize the intuition behind our example to address the following questions: In equilibrium, which agenda is put to a vote? What is the legislative outcome? How does it affect all legislators? What are the implications for institutional design?

Related Literature: The power of an agenda setter depends on institutional features. If the policy choice is unidimensional, the proposer's power is constrained by the need to satisfy the median legislator (Romer and Rosenthal 1978 and Baron 1996). With multiple dimensions, a strategic agenda setter attains her ideal outcome if other legislators are not sophisticated (McKelvey 1976), but the outcome is in the uncovered set if all legislators are sophisticated (Shepsle and Weingast 1984).

In a divide-the-pie game with sequentially random proposers and policies that are irrevocable once approved, the first proposer obtains a little more than half the pie (Baron and Ferejohn 1989) and ex-ante payoffs depend on the probability of being recognized to make a proposal (Kalandrakis 2006). With revisable policies, a finite horizon and a known sequence of rotating proposers, the last proposer obtains most of the pie (Bernheim, Rangel and Rayo 2006). With a fixed proposer, an infinite horizon and revisable policies, other legislators can limit the proposer's power by voting down any proposal that would later be revised to an unwanted outcome (Diermeier and Fong 2011).

We consider a finite number of proposals by a fixed proposer.[3] We depart substantively from the literature by considering a collection of policies that are divisible into slices. We show that an agenda setter who can slice policies holds great power: she can get much of her

[3] In the US Congress, a "procedural cartel" composed of the most senior members of the majority party controls the agenda (Cox and McCubbins 2005 and Gailmard and Jenkins 2007); this cartel is a fixed proposer for a given legislative session. For a survey of other agenda-setting procedures, see Cox (2006).

desired platform to pass, even if it harms most or all voters. We explore institutional design features that curtain such power.

The Model

Overview: We model a game between a proposer and a group of n voters. The proposer wants to implement a set of policies, but she needs voter approval. The proposer strategically puts a list of bills to a vote. A bill is a collection of policy parts. Each voter chooses whether to approve or reject each bill. Bills that receive at least q approval votes pass, where $q \in \{1, ..., n\}$ is the established voting rule. Any legislation in a bill that passes is implemented.

Players: A proposer 0 and $n \in \mathbb{N}$ voters. Let $N \equiv \{0, 1, ..., n\}$.

Policies: We define a platform $J \equiv \{1, ..., m\}$ as a finite set with m policies, with arbitrary policy $j \in J$. Each policy j is composed of a unit mass of policy activity.[4]

Bills: A bill is a vector $b = (b(1), \dots, b(m)) \in [0, 1]^m$. Each $b(j)$ represents the mass of policy $j \in J$ contained in bill b.

Agendas: An agenda is a finite list of bills. Let B denote an arbitrary agenda, and let $b^t \in B$ denote an arbitrary bill in agenda B. An agenda B is feasible if and only if $\sum_{b^t \in B} b^t(j) \leq 1$ for each policy $j \in J$. Let $\mathcal{B}$ be the set of all feasible agendas.

Preferences: Let $v_i(j)$ denote the per unit utility for player $i \in N$ of policy j. For each player, normalize the utility of not passing anything to zero. We interpret J as the proposer's platform, so we assume that $v_0(j) > 0$ for each policy in the platform.

[4] We consider policies with heterogeneous measures (mass) of activity in the online Appendix.

If an agenda B passes, it yields to player i a payoff

$$u(B, v_i) = \sum_{b^t \in B} \sum_{j \in J} b^t(j) v_i(j). \tag{1}$$

Timing: First, the proposer chooses an agenda $B \in \mathcal{B}$. Let T be the number of bills in this agenda, $B = \{b^1, \ldots, b^T\}$. Bills are considered sequentially: for each $t \in \{1, \ldots, T\}$, all voters simultaneously vote on bill b^t, observe the vote outcome, and then, if $t < T$, they move on to bill b^{t+1}. Let agenda $\hat{B} \subseteq B$ denote the subset of bills that receive q or more votes. Agenda $\hat{B}$ passes and payoffs accrue.

Information: All information is common knowledge.

Rationality: All players are strategic and maximize their expected utility, and they do not use weakly dominated strategies. To simplify the exposition, we assume that if a legislator is indifferent between approving and rejecting a bill, then he votes for approval.

Solution concept: Subgame perfect Nash equilibrium.

Results

The proposer's agenda setting problem is to choose a feasible agenda that maximizes her expected utility, given the expected voting behavior of all other legislators. Fix any agenda $B \in \mathcal{B}$. For $t = T$, each legislator i votes for bill b^t if and only $\sum_{j \in J} b^t(j) v_i(j) \geq 0$, independently of the past history. By backward induction, the same holds for each $t < T$. For any bill b^t, define the indicator function $\mathbb{I}(b^t) = 1$ if at least q voters weakly prefer bill b to pass, and $\mathbb{I}(b^t) = 0$ otherwise. The proposer's problem then reduces to choosing an agenda in

$$\arg\max_{B\in\mathcal{B}} \sum_{b^t\in B} \mathbb{I}(b^t) \sum_{j\in J} b^t(j) v_0(j). \tag{2}$$

Problem (2) may appear difficult to solve. Fortunately, we can appeal to the literature to solve it for us. Alonso and Câmara (2016) (AC) introduce a voting model of Bayesian Persuasion. As in the seminal theory by Kamenica and Gentzkow (2011), the main idea is that an information designer chooses an experiment that generates signals about the state of the world, and these signals shift the posterior beliefs of a receiver. The designer strategically chooses the experiment that is ex-ante most likely to generate posteriors desired by the designer. In AC, the receiver is a committee and the designer needs to generate favorable beliefs among at least q members of the committee.

While, substantively, our legislative agenda-setting model has nothing to do with experimentation or information design, it turns out that, mathematically, it is identical to AC.

Lemma 1 *The agenda choice problem* (2) *is isomorphic to the information designer's experiment choice problem in AC.*

Proof. See the online Appendix. ■

What we mean by "isomorphic" and "mathematically identical" is that the two models are the same, up to a reinterpretation of the variables and parameters: any result that is true in AC's is also true in ours, with the appropriate reinterpretation.[5] Once we prove this equivalence, we can import all of their results, suitably reinterpreted, without further proof. In particular, we obtain the following:

[5] Our model stands in the same relation to AC as Downs' (1957) model of electoral competition stands in relation to Hotelling's (1929) model of seller location in a linear market. Our model is also mathematically related to the cheap-talk models of Schnakenberg (2015 and forthcoming).

Proposition 1 *There exists an optimal policy agenda B^* that solves the agenda choice problem* (2) *and contains, at most,* $\min\left\{m, \frac{n!}{(n-q)!q!}+1\right\}$ *bills.*

Proof. It follows from result **(R2)** in the online Appendix of AC. ■

Proposition 1 establishes that there exists an optimal agenda containing, at most, as many bills as there are policies (m), and, at most, one bill targeted to each of the $\frac{n!}{(n-q)!q!}$ possible minimum winning coalitions of voters plus one bill that will not pass.

Preferences such that the whole platform J can pass as a single bill or such that no bill can pass are trivial cases. The next restriction on voter preferences rules them out. It also assumes that the proposer's marginal utility is the same across all the policies in her platform,[6] and it assumes that voters have strict preferences over policies.

Assumption 1 (A1) *Suppose that voters' preferences are such that at least $n-q+1$ voters strictly prefer the status quo over platform J, but there exists a bill $b \in [0,1]^m$ such that at least q voters strictly prefer bill b over the status quo. Assume $v_0(j) = 1$ for each policy $j \in J$ and assume that $v_i(j) \neq v_i(j')$ for any two policies $\{j, j'\} \subset J$ and any voter $i \in N \backslash \{0\}$.*

Proposition 2 *Assume **(A1)**. If the voting rule is not unanimity ($q < n$), then at least $n-q+1$ voters weakly prefer the status quo over the set of bills that pass. In particular, under a simple majority, the collection of bills that pass makes a majority of voters weakly worse off.*

Proof. It follows from Corollary 1 of AC. ■

Proposition 2 holds because the proposer wants to implement as much of her platform as

[6] This is merely a normalization on the measure (mass) of each policy. It is without loss of generality in the scope of admissible preferences. If the proposer values policy j twice as much as policy j', we can represent this by $v_0(j) = v_0(j')$ and then assign measure 2 to the activity on policy j. See the online Appendix.

possible. If at least q voters are strictly better off, then the proposer can include more of her policies on the bills that pass. Therefore, at least $n-q+1$ voters must be weakly worse off.

To highlight the importance of controlling the agenda and the conflicts of interest between proposer and voters, we next consider an assembly in which all voters agree on their ordinal preferences over policies, and they all oppose certain policies favored by the proposer. Let policy 0 denote the status quo, which yields utility normalized to zero to all agents.

Definition 1 *Voters have homogeneous ordinal policy preferences if, for any pair of policies $j, j' \in \{0, ..., m\}$ and any pair of voters $i, i' \in N \backslash \{0\}$, voter i prefers policy j to policy j' if and only if voter i' prefers policy j to j' $(v_i(j) \geq v_i(j') \Longleftrightarrow v_{i'}(j) \geq v_{i'}(j'))$.*

We next present an example in which voters have homogeneous ordinal policy preferences, and yet policies that voters don't like pass, making voters strictly worse off. This is so because voters disagree on bills in spite of their homogeneous ordinal policy preferences. The proposer exploits this disagreement by properly slicing and bundling policies into different bills.

Example 2 *There are two voters, and the voting rule is $q = 1$. There are three policies: one policy (education) that both voters favor, and two policies (gun control and taxes) that voters oppose to differing degrees. Policy preferences are represented by the following utilities:*

Policy	v_0	v_1	v_2
Education	+1	+2	+2
Gun control	+1	-1	-3
Taxes	+1	-6	-5

The optimal agenda is $B^* = \left\{ \left(\frac{1}{2}, 1, 0\right), \left(\frac{1}{2}, 0, \frac{1}{5}\right), \left(0, 0, \frac{4}{5}\right) \right\}$.[7] The first bill passes with the vote of voter 1; the second bill passes with the vote of voter 2; and the third bill fails. The

[7]We provide a general algorithm to find the optimal agenda in the online Appendix.

proposer slices the education and tax policies. She bundles a slice of the education policy with a slice of the gun control policy into bill b^1 *to target voter 1, and she bundles a slice of education policy with a slice of tax policy into bill* b^2 *to target voter 2.*

In Example 2, voters would like to collude to reject the proposals. However, in the subgame equilibrium, voters would be tempted to deviate from this deal. To create an enforceable commitment device, voters prefer to change the voting rule to unanimity, or to limit the proposer to include a single bill in the agenda. Both of these observations generalize. First:

Proposition 3 *Assume (**A1**) and homogeneous ordinal policy preferences. All voters weakly prefer unanimity over any other q-voting rule.*

Proof. It follows from Proposition 5 of AC. ■

In addition to importing AC's results, new results arise that have no substantive interpretation in AC's theory. Suppose that we introduce a constraint, in the form of a cap $\kappa \in \mathbb{N}$ on the number of bills. Say that a feasible agenda is admissible if it contains, at most, κ bills, and suppose that the proposer can propose only admissible agendas.

Proposition 4 *Assume (**A1**) and homogeneous ordinal policy preferences. Then, all voters are weakly better off if the number of bills in an admissible agenda is capped at* $\kappa = 1$.

Proof. See the online Appendix. ■

Voters are worse off with higher caps because they allow the proposer to design bills targeting different coalitions. Therefore, our result provides theoretical support for the use of omnibus bills. This result has no analogue in AC because it would mean a limit on the number of signal realizations of an experiment. Such a restriction makes no sense in their setting. In the context of a legislative body, a Constitution or a rules committee can impose any restrictions it wishes on the nature of admissible agendas. Proposition 4 highlights that, although our model and AC's are isomorphic, the two theories address different questions and provide distinct insights.

Conclusion

We present a theory of legislative policy making based on a new model of agenda formation. We show that, by slicing policies and bundling the slices into bills, an agenda setter can pass more legislation than had been previously understood. Other legislators prefer to curtail the agenda setter by choosing a more stringent voting rule, or by capping the maximum number of bills under consideration.

We consider a simple model, with assumptions that allow us to use existing mathematical tools to quickly characterize the equilibrium. Our main insights hold if we relax some of these assumptions, at the cost of a more burdensome equilibrium characterization — e.g., if we impose limits on the proposer's ability to slice policies. Our benchmark model can be extended to study other important questions, such as: what is the equilibrium if there are payoff externalities across policies? How do different legislative rules, such as an endogenously elected proposer, affect policy slicing and bundling? Finally, while there exists an extensive empirical literature studying bundling of policies, we know less about the slicing of policies. We hope that our theoretical insights can guide future empirical work on the topic.

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A Online Appendix

This online Appendix presents the proofs of Lemma 1 and Proposition 4, from the paper "Slicing and Bundling," SB henceforth. This Appendix is organized as follows. In Section A.1, we rewrite the agenda choice model of SB. In Section A.2, we rewrite the experiment choice model of Alonso and Câmara (2016), AC henceforth. In Section A.3, we prove Lemma 1 from SB — that is, the models of SB and AC are isomorphic. In Section A.4, we present a simple algorithm to describe the procedure to use the results from AC to solve for an optimal agenda in SB. In Section A.5, we normalize the measures (mass) for each policy as indicated in footnote 6 in SB. In Section A.6, we prove Proposition 4 from SB — that is, voters benefit from a cap on the number of proposals.

A.1 Model 1 - Slicing and Bundling

In this section, we rewrite the problem of the proposer in SB.

We first rewrite each players' payoff as follows. Recall that the approval of bill b yields to player i a payoff

$$\sum_{j\in J} b(j)v_i(j), \tag{A-1}$$

where $v_i(j)$ is the utility over policy j for player i. For each policy $j \in J$, define

$$p(j) \equiv \frac{v_0(j)}{\sum_{j\in J} v_0(j)}. \tag{A-2}$$

It is useful to decompose the utility term $v_i(j)$ into two terms. For each player $i \in N$ and each policy $j \in J$, define

$$\delta_i(j) \equiv \frac{v_i(j)}{p(j)}. \tag{A-3}$$

We then write the utility term $v_i(j)$ as $p(j)\delta_i(j)$. We interpret the term $p(j) \in (0, 1)$ as the relative importance, salience or payoff-weight that the proposer attaches to passing policy j. And for each voter we interpret $\delta_i(j)$ as a preference parameter derived from $v_i(j)$ through a normalization given by $p(j)$. We thus rewrite (A-1) as

$$\sum_{j\in J} b(j)p(j)\delta_i(j). \tag{A-4}$$

We next use backward induction to solve for the equilibrium. Consider any feasible agenda $B \in \mathcal{B}$, with T bills. By backward induction, when $t = T$, each legislator i votes for bill b^t if and only $\sum_{j\in J} b^t(j)p(j)\delta_i(j) \geq 0$, independently of the past history.[1] Consequently, the same holds for each $t < T$.

Therefore, we can represent voters' equilibrium strategies as a function g as follows. Let $g(b, \delta_i) = 1$ if voter δ_i approves the bill, and $g(b, \delta_i) = 0$ if he rejects the bill:

$$g(b, \delta_i) = \begin{cases} 1 & \text{if} \quad \sum_{j \in J} b(j)p(j)\delta_i(j) \geq 0 \\ 0 & \text{if} \quad \sum_{j \in J} b(j)p(j)\delta_i(j) < 0 \end{cases}. \tag{A-5}$$

For any bill $b \in [0,1]^m$, define the indicator function $\mathbb{I}(b) = 1$ if at least q voters vote to approve the bill, and $\mathbb{I}(b) = 0$ otherwise:

$$\mathbb{I}(b) = \begin{cases} 1 & \text{if} \quad \sum_{i=1}^{n} g(b, \delta_i) \geq q \\ 0 & \text{if} \quad \sum_{i=1}^{n} g(b, \delta_i) \geq q \end{cases}. \tag{A-6}$$

Now consider the choice of the proposer. Recall that a bill is a vector $b = (b(1), \ldots, b(m)) \in [0,1]^m$; a feasible agenda B is a finite set of bills such that $\sum_{b^t \in B} b^t(j) \leq 1$; and $\mathcal{B}$ is the set of all feasible agendas. Note that, for any agenda B with T bills, the proposer is weakly better off by proposing an alternative agenda B' with $T+1$ bills, where the first T bills are the same as in B, and bill

$$b^{T+1} \equiv (1, ..., 1) - \left(\sum_{t=1}^{T} b^t(1), ..., \sum_{t=1}^{T} b^t(m) \right)$$

includes anything left in platform J that was not proposed by B. Therefore, without loss of generality, we can focus on feasible agendas such that the entire platform is proposed. Moreover, if a bill b^t is a vector of zeros, than this bill is equivalent to no proposal. Therefore, without loss of generality, we can focus on feasible agendas in which each bill is not a vector of zeros. Hence, define $\widetilde{\mathcal{B}}$ as the set of all feasible agendas such that $\sum_{b^t \in B} b^t(j) = 1$ for all $j \in J$, and $\sum_{j \in J} b^t(j) > 0$ for all $b^t \in B$.

The proposer's problem (2) from SB is then equivalent to

$$\arg\max_{B \in \widetilde{\mathcal{B}}} \sum_{b^t \in B} \mathbb{I}(b^t) \sum_{j \in J} b^t(j)p(j)\delta_0(j). \tag{A-7}$$

A.2 Model 2 - Persuading Voters

In this section, we briefly describe the model of AC. We change some of the notation used by AC to match our notation.

[1] Recall that we are focusing on equilibria in which players do not use weakly dominated strategies and in which, for each legislator and each bill such that the expected utility for the legislator of passing the bill is equal to the expected utility of not passing the bill, the legislator votes to approve the bill.

Overview: AC consider a game between one information designer 0 and a group of n voters indexed by $i \in \{1, \ldots, n\}$. The information designer supports one proposal (a new policy) and wants to persuade voters to approve this proposal. There is uncertainty over the payoff from this proposal. The information designer can influence voters' decision by designing a policy experiment — a public signal that reveals information about the payoff from the proposal. After voters observe the result of the policy experiment and update their beliefs according to Bayes' rule, each voter chooses whether to approve or reject the proposal. Voters cast their ballots simultaneously. The proposal is implemented if it receives at least q approval votes, where q is the stablished voting rule.

Payoffs: We can normalize to zero the status quo payoff of all players — i.e., the payoff if the proposal is not approved. The payoff from approving the proposal depends on the unknown state of the world $\theta \in \Theta = \{\theta_1, \ldots, \theta_m\}$, which takes a finite number $m \in \mathbb{N}$ of values. Players have a common prior belief $p = (p(1), \ldots, p(m))$ in the interior of the simplex $\Delta(\Theta)$. For each voter i, let $\delta_i(j) \in \mathbb{R}$ be the payoff from approving the proposal if state θ_j is realized. Hence, we can represent voter i by his payoff vector $\delta_i = (\delta_i(1), \ldots, \delta_i(m))$. Similarly define the information designer's approval payoff vector δ_0, with $\delta_0(j) > 0$ for all $j \in J \equiv \{1, \ldots, m\}$ (the designer always supports the proposal).

Policy Experiment: Before voters cast their ballots, the information designer can influence their decision by designing a policy experiment. The designer can choose any experiment that is correlated with the state, as in Kamenica and Gentzkow (2011). An experiment π consists of a finite set S of signal realizations, with generic element $s \in S$, and a collection of probability distributions $\pi(s|\theta)$.

Timing: At the beginning of the game, the information designer chooses a policy experiment π. All voters observe the realization s of experiment π, and update their beliefs according to Bayes' rule. Each voter then chooses whether or not to approve the proposal. Voters cast their ballots simultaneously. The proposal is approved and implemented if and only if it receives q or more approval votes. Payoffs are realized and the game ends.

A.2.1 Equilibrium

We next use backward induction to solve for the equilibrium — see AC for details.

Voters: Let $\mu_{s,\pi} \in \Delta(\Theta)$ be the posterior belief of players after observing realization s of experiment π. Voter δ_i approves the proposal if and only if it yields a non-negative expected payoff, $\sum_{j \in J} \mu_{s,\pi}(j)\delta_i(j) \geq 0$. We can then represent his equilibrium strategy as a function $\tilde{g}$ as follows. Let $\tilde{g}(\mu_{s,\pi}, \delta_i) = 1$ (voter approves the proposal) if $\sum_{j\in J}\mu_{s,\pi}(j)\delta_i(j)\geq 0$, and $\tilde{g}(\mu_{s,\pi},\delta_i)=0$ (voter rejects the proposal) if $\sum_{j\in J}\mu_{s,\pi}(j)\delta_i(j)<0$. Given the electorate $\{\delta_1,\ldots,\delta_n\}$, we define the following indicator function, which indicates the posterior beliefs such that the proposal is approved by at least q voters: let $\tilde{\mathbb{I}}(\mu_{s,\pi})=1$ if $\sum_{i=1}^n \tilde{g}(\mu_{s,\pi},\delta_i)\geq q$, and $\tilde{\mathbb{I}}(\mu_{s,\pi})=0$ otherwise.

Information designer: The information designer's problem is to choose the experiment that maximizes her expected payoff, given the equilibrium strategy of voters. Let $\Pr[s|\pi]$ be the probability of observing realization s of experiment π. Without loss of generality, we focus on all experiments π with finite realization space S such that $\Pr[s|\pi]>0$ for all $s\in S$.[2] Let Π be the set of all such experiments. The designer's problem is then

$$\arg\max_{\pi\in\Pi}\sum_{s\in S}\Pr[s|\pi]\tilde{\mathbb{I}}(\mu_{s,\pi})\sum_{j\in J}\mu_{s,\pi}(j)\delta_0(j). \tag{A-8}$$

A.3 Equivalence

The agenda setting problem (A-7) in SB and the experiment design problem (A-8) in AC are mathematically identical, up to a reinterpretation of the variables and the terms in each model. The mapping from one model to the other is as follows.

- A policy j in SB maps to a state θ_j in AC. Thus, the platform J in SB maps to the set of all possible states in AC.
- The payoff-weight $v_0(j)/\sum_{j'\in J}v_0(j')$ that the proposer in SB attaches to policy j maps to the prior belief $p(j)$ in AC.
- A bill b^t in SB maps to a vector of probabilities in AC associated to a signal s^t. Specifically, for each state θ_j in AC, $b^t(j)$ in SB maps to $z^t(j)$ in AC, where $z^t(j)\equiv\pi(s^t|\theta_j)$ denotes the conditional probability that state θ_j induces signal realization s^t. Just as a bill in SB is a vector with bits of mass of each policy, a signal realization can be seen as a vector with bits of probabilities of each state in AC.
- A feasible agenda B in which the whole platform is proposed in SB maps to an experiment π in AC.
- In SB, the utility that a player i derives from a bill b^t is additively separable across each component $b^t(j)$, and within each component, it is linear in $b^t(j)$ with slope given by the marginal utility of policy j. Analogously in AC, the expected utility of taking action given a signal s^t is additively separable across

[2] If experiment π has a signal realization $s'\in S$ that occurs with probability zero, then π is payoff equivalent to an experiment π' that simply excludes realization s' from π.

each state, and within each state, it is linear in the probability $p(\theta_j)z^t(j)$ that the state and signal occur, with slope given by the marginal utility of taking action given state θ_j.

- A bill b^t passes in SB if and only if the AC assembly votes to take the action given the signal s^t that b^t maps to. Therefore, setting an agenda B in SB is the same problem as designing an experiment in AC.

We now prove Lemma 1 of SB.

Proof of Lemma 1: Since (A-7) is equivalent to the proposer's problem in SB and (A-8) is equivalent to the information designer's problem in AC, it suffices to show that (A-7) is isomorphic to (A-8).

Rewrite the designer's problem (A-8) as follows. First, rewrite any given experiment π as a set of vectors representing the conditional probabilities of the signal realizations. Take any $\pi \in \Pi$. Recall that experiment π has a finite number of signal realizations and $\Pr[s|\pi] > 0$ for all $s \in S$. For each $s^t \in S$, construct a corresponding vector $z^t = (z^t(1), \ldots, z^t(m))$, where $z^t(j)$ is the probability that the signal realization s^t occurs, conditional on state θ_j being realized. Let Z be the set of all vectors z^t constructed from the signal realizations in S. By the definition of Π, it follows that Z is a finite set of vectors, with $z^t \in [0,1]^m$ for all $z^t \in Z$, $\sum_{z^t \in Z} z^t(j) = 1$ for all $j \in J$, and each $z^t \in Z$ is not a vector of zeros. Let $\mathcal{Z}$ be the set of all such Z. Note that each experiment $\pi \in \Pi$ can be represented by some $Z \in \mathcal{Z}$, and each $Z \in \mathcal{Z}$ can be represented by some experiment $\pi \in \Pi$. Moreover, the set $\mathcal{Z}$ and the set of feasible agendas $\widetilde{\mathcal{B}}$ in Model 1 are isomorphic.

Given any $Z \in \mathcal{Z}$, signal realization s^t occurs with probability $\lambda^t \equiv \sum_{j \in J} z^t(j)p(j)$. Note that $\lambda^t > 0$, since z^t is not a vector of zeros. Bayes' rule implies that, after observing realization s^t, players' posterior belief becomes $\mu^t = (\mu^t(1), \ldots, \mu^t(m))$, with $\mu^t(j) = \frac{z^t(j)p(j)}{\lambda^t}$. Consequently, after observing realization s^t, voter δ_i approves the proposal if and only if $\sum_{j \in J} \mu^t(j)\delta_i(j) \geq 0$. Note that $\sum_{j \in J} \mu^t(j)\delta_i(j) = \frac{1}{\lambda^t} \sum_{j \in J} z^t(j)p(j)\delta_i(j)$. Since $\lambda^t > 0$, the voter approves the proposal if and only if $\sum_{j \in J} z^t(j)p(j)\delta_i(j) \geq 0$.

Therefore, we can represent voters' equilibrium strategy as a function $\hat{g}$ as follows. Let $\hat{g}(z, \delta_i) = 1$ if voter δ_i approves the proposal, and $\hat{g}(z, \delta_i) = 0$ if he rejects the proposal:

$$\hat{g}(z, \delta_i) = \begin{cases} 1 & \text{if} \quad \sum_{j \in J} z(j)p(j)\delta_i(j) \geq 0 \\ 0 & \text{if} \quad \sum_{j \in J} z(j)p(j)\delta_i(j) < 0 \end{cases}. \tag{A-9}$$

Note that $\hat{g}$ in (A-9) is isomorphic to g in (A-5): we simply replace the bill b by the vector of conditional probabilities z.

For any vector $z \in [0,1]^m$, define the indicator function $\hat{\mathbb{I}}(z) = 1$ if at least q voters vote to approve the bill, and $\hat{\mathbb{I}}(z) = 0$ otherwise:

$$\mathbb{I}(z) \quad = \quad \begin{cases} 1 & \text{if} \quad \sum_{i=1}^{n} \hat{g}(z, \delta_i) \geq q \\ 0 & \text{if} \quad \sum_{i=1}^{n} \hat{g}(z, \delta_i) \geq q \end{cases} . \tag{A-10}$$

Since $\hat{g}$ and g are equivalent, it follows that $\hat{\mathbb{I}}(z)$ in (A-10) is isomorphic to $\mathbb{I}(b)$ in (A-6): we simply replace the bill b by the vector of conditional probabilities z.

Given any $Z \in \mathcal{Z}$, the proposer's expected utility is $\sum_{z^t \in Z} \lambda^t \hat{\mathbb{I}}(z^t) \sum_{j \in J} \mu^t(j)\delta_0(j)$. Since $\lambda^t \mu^t(j) = \lambda^t \frac{z^t(j)p(j)}{\lambda^t} = z^t(j)p(j)$, the term $\lambda^t \sum_{j \in J} \mu^t(j)\delta_0(j)$ simplifies to $\sum_{j \in J} z^t(j)p(j)\delta_0(j)$. Therefore, we can rewrite the information designer's problem as

$$\arg\max_{Z \in \mathcal{Z}} \sum_{z^t \in Z} \hat{\mathbb{I}}(z^t) \sum_{j \in J} z^t(j)p(j)\delta_0(j). \tag{A-11}$$

Since the indication function $\hat{\mathbb{I}}$ is isomorphic to $\mathbb{I}$, we have that problems (A-11) and (A-7) are isomorphic. We simply replace $\{b, B, \widetilde{\mathcal{B}}\}$ with $\{z, Z, \mathcal{Z}\}$. Problems (A-8) and (A-7) are then equivalent, concluding the proof. ■

Note that, in both models, the equilibrium behavior of voters is defined by the multiplicative term $p(j)\delta_i(j)$ — see (A-5) and (A-9). The same holds for the proposer's (information designer's) problem — see (A-7) and (A-11). Since the proposers' payoff from each policy in her platform is positive, we can normalize the proposer's payoff to any strictly positive vector by appropriately rewriting the prior belief p and voters' preferences — e.g., see (A-2) and (A-3).

A.4 Algorithm

In this section, we present a simple algorithm to describe the procedure to use the results from AC to solve for an optimal agenda in SB.

Step 1) Fix the fundamental parameters of SB: the set J of policies in the platform, the set of preferences $\{v_0, v_1, \ldots, v_n\}$, and the value q of the voting rule.

Step 2) Construct an AC model as follows. Define the state space as $\Theta = \{\theta_1, \ldots, \theta_m\}$, where state θ_j is simply the label of policy $j \in J$. Define the prior belief over states $p = (p(1), \ldots, p(m))$ according to (A-2). For each player $i \in N$, define the preference vector $\delta_i = (\delta_i(1), \ldots, \delta_i(m))$ according to (A-3). Keep the same

q voting rule.

Step 3) Given Θ, p, $\{\delta_0, \delta_1, \ldots, \delta_n\}$ and q, use the results from AC to solve (A-8) an find an optimal experiment π^*.

Step 4) Given π^*, for each signal realization $s^t \in S$, construct a vector $z^t = (z^t(1), \ldots, z^t(m))$ of conditional probabilities, where $z^t(j)$ is the probability that state θ_j induces signal realization s^t, conditional on θ_j being realized. Let Z be the collection of vectors z^t constructed from S.

Step 5) Policy agenda $B = Z$ is then a solution to the proposer's problem (A-7). That is, each vector $z^t \in Z$ becomes one bill $b^t \in B$.

We now present a simple example to illustrate our result.

Example: Consider a proposer who has a platform with three policies: education, gun control, and taxes. There are two voters and the voting rule is $q = 1$. Preferences are described below.

Policy	v_0	v_1	v_2
Education	+1	+2	+2
Gun control	+1	-1	-3
Taxes	+1	-6	-5

To solve for the optimal agenda, we write a persuasion model as follows. There are three states, $\Theta = \{\theta_1, \theta_2, \theta_3\}$, where state θ_1 represents education, θ_2 represents gun control, and θ_3 represents taxes. Using (A-2), the prior belief over states becomes $p = (1/3, 1/3, 1/3)$. Using (A-3), players' preferences become $\delta_0 = (3, 3, 3)$, $\delta_1 = (+6, -3, -18)$, and $\delta_2 = (+6, -9, -15)$. Same q voting rule as before. Figure 1 depicts the simplex of posterior beliefs representing this persuasion game.

AC solve a very similar game; see their Example 2 for details on how to solve the persuasion game. There is an optimal experiment π^* with three signal realizations, $S = \{s^1, s^2, s^3\}$. Figure 1 depicts the posterior beliefs induced by π^*. Realization s^1 leads to posterior belief μ^1 and voter 1 approves the proposal. Realization s^2 leads to posterior belief μ^2 and voter 2 approves the proposal. Realization s^3 leads to posterior belief μ^3 and both voters reject the proposal. Experiment π^* has the following matrix of conditional probabilities:

$$Z = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & 0 \\ 1 & 0 & 0 \\ 0 & \frac{1}{5} & \frac{4}{5} \end{bmatrix}.$$

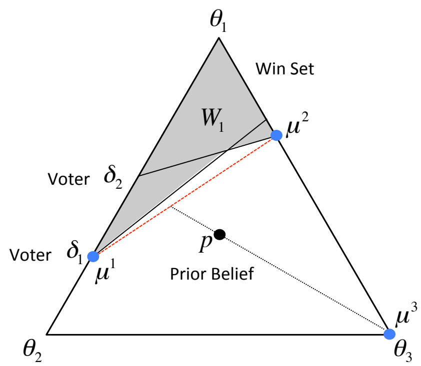

Figure 1: Representing the Optimal Agenda as a Persuasion Game

Each row of Z represents a state θ_j, and each column represents a signal realization s^t. Hence, state θ_1 induces realization s^1 with probability $\frac{1}{2}$, and so forth. Therefore, agenda $B = Z$ maximizes the proposer's payoff in (A-7). The proposer optimally includes three bills in the agenda. The first bill $b^1 = (\frac{1}{2}, 1, 0)$ is approved by voter 1, while the second bill $b^2 = (\frac{1}{2}, 0, \frac{1}{5})$ is approved by voter 2. No voter approves bill $b^3 = (0, 0, \frac{4}{5})$.

A.5 Policies with Heterogeneous Measures

In our benchmark model, we normalized the measure (mass) of each policy to one, so that $v_i(j)$ could be identically interpreted as the marginal utility of policy j, and the total utility of implementing policy j in full, for agent $i \in N$. We now normalize the measure of each policy differently. In Assumption **(A1)**, we assumed that the proposer's marginal utility over each policy is the same across all policies. In footnote 6 in SB, we claim that this assumption is without loss of generality in the domain of preferences. We use the new normalization of the measure of each policy to prove this claim.

Let $a(j) \in \mathbb{R}_{++}$ be the total measure (mass) of policy $j \in J$. Let $a = (a(1), ..., a(m))$ be the vector of measures for each policy. In the paper's benchmark model, we assume $a(j) = 1$ for each $j \in J$. Therefore, for each policy $j \in J$ and each player $i \in N$, the term $v_i(j)$ is both the marginal utility of policy j for player i, and the total utility of implementing policy j in full for player i. With heterogeneous measures for each policy, we need to differentiate total and marginal utility from a policy. Let $v_i(j)$ keep its meaning as the marginal utility of policy j for i. And let $\bar{v}_i(j)$ denote the total utility of implementing policy j in full for i. We treat $\bar{v}_i(j)$ as a primitive that represents the preferences of player i, and we derive $v_i(j)$ endogenously.

We want to show that, for any proposer preferences represented by $\bar{v}_0$, we can find a vector of measures of policies $(a(1), ..., a(m))$ such that $v_0(j) = 1$ for each $j \in J$ (footnote 6 in SB). This is directly shown by construction: since, by definition, $\bar{v}_i(j) = a(j)v_i(j)$ for each player $i \in N$ and each policy $j \in J$, choosing

$a(j) = \bar{v}_0(j)$ we obtain $v_0(j) = 1$ for each policy $j \in J$, as assumed in **(A1)**. Further, we also obtain $v_i(j) = \frac{\bar{v}_i(j)}{\bar{v}_0(j)}$ for each voter $i \in N\backslash\{0\}$.

A bill is a vector $b \in [0,1]^m$ such that $b(t)$ represents the fraction of the total mass of policy j that is included in the bill. With the vector of measures a, if bill b is approved and implemented, then player i receives a payoff

$$\sum_{j\in J} b(j)a(j)v_i(j) = \sum_{j\in J} b(j)\bar{v}_i(j). \tag{A-12}$$

If an agenda B passes, it yields to player i a payoff

$$u(B, \bar{v}_i) = \sum_{b^t\in B}\sum_{j\in J} b^t(j)\bar{v}_i(j) = \sum_{b^t\in B}\sum_{j\in J} b(j)a(j)v_i(j). \tag{A-13}$$

This is similar to expression (1) in the paper, except that in the paper $\bar{v}_i(j) = v_i(j)$ because $a(j) = 1$. Moreover, optimization problem (2) in the paper,

$$\arg\max_{B\in\mathcal{B}} \sum_{b^t\in B} \mathbb{I}(b^t) \sum_{j\in J} b^t(j)v_0(j), \tag{A-14}$$

now becomes

$$\arg\max_{B\in\mathcal{B}} \sum_{b^t\in B} \mathbb{I}(b^t) \sum_{j\in J} b^t(j)\bar{v}_0(j) = \arg\max_{B\in\mathcal{B}} \sum_{b^t\in B} \mathbb{I}(b^t) \sum_{j\in J} b^t(j)a(j). \tag{A-15}$$

Note that, despite the difference in notation, we can solve problems (A-14) and (A-15) in the same manner.

Consider now Section A.1 in this online Appendix, with heterogeneous measures of policies. Instead of defining p as in (A-2), for each policy j we now rewrite

$$p(j) \equiv \frac{\bar{v}_0(j)}{\sum_{j\in J}\bar{v}_0(j)} = \frac{a(j)}{\sum_{j\in J} a(j)}. \tag{A-16}$$

Therefore, for each player $i \in N$ and each policy $j \in J$, define

$$\delta_i(j) \equiv \frac{\bar{v}_i(j)}{p(j)}. \tag{A-17}$$

We can then rewrite the payoff (A-12) as (A-4). All our results then follow from (A-4).

A.6 Preferences over Agenda Limits

In this section, we solve for the proposer's optimal agenda when she is constrained: the proposer cannot propose more than κ bills. In this case, agenda B is feasible if and only if it contains at most κ bills, and, aggregating over all bills, it contains no more than a unit mass of each policy. Let $\mathcal{B}(\kappa)$ be the set of all feasible agendas with at most κ bills.

Define $p = (p(1), \dots, p(m))$ according to (A-2). For each voter, define the preference vector $\delta_i = (\delta_i(1), \dots, \delta_i(m))$ according to (A-3). For the proposer, δ_0 is a constant vector, and we can rescale utilities so that the constant is one. Define g and $\mathbb{I}$ according to (A-5) and (A-6). Given κ, the proposer's problem (A-7) becomes

$$\max_{B \in \mathcal{B}(\kappa)} \sum_{b^t \in B} \mathbb{I}(b^t) \sum_{j \in J} b^t(j) p(j) \delta_0(j).$$

To simplify the exposition, in the rest of this section we assume that the proposer's payoff is constant across all policies, $v_0(j) = v_0(j')$ for all $j, j' \in J$. If the proposer's payoff is not constant across policies, then we use (A-3) to define voters' adjusted payoffs δ_i. All the following results continue to hold by rewriting Assumptions **(A2)** and **(A3)** in terms of these adjusted payoffs δ_i.

We consider two alternative assumptions regarding voters' preferences:

Assumption 2 (A2) *Voters rank policies $j \in J = \{1, \dots, m\}$ in the same order: for each pair of policies $j, j' \in J$, we have $v_i(j) > v_i(j')$ for some voter i if and only if $v_{i'}(j) > v_{i'}(j')$ for every other voter i'. Without loss of generality, suppose $v_i(j)$ strictly increases in $j \in J$ for all voters.*

Assumption 3 (A3) *Homogeneous ordinal preferences: for each pair of policies $j, j' \in \{0, 1, \dots, m\}$, we have $v_i(j) > v_i(j')$ for some voter i if and only if $v_{i'}(j) > v_{i'}(j')$ for every other voter i'. Without loss of generality, suppose $v_i(j)$ strictly increases in $j \in J$ for all voters.*

Note that (**A2**) is a weaker assumption than (**A3**), and recall that assumption (**A1**) was defined in the main text of SB. We next present a series of results.

Claim 1 *Suppose **(A1)** and **(A2)** hold. Consider any constraint $\kappa \in \mathbb{N}$ on the number of bills. Then, in equilibrium, there exists a cutoff policy j such that all policies ranked above j are fully approved, and no mass from policies ranked below passes. That is, if $\sum_{t=1}^{\kappa} \mathbb{I}(b^t) b^t(j) > 0$ for some policy $j \in J$, then $\sum_{t=1}^{\kappa} \mathbb{I}(b^t) b^t(j') = 1$ for all $j' > j$.*

Proof To see this, by contradiction, suppose that agenda B is optimal, $\sum_{t=1}^{\kappa} \mathbb{I}(b^t) b^t(j) > 0$ and $\sum_{t=1}^{\kappa} \mathbb{I}(b^t) b^t(j') < 1$ for some $j' > j$. We will construct a feasible alternative agenda $\hat{B}$ such that the proposer strictly prefers $\hat{B}$

over B, yielding a contradiction.

Since $\sum_{t=1}^{\kappa} \mathbb{I}(b^t)b^t(j) > 0$, there exists at least one bill $\hat{t}$ such that $\mathbb{I}(b^{\hat{t}})b^{\hat{t}}(j) > 0$. Moreover, since $\sum_{t=1}^{\kappa} \mathbb{I}(b^t)b^t(j') < 1$, there exists a strictly positive measure of mass from policy j' that was not proposed (or proposed by a bill that is not approved by voters).

Construct alternative agenda $\hat{B}$ as follows. First, let $\hat{B}$ be equal to B. Now change bill $b^{\hat{t}}$ to a new bill b^* as follows: Decrease $b^{\hat{t}}(j)$ by ϵ and increase $b^{\hat{t}}(j')$ by $\epsilon(1+\alpha)$, where $\epsilon, \alpha > 0$. For each player $i \in N$, the difference in payoffs from the two bills is

$$
\begin{aligned}
& \sum_{j \in J} b^*(j)v_i(j) - \sum_{j \in J} b^{\hat{t}}(j)v_i(j) && \text{(A-18)} \\
= \quad & \left[\sum_{j \in J} b^{\hat{t}}(j)v_i(j)\right] + \Big[\epsilon(1+\alpha)v_i(j') - \epsilon v_i(j)\Big] - \sum_{j \in J} b^{\hat{t}}(j)v_i(j) && \text{(A-19)} \\
= \quad & \epsilon\left[v_i(j') - v_i(j) + \alpha v_i(j')\right]. && \text{(A-20)}
\end{aligned}
$$

Given assumptions **(A1)** and **(A2)**, we have that $v_i(j') - v_i(j) > 0$ for every voter and $v_i(j') = v_i(j) > 0$ for the proposer. Therefore, there exits an upper bound $\overline{\alpha} > 0$ such that all players strictly prefer bill b^* over $b^{\hat{t}}$ for any $\alpha \in (0, \overline{\alpha})$, independently of $\epsilon > 0$. Moreover, for any fixed $\alpha \in (0, \overline{\alpha})$, the new agenda $\hat{B}$ is feasible for any sufficiently small $\epsilon > 0$.[3]

Therefore, since $b^{\hat{t}}(j)$ was approved by at least k voters, the new bill b^* is also approved by at least k voters. Thus, the proposer is strictly better off, a contradiction to the optimality of the original agenda B. ■

Claim 2 *Suppose **(A1)** and **(A2)** hold. Consider a constraint κ on the number of proposals. Then, all voters have single-peaked preferences over κ.*

Proof From the previous claim, we know that the optimal agenda defines a cutoff j on the policies. Increasing the limit κ relaxes the constraint faced by the proposer, hence the cutoff j^* must weakly decrease with κ — the proposer is able to approve weakly more mass of policies in her platform if she is able to make more proposals. Each voter i benefits from a lower j^* if $v_i(j^*) > 0$, and he is worse off if $v_i(j^*) < 0$. Hence, each voter has single-peaked preferences over cutoff j^*, which is equivalent to single-peaked preferences over κ. ■

Claim 3 *Suppose **(A1)** and **(A2)** hold. Given any k-voting rule, $n-k+1$ voters (weakly) prefer $\kappa = 1$ over any higher κ. If **(A1)** and **(A3)** hold, then all voters (weakly) prefer $\kappa = 1$ over any higher κ.*

[3]Since $\mathbb{I}(b^{\hat{t}})b^{\hat{t}}(j) > 0$, we can decrease the mass from policy j included in the bill. Since $\sum_{t=1}^{\kappa} \mathbb{I}(b^t)b^t(j') < 1$, we can increase the measure of policy j' included in the modified bill b^* by either including mass that was not previously proposed by any bill or shifting mass from a bill that is not approved by voters to the modified bill b^*.

Proof Consider $\kappa = 1$, and let b^* be the (single) optimal bill proposed by the proposer. It must be the case that at most $q - 1$ voters strictly prefer b^* over the status quo — if q or more voters are strictly better off, then the proposer could bundle more mass of policies into b^* and still get the bill approved, a contradiction to the optimality of b^*. Therefore, at least $n - q + 1$ voters weakly prefer the status quo over b^*. Since an optimal b^* defines a cutoff j^* on the policies, it must be the case that, for all of these $n - q + 1$ voters, we have $v_i(j^*) \leq 0$. Therefore, increasing κ would imply a decrease in cutoff j^*, and these $n - q + 1$ voters would be weakly worse off.

If **(A3)** holds, then all voters agree on which policies yield a positive payoff (relative to the status quo), and agree on which policies yield a negative payoff. Therefore, it must be the case that $v_i(j^*) < 0$ for all κ. Hence, the payoff of all voters weakly decrease in κ for all values of κ. ■

Claim 3 implies Proposition 4 of SB.