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Supermajority rule and bicameral bargaining

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Abstract This paper revisits the claim that supermajority rules and bicameral legislative structures restrain excessive government spending and taxation. Our analysis suggests that the extension effect of a supermajority rule—that requires logrolling across additional members—increases with the ratio of seats in the House relative to seats in the Senate. Using a panel of US states, 1970–2008, we find that the ratio of House-to-Senate seats has a robust, positive impact on the tendency of a supermajority rule to inflate the budget. Our finding implies that a supermajority rule can have a perverse effect on budget outcomes in bicameral legislatures owing to two factors: the geographic overlap between chambers and the low price elasticity of demand for public goods.

Keywords Supermajority rule · Bicameral legislatures · Legislative bargaining · Budget institutions

JEL Classification D72 · H72

1 Introduction

The early literature on legislatures claimed that outcomes in bicameral legislatures depend on the ratio of seats in one chamber relative to seats in the other (e.g., Crain 1979; McCormick and Tollison 1981). The argument was that the more unequal the sizes of the two chambers, the more costly (difficult) it would be to obtain simple majorities in both chambers.[1]

[1] This argument assumes that the marginal cost of building a coalition increases with the size of the coalition. For instance, the cost of achieving a simple majority is higher in a 100-member legislature divided into 66 representatives and 34 senators than in a legislature equally divided between House and Senate—

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In line with this argument, recent studies showed that public spending declines with increases in the ratio of seats in the House relative to seats in the Senate (e.g., Chen and Malhotra 2007; Chen 2010). Chen and Malhotra (2007) argued that dividing a Senate district into more House districts reduces the incentive of House legislators to pursue large pork barrel projects, because each House member's share of the benefits from a Senate project, within which his constituency is nested geographically, obviously is smaller.[2]

Most studies on bicameral legislatures assume simple majority voting. Choice among voting rules, however, critically affects budget outcomes by adjusting the distribution of voting powers among different coalitions (Buchanan and Tullock 1962; Lee et al. 2014).

Supermajority rules are frequently claimed to reduce inefficient spending enacted under majority rule—by making the formation of a winning coalition more difficult (Tullock 1959; Buchanan and Tullock 1962; Knight 2000; Primo 2006). Such rules undermine the "tyranny of the majority", a flaw inherent in democracy (Bradbury and Johnson 2006). On the other hand, supermajority rules can increase pork barrel spending if the dominant coalition requires additional members to achieve a supermajority (Shaviro 1997; Gabel and Hager 2000; Miller and Vanberg 2013). For instance, new marginal members will demand subsidies as a condition of joining the coalition, increasing side payments and omnibus budget deals (Lee 2015).[3]

Previous studies examined the effect of supermajority rule in a unicameral legislative structure (e.g., Knight 2000; Dixit et al. 2000; Bradbury and Johnson 2006; Lee 2015).[4] A bicameral structure, however, critically influences budget allocation because of the strategic interactions and bargaining between the two chambers (Riker 1992; Tsebelis and Money 1997; Bradbury and Crain 2001, 2002; Congleton 2006; Chen 2010; Hickey 2013; Dahl 2014). The dual-chamber legislature is an empirical reality in many places, including 49 American states and most OECD countries.

A bicameral structure is said to reduce spending on parochial projects—similar to a supermajority rule in a unicameral structure—if the two chambers represent different constituencies (Buchanan and Tullock 1962; Gilligan et al. 1989; Bradbury and Crain 2001, 2002; Crepaz and Moser 2004; Muller 2005). Indeed, if the seats in the two chambers are apportioned on the same basis (e.g., population), the collective choices of bicameral and unicameral legislatures will not differ materially. In practice, coalition formations in the two chambers are not independent owing to geographical overlap between chambers (Buchanan and Tullock 1962; Levmore 1992; Ansolabehere et al. 2003). For instance, representatives usually work with a senator in which their districts are geographically embedded, and a senator is more likely to support a bill if her House colleagues are included in the coalition (Buchanan and Tullock 1962; Ansolabehere et al. 2003; Chen and Malhotra 2007).

Footnote 1 continued
because the additional cost of buying eight more votes (34–26) in the House exceeds the saving from buying eight less votes (18–26) in the Senate (McCormick and Tollison 1981). We thank William F. Shughart II for pointing out this argument.

[2] This assumes that House proposers cannot target large projects to their own districts.

[3] In a dynamic setting, supermajority rule can increase majority tyranny because the ruling supermajority is more likely to avoid future retaliation by the current minority—who has a smaller chance of achieving a supermajority in the future (Dixit et al. 2000).

[4] Although some studies analyzed the effect of supermajority rule in bicameral settings, the chambers were treated as independent unicameral legislatures with no veto powers. See Bradbury and Crain (2001) for a similar discussion in the context of the law of $1/n$.

This paper advances the existing literature by bringing the role of supermajority voting rules into the analysis of distributive politics in bicameral legislatures. Our major finding is that the extension effect of a supermajority rule, which requires logrolling across additional members, increases with the ratio of seats in the House relative to seats in the Senate. Intuitively speaking, if supermajority rule increases the number of senators needed to approve parochial expenditures, the number of House district projects located within the Senate coalition likewise must increase to secure passage of the budget.

In terms of past research, this paper brings together three different institutions that influence budgetary decision-making: coalition success rules (Buchanan and Tullock 1962; Bradbury and Johnson 2006), the sizes of legislatures (Weingast et al. 1981; Primo 2006), and bicameral legislative structures (McCormick and Tollison 1981; Riker 1992; Bradbury and Crain 2001).[5] Different configuration of these institutional rules can lead to different budget outcomes (Raudla 2000). Only a few studies have related supermajority rules and bicameral structure. Diermeier and Myerson (1999) claimed that bicameralism induces legislative chambers to create supermajority rules—an internal procedural hurdle that functions like prices for new legislation for which lobbyists pay. Ansolabehere et al. (2003) showed that small-state biases in bicameral legislatures can emerge when supermajority rules, such as the cloture requirement in the US Senate, govern the upper chamber. Our study focuses on supermajority rules for budget decisions that apply to both legislative chambers.

To test the proposition suggested by our model of supermajority rules in bicameral legislatures, we estimate a panel data model of the revenues and expenditures of 49 U.S. states from 1970 to 2008. Our empirical methodology uses a structural equation model in order to examine the effect of adopting supermajority rules on government size as the ratio of House-to-Senate seats changes. The empirical results confirm that an increase in the House-to-Senate seat ratio magnifies the tendency of a supermajority rule to inflate the budget.

This paper is organized as follows. In Sect. 2, we offer a model of supermajority rules in bicameral legislatures. Section 3 presents an empirical investigation of the hypothesis suggested by the model. Section 4 concludes our discussion.

2 A model of supermajority rules in bicameral legislatures

This section shows how a supermajority rule affects budget outcomes in bicameral legislatures. We follow previous models of distributive politics: Ansolabehere et al. (2003), Chen and Malhotra (2007), and Chen (2010) for geographical setup of districts; Baron and Ferejohn (1989), Primo (2006), and Knight (2008) for legislative bargaining; and Lee et al. (2014) and Lee (2015) for fiscal outcomes under different voting rules. To keep the model simple, we focus on district projects funded from a common tax base and do not specify other elements, such as spillover effects and heterogenous preferences.[6]

[5] For instance, House-to-Senate seat ratio of 1 indicates a complete constituent homogeneity across chambers—that is, two chambers have equal bases of representation.

[6] We assume that there is no spillover in project benefits across districts (to focus on the case of distributive goods). See Besley and Coate (2003) and Lockwood (2002) for a local public good model with a degree of spillovers.

2.1 Bargaining in bicameral legislatures

Consider a state that is divided into n Senate (or upper house) districts. A Senate district $j \in \{1, \ldots, n\}$ is divided into τ_j equally populated House (or lower house) districts, where $\tau_1 \leq \cdots \leq \tau_n$.[7] With single-member districts, Senate or House, the legislature consists of n senators and $T = \sum_{j=1}^{n} \tau_j$ representatives.

Spending projects are targeted at the House district level.[8] The jth senator supports (votes for) the spending bill if more than half of her τ_j House districts (located within her Senate district) receive money. The idea is that a district project is valued by both the House member from that district and the senator in which the district is nested (Ansolabehere et al. 2003).

Coalition success rules require a α-majority ($\alpha \in [0.5, 1]$) to pass a spending bill. Thus, a proposal requires αn Senate votes and αT House votes to pass. For simplicity, we abstract from the integer problem by interpreting αn and αT as the smallest integers weakly greater than the actual values.[9] Based on the previous studies (e.g., Persson et al. 1997; Chen and Malhotra 2007), we assume that forming a coalition is less costly for representatives who are geographically embedded within the same Senate district than for representatives from different Senate districts.[10]

The legislature selects a set of House district projects $X = (x_1, x_2, \ldots, x_T)$ using the following procedure: (1) A legislator is randomly recognized from the entire legislature, (2) a recognized legislator proposes a project for each of T House districts, (3a) if approved by both chambers, the proposal is implemented, and (3b) if the proposal is not approved, another proposer is randomly recognized to make a new proposal. The process continues until a proposal passes both chambers. This bargaining structure is a non-cooperative game with infinite periods and two stages within each period (Baron and Ferejohn 1989).[11] Note that in line with previous literature (e.g., Chen 2010), a legislator recognized from either chamber can make project proposals. (At the federal level, the US House is empowered constitutionally to originate "money bills", but in practice a Senator can convince one of House members representing a district in his or her state to introduce spending proposals.)

We focus on stationary subgame perfect equilibrium, in which each legislator takes the same action in structurally identical subgames (Baron and Ferejohn 1989; Primo 2006). For simplicity, legislators are risk neutral, have a discount factor of one, cannot vote against their true preferences (i.e., weakly dominated strategies are ruled out), and are not allowed to make amendments once a proposal has been made (i.e., the legislature operates under a closed rule). We also assume that side payments are allowed among coalition members.

[7] We assume that $n \geq 3$ and $\tau_j \geq 1$ $\forall j$.

[8] Alternatively, projects can be targeted to a Senate district, and the benefits are divided equally among all House districts within the targeted district (e.g., Chen and Malhotra 2007). Our results do not change qualitatively under the alternative setup, although the current setup allows us to pinpoint the effects of supermajority rules in both chambers.

[9] For instance, formally, $\alpha n = \min\{a \in N \mid a \geq \alpha n\}$ where N is the set of natural numbers.

[10] Chen and Malhotra (2007) suggested that representatives usually do not work with representatives in different Senate districts—even with geographically close representatives—due to logistical and other transaction costs. Similarly, Persson et al. (1997) noted that bargaining within a chamber is less costly than bargaining across chambers.

[11] That is, a proposal is made in stage 1, and legislators in both chambers vote on the proposal in stage 2.

2.2 Equilibrium

The agenda setter assembles the cheapest possible coalition (Riker 1962; Knight 2008). Let $\tau = T/n$ denote the ratio of House-to-Senate seats, or the average number of House districts nested within a Senate district.

Lemma *The minimal winning coalition consists of $\alpha n\tau$ House districts located within αn or more Senate districts.*

Proof See Appendix. □

Intuitively, senators and their House colleagues collaborate to form a supermajority coalition. A proposer builds a winning coalition of $\alpha n\tau$ ($\equiv \alpha T$) House districts, which is large enough to secure the required votes in the Senate—i.e., αn or more senators.[12] Note that the proposer chooses the smallest possible Senate coalition—the one comprising the fewest senators—because a House coalition is cheaper to build within a Senate district than across Senate districts. In the simple case of $\tau_j = \tau, \forall j$, winning coalitions range from αn Senate districts $\times$ τ House districts (in each of αn Senate districts) to n Senate districts $\times$ $\alpha\tau$ House districts (in each of n Senate districts). The cheapest winning coalition consists of αn Senate districts $\times$ τ House districts.

The geographical setup in the Lemma assumes that House districts are nested *completely* within a Senate district. In some state legislatures, however, House district boundaries cut across Senate district boundaries. The Appendix shows that the basic results hold in this case. Intuitively, a coalition of $\alpha n\tau$ House districts can nest at least half of House district fragments overlapping with each of αn coalition Senate districts.

Let G denote the total value of district projects. The stationary subgame perfect equilibrium is as follows: In every period, the agenda setter, who is a representative, offers $\alpha n\tau - 1$ House districts their continuation values—$G/n\tau$ per district—and keeps the remaining value for her own House district. The agenda setter, who is a senator, offers $\alpha n\tau - b_k$ House districts their continuation values—$G/n\tau$ per district—where b_k is the coalition's House members located within the agenda setter's Senate district k, and keeps the remaining value for the House districts within her own Senate district.[13] The proposal is approved in the first period.

2.3 Impact of a supermajority rule

The equilibrium results give the following:

Proposition *The total expenditures G are given by:*

$$G = p \cdot \alpha \cdot n \cdot \tau \cdot x(p \cdot \alpha) \tag{1}$$

where $x(p \cdot \alpha)$ is a representative's preference for x ($x' < 0$), and p is the constant marginal cost of providing x.

[12] Consistent with Ansolabehere et al. (2003), the marginal value of a senator is zero. The $\alpha n\tau$ House districts are large enough to win the αn Senate districts.

[13] A House member's continuation value C is the expected payoff in any round. Suppose that a representative is recognized with probability σ, and a senator recognized with probability $1 - \sigma$. Then, $C = \sigma\left[\frac{\alpha n\tau - 1}{n\tau} \times C + \frac{1}{n\tau} \times (G - (\alpha n\tau - 1)C) + \frac{n\tau - \alpha n\tau}{n\tau} \times 0\right] + (1 - \sigma)\left[\frac{\alpha n\tau - b_k}{n\tau} \times C + \frac{b_k}{n\tau} \times \frac{G - (\alpha n\tau - b_k)C}{b_k} + \frac{n\tau - \alpha n\tau}{n\tau} \times 0\right]$. This indicates that $C = G/n\tau$.

Proof See Appendix. □

The intuition behind the Proposition is that the agenda setter effectively maximizes the sum of the utilities of $\alpha n\tau$ coalition House districts—because the agenda setter shares in the project benefits of other coalition members. This is as if a randomly chosen coalition of $\alpha n\tau$ representatives chooses G to maximize its aggregate utility (Battaglini and Coate 2008). With an equal distribution of the tax burden across all districts, each of the coalition's House districts pays a α fraction of the cost of providing x, or $p \cdot \alpha$.

Equation (1) shows that total expenditure G depends on the size of the winning coalition $\alpha n\tau$ and the effective price of pork barrel projects to the coalition members $p \cdot \alpha$. Note that the sizes of the Senate n and the House $T(\equiv n\tau)$ affect the size of government indirectly through the coalition success rule α. Thus, it is not the sizes of the legislatures, but the sizes of the logrolling coalitions that determine the amount of pork barrel spending (Inman and Fitts 1990; Lee 2015).

To determine the impact of a supermajority rule, Equation (1) can be partially differentiated with respect to α to obtain:

$$G_\alpha = p \cdot n \cdot \tau \cdot \left[\underbrace{x(p \cdot \alpha)}_{+} + \underbrace{p \cdot \alpha \cdot x'(p \cdot \alpha)}_{-}\right] \tag{2}$$

where the subscript α denotes a derivative. In Eq. (2), a more inclusive rule has two offsetting effects on the size of government.[14] In the first term in the square brackets, α has a direct, positive impact on G because a supermajority rule requires logrolling to attract additional House members. In the second term, α has an indirect, negative effect on G because more inclusive rules raise the effective prices for the existing coalition members $(x'(\cdot) < 0)$. Note that the second term formalizes the original intuition of Buchanan and Tullock (1962)—a supermajority rule will reduce the sizes of redistributive projects that can secure the support of only 50 % of the legislature.[15] However, the extension effect in the first term dominates the voting qualification effect in the second term if the demand for x is price-inelastic (Lee et al. 2014). Specifically, Eq. (2) can be rewritten as

$$G_\alpha = p \cdot n \cdot \tau \cdot x \cdot (1 + \eta_{xx}) \tag{3}$$

where $\eta_{xx} = (p \cdot \alpha)/x \cdot x'$ is the elasticity of demand for x with respect to its effective price to the winning coalition members $p \cdot \alpha$. Previous studies have established that η_{xx} ranges between -0.3 and -0.5.[16] Thus, the House-to-Senate seat ratio τ strengthens the tendency of supermajority rules to expand the budget, other things equal. Intuitively, if supermajority rule increases the size of winning coalition in the Senate, αn, the size of winning coalition in the House located within the Senate coalition, $\alpha n\tau$, also must increase. A larger House-to-Senate seat ratio increases the extension effect of a supermajority rule.[17]

[14] This result is similar to the budget outcomes under a supermajority rule (Lee et al. 2014; Lee 2015).

[15] For instance, a simple majority can exploit the tax base of 49 % of the polity, while a 3/4 majority rule limits the tax base to just 25 % of the polity (Bradbury and Johnson 2006).

[16] See Borcherding (1985), Reiter and Weichenrieder (1997), Brasington (2002), and Oates (1996, 2006) for the estimation of the price elasticity of demand for government services.

[17] In some previous models (e.g., Chen and Malhotra 2007), an increase in House-to-Senate seat ratio reduces the incentive of lower chamber proposers to pursue large projects. In our model, the agenda setter keeps the bargaining surplus, effectively sharing in the projects of other coalition members. Thus the agenda setter proposes the spending projects of size G [in Eq. (1)]—even if an increase in House-to-Senate seat ratio reduces the agenda setter's payoff from her own district. In addition, our paper focuses on the interaction

Note that if T is fixed, increasing τ leads to a reduction in n, because $T = n\tau$ (although this rarely happens in practice).[18] Then, G_α may be constant in τ. If n is fixed, then the effect of τ on G_α in Eq. (3) would simply reflect the fact that more House members are required in the winning coalition.

In addition, the agenda setter may want to build a larger-than-minimal winning coalition. The reasons include that (1) if uncertain about legislators' preferences, the agenda setter may add extra members to increase the chance of assembling a supermajority (Riker 1962), and (2) if other vote buyers vie for the winning majority, the agenda setter may build a buffer to deter the competitors (Groseclose and Snyder 1996). In our context, the agenda setter may build a winning coalition of $\alpha^* n\tau$ House members, where $\alpha^* \geq \alpha$. In that case, G in Eq. (1) can be treated as the lower bound of the budget size.

3 Empirical evidence

This section provides an empirical analysis of the main hypothesis: that the ratio of House-to-Senate seats increases the effect of adopting supermajority rules on government size.

3.1 Variables and data

We use data from 49 US states for the 1970–2008 period.[19] US state legislatures provide a natural setting for testing the effects of supermajority rule in a bicameral legislature. U.S. states adopted a supermajority rule with sufficient time variance (mostly after 1970), and all but one state (Nebraska) have bicameral legislatures.[20] The states also have independent fiscal authority as well as similar electoral rules and political institutions (Bradbury and Johnson 2006; Chen and Malhotra 2007).

Dependent variables are total tax revenue, general expenditure, and eight categories of spending, including education, roads, public welfare, public safety, health, natural resources, sanitation and public utilities.

Seventeen states have adopted a variant of supermajority rules to restrain taxes and government spending. In those states, a supermajority vote is required to pass the budget, to raise taxes and expenditures, to approve bond issues, or to limit government expenditure growth to income or inflation growth unless a supermajority overrides (Bradbury and Johnson 2006). Supermajority rules typically were adopted in 10-year waves: around 1970 (three states), around 1980 (three states), around 1990 (six states), and around 2000 (four states).[21] The rules vary relatively little across states: a 2/3 rule (nine states), a 3/5 rule (five states), and a 3/4 rule (three states).

Footnote 17 continued
between the supermajority rule and the ratio of House-to-Senate seats, in which the coalition success rule α varies rather than being fixed at a simple majority.

[18] For instance, in the U.S. Congress and other federal systems, the Senate represents geographical areas (states), the size of which rarely changes. At the U.S. state level, few state legislatures have reduced the number of upper house districts (n) without also changing the size of the lower house (T).

[19] Nebraska has a unicameral legislature.

[20] Other bicameral legislatures with supermajority rules include the European Union and the democratic countries that require a supermajority to override an executive veto.

[21] Out of 17 states with a supermajority rule, 15 states adopted the rule after 1970.

Among the 49 states with bicameral legislatures, the average legislature size in 2008 was 39 seats in the Senate and 110 seats in the House.[22] Thus, on average, a Senate district geographically overlaps about 2.8 House districts in 2008. Table 1 shows the supermajority requirements in various states and the mean number of seats in both chambers.

The socioeconomic control variables are in line with previous studies on government growth (Bradbury and Johnson 2006; Lee et al. 2014; Lee 2015). Standard variables include income per capita (in natural logs), population (in natural logs), percentage of the population over age 65, percentage of the population under age 18, and a dummy variable indicating whether the Republicans control a chamber. All these variables determine the nature of the demand side activities for government services.[23] Appendix Table 7 presents summary statistics for all the variables described in this section.

3.2 Empirical model

We specify a structural equation to determine the effects of a supermajority rule in bicameral legislatures. The specification is an augmented dummy endogenous variable model with multiplicative interactions:

$$G_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 Ratio_{it} + \beta_3 S_{it} Ratio_{it} + \beta_4 U_{it} + \Phi X_{it} + \omega_i + \lambda_t + \zeta_{it} \tag{4}$$

$$S^*_{it} = \gamma_0 + \gamma_1 D_{it} + \gamma_2 Ratio_{it} + \gamma_3 U_{it} + \gamma_4 X_{it} + \theta_i + \mu_t + u_{it} \tag{5}$$

$$S_{it} = \begin{cases} 1 & \text{if} \quad \mathrm{S}^*_{\mathrm{it}} > 0 \\ 0 & \text{if} \quad \mathrm{S}^*_{\mathrm{it}} \leq 0 \end{cases}$$

where G_{it} is total revenue or government expenditures in state i at time t; S_{it} is a dummy variable for supermajority rule; $Ratio_{it}$ is the ratio of House-to-Senate seats; U_{it} is the size of the Senate; X is a vector of control variables; ω_i and θ_i are the state-specific effects; λ_t and μ_t are the time effects; and ζ_{it} and u_{it} are the error terms. Note that $\beta_1 + \beta_3 Ratio$ is the marginal effect of the supermajority rule on the size of government.[24]

In Eq. (4), S_{it} potentially is correlated with ζ_{it} because the latent index function (5) shows that the adoption of a supermajority rule is a political decision that depends on the preferences of voters. For instance, a downward bias in the estimate of $\beta_1 + \beta_3 Ratio$ would ensue if a state with a larger government is less likely to adopt a supermajority rule (Knight 2000). To control for the endogeneity, the structural equation assumes that D_{it}, an instrumental variable, is independent of the error terms ζ_{it} and u_{it}. Note that correlation between S_{it} and D_{it} is assumed. Then, any effect of D_{it} on G_{it} is channeled only through an effect of D_{it} on S_{it}. In this structural model, the $\beta_1 + \beta_3 Ratio$ estimates the causal marginal effect of S_{it} on G_{it}—analogous to the local average treatment effect (LATE) (Imbens and Angrist 1994). Thus, Eqs. (4) and (5) address both adoption of a supermajority rule and its causal effects on government spending, conditional on the ratio of House-to-Senate seats.

The index function (5) uses two instrumental variables taken from the previous literature (e.g., Knight 2000; Lee et al. 2014): the neighboring state effect (adoption of

[22] During the sample period, 21 states changed the size of legislature, either House or Senate, at least once.

[23] Most of the socioeconomic data were obtained from the U.S. Census Bureau; the income per capita data were collected from the U.S. Bureau of Economic Analysis. Legislative votes for constitutional amendment (one of our instrumental variables) were collected from the Book of the States.

[24] We ignore the potential multicollinearity between S_{it} and $Ratio_{it}$ because the correlation between the two variables is low (−0.13).

Table 1 Legislature sizes of the supermajority states. *Source* National Conference of State Legislatures

State	Supermajority required	Senate seats	House seats
Arizona (1992)	2/3	30	60
Arkansas (1934)	3/4	35	100
California (1979)	2/3	40	80
Colorado (1992)	2/3	35	65
Delaware (1980)	3/5	21	41
Florida (1971)	3/5	40	120
Kentucky (2000)	3/5	38	100
Louisiana (1966)	2/3	39	105
Michigan (1994)	3/4	38	110
Mississippi (1970)	3/5	52	122
Missouri (1996)	2/3	34	163
Nevada (1996)	2/3	21	42
Oklahoma (1992)	3/4	48	101
Oregon (1996)	3/5	30	60
Rhode Island (1992)	2/3	38	75
South Dakota (1978)	2/3	35	70
Washington (1993)	2/3	49	98
AVERAGE	0.66	37	89

Year of adoption in parentheses. Number of seats as of 2008

supermajority rules in neighboring states) and the legislative vote required to initiate a constitutional amendment. These instrumental variables satisfy the requirement of affecting the adoption of supermajority rules, but not influencing budget sizes directly. States neighbored by a supermajority state are more likely to adopt a supermajority rule, but the characteristics of the neighboring states are not directly related to government size (Lee 2015).[25] For instance, 12 of the 17 states with supermajority rules are bordered by states adopting a supermajority rule. Regional spillovers of various fiscal institutions (such as fiscal rules) often are the result of yardstick competition and learning processes (Debrun et al. 2008; Keen and Lockwood 2010; Besley and Case 1995). In addition, 32 states require supermajority votes to initiate a constitutional amendment, including the adoption of a supermajority rule. This requirement makes the adoption of a supermajority rule more difficult, but rules for amending constitution—being part of states' original or revised constitutions—apply to all amendments, not just the adoption of supermajority rules (Knight 2000).

The ratio of House-to-Senate seats is treated as exogenous because (1) enacting a larger budget is more likely to require more government employees rather than more legislators (Baqir 2002) and (2) the number of legislative seats typically is determined by a state's original constitution—that is, constitutional links between seats and counties, and seats and

[25] The neighborhood adoption dummy is one if neighboring states have adopted a supermajority rule within 10 years.

population (Gilligan and Matsusaka 1995).[26] In the next section, we discuss the potential endogeneity of chamber sizes and report robustness checks.

3.3 Results

Table 2 reports the results of estimating Eqs. (4, 5). The dependent variables are total revenue per capita. As a benchmark model, column 1 takes a basic equation with the legislature sizes in two chambers (*Lower* and *Upper*) and the supermajority rule dummy—instrumented by the neighboring state effects and the constitutional amendment rules. Column 2 simply substitutes the ratio of House-to-Senate seats (*Ratio*) for the legislature size in the lower chamber (*Lower*). Column 3 adds the interaction term that allows the impact of the adoption of a supermajority rule to vary across time and states according to the House-to-Senate seat ratio. Column 4 adds the interaction term of the supermajority rule dummy and the size (number of seats) in the upper chamber. Finally, columns 5 and 6 substitute the actual supermajority requirements for the dummy variable for supermajority rule.

Note first that both legislature sizes and supermajority rules have a positive impact on total revenue. Columns 1 and 2 show that the size of the upper chamber, *Upper*, has a positive and significant impact on total revenue. In column 1, a one seat increase in *Upper* increases total tax revenue by about \$43 (or about 2.4 % of the average per capita revenue). The coefficient on *Lower* is statistically insignificant, however. These results are similar to the previous findings that the $1/n$ effect is significant in the upper house, but not in the lower house (e.g., Gilligan and Matsusaka 1995, 2001; Chen and Malhotra 2007). In column 2, supermajority rule adoption has a robust, sizable impact on total revenue (\$1560, or about 87 % of the mean total revenue).

What is more important for our purpose, columns 3 through 6 show the effects of adopting a supermajority rule, conditional on the House-to-Senate seat ratio. One broad effect of adding the interaction terms in S is that the coefficients on the simple supermajority rule become negative or insignificant.[27] On the other hand, the interaction effects, $S * Ratio$, are positive and statistically significant. This result confirms the hypothesis that the House-to-Senate seat ratio increases the revenue impact of a supermajority rule, the size of which we discuss below. In addition, the interaction terms in the upper chamber, $S * Upper$, are positive and significant—results that are consistent with the previous findings that the $1/n$ effect is robust only if combined with budgetary rules (Raudla 2000; Lee 2015).

In general, the effects of socioeconomic control variables are in line with common expectations. Income has a positive and significant impact on total revenue. The effect of population, sensitive to specification, does not exhibit a consistent relationship with government size—perhaps because of the offsetting effects of joint consumption economies

[26] Although some states have amended their constitutions to alter the legislative size, these changes were motivated by all legislative matters, including efficiency in representation and other exogenous events (banking crises, political scandals, court decisions regarding equal population reapportionment, and statewide legislative reforms), not limited to budget allocation (Lee 2015).

[27] More specifically, S is statistically significant in columns 4 and 6 (with both $S * Ratio$ and $S * Upper$ included), but insignificant in columns 3 and 5 (with only $S * Ratio$ included). With interaction terms included in a regression, however, the coefficients on S alone becomes less meaningful. In fact, it is possible that the marginal effects of S are significant even if the point estimates on S are insignificant (Brambor et al. 2006).

Table 2 Effects of supermajority rule on total revenue

	1	2	3	4	5	6
Dependent variable: Per capita total tax revenue						
Lower	−1.092					
	(1.117)					
Upper	43.44**	41.60**	19.37	−2.292	18.90	−4.145
	(20.28)	(19.14)	(13.14)	(17.13)	(13.12)	(16.12)
Ratio		−29.36	−53.23	−155.8**	−56.28	−158.4**
		(48.68)	(48.43)	(64.48)	(49.32)	(66.27)
S	1548**	1559**	−834.9	−5604***	−1235	−8377***
	(630.7)	(635.6)	(847.8)	(2018)	(1282)	(3012)
S * Ratio			819.0**	1285***	1246**	1950***
			(332.1)	(431.1)	(506.6)	(657.5)
S * Upper				96.91**		142.8**
				(40.65)		(60.20)
Ln(YPC)	3697***	3702***	3720***	3843***	3786***	3912***
	(734.0)	(738.3)	(693.2)	(749.3)	(701.8)	(761.5)
Ln(POP)	−663.1**	−671.9**	−174.7	751.1*	−149.6	778.7**
	(281.8)	(285.5)	(245.1)	(384.0)	(241.2)	(382.0)
Elderly	4074	4070	7631***	16903***	8259***	16587***
	(2744)	(2751)	(2671)	(5322)	(2639)	(5107)
Youth	−4948*	−4963*	−1934	−1078	−2043	−1016
	(2648)	(2648)	(2041)	(2284)	(2097)	(2292)
Repub (L)	−2.647	−3.586	−29.70	−58.44	−29.29	−62.98
	(50.06)	(49.99)	(47.69)	(52.20)	(48.19)	(52.82)
Repub (U)	−28.59	−27.80	−114.1**	−158.4***	−120.2**	−160.4***
	(45.77)	(45.87)	(49.13)	(58.65)	(50.09)	(59.01)
No. obs.	1911	1911	1911	1911	1911	1911
Pseudo R^2	0.133	0.128	0.232	0.069	0.215	0.059
No. id	49	49	49	49	49	49
1st stage F statistic		10.36	10.09	11.22	10.17	11.34
Sargan test, $p <$		0.836	0.278	0.778	0.244	0.763

All columns include fixed effects and time dummies. *Ratio* is the ratio of House-to-Senate seats. In columns 2 through 4, *S* is a dummy variable that is 1 if a supermajority rule is present and 0 otherwise. In columns 5 and 6, *S* is the actual supermajority requirements. All dollar figures are in constant 2005 US dollars. Estimation methods: Fixed effects 2SLS. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

and tax share reductions (Borcherding 1985).[28] In most columns, the percentage of elderly has a positive impact on government revenue. However, the fraction of young (under 18) people is negatively associated with government revenue, reflecting that the group is not often a part of the taxable population. Republican Party controls are correlated negatively

[28] Another potential reason for the inconsistent effects of Ln(POP) is the use of natural log form. In any case, our main results are qualitatively similar when Ln(POP) is dropped.

with government revenue, although that relationship is not statistically significant in the lower chamber.

The first stage F-statistics and the Sargan statistics reported in Table 2 indicate that the instrumental variables sufficiently explain the adoption of supermajority rules without overidentifying the effect.[29]

Table 3 reports the regression estimates for general government expenditures per capita. The results are similar to the results for total revenue in Table 2. Columns 1 and 2 show that the coefficients on the sizes of the upper legislative chambers and supermajority rule are positive and statistically significant. In columns 3 through 6, all the interaction effects, $S * Ratio$, are positive and statistically significant. This again confirms the hypothesis that the effects of supermajority rules rise along with the number of House districts within a Senate district.

With interaction terms entered, the marginal effects are more meaningful. Table 4 reports the marginal effect of a supermajority rule, conditional on the ratio of House-to-Senate seats (*Ratio*). More specifically, we examine the effect of a supermajority rule at three different levels of *Ratio*: mean, mean minus one standard deviation (SD), and mean plus one standard deviation (SD). Note that all the marginal effects are positive and larger in magnitude when *Ratio* also is relatively larger. For instance, at the mean value of *Ratio* (that is, about 3.0), adopting a supermajority rule inflates per capita tax collections by about \$1603. The marginal effect increases to about \$3373 at one SD above the mean of *Ratio* (that is, about 5.1). These results indicate that the effect of the supermajority rule rises with the House-to-Senate seat ratio, possibly because a larger *Ratio* increases the number of House district projects required to form a winning coalition in the Senate.

The results in Table 4 also imply that if the states with a *Ratio* of 3 (roughly the values for Alabama, Ohio, Tennessee and Wisconsin) were to introduce supermajority rules, per capital expenditure would increase by about \$1500. Alternatively, Appendix Table 9 (Panel *A*) shows that if one of the 17 states with supermajority rules in place were to redistrict, increasing the House-to-Senate seat ratio by one (that is, adding one more House district to each Senate district), per capita expenditures would increase by about \$675—about one-fifth of the mean per capita expenditures of those states.

Table 5 reports the regression estimates for eight categories of state government expenditures. Most coefficients on the interaction term, $S * Ratio$, are positive and statistically significant.[30] The marginal effects of supermajority rule, evaluated at the mean of *Ratio* and *Upper*, are positive and statistically significant for four types of expenditures: roads, public safety, health and sanitation. Such collectively supplied goods are likely to be price-inelastic in demand owing to their high degrees of publicness. Our hypothesis—that *Ratio* increases the extension effect of supermajority rule—depends on the assumption that the demands for government services are price-inelastic. For public welfare, the coefficient on $S * Ratio$ is negative and significant. However, the marginal effect of a supermajority rule on public welfare expenditure is insignificant (evaluated at the mean of *Ratio* and *Upper*). Potential reasons for the inconsistent effect are that (1) public welfare services, largely subsidized by federal grants, are not determined at the state level (Lee et al. 2014), and (2) much of the welfare spending is entitlement programs, whose costs depend on the

[29] The first stage regressions reported in Appendix Table 8 show that the coefficients on the neighboring state effects and the constitutional amendment rules are statistically significant in most cases.

[30] Most coefficients on the key variables (S, $S * Ratio$, $S * Upper$) are significant in columns (1) through (5), but results are mixed in columns (6) through (8). This explains that the marginal effects of S are generally insignificant in the latter cases (i.e., columns (6) and (8)).

Table 3 Effects of supermajority rule on general expenditure

	1	2	3	4	5	6
Dependent variable: per capita general expenditure						
Lower	0.0164					
	(1.313)					
Upper	38.44**	37.85**	25.61*	5.996	25.56*	4.693
	(19.23)	(17.77)	(13.48)	(13.06)	(13.49)	(12.35)
Ratio		−24.40	−58.03	−105.6*	−61.69	−106.9*
		(54.49)	(54.10)	(57.03)	(54.85)	(57.64)
S	1190*	1179*	−668.2	−3681**	−966.8	−5489**
	(610.9)	(612.4)	(848.5)	(1543)	(1288)	(2295)
S * Ratio			733.3**	1023***	1118**	1548***
			(333.0)	(359.6)	(510.3)	(547.3)
S * Upper				54.26*		79.53*
				(30.36)		(44.62)
Ln(YPC)	1971***	1961***	2093***	2061***	2164***	2109***
	(639.4)	(641.2)	(593.1)	(602.4)	(605.5)	(613.0)
Ln(POP)	−938.7***	−929.5***	−589.0**	38.45	−569.4**	57.15
	(267.7)	(270.1)	(237.3)	(291.0)	(234.8)	(287.7)
Elderly	2556	2561	6012**	11098***	6660**	10947***
	(2633)	(2624)	(2557)	(4118)	(2603)	(3907)
Youth	−6126**	−6092**	−4382**	−2920*	−4540**	−2878
	(2506)	(2494)	(2029)	(1764)	(2095)	(1772)
Repub (L)	20.20	21.05	−0.438	−19.11	0.0856	−21.65
	(44.02)	(43.70)	(45.56)	(45.99)	(46.31)	(46.67)
Repub (U)	8.207	7.889	−68.27	−97.05**	−74.18	−99.22**
	(44.73)	(44.45)	(47.79)	(49.12)	(48.89)	(49.11)
No. obs.	1911	1911	1911	1911	1911	1911
Pseudo R^2	0.741	0.743	0.738	0.745	0.730	0.743
No. id	49	49	49	49	49	49
1st stage F statistic		10.36	10.09	11.22	10.17	11.34
Sargan test, $p<$		0.508	0.710	0.921	0.701	0.895

All columns include fixed effects and time dummies. *Ratio* is the ratio of House-to-Senate seats. In columns 2 through 4, *S* is a dummy variable that is 1 if a supermajority rule is present and 0 otherwise. In columns 5 and 6, *S* is the actual supermajority requirements. All dollar figures are in constant 2005 US dollars. Estimation methods: Fixed effects 2SLS. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

number of people who qualify to receive programmatic taxpayer-financed benefits. Note that the marginal effect of a supermajority rule also is insignificant for education, natural resources, and public utilities. One potential explanation is that these services are price-elastic in demand. For instance, private market substitutes (e.g., private schooling) are readily available for public education. In addition, legislators have price-elastic demand for large natural resources or utility projects because local cost shares increase with project sizes (e.g., DelRossi and Inman 1999).

Table 4 Marginal effects of supermajority rules with House-to-Senate seat ratio

Specifications from	Table 2		Table 3	
	Column 3	Column 5	Column 3	Column 5
Ratio				
Mean − one SD	−169.9	−224.1	−72.8	−59.17
	(624.9)	(948.2)	(623.8)	(949.1)
Mean	1603.2***	2472.6***	1514.9***	2360.9***
	(475.5)	(752.4)	(471.1)	(746.7)
Mean + one SD	3373.1***	5164.2***	3099.6***	4776.5***
	(1045.4)	(1622.5)	(1044.9)	(1627.6)

Marginal effects of supermajority rules are based on the estimates in columns 3 and 5 in Tables 2 and 3—evaluated at the three levels of House-to-Senate seat ratio: mean − one standard deviation, mean, and mean + one standard deviation. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6 presents the regression estimates from alternative specifications of the empirical model. Panel *A* excludes Alaska and Hawaii because the two states' revenues and expenditures are often considered outliers. Panel *B* employs pooled 2SLS models using variation in supermajority rules across states and years. Although pooled 2SLS results ignore state fixed effects, such fixed effects cannot address within-state temporal changes in attitudes towards taxes and spending (Knight 2000; Lee 2015). In Panel *C*, we include the states that allow line-item vetoes by governors only. Executive veto power can reduce pork barrel spending by shifting budgetary power from the legislature to the governor (Primo 2006). Hence, the executive veto functions as a constitutional check on logrolling-type bargains similar to a supermajority rule (as originally understood). Panel *D* limits the sample to the 1980–2008 period. After *Baker v. Carr* in 1962, many state legislatures redrew their district lines to eliminate unequal representation. By the mid-1970s, all states nearly equalized the populations of state legislative districts, both House and Senate (Ansolabehere et al. 2002). Including the reapportionment period (from 1962 to the 1970s) could weaken the assumption of exogenous legislature sizes, because court-ordered redistricting potentially altered both the sizes of legislative districts and the size of government (Ansolabehere et al. 2002). That is, during that adjustment period, the legislatures determined their district boundaries and made spending decisions.

Throughout the panels, all of the estimated coefficients on the interaction terms are positive and statistically significant. This confirms the finding that House-to-Senate seat ratio magnifies the impact of a supermajority rule on the size of government. Note in Panel *C* that the coefficients on $S * Ratio$ appear larger when gubernatorial line-item vetoes are available (relative to the results in Tables 2 and 3). However, Appendix Table 9 (Panel *B*) shows that the marginal effects of supermajority rule, evaluated at the means of *Ratio* and *Upper*, are smaller in magnitude when line-item vetoes are allowed. For instance, the marginal effect of *S* in the first model is about \$1779 when line-item vetoes are present—smaller than \$2047 for the entire sample. This implies that executive veto power indeed limits the effects of supermajority rule. In Panel *D*, both *S* and $S * Ratio$ are statistically significant at the 1 % level across all specifications. On the other hand, the coefficients are less significant if the sample is limited to the reapportionment period from 1970 to 1980

Table 5 Effects of supermajority rule on expenditure categories

	1 Education	2 Roads	3 Welfare	4 Safety	5 Health	6 Natural res.	7 Sanitation	8 Utility
Dependent variable: per capita expenditures								
Upper	3.815	1.259	7.354	−1.518**	1.567	−1.648*	−0.0644	1.145
	(4.198)	(2.281)	(5.227)	(0.744)	(1.891)	(0.863)	(0.500)	(1.128)
Ratio	153.5***	−57.67***	86.13***	−13.45***	−48.93***	3.417	−21.30***	7.963*
	(26.40)	(12.99)	(23.03)	(3.278)	(6.379)	(3.570)	(4.086)	(4.402)
S	−1441**	−552.0*	2613***	−196.4**	−669.2***	−182.9	7.113	−185.9
	(602.8)	(294.5)	(617.9)	(87.45)	(192.0)	(123.7)	(66.75)	(172.0)
S * Ratio	155.9*	133.4**	−226.3**	49.11**	116.7***	47.03**	43.93**	62.76**
	(93.68)	(66.11)	(96.22)	(19.12)	(35.24)	(20.73)	(19.73)	(27.30)
S * Upper	26.57**	13.05**	−54.12***	2.568	12.12***	1.914	−1.384	0.884
	(12.34)	(6.126)	(12.47)	(1.680)	(3.662)	(2.391)	(1.163)	(3.185)
No. obs.	1911	1911	1911	1911	1911	1911	1911	1911
No. id	49	49	49	49	49	49	49	49
Marginal effects of supermajority rule evaluated at the mean of Ratio and Upper								
	71.97	360.3***	−196.7	51.3**	156.5***	32.7	83.2***	35.8
	(139.2)	(85.9)	(136.7)	(24.1)	(42.3)	(28.7)	(23.8)	(39.7)

Notes: Other control variables (not shown) include Ln(YPC), Ln(POP), Elderly, Youth, and Republican controls in the lower and upper chamber. *S* is a dummy variable that is 1 if a supermajority rule is present and 0 otherwise. All columns include fixed effects and time dummies. All dollar figures are in constant 2005 US dollars. Estimation methods: Fixed effects 2SLS. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6 Alternative specifications

	1	2	3	4
Panel A: Alaska and Hawaii excluded				
Ratio	−92.22***	−87.60***	−55.77	−51.43
	(32.11)	(32.11)	(52.20)	(52.51)
S	−1801**	−2543**	−2283**	−3265**
	(731.7)	(1072)	(1048)	(1556)
S * ratio	500.2***	721.1***	446.7**	641.3**
	(166.4)	(242.4)	(186.4)	(275.9)
No. obs.	1833	1833	1833	1833
Panel B: pooled 2SLS				
Ratio	−95.30***	−104.4***	−105.0***	−133.4***
	(7.925)	(8.837)	(13.87)	(14.25)
S	−1852***	−4347***	1196	−2175
	(646.9)	(1144)	(1531)	(2345)
S * ratio	299.8**	468.8**	560.8**	847.3**
	(126.4)	(194.2)	(242.5)	(335.9)
No. obs.	1911	1911	1911	1911
Panel C: line-item veto present				
Ratio	−71.22	−74.94	−87.17	−89.60
	(58.39)	(58.59)	(55.33)	(55.54)
S	−8918*	−12576*	−5349	−7642
	(4749)	(6749)	(3704)	(5306)
S * ratio	1542***	2279***	1217***	1815***
	(561.6)	(822.6)	(454.1)	(669.0)
No. obs.	1677	1677	1677	1677
Panel D: sample period from 1980 to 2008				
Ratio	96.31	89.21	352.1***	347.2***
	(191.0)	(192.3)	(131.7)	(131.5)
S	−3864***	−5644***	−3203***	−4697***
	(1243)	(1809)	(899.1)	(1309)
S * ratio	859.8***	1325***	702.0***	1074***
	(286.5)	(441.6)	(214.8)	(328.1)
No. obs.	1421	1421	1421	1421

Dependent variable: per capita total revenue (columns 1 and 2) and per capita general expenditure (columns 3 and 4). Columns 1 and 2 refer to models 4 and 6 in Table 2, and columns 3 and 4 refer to models 4 and 6 in Table 3. Only the coefficients on the supermajority rule (*S*), the ratio of House-to-Senate seats (*Ratio*), and the interaction terms are reported from the full equation. All columns include fixed effects and time dummies. All dollar figures are in constant 2005 US dollars. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

(not reported). This implies that court-ordered redistricting potentially diluted the fiscal impacts of supermajority rules and bicameralism.

4 Concluding remarks

A supermajority rule frequently is claimed to restrain excessive government spending by limiting the tyranny of the (legislative) majority. Reflecting this claim, 17 American states have adopted some variant of supermajority rule for the purpose of restraining excessive spending and taxation. Voters in California, however, appear to disagree with that idea because they passed Proposition 39 in 2000 and Proposition 25 in 2010, both of which reduced the supermajority vote requirement.[31]

Previous literature has examined separately the effects of supermajority rule and bicameralism on public budget outcomes. The two political institutions are not independent, however, because the formation of a winning coalition crosses the two chambers' lines. Our study has shown that the extension effect of a supermajority rule—adding more members to the logrolling coalition—increases with the ratio of seats in the House relative to seats in the Senate.

Using data from American state legislatures from 1970 to 2008, we find that an increase in House-to-Senate seat ratio indeed increases the tendency of a supermajority rule to magnify the size of government. Our finding suggests that a supermajority rule and the geographic linkages across chambers tend to worsen the fiscal commons problem in bicameral legislatures.

Our study points to a number of directions for future research. First, our theoretical model has assumed that legislators do not vote insincerely, that is, against their true preferences (Baron and Ferejohn 1989; Primo 2006). Although this assumption makes the equilibrium outcome analytically tractable, logrolled spending decisions do encourage strategic behavior—that is, voting against a proposal that generates more utility than the alternative. If such behavior is allowed, different outcomes may emerge. In a cooperative setting, for instance, coalition members may collude to vote against a proposal unless it delivers more than continuation values. This alters the proposer's incentive to pursue pork barrel projects. A direction for future research would be to account explicitly for the (weakly dominated) strategic behavior.

Our theoretical model also assumed that legislators share the same preferences for district projects. However, constituent diversity across (and within) districts could influence the extension effect of supermajority rule. Crain (1999) showed that, for instance, the number of district-specific projects increases with the degree of constituent diversity across districts. In general, constituent diversity in preferences affects the political calculus of distributive politics (Crain 1999). Future research can extend our standard framework to account for the district configurations that mediate the extent of constituent diversity.

We have used the House-to-Senate seat ratio to identify a bicameral structure. Alternatively, future research can focus on Senate district fragmentation—roughly defined as the number of House district fragments within a Senate district.[32] Using the 2002 New York Senate expansion, Chen (2010) showed that an increase in Senate district fragmentation reduces incentives for senator-representative collaboration on pork barrel projects. That is, Senate districts that are fragmented into more House districts receive less pork barrel spending.

Some states have adopted rules that stipulate specific relationships between two chambers in the drawing of district boundaries. In particular, in states with nesting requirements, a Senate district contains two or more intact House districts. In states without nesting requirements, the districts in two chambers are drawn independently and House district lines may cross those of Senate districts (Levitt 2010, p. 76). Our theoretical model

[31] Proposition 39 reduced the required vote on local school bond measures from two-thirds to 55 percent; Proposition 25 reduced the vote requirement to pass the budget from two-thirds to a simple majority.

[32] At the state level, the House-to-Senate seat ratio equals the average Senate district fragmentation only if House districts are completely nested within the Senate district.

showed that the main results hold whether House districts are completely nested within Senate districts or cut across Senate district boundaries. In relation to this, future research can examine the implications of "floterial" districts—districts that overlap other districts in the same legislative chamber.

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Appendix

Proof of Lemma The proof of Lemma is identical for proposers from both the Senate and the House. To secure passage of the budget, the recognized proposer must build a coalition that includes at least αn Senate districts and $\alpha n\tau$ House districts (since $T \equiv n\tau$). This proof simply shows that it is possible to build a minimal winning coalition entirely within the House, without having to give additional projects to obtain votes in the Senate (see Ansolabehere et al. 2003). Let $k \in \{1, \ldots, n\}$ denote the Senate district within which the proposer resides. We consider two cases:

(1) $k \leq \alpha n$:
A coalition of $\alpha n\tau$ House districts contains all of the House districts within at least αn Senate districts because

$$\alpha n\tau \geq \sum_{j=1}^{\alpha n} \tau_j \tag{6}$$

Otherwise, $\tau < (\sum_{j=1}^{\alpha n} \tau_j)/\alpha n$, which contradicts the assumption that $\tau_1 \leq \tau_2 \leq \cdots \leq \tau_n$. Thus, a coalition of $\alpha n\tau$ House districts guarantees a minimal winning coalition in the Senate. Note that (6) shows the cheapest possible coalition—with the fewest Senate districts. Alternatively, a coalition might include a simple majority of the House districts in more than the required majority of the Senate districts.

(2) $k > \alpha n$:
Suppose that the proposer builds a coalition by including the House districts: $\tau_1, \ldots, \tau_{\alpha n-1}, \tau_{\alpha n} - 1$, and one district within k. Similar to (6) we have

$$\alpha n\tau \geq \left(\sum_{j=1}^{\alpha n-1} \tau_j\right) + (\tau_{\alpha n} - 1) + 1 \tag{7}$$

Thus, a coalition of $\alpha n\tau$ House districts contains at least αn Senate districts—guaranteeing a minimal winning coalition in the Senate.[33] Summing (1) and (2), the cheapest winning coalition consists of αn or more Senate districts and $\alpha n\tau$ House districts within the coalition Senate districts.

[33] Note that a Senate proposer obtains a project for only one of her House colleagues. The proposer can distribute surplus from the bargaining to the other House districts within her own Senate territory.

Table 7 Summary statistics

	Mean	SD	Minimum	Maximum
Total revenue	1799	750	616	11,907
General expenditure	3364	1507	1308	15,712
Education	1219	439	366	3901
Roads	364	192	120	2086
Welfare	676	382	94	2300
Public safety	123	73	22	635
Health	112	76	9	650
Natural resource	82	79	13	924
Sanitation	13	24	0	361
Utility	26	76	0	1018
Legislature size (Senate)	39	11	19	67
Legislature size (House)	112	56	39	400
Ratio	3.0	2.2	1.7	16.7
Supermajority rule	0.201	0.401	0	1
Income per capita	27,295	6201	13,217	52,396
Population	5,011,346	5,462,022	302,583	3.66E+07
Percentage over 65	0.117	0.023	0.022	0.182
Percentage under 18	0.279	0.036	0.204	0.400
Republicans control (Senate)	0.373	0.484	0	1
Republicans control (House)	0.343	0.475	0	1
Neighboring effects	0.311	0.463	0	1
Legislative vote for constitutional amendment	0.610	0.092	0.5	0.8
Line-item veto	0.880	0.325	0	1

The case of House district fragments

Let a_j denote the number of House district fragments within the jth Senate district $\forall j \in \{1, \ldots, n\}$. Following Chen (2010), we assume that each of the a_j fragments within the jth Senate district contains the same population, and that if a House district is fragmented into more than one Senate districts, each fragment has the same population.[34] By definition, the geographic limits on a_j are

$$\lceil T/n \rceil \leq a_j \leq T \tag{8}$$

where we assume that $\lceil T/n \rceil$ denotes the smallest integer weakly greater than T / n.

Dividing (8) by 2,

$$\lceil \tau \rceil /2 \leq a_j/2 \leq n\tau/2$$

Since $\alpha n\tau \geq n\tau/2$, a coalition of $\alpha n\tau$ House districts can win the support of any jth senator

[34] Thus, any one House district that overlaps with the Senate district j has $1/a_j$th of the Senate j's population.

Table 8 2SLS 1st stage regressions

Dependent variable	1 S	2 S	3 S*Ratio	4 S	5 S*Ratio	6 S*Upper
Neighbor	0.036***	0.019	−0.268*	−0.173***	−0.701***	−6.578***
	(0.011)	(0.426)	(0.138)	(0.065)	(0.174)	(2.106)
Amendment	0.840*	−0.179	0.042	−14.758***	−26.059***	−448.47***
	(0.430)	(0.415)	(0.918)	(2.348)	(5.188)	(93.017)
Ratio*Neighbor		0.006	0.133**	0.013	0.149***	0.017
		(0.147)	(0.054)	(0.015)	(0.054)	(0.533)
Ratio*Amendment		0.302***	0.682***	0.357***	0.780***	12.364***
		(0.041)	(0.095)	(0.043)	(0.098)	(1.623)
Upper*Neighbor				0.004***	0.010***	0.204***
				(0.001)	(0.002)	(0.036)
Upper*Amendment				0.252***	0.451***	7.864***
				(0.041)	(0.090)	(1.607)
Upper	−0.026***	−0.025***	−0.048***	−0.167***	−0.302***	−5.229***
	(0.0060)	(0.006)	(0.014)	(0.023)	(0.048)	(0.946)
Ratio	0.481***	−0.109***	−0.180***	−0.125***	−0.204***	−3.322***
	(0.017)	(0.024)	(0.055)	(0.026)	(0.061)	(0.965)
Ln(YPC)	−0.348***	−0.356***	−1.181***	−0.402***	−1.279***	−14.824***
	(0.108)	(0.111)	(0.270)	(0.111)	(0.269)	(3.967)
Ln(POP)	0.345***	0.336***	0.480***	0.407***	0.603***	7.648***
	(0.056)	(0.057)	(0.135)	(0.057)	(0.136)	(1.975)
Elderly	−0.715	−0.826	−7.628***	−1.259	−8.543	−116.68***
	(1.122)	(1.139)	(2.918)	(1.148)	(2.938)	(39.437)
Youth	3.403***	3.469***	6.170***	3.139***	5.489***	118.72***
	(0.641)	(0.642)	(1.444)	(0.652)	(1.462)	(25.866)
REP (U)	−0.007	−0.008	0.082	−0.005	0.087*	−0.264
	(0.020)	(0.201)	(0.051)	(0.020)	(0.051)	(0.715)
REP (L)	−0.005	−0.005	0.173	−0.002	0.026	0.168
	(0.018)	(0.018)	(0.046)	(0.018)	(0.047)	(0.669)
No. obs.	1911	1911	1911	1911	1911	1911
R^2	0.270	0.274	0.243	0.286	0.251	0.260

Column 1 refers to the 1st stage regressions in model 2 in Table 2. Columns 2 and 3 refer to model 3 in Table 2; columns 4 through 6 refer to model 4 in Table 2. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

by giving projects to at least half of her House districts. Thus, a coalition of $\alpha n \tau$ House districts guarantees a minimal winning coalition in the Senate.

Proof of proposition In equilibrium, the agenda setter selects $\alpha n \tau$ district projects of total value G that will maximize her payoff. Note that the agenda setter effectively shares in the projects of other coalition members because she keeps the bargaining surplus through side payments. This means selecting a set of projects $(x_1, x_2, \ldots, x_{\alpha n \tau})$ to maximize the sum of

Table 9 Alternative marginal effects

Specifications	Table 2		Table 3	
	Column 3	Column 5	Column 3	Column 5
Panel A: Marginal effects of House-to-Senate seat ratio				
Supermajority present	765.8**	1189.3**	675.3**	1056.1**
	(319.8)	(492.3)	(320.7)	(495.5)
Specifications	Table 2		Table 3	
	Column 4	Column 6	Column 4	Column 6
Panel B: Marginal effects of supermajority rules				
Line-item veto present	1778.5***	2651.0***	1226.6***	1845.1***
	(481.9)	(716.4)	(408.1)	(621.9)
All states	2046.5***	3066.3***	1505.8***	2257.8***
	(568.4)	(867.5)	(446.8)	(681.4)

Marginal effects of supermajority rules are evaluated at the mean of Ratio and Upper. Cluster-robust standard errors are reported in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

the utilities of all coalition House districts. A coalition House member's utility can be written as:

$$u_i = u(x_i) - \frac{(x_1 + x_2 + \cdots + x_{\alpha n \tau}) \cdot p}{n\tau}$$

where $u(x_i)$ is the value of x_i to the ith coalition House member.[35] Summing this across all $\alpha n \tau$ coalition House members, we have:

$$U = \sum_{i=1}^{\alpha n \tau} \left[u(x_i) - x_i \cdot p \cdot \alpha \right]$$

Maximizing U gives the first-order conditions: $u'(x_i) = p \cdot \alpha, \forall i \in (1, \ldots, \alpha n \tau)$. These imply that $x_i^* = x(p \cdot \alpha)$ for all i. Since each of $\alpha n \tau$ legislators gets x_i^*, the total government expenditures G can be written as $p \cdot \alpha \cdot n \cdot \tau \cdot x(p \cdot \alpha)$. □

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[35] By standard assumption, u is concave and increasing in x_i.

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