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LEGISLATIVE REPRESENTATION, BARGAINING POWER, AND THE DISTRIBUTION OF FEDERAL FUNDS: EVIDENCE FROM THE U.S. SENATE

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ABSTRACT

While representation in the U.S. House is based upon state population, each state has an equal number (two) of U.S. Senators. Thus, relative to the state delegations in the U.S. House, small population states are provided disproportionate bargaining power in the U.S. Senate. This paper provides new evidence on the role of this small state bargaining power in the distribution of federal funds using data on projects earmarked in appropriations bills between 1995 and 2003. Relative to earmarks secured in House appropriations bills, Senate earmarks exhibit a small state advantage that is both economically and statistically significant. The paper also examines two theoretically-motivated channels through which this small state advantage operates: increased proposal power through appropriations committee representation and the lower cost of securing votes due to smaller federal tax shares. Taken together, these two channels explain over 80 percent of the measured small state bias. Finally, a welfare analysis demonstrates the inefficiency of hte measured small state bias.

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1 Introduction

In the U.S. Senate, each state has two delegates regardless of state population, providing small population states with disproportionate representation on a per-capita basis.[1] Wyoming, the state with the smallest population, currently has over 70 times the per-capita representation of California, the state with the largest population. This divergence is expected to become only more severe in the coming years; according to projections by the Census Bureau, three of the largest states by current population measures (California, Texas, and Florida) are also expected to be among the fastest growing states. While Senate delegations are fixed, delegation sizes in the U.S. House, by contrast, are much more closely aligned with state population and are adjusted every ten years to reflect changes in population across states.

Many have hypothesized that this disproportionate political power for small states in the U.S. Senate should translate into higher levels of federal spending being located in these states. More specifically, researchers have investigated a possible link between per-capita federal spending and per-capita representation in the U.S. Senate. While both Atlas et. al. (1995) and Lee (1998) report statistically significant relationships, the magnitude of these relationships are relatively weak from an economic perspective.

This paper provides several contributions to this existing literature. First, unlike the existing literature, the hypothesized relationship between representation and the distribution of federal funds is formally derived from a theoretical legislative bargaining model modified to allow for variable delegation sizes. Due to the common pool tax base, which provides incentives for agenda-setters to minimize coalition sizes, and the disproportionate political power afforded small states in the U.S. Senate, the theoretical model predicts a bargaining advantage for small states, defined as a positive relationship between delegates per-capita and federal spending per-capita. In addition, this model provides a theoretical foundation for the per-capita normalizations that have been employed in the existing literature. The model also identifies two channels underlying this small-state bargaining advantage: after adjusting for

[1] Of course, other central legislatures, such as those of Brazil and the European Union, also provide small jurisdictions with representation disproportionate to their populations.

population differences, small states are both more likely to be represented on relevant Congressional committees (the proposal-power channel) and are more attractive coalition partners due to their lower federal tax liabilities (the vote-yield channel). Given that measures of these two underlying channels are readily available, one can empirically gauge the relative contribution of these two factors to a small-state bargaining advantage in the U.S. Senate. Finally, a welfare analysis examines the efficiency properties of the observed small state bias.

In addition to these theoretically-based contributions, the project-based data on the cross-state allocation of federal funds are richer than those used in previous studies and thus afford several empirical contributions. First, previous studies have tended to use highly aggregated data that include federal spending programs, such as Social Security, that are difficult for Congressional delegations to geographically manipulate. The projects studied here were earmarked in Congressional appropriations bills and were thus more easily manipulated by delegations, providing more accurate estimates of small state bias in the U.S. Senate. While these types of projects seem a reasonable focus in a test for the effects of Senate representation, it is important to note that the results in this paper can be generalized to only the subset of federal spending programs for which Congress has significant influence over the geographic allocation. Regarding the second empirical contribution, the data identify a sponsoring chamber (House or Senate), allowing for more accurate estimates of the small-state bias in the U.S. Senate as well as a means for controlling for unobserved state characteristics. Using this previously untapped data source, the preliminary results demonstrate relationships between per-capita federal spending and per-capita Senate representation that are much stronger than those found using the data and methods in the existing literature.

This paper also provides a justification, at least in part, for recent worldwide movements towards decentralization of the public sector. If political factors, rather than economic fundamentals, determine the geographic allocation of public goods under centralized provision, public goods may be over-provided in politically powerful states (small states in this instance) and under-provided in politically weak states. Thus, the centralized provision of local public goods may entail inefficiencies. Under decentralized provision, by contrast, states are forced to fully internalize tax costs associated with spending in their jurisdictions and thus more appropriately weigh the economic costs and benefits of spending on public goods.[2] Of course, this advantage of decentralization must be balanced against any disadvantages of decentralization, such as possible inefficiencies resulting from cross-state externalities.

2 Related Literature

Atlas et. al. (1995) report a statistically significant relationship between per-capita representation in the U.S. Senate and per-capita federal spending in an econometric analysis of aggregate federal spending, as reported in Census data, between 1972 and 1990. This result is robust across several spending categories, including defense and entitlements. Unfortunately, the article does not provide summary statistics for the key empirical measures and thus one cannot gauge the economic significance of these results. To address this limitation, I will conduct an analysis using similar data and methods in order to compare their results with my results.

Lee (1998) tests for a small state advantage using data from the U.S. Domestic Assistance Programs Database, as compiled by Bickers and Stein (1991). These data contain federal spending by Congressional districts, although the author aggregates up to the state level in order to focus on differences in per-capita Senate representation. While the study finds statistically significant evidence of a small state bias, the economic relationship between redistributive spending and Senate representation is fairly weak, as I calculate the elasticity (evaluated at sample means) to be less than 0.01. In an analysis of 12 functional policy areas, six provide evidence of a statistically significant relationship and the implied elasticities are again small, ranging from -0.05 to 0.10.

Two additional papers have examined the effect of representation in other legislative settings. Rodden (2001) finds a connection between votes per-capita and net transfers per-capita in the European Union. Ansolabehere, Gerber, and Snyder (2000) find that *Baker v. Carr*, which forced state legislatures to switch from unit representation, as found in the U.S. Senate,

[2] See Inman and Rubinfeld (1997, 1999), Besley and Coate (2003), and Lockwood (2002).

to population-based representation, significantly altered the flow of state transfers to county governments. The authors calculate that, as a result of this ruling, approximately $7 billion were diverted annually from formerly over-represented counties to formerly under-represented counties.

3 Theoretical framework

3.1 Economic environment

Consider a collection of S states with a total national population equal to N. In a given state (s), each of N_s residents is assumed to have quasilinear preferences over consumption of a local public good (G_s) and consumption of a private good (z_s):

$$U(g_s, z_s) = h(G_s/N_s^{\gamma}) + z_s \tag{1}$$

Preferences over public goods $[h(G_s/N_s^{\gamma})]$ are assumed to be increasing and concave and are normalized such that zero utility is obtained from zero spending $[h(0) = 0]$. The congestion parameter $[\gamma \in [0, 1]]$ captures the degree of rivalry in consumption; this specification nests the case of private goods $(\gamma = 1)$ as well as the case of pure public goods $(\gamma = 0)$. Each resident in state s is endowed with m_s units of the private good, which can be converted into public goods at a dollar-for-dollar rate.

3.2 Political environment

A central legislature determines the distribution of local public goods from a fixed budget (G). In the legislature, each state has a delegation of size V_s, and the total number of delegates (V) is given by $V = \sum_s V_s$. Public goods are financed from a national, or common pool, tax base, and, for simplicity, per-capita federal tax prices are assumed to be equal across the federation $(p_s = 1/N)$; the more general case of cross-state heterogeneity in federal tax prices will be examined in the empirical section. Finally, private consumption is determined residually

($z_s = m_s - p_s G$).

The political process is modeled as a version of the legislative bargaining model due to Baron and Ferejohn (1987 and 1989) and Persson and Tabellini (2002). In the first stage, a single delegate is chosen, each with equal probability $1/V$, to be the agenda-setter. Denote the home state of the agenda setter as $s = a$. This agenda-setter then proposes a geographic distribution of the federal budget, subject to a balanced budget condition ($\sum_s G_s \leq G$). In the second stage, each delegate votes over whether to accept or reject the proposed budget. If the proposal receives a majority of votes from delegates in support, it is implemented; otherwise, a reversion distribution of zero spending is implemented. This assumption of a zero reversion budget is stronger than is required but is made to simplify the analysis; in addition, this assumption seems reasonable in the empirical analysis of spending on new projects, for which a zero reversion seems natural.

3.3 Equilibrium

Working backwards, and using the assumption that zero spending provides zero utility [$h(0) = 0$], each delegate will support proposals for which the total benefits accruing to a representative constituent exceed the associated tax costs:

$$h(G_s/N_s^\gamma) \geq p_s G = G/N \tag{2}$$

Given that, within a state, delegates use equivalent voting rules, the minimum total cost (C_s) and per-capita cost ($c_s = C_s/N_s$) to the proposer, expressed as a fraction of the total budget, of securing votes from all of the delegates of state s can be expressed as follows:

$$C_s = \beta N_s^\gamma \tag{3}$$

$$c_s = \beta N_s^{\gamma-1} \tag{4}$$

where $\beta = h^{-1}(G/N)/G$. In forming a majority coalition (M_a), the agenda-setter, taking voting rules as given, has an incentive to select as partners delegates from those states with the highest vote yield, which is defined as the ratio of delegation sizes to the total cost of securing all of the votes from a given delegation:

$$\frac{V_s}{C_s} = \frac{V_s}{\beta N_s^{\gamma}} \tag{5}$$

As shown, vote yields are increasing in the number of delegates and are decreasing in population so long as some congestion is present ($\gamma > 0$). Under the special case of perfectly congestible public goods ($\gamma = 1$), vote yields are proportional to delegates per-capita, suggesting one channel through which a small state bias, as typically measured in the empirical literature, in the U.S. Senate may operate.

At the agenda setter's optimal proposal, expected per-capita budget shares ($g_s = G_s/GN_s$) can be summarized as follows:

$$E(g_s) = \underbrace{\frac{V_s}{V}}_{\Pr(s=a)} \underbrace{\frac{\delta_s}{N_s}}_{E(g_s|s=a)} + \underbrace{(1 - \frac{V_s}{V})}_{\Pr(s\neq a)} \underbrace{\sum_{k\neq s} \frac{V_k}{V - V_s} 1(s \in M_k)\beta N_s^{\gamma-1}}_{E(g_s|s\neq a)} \tag{6}$$

where the share accruing to the agenda-setter's state is given by $\delta_s = 1 - \sum_{k \in M_s} \beta N_k^{\gamma}$, and $1(s \in M_k)$ indicates whether or not state s would be included in a coalition formed by an agenda setter representing state k.

Given the empirical focus on the U.S. Senate, consider next the special case of equal delegation sizes ($V_s = V/S$); note that populations (N_s) and thus delegates per-capita $[v_s = V_s/N_s]$ continue to vary across states. In the case of equal delegation sizes, each state has an equal probability of being represented by the agenda setter, coalitions are nearly identical, and per-capita payments can be summarized as follows:[3]

$$E(g_s) = \frac{\delta V_s}{N_s V} + (1 - \frac{V_s}{V})\beta N_s^{\gamma-1} 1\left[V_s/N_s^{\gamma} > \text{median}\left(V_k/N_k^{\gamma}\right)\right] \quad (7)$$

where the median is taken across all states. Next, using the fact that $V_s = V/S$, $N_s = V/Sv_s$, and median$(f(x)) = f(\text{median}(x))$ if the function f is monotonic, per-capita federal spending can be expressed solely as a function of delegates per-capita:

$$E(g_s) = \frac{\delta v_s}{V} + (\frac{S-1}{S})\beta(V/S)^{\gamma-1} v_s^{1-\gamma} 1\left[v_s > \text{median}\left(v_k\right)\right] \quad (8)$$

As shown in equation 8, as well as in Figure 1, the model predicts that disproportionate representation by small states in the U.S. Senate confers a small-state bargaining advantage as expected per-capita federal spending is strictly increasing in per-capita representation. The linear portion of the relationship reflects the increase in the probability of selection as the agenda-setter given an increase in per-capita delegation sizes, while the jump reflects the guarantee of inclusion in the majority coalition as delegates per-capita moves beyond its median value. Beyond the median value, the slope incorporates both the increased probability of selection as the agenda setter as well as the higher per-capita cost of obtaining a states' votes (note that $c_s = \beta N_s^{\gamma-1} = \beta(V/S)^{\gamma-1} v_s^{1-\gamma}$). This figure demonstrates that the bargaining advantage afforded small states in the U.S. Senate can be decomposed into two underlying channels: a proposal-power channel and a vote-cost channel. The role of these two underlying channels will be analyzed more completely towards the end of this paper.

3.4 Alternative Political Environment

This section considers the robustness of this theoretical prediction of the legislative bargaining model. In particular, an alternative political process, namely the universalism model of

[3] Coalitions are identical except that the inclusion of the state with median vote yields depends upon the identity of the agenda-setter. The median state will be included/excluded if agenda setter's state is below/above the median. With a sufficiently large number of states, the role of this one state will be small. For simplicity, the expressions abstract from the role of this one state.

Weingast, Shepsle, and Johnsen (1981), is shown to also predict a small state bias. In the universalism model, the total budget size (G) is endogenous, and state delegations, acting independently, increase spending on the local public good until marginal benefits are equal to marginal costs:

$$h'(G_s/N_s^\gamma)/N_s^\gamma = 1/N \tag{9}$$

Solving this equation for G_s yields the following expression:

$$G_s = N_s^\gamma f(N_s^\gamma/N) \tag{10}$$

where $f(x) = [h'(x)]^{-1}$. Note two key properties of this inverse function: $f(x) > 0$ and $f'(x) = 1/h''(f(x)) < 0$. In order to demonstrate the small state bias predicted by the universalism model, federal spending is next converted to a per-capita basis:

$$g_s = N_s^{\gamma-1} f(N_s^\gamma/N)/G \tag{11}$$

Next, using the fact that $N_s = V/Sv_s$, delegation demands can be written solely as a function of delegates per-capita:

$$g_s = (V/S)^{\gamma-1} v_s^{1-\gamma} f((V/S)^\gamma v_s^{-\gamma}/N)/G \tag{12}$$

Thus, this model also predicts a positive relationship between per-capita federal spending and delegates per-capita; that is, $\partial g_s/\partial v_s > 0$. Note that, in this model, which has no explicit political process, the small state bias result is driven purely by differences in population, as opposed to differences in representation; in aggregate, small states have lower federal tax liabilities and thus are more responsive to common pool incentives.

4 Data

4.1 Project Spending Data

In order to test for a small state bias in the U.S. Senate, I use data from several sources. The main source of data on federal spending is provided by the Citizens Against Government Waste (CAGW), a private, non-partisan, non-profit organization that, for several years, has catalogued funds for projects that were earmarked in annual appropriations bills. The data are currently available on CAGW's website for fiscal years 1995-2003. For each of the 37,336 catalogued projects, data include 1) the state in which the project is to be located, 2) the dollar amount appropriated, 3) relevant appropriations bill (Congress appropriates funds through 13 separate bills each fiscal year), and 4) the sponsoring chamber (i.e. the chamber, House or Senate, responsible for the appropriation).

As shown in Table 1 and Figure 2, Congressional earmarks are an important component of federal spending; the 9,362 projects listed in the fiscal year 2003 appropriations bills totaled $23 billion. Moreover, as shown, these appropriations earmarks have increased over time, rising from about $13 billion in fiscal year 1995.

For the purposes of the econometric analysis, I focus on the subset of projects for which the relevant state is listed. To provide a sense of the types of projects funded, Table 2 lists the largest projects, those with appropriations in excess of $60 million in 2003 dollars. As shown, the three largest projects were all included in the Defense appropriations bill, were sponsored by the Senate, and were located in Mississippi, a relatively small state and also the home state of Sen. Trent Lott, who served as Senate Majority Leader during the period in which the projects were funded. The remaining projects listed span a wide variety of states, appropriations bills, and sponsoring chambers.

To provide a broader sense of spending categories, Table 3 and Figure 3 detail the number of projects and total funding by appropriations bill over this time period. As shown, military construction and transportation appropriations bills provided the most funding, followed by VA/HUD, defense, and energy. The District of Columbia, foreign operations, legislative, and Treasury provided, perhaps not surprisingly, the least project funding.

Table 4 and Figure 4 provide a breakdown of project spending by sponsoring chamber, one of the key variables in the econometric analysis. As shown, Senate projects provided the most funding, at $20 billion, followed by House projects, which funded just over $13 billion. Conference committees added a smaller amount, and the CAGW did not classify an additional $9 billion in project spending (presumably due to missing or ambiguous data).

4.2 Additional data sources

For comparability with the existing literature, which has tended to use highly aggregated data, I also analyze data from the Consolidated Federal Funds Reports, an annual Census Bureau publication on the cross-state allocation of federal outlays. Spending programs include retirement and disability, grants, procurement, salaries and wages, and other direct payments. For comparability with the CAGW data, I use fiscal years 1995-2002; at the time of this writing, data from fiscal year 2003 were unavailable. Unlike the CAGW data, the Census data provide neither a sponsoring chamber nor a relevant appropriations bill.

In order to convert these measures of federal funding to a per-capita basis, as motivated by equation 8 in the theoretical model, data on population by year from the Census Bureau are incorporated into the analysis. Although the Census is only conducted every 10 years, the Census Bureau provides annual estimates of population by state; populations are estimated as of July 1 of the relevant year.

5 Measuring Small State Bias

Table 5 provides preliminary results of tests for the presence of a small-state bargaining advantage in the U.S. Senate. For comparability with the existing literature, I first analyze aggregated Census data and estimate the following simple linear equation relating per-capita federal spending to per-capita representation:

$$g_{st} = \alpha + \beta_1 v_{st}^{SENATE} + \beta_2 v_{st}^{HOUSE} + u_{st} \tag{13}$$

where s indexes states, t indexes time, and u_{st} represents unobserved determinants of the geographic distribution of per-capita federal spending. As shown in column 1, an extra Senator is associated with an extra 0.02 percentage point share of federal spending. While statistically significant, this relationship is economically weak; the implied elasticity of federal spending with respect to representation is just 0.05. The coefficient associated with representatives per-capita in the U.S. House is also statistically significant, and the regression has non-negligible explanatory power, as the R-squared equals 0.1107.

There are several possible explanations for this economically weak relationship between per-capita federal spending and the number of Senators per-capita. I address and attempt to empirically account for three such explanations below. First, for institutional reasons, it may be difficult to geographically manipulate many types of federal spending in the Census data, such as Social Security payments, veterans payments, Medicaid, and Medicare. The second column addresses this concern by focusing on CAGW projects, whose geography was more easily manipulated by Congressional delegations. As shown, an extra Senator is associated with a 0.44 percentage point share of federal spending, and this relationship is statistically significant. These results imply an elasticity of spending per-capita with respect to Senate representation of 0.54, a significantly stronger result than that using the Census data in column 1. As expected, data on CAGW project spending, which, relative to other types of federal spending, is more easily manipulated by Congressional delegations, provide stronger evidence for a small-state bargaining advantage in the U.S. Senate. Relative to the Census data results, the R-squared is somewhat higher using the CAGW data, and representatives per-capita in the U.S. House does not have a statistically significant effect.

Even with this data on highly manipulable project spending, it may prove difficult to isolate the effect of Senate representation from other factors. In addition to the U.S. Senate, several other political agents play a role in the geographic distribution of funds associated with federal projects. The executive branch often proposes projects in its own budget documents and also has veto power over appropriations bills. In addition, the U.S. House passes their own version of appropriations bills; House and Senate versions are then reconciled in conference committees, which are composed of members from both chambers. To better isolate the effects of Senate representation, I next focus on the subset of projects that were identified by the CAGW as

Senate-sponsored. While these projects would also have to be approved by the U.S. House and signed into law by the President, such projects seem the source of funds most likely to reflect differences in Senate representation. In this case, the estimated model is very similar to that above, although representatives per-capita is excluded from the specification:

$$g_{st} = \alpha + \beta_1 v_s^{SENATE} + u_{st} \tag{14}$$

As shown in column 3, as well as in Figure 5, Senators per-capita again has a statistically significant effect and the implied elasticity is 0.95, up significantly from 0.54 in column 2. By focusing solely on Senate-sponsored projects, the effect of Senate representation on the geographic distribution of federal funds becomes even more apparent.

The final innovation of this empirical analysis involves the role of unobserved state characteristics. States with high per-capita representation in the Senate are concentrated in the Rocky Mountain states, such as Wyoming, Montana, North Dakota, and South Dakota. These states are considered outliers across many dimensions; they tend, for example, to be more rural, conservative, and agriculture-based. Without controlling for these unobserved characteristics, any measured relationship, or lack thereof, between Senate representation and the distribution of federal funds may reflect the role of these unobserved, correlated factors, rather than the role of representation in the Senate itself. To address this omitted variable bias, column 4 includes observations on both Senate-sponsored projects and House-sponsored projects, allowing for the inclusion of state fixed effects.[4] The estimating equation in this instance is given as follows:

$$g_{stc} = \alpha_s + \beta_1 v_{sct} + u_{stc} \tag{15}$$

where c indexes chambers and α_s captures the state fixed effects. In this case, identification is driven by within-state variation in per-capita delegation sizes between the House and the Senate. As shown, after controlling for unobserved state factors, delegates per-capita has a strong and statistically significant effect on the distribution of per-capita federal spending, and

[4] House delegation sizes are normalized to Senate delegation sizes; that is, House delegations are divided by 4.35.

the economic relationship becomes even stronger, as the implied elasticity rises to 1.04. Taken together, the regression results in columns 2-4 provide strong evidence of a link between per-capita delegation sizes and federal spending per-capita, thus providing strong support for the existence of a small-state bargaining advantage in the U.S. Senate.

These results in column 4 rest upon an implicit assumption of strategic independence across legislative chambers. Under this strategic independence assumption, the House and the Senate independently develop an allocation of projects, which are then simply merged during the conference committee, which reconcile the House and Senate appropriations bills. Unfortunately, I cannot directly test this implicit assumption as projects that were removed during the conference committee are excluded from the CAGW data. As an alternative to this direct test, I conducted a case study of the fiscal year 2003 Military Construction appropriations bill. Based upon an analysis of projects included in the initial House bill, the initial Senate bill, and the final conference bill, over 80 percent of projects included in the House and Senate bills were also included in the conference version. The large proportion of projects funded is consistent with this implicit assumption of strategic independence across chambers. Note that, even if the assumption of strategic interdependence were violated, the results in column 2, which were based solely on the cross-state variation in project spending, would remain valid.

6 Underlying Channels and Welfare Analysis

I build upon this strong evidence of a small-state bargaining advantage in the U.S. Senate with an analysis investigating two underlying channels, or sources, of a small-state bargaining advantage as identified by the theoretical model: the proposal-power channel and the vote-yield channel. In addition, this estimation approach permits an efficiency analysis of the observed small state bias.

6.1 Econometric Model

In order to derive an empirical version of this model, one must specify a functional form for utility from consuming public goods $[h(G_s/N_s^{\gamma})]$; for tractability purposes, consider a simple Cobb-Douglas parameterization:

$$h(G_s/N_s^{\gamma}) = \left(\frac{G_s}{\theta \xi_s N_s^{\gamma}}\right)^{\alpha} \tag{16}$$

where the parameter $\alpha \in (0,1)$ captures the diminishing marginal utility from consuming public goods, $\theta > 0$ captures common, or nationwide, preferences for private goods, relative to public goods, and $\xi_s > 0$ captures heterogeneity across states in preferences for private goods; this heterogeneity is assumed to be observed by representatives in the legislature but not by the econometrician.

For empirical purposes, we allow for cross-state variation in per-capita tax prices (p_s); the previous analysis focused on the special case of homogenous tax prices ($p_s = 1/N$). Under this specification, vote costs, per-capita vote costs, and vote yields are given as follows:

$$C_s = \widetilde{\theta} N_s^{\gamma} p_s^{1/\alpha} \xi_s \tag{17}$$

$$c_s = \widetilde{\theta} N_s^{\gamma-1} p_s^{1/\alpha} \xi_s \tag{18}$$

$$V_s/C_s = \widetilde{\theta}^{-1} V_s N_s^{-\gamma} p_s^{-1/\alpha} \xi_s^{-1} \tag{19}$$

where $\widetilde{\theta} = \theta G^{(1-\alpha)/\alpha}$. Next, in order to highlight the various channels, consider expected per-capita federal payments (conditional on the identity of the agenda-setter) and the probability of inclusion in the coalition:

$$E(g_s) = \underbrace{\delta 1(s=a)/N_s}_{\text{Proposal-power channel}} + \underbrace{\widetilde{\theta} 1(s \neq a) N_s^{\gamma-1} p_s^{1/\alpha} \mathrm{E}(\xi_s | s \in M)[\Pr(s \in M)]}_{\text{Vote-cost channel}} \tag{20}$$

$$\Pr(s \in M) = \Pr\left[\ln(\xi_s) < \ln(V_s) - \gamma \ln(N_s) - (1/\alpha)\ln(p_s) - \eta\right] \tag{21}$$

where η, a constant, incorporates the delegates per-capita cutoff level for inclusion in the agenda-setter's coalition. In equation 20, which is derived directly from the theoretical model, per-capita federal spending is expressed as non-linear function of four exogenous, measurable variables: 1) committee representation, 2) per-capita federal tax prices, 3) state populations, and 4) delegation sizes.[5]

Measures of delegation sizes, which vary across states in the U.S. House, and population are those used in the previous section. In order to construct a measure of federal tax prices (p_s), I have obtained state-specific estimates of U.S. federal tax liabilities for the relevant fiscal years from the Tax Foundation.[6] For the agenda-setter variable, I use data regarding membership on House and Senate Appropriations committees, which had significant control over the appropriations process. Given that the CAGW data on project spending also include the relevant appropriations bill, I have also constructed measures of membership on the 13 appropriations subcommittees, each of which has jurisdiction over an appropriations bill. With 13 appropriations subcommittees, 2 chambers (House or Senate), 9 years, and 50 states, the total sample size is 11,700; after eliminating appropriations bills with zero or negligible spending, the remaining sample size is 7,050.

For purposes of empirical implementation, the estimating equations 20 and 21 are further modified in two ways. The first modification assumes a log-normal distribution for unobserved preferences:

$$\ln(\xi_j) \sim N(0, \sigma^2) \tag{22}$$

For the purposes of this econometric analysis, this lognormal distribution exhibits a useful property:

[5] Note that per-capita federal spending is non-linear in delegates per-capita. Thus, the empirical estimates of equation 20 will be more closely aligned with the theoretical model than were those in the reduced form analysis, which assumed a linear relationship between per-capita federal spending and delegates per-capita.

[6] Denote T_s the total federal tax collections from a given state. These collections are converted into per-capita tax prices using the equation $p_s = (T_s/N_s)/\sum_k T_k$.; these tax prices sum to one nationally.

$$\mathrm{E}(\xi_s|\xi_s < a) = \frac{\exp(\sigma^2/2)\Phi[(\ln(a)/\sigma) - \sigma]}{\Pr(\xi_s < a)} \tag{23}$$

where Φ is the cumulative distribution function for the standard normal distribution. The second modification accounts for the fact that agenda setting powers in the appropriations process are conferred upon committees, rather than a single agenda setter. Denote A as the committee, $A_s = 1(s \in A)$ as a dummy variable indicating state representation on the committee, N_A as the size of the committee, and $a_s = A_s/N_sN_A$ as adjusted per-capita committee representation. Finally, assuming both efficient bargaining (within committees) and an equal sharing rule (within committees), equations 20 and 21 can be re-written as follows:

$$E(g_s) = \delta a_s + \widetilde{\theta}(1-A_s)N_s^{\gamma-1}p_s^{1/\alpha}\exp(\sigma^2/2)\Phi\left[(1/\sigma)\ln(V_s) - (\gamma/\sigma)\ln(N_s) - (1/\alpha\sigma)\ln(p_s) - \eta/\sigma - \sigma\right] \tag{24}$$

$$\Pr(s \in M) = \Phi\left[(1/\sigma)\ln(V_s) - (\gamma/\sigma)\ln(N_s) - (1/\alpha\sigma)\ln(p_s) - \eta/\sigma\right] \tag{25}$$

The parameters of equation 24 and 25 are estimated using a two-step approach. In the first stage, I estimate a subset of the parameters $(\gamma, \alpha, \sigma, \eta)$, those of equation 25, through a Probit analysis of inclusion in the coalition for non-committee members. Using these four parameter estimates, I then estimate the final two parameters $(\delta, \widetilde{\theta})$ through an OLS regression of per-capita shares (g_s) on committee membership (a_s) and the constructed variable in equation 24: $(1 - A_s)N_s^{\gamma-1}p_s^{1/\alpha}\exp(\sigma^2/2)\Phi\left[(1/\sigma)\ln(V_s) - (\gamma/\sigma)\ln(N_s) - (1/\alpha\sigma)\ln(p_s) - \eta/\sigma - \sigma\right]$.

In order to account for both possible within-state correlations in the sample and the increased uncertainty from including a generated regressor in the second stage regression, bootstrap standard errors are reported. These standard errors are based upon 100 bootstrap replications and are clustered at the state level.

6.2 Parameter Estimates

As shown in Table 6, the predictions of the model are largely supported in the data. More specifically, four of the five coefficients have the signs predicted by equations 24 and 25. Regarding the first-stage coefficients, states costly to include in the coalition, namely those with high tax prices, are less likely to be included in the coalition. There is less evidence that small population states are more likely to be included in the coalition as this coefficient is statistically insignificant. Conditional on population, states with larger delegations are more likely to be included in the coalition, supporting this theoretical hypothesis. As shown in the second stage results, states represented on the appropriations subcommittee receive significantly more funds, demonstrating the value of proposal power. Also, states more likely to be included in the coalition, as captured by the constructed variable, also receive significantly more funds than do other states.

One important caveat of this baseline analysis involves endogenous committee representation. In particular, state delegations may self-select onto appropriations subcommittees with jurisdiction over policy areas for which their state has a strong preference. The obvious approach to addressing such self-selection concerns is the inclusion of state by appropriations bills fixed effects. Unfortunately, several of the variables in equation 24, such as tax prices and state population, vary almost exclusively across states. In order to address the concern of endogenous committee representation, columns 3 and 4 of Table 6 report results from simple OLS regressions of per-capita federal spending on per-capita committee representation (excluding the constructed variable). As shown, the results from column 4, which includes state by appropriations bills fixed effects, suggest a slightly smaller effect of proposal power but are similar in sign and magnitude to those of column 3, which do not include fixed effects. The similarity in these two coefficients suggests that endogeneity alone is not driving the positive coefficient on committee representation in column 2.

6.3 Policy Simulations

As noted above, these parameter estimates are then used to provide two insights into the small state bias measured in section 5. First, using the coefficients and regressors from the second stage regression, I decompose per-capita federal spending into three components: the proposal-power channel, the vote-cost channel, and a residual. By definition, these three components sum to observed per-capita federal spending. I then regress each of these components on delegates per-capita; these regressions are analogous to the specifications measuring the small state bias in Table 5. As shown in Table 7, the proposal-power and vote-cost channels each explain 43 percent of the small state bias, leaving only 14 percent unexplained. The interpretation of these proportions follows: were representation on the Senate appropriations committee determined by state population rather than delegation sizes, the observed small state bias would fall by 43 percent. A similar interpretation is possible for the vote-cost channel.

The second simulation, using a subset of the parameters (α, γ), calculates the Samuelson allocation, that chosen by a central planner maximizing a population-weighted utilitarian social welfare function $[W = \sum_s N_s h(G_s/N_s^{\gamma})]$. These parameter estimates, as implied by the two-stage coefficients, are displayed in Table 8; as shown, all except the congestion parameter fall within their assumed range.[7] As shown in the upper panel of Figure 6, this optimal allocation exhibits a *large-state bias*, a positive correlation between per-capita federal spending and population. Equivalently, as shown in the bottom panel, the Samuelson allocation exhibits a negative correlation between per-capita federal spending and Senators per-capita. This result demonstrates the inefficiency of the documented small-state bias and suggests that, if anything, large states should be over-represented in central legislatures.[8] To provide intuition for this result, consider first the extreme case of constant marginal utility from consumption of public goods ($\alpha = 1$); in this case, so long as public goods are not perfectly congestible ($\gamma < 1$), social welfare is maximized by concentrating all spending in the state with the largest number

[7] For the purposes of this simulation, the stochastic component of the model is set to zero ($\sigma = 0$).

[8] Of course, this result is dependent on the assumed social welfare function; maximization of an unweighted social welfare function, for example, may result in the optimality of a small-state bias.

of users, or residents. The introduction of diminishing marginal utility from consumption ($\alpha < 1$) mitigates, but does not eliminate, this large-state bias. Thus, while the estimated congestion parameter is close to zero, the efficiency of the large state bias requires only that the congestion parameter be less than one.

One caveat involves cross-state spillovers, which are not incorporated into this welfare analysis. To the extent that spending in geographically small states, such as Rhode Island, generates more benefits for neighbors of bordering states than does spending in geographically large states, the case for the efficiency of a large state bias is overstated. However, small states on a geographic basis are not necessarily small states on a population basis. In fact, the correlation between state square miles and state population is only 0.1 and is not statistically different from zero.

A related issue of interpretation involves the concentration of project benefits within states. In particular, many of these projects are not statewide public goods but are local public goods within the state, suggesting that all residents of large states, such as California, may not benefit from project spending. This property of project spending would also weaken the case for the efficiency of a large state bias. However, given that large population states are also more densely populated than are small population states (and so long as congestion is incomplete), more residents from large population states will benefit from project spending with localized benefits, relative to smaller population states. Thus, the concentration of project benefits within states may weaken somewhat, but does not eliminate, the efficiency of a large state bias.

7 Conclusion

This paper has provided a theoretical and empirical analysis of a small-state bargaining advantages in the U.S. Senate. A legislative bargaining model, modified to allow for heterogeneous delegation sizes, demonstrates this bargaining advantage, expressed as a positive relationship between per-capita delegation sizes and per-capita federal spending. Two estimable underlying channels of a small-state bargaining advantage in the U.S. Senate are then theoretically identified: the proposal-power channel and the vote-yield channel.

The empirical analysis, which is based upon project spending in Congressional appropriations bills, provides several contributions to the literature. The project-based data are highly manipulable by Congressional delegations, thus providing more accurate estimates of a small-state bargaining advantage in the U.S. Senate. In addition, the data identify a sponsoring chamber (i.e. House or Senate), again allowing for more accurate estimates of this bargaining advantage as well the inclusion of state fixed effects, which control for unobserved state characteristics. Using this rich data source, the preliminary results demonstrate relationships between per-capita federal spending and delegates per-capita that are economically significant, statistically significant, and much stronger than those found in the existing empirical literature. Simulations demonstrate that the two theoretically-motivated underlying channels, taken together, explain over 80 percent of the measured small-state bias. Finally, a welfare analysis, which is based upon Samuelson conditions for the optimal allocation of local public goods, demonstrates the inefficiency of the observed small-state bias.

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Table 1: Total Project Appropriations by Fiscal Year

Fiscal year	Number of projects	Appropriations (billions of $2003)
1995	1439	$12.8
1996	958	$10.1
1997	1596	$16.3
1998	2143	$14.6
1999	2838	$13.1
2000	4326	$18.6
2001	6333	$19.0
2002	8341	$20.0
2003	9362	$22.5

Table 2: Largest Projects in CAGW data

(among those projects with state listed in project description)

State	Cost	Approp.	FY	Chamber	Description (abbreviated)
MS	$807,579,462	DEF	1998	S	DDG-51 (Ship Building and Conversion - Navy)
MS	$473,415,592	DEF	2001	S	LHD-8 [LHD-1 Amphibious Assault Ship [MYP]
MS	$396,157,168	DEF	2000	S	LHD-1 Amphibious assault ship [MYP]
MO	$290,515,256	DEF	2000		F-15 [+5] (Aircraft Procurement - Air Force)
SC	$176,000,000	ENERGY	2003	S	Cleanup for the Savannah River Site
NY	$166,806,855	TREAS	1999		Brooklyn U.S. Courthouse (General Services Administration)
WA	$141,000,000	ENERGY	2003	S	Cleanup for the Hanford site Richland
GA	$122,843,359	DEF	1999	H	KC-130J (Aircraft Procurement - Navy)
MO	$120,000,000	DEF	2003	S	Purchase 2 additional aircraft [F/A-18E/F Hornet]
LA	$116,872,000	COM	2003	S	FCI Pollock (Buildings and Facilities - Federal Prison System)
NM	$113,000,000	ENERGY	2003	S	Microsystems and engineering science applications [MESA]
LA	$112,163,814	DEF	1998	H	LPD-17 [AP-CY] (Ship Building and Conversion - Navy)
ID	$105,000,000	ENERGY	2003	C	Idaho site (Environmental and Other Defense Related Activities)
AZ	$97,868,264	TREAS	1995		U.S. courthouse- Tucson ($69 million ABR)
FL	$94,001,400	TREAS	1999		Jacksonville U.S. Courthouse (General Services Administration)
CO	$91,759,836	TREAS	1999		Denver U.S. Courthouse (General Services Administration)
WV	$89,833,551	ENERGY	1995		Corridor H (Appalachian Regional Commission)
TX	$81,504,963	MILCON	1997		Family Housing Construction Improvements (Army)
AL	$80,875,521	DEF	1999	S	Space based laser demonstrator
AL	$79,245,653	DEF	2001	S	Procure HAB [Heavy Assault Bridge {HAB} SYS {MOD}]
FL	$74,028,117	INT	1998	S	Everglades National Park
OR	$70,000,000	TRANS	2003	H	Portland Interstate MAX Light Rail Extension
CO	$70,000,000	TRANS	2003	H	Denver Southeast Center LRT [T-REX]
WV	$66,600,000	COM	2003	S	Hazelton (Buildings and Facilities - Federal Prison System)
FL	$65,574,747	INT	1999		Grant to the state of Florida (National Park Service)
TN	$65,000,000	ENERGY	2003	S	East Tennessee Technology Park [ETTP]
WA	$63,000,000	ENERGY	2003	S	To accelerate cleanup of the River Corridor
UT	$61,749,860	TRANS	2001	H	Olympic Transit Program, Salt Lake City
IN	$61,494,000	MILCON	2003		Ammunition Demilitarization Facility (Phase V)

Table 3: Project Appropriations by Appropriations Bill
(among those projects with state listed in project description)

Appropriations bill	Number of projects	Appropriations (billions of $2003)
Agriculture	2076	$1.3
Commerce	2131	$2.8
District of Columbia	1	$0.0
Defense	576	$5.3
Energy	2965	$5.6
Foreign Operations	12	$0.0
Interior	1896	$2.3
Labor, HHS	4297	$2.6
Legislative	4	$0.0
Military Construction	1692	$10.7
Transportation	5149	$11.8
Treasury	153	$1.2
VA/HUD	5994	$5.3

Table 4: Project Appropriations by Sponsoring Chamber
(among those projects with state listed in project description)

Sponsoring chamber	Number of projects	Appropriations (billions of $2003)
Senate	8820	$19.6
House	6600	$12.7
Conference committee	8646	$7.5
Not listed	2883	$9.2

Table 5: Small State Bias in the U.S. Senate: Preliminary estimates

	(1)	(2)	(3)	(4)
Data description	Census	CAGW	CAGW	CAGW
spending included	all	all projects	Senate projects	House / Senate projects
Senators per capita	0.0002**	0.0044**	0.0097**	
	(0.0000)	(0.0005)	(0.0009)	
Representatives per capita	0.0023**	-0.0101		
	(0.0008)	(0.0115)		
Delegates per capita				0.0106**
				(0.0007)
Implied Senate elasticity	0.05	0.54	0.95	1.04
Observations	400	450	450	900
Fiscal Years	1995-2002	1995-2003	1995-2003	1995-2003
State fixed effects	no	no	no	yes
R-squared	0.1107	0.1522	0.1897	0.5024

Notes: dependent variable is per-capita budget shares in 2003 dollars, std errors in parentheses, ** denotes 95% significance, * denotes 90%.
Census data refer to Consolidated Federal Funds Report, CAGW to Citizen Against Government Waste, constant not reported.
House delegation sizes normalized to Senate delegation sizes(i.e. divided by 4.35)

Table 6: Small State Bias in the U.S. Senate: Underlying Channels Specification

Dependent variable Estimator	First-stage Coalition indicator Probit	Second-stage Per-capita spending OLS	Per-capita spending OLS	Per-capita spending OLS
log per-capita tax prices	-1.0046**			
	(0.1521)			
log population	0.0789			
	(0.0622)			
log delegation size	0.5514**			
	(0.0717)			
constant	-1.1897**			
	(0.2501)			
per-capita committee representation		0.5959**	0.5408**	0.4113**
		(0.1606)	(0.1581)	(0.0968)
constructed variable		0.3696*		
		(0.2183)		
Observations	5420	7050	7050	7050
State × appropriations fixed effects	no	no	no	yes
Fiscal Years	1995-2003	1995-2003	1995-2003	1995-2003

Notes: bootstrap std errors in parentheses, ** denotes 95% significance, * denotes 90%.

Table 7: Underlying channels analysis

Channel	Total spending	Proposal-power	Vote-cost	residual
Estimator	OLS	OLS	OLS	OLS
delegates per-capita	0.0130**	0.0056**	0.0056**	0.0018**
	(0.0005)	(0.0002)	(0.0001)	(0.0005)
constant	-0.1290**	0.0418**	-0.0190**	-0.1518**
	(0.0512)	(0.0178)	(0.0051)	(0.0498)
proportion explained	**100 percent**	**43 percent**	**43 percent**	**14 percent**
Observations	7050	7050	7050	7050
Fiscal Years	1995-2003	1995-2003	1995-2003	1995-2003

Notes: std errors in parentheses, ** denotes 95% significance, * denotes 90%.

Table 8: Underlying parameter estimates

Parameter	Assumed range	Parameter estimate
δ	>0	0.5959
θ	>0	0.3696
γ	[0,1]	-0.1431
α	[0,1]	0.5489
σ	>0	1.8136
η	>0	2.1576

Figure 1
Per-capita spending and per-capita representation:
Theoretical Prediction

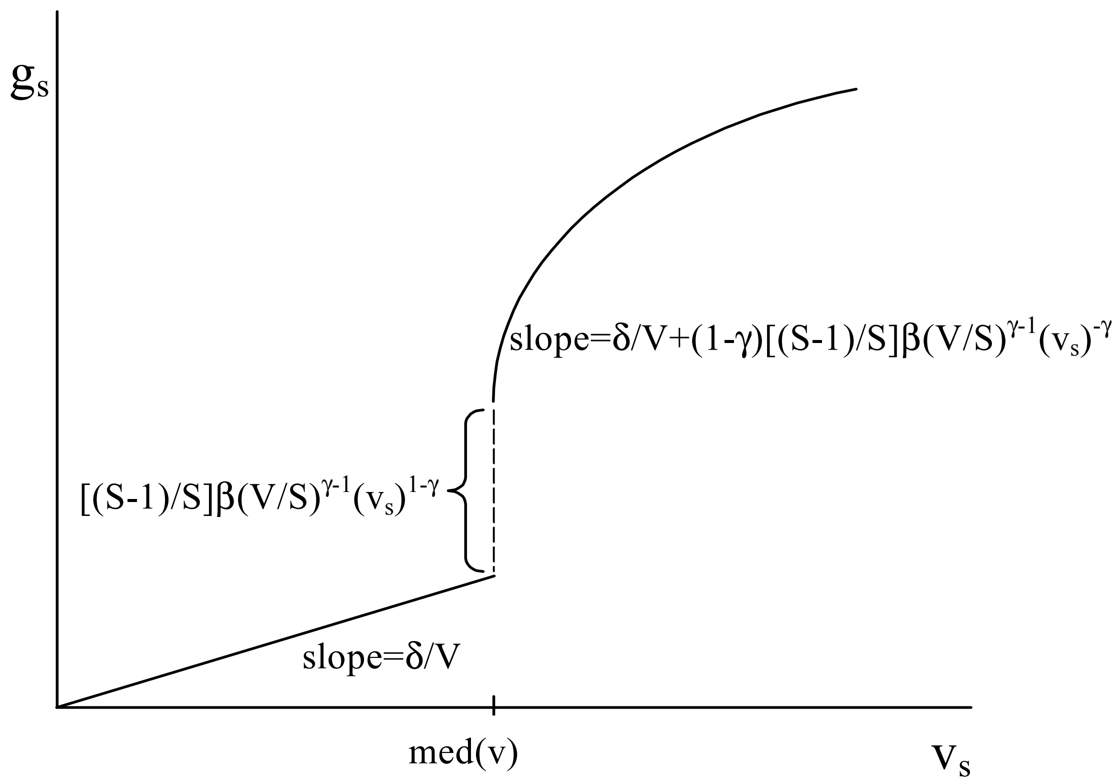

Figure 2
CAGW Project Appropriations by Fiscal Year

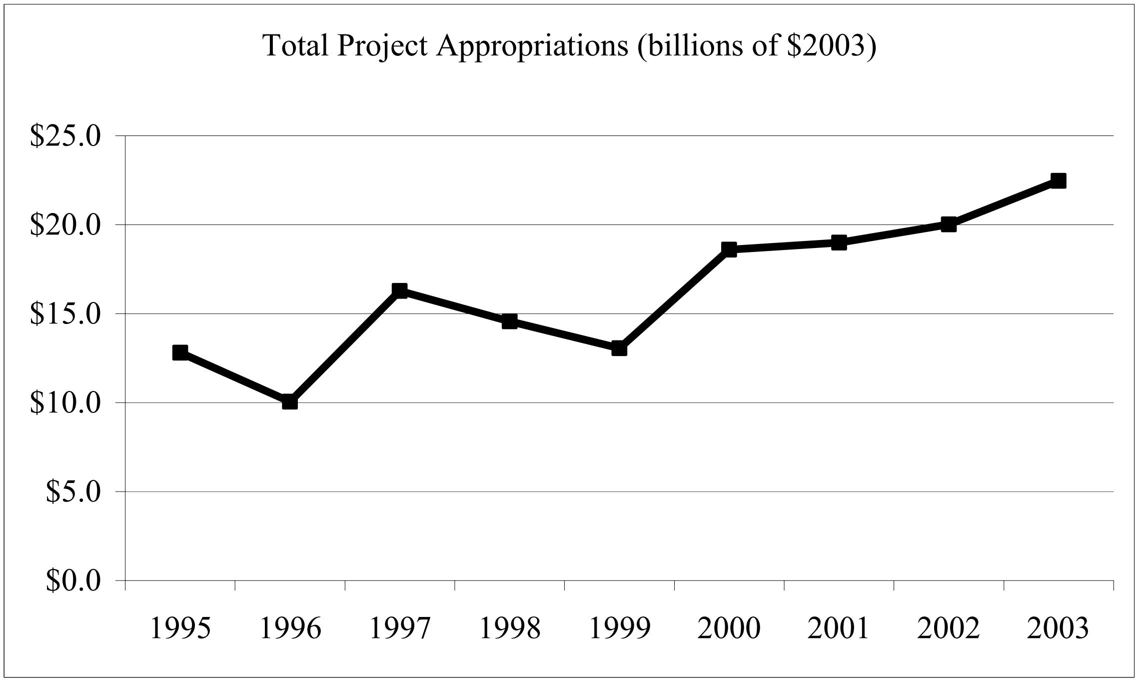

Figure 3
CAGW Project Appropriations by Appropriations Bill

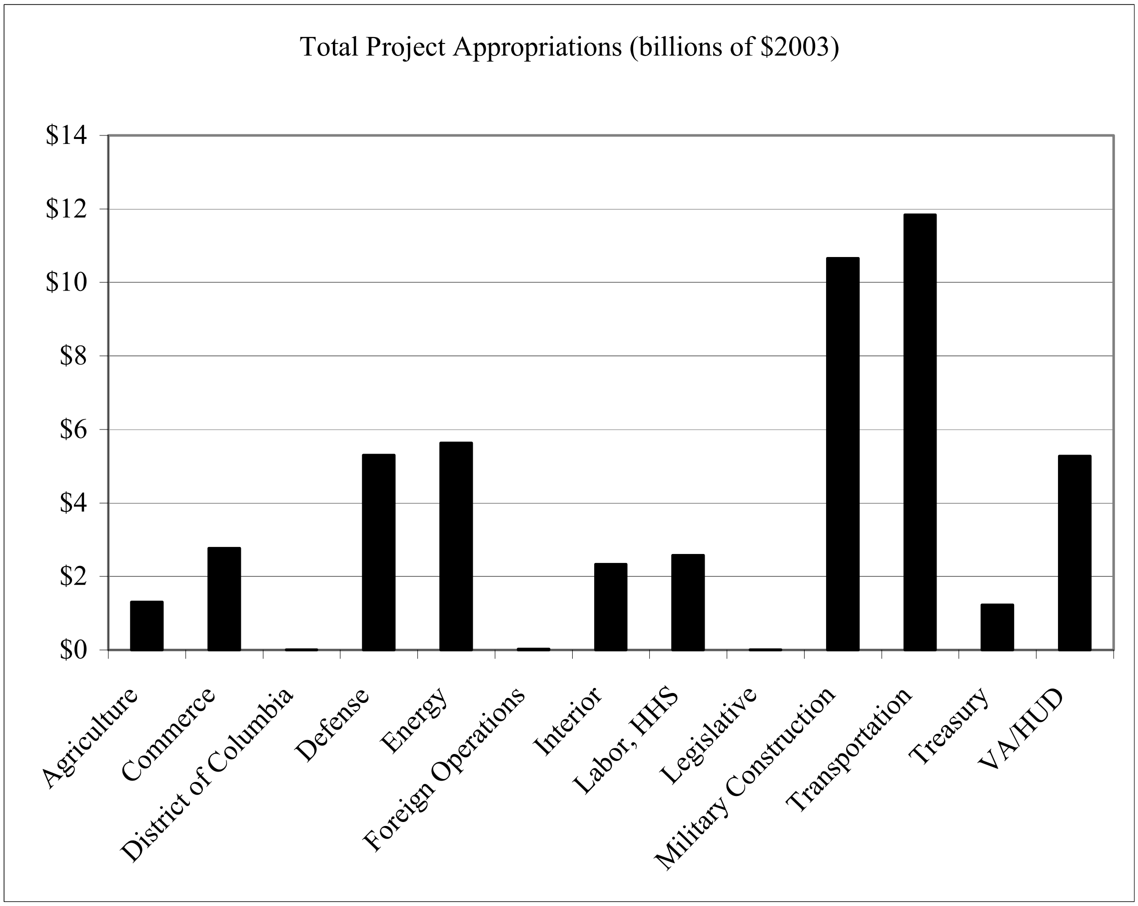

Figure 4
CAGW Project Appropriations by Sponsoring Chamber

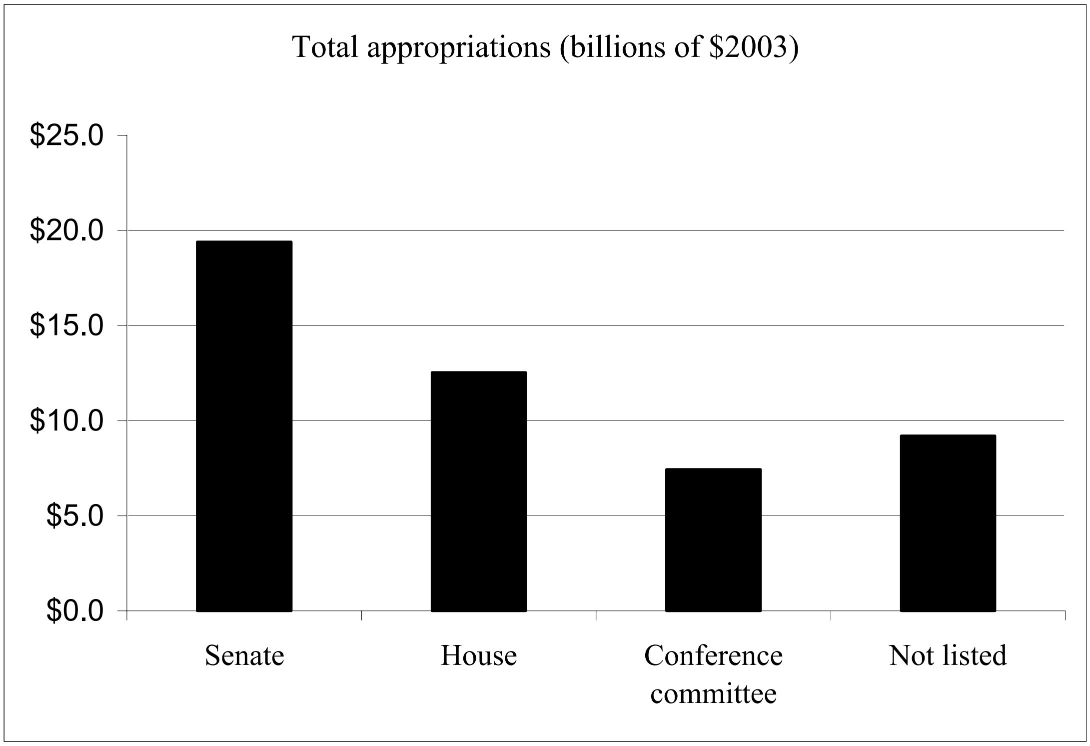

Figure 5
Per-capita spending and per-capita representation:
Evidence from Senate Projects

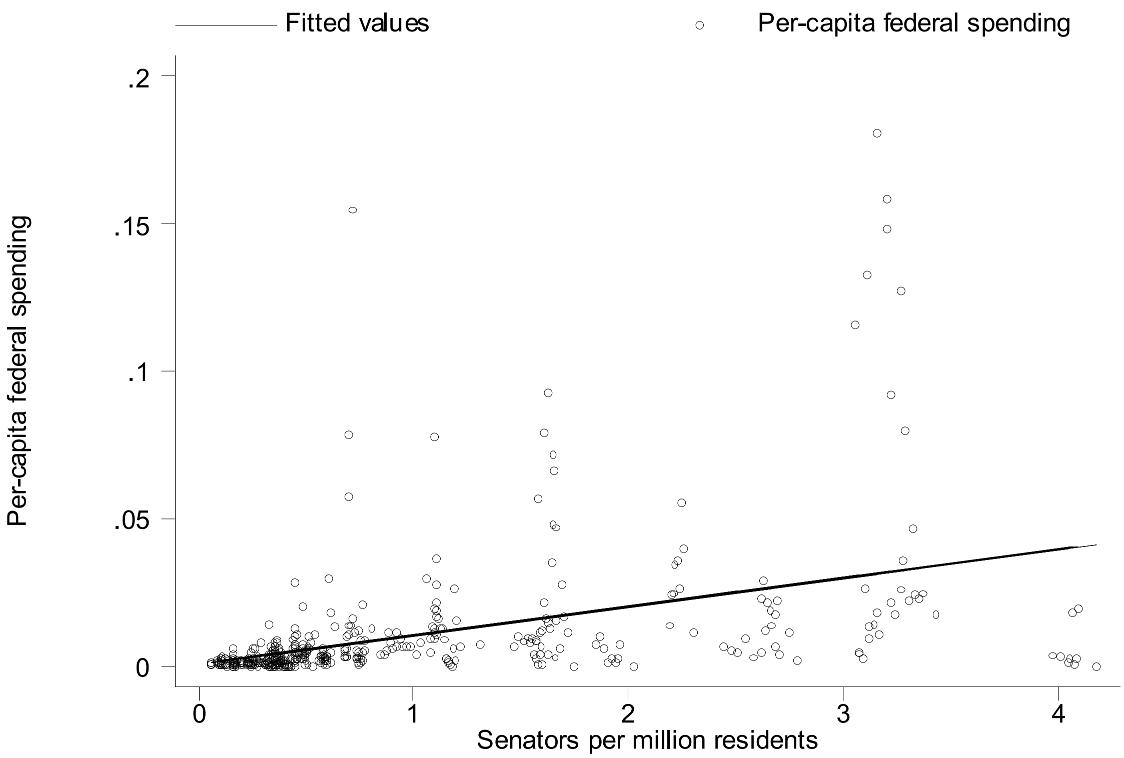

Figure 6
Per-capita distribution of Samuelson spending