Congressional Bargaining and the Distribution of Grants

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Abstract

In the U.S., over $540 billion in grants is allocated annually based on formulas written by Congress. While scholars have long been interested in how the federal government distributes funding, little is known about how Congress designs these formulas. I formalize a theory of bargaining over grants wherein legislators attempt to increase funding for their states, and provide empirical evidence consistent with the theory. The structure of grant programs imposes additional constraints, which can lead to certain legislators being cheaper to include in the winning coalition, positive distributions outside of the winning coalition, oversized winning coalitions, and retention of the status quo policy. In line with theories of distributive politics, I also find evidence that authorizing committee members are able to procure more grant funding for their states. These results have implications for understanding the congressional policymaking process as well as for the effectiveness of federal grant programs.

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1 Introduction

Scholars have long been interested in how the federal government allocates funding. Yet little is know about the formula grant programs that account for the majority of federal assistance. These are grant programs where Congress specifies the allocation criteria or formula in statute. Many of the programs Americans think of when they think about federal policy fall into this category: Medicaid, Section 8 Housing Choice Vouchers, the Title I-A program, Children's Health Insurance Program (CHIP), and the Community Development Block Grant (CDBG). These programs accounted for $540.9 billion of federal funding in 2016. However, most of the research on federal spending focuses on earmarks or "pork barrel" spending, which, at its peak in 2006, only accounted for $29 billion of federal funding. Thus, to understand federal spending and federal policy more broadly, it is essential to understand formula grant programs.

Existing research highlights the role political and institutional factors play in the distribution of federal funding (e.g., Fenno 1966; Ferejohn 1974; Mayhew 1974; Arnold 1979; Cox and McCubbins 1986; Weingast and Marshall 1988; Evans 1994; Balla et al. 2002; Lee 2003). I argue that these same factors influence grant programs. However, there are three key aspects of formula grants that make them different than other types of spending. First, legislators must allocate grants based on a formula as opposed to directly specifying the payoff for each state or district. That is, grants are allocated based on a set of observable attributes or "formula factors" (e.g., population, poverty, per capita income) rather than the identity of each place. Second, in addition to these observable attributes, legislators can set a minimum grant amount that each state or district must receive. Third, formula grant provisions typically remain in effect until amended or repealed. Thus, if Congress does not change the formula then grants will be allocated based on the status quo policy.

In this paper, I formalize a theory of congressional bargaining over the distribution of formula grants, and provide empirical evidence consistent with the theory. I show how the distribution of grants is shaped, and at times distorted, by the committee system, majority rule, and legislators attempting to maximize funding for their states. While much of the theory on federal spending focuses on earmarks, one notable exception is the extension of the Baron and Ferejohn (1989) divide-the-dollar model by Martin (2018). Martin shows how bargaining over the weights placed on formula factors limits legislators' abilities to direct funds to specific states or districts. I build on Martin's model by incorporating two additional elements of formula grant programs: (1) the role of the status quo when amending an existing formulas; and (2) legislators' option to provide each grantee a minimum grant amount. Unlike Martin, I fix the number of factors or attributes included in the formula in order to extract predictions about what formulas are enacted and which states benefit from these formulas.

I model bargaining over formula grants as a divide-the-dollar game in which legislators attempt to adjust grant programs to bring as much funding as possible to their states. However, legislators are constrained by both the structure of formulas and congressional rules. I incorporate the role of committees by endowing the committee chair with proposal power. In line with existing theories, I find that proposers disproportionately benefit from formula changes. Since the proposer is the committee chair, states represented by the committee chair generally benefit from formula changes. However, unlike with earmarks, the proposer must allocate funding based on a finite number of formula factors and by setting a minimum grant amount. Thus, states with similar characteristics receive similar grant amounts. As Martin (2018) shows, this constraint results in positive distributions to members outside of the winning coalition. Three new predictions also come out of the model. First, there exist equilibria in which the proposer does not change the formula. Second, states doing poorly under the status quo are "cheaper" to include in the winning coalition and thus benefit from formula changes. Third, the size of the winning coalition depends on the status quo, committee chair, and distribution of formula factors across states. In some cases the winning coalition is minimal sized and in others it is oversized.

To test this theory, I compile a data set that matches education grant programs to the bills that authorized them. First, I examine which states are most likely to be included in the winning coalition. Consistent with theoretical predictions, I find that states receiving relatively small amounts of funding under the status quo are more likely to be included in the winning coalition when formula grant programs are reauthorized. Second, to examine the role of committees, I use a matched differences-in-differences design to estimate the committee advantage when formula grant programs are reauthorized. In line with the assumption that committees have proposal power in Congress, I find evidence that states represented by committee members, and particularly committee chairs, receive more grant funding.

Understanding how Congress designs and amends the formulas used to allocate grants and which states benefit from these formulas has important implications for the effectiveness of grant programs as well as our understanding of the federal policymaking process. Many formula grant programs are inefficient in the sense that they do not target funding to areas with the highest need. Some formulas are not responsive to changes in population (Larcinese, Rizzo, and Testa 2013; Szymendera 2008) and provide more per capita funding to small states (Lee 2000) and to areas with lower economic need (Hall 2010). In this paper, I offer an explanation for these findings. I show that how efficiently a program targets funding toward areas with the greatest need depends on the distribution of need across states, which legislator is the committee chair, and the status quo policy. In particular, committee chairs with high need try to improve allocation formulas that do a poor job of targeting and protect formulas that target well. However, depending on the status quo and the distribution of need, the chair may not always be able to do this.

The remainder of the paper proceeds as follows. I begin by offering background on formula grant programs and the related literature. I then develop a theory of congressional bargaining over the distribution of grants. Next, I describe the data and empirically test predictions from the theory. The final section offers concluding remarks and discusses the implications of the theory for how effectively grant programs allocate funding to areas with the highest need.

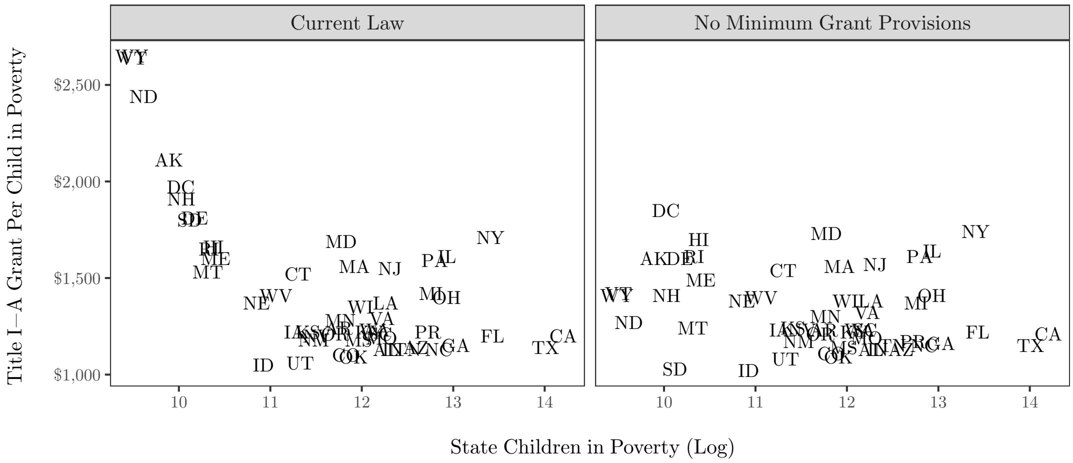
2 Formula Grants

Legislators have the ability to direct additional grant funding to their states and districts because, in many cases, Congress writes the grant allocation formula. Under formula grant programs, funds are generally allocated based on factors (e.g., population, state spending), subject to available appropriations. For example, a formula might specify that grants be allocated proportionally to population. A program targeting poverty might include a count of people living below the poverty line in a state. It may also include a factor related to a state's tax base to capture a state's fiscal capacity. For example, consider the Title I-A program in the Elementary and Secondary Education Act. The purpose of the Title I-A program is to provide "financial assistance to local educational agencies (LEAs) and schools with high numbers or high percentages of children from low-income families" ("Title I, Part A Program" 2015). Grants under Title I-A are primarily allocated in proportion to the number of children in families living in poverty multiplied by state average per pupil expenditures. As a result, states with higher education spending receive more Title I-A funding.

Formulas often include minimum grant provisions to ensure that grantees have enough funding to run a program and to prevent large losses in grant amounts from year to year. Minimum grant provisions can ensure that each grantee receives a specific dollar amount or percentage of available appropriations. Additionally, some minimum grant provisions (commonly referred to as "hold harmless provisions") stipulate that each grantee receive a percentage of their grant amount from a prior year. Other provisions, often referred to as "foundation grants" or "base guarantees," allocate each grantee a set dollar amount and then distribute the remaining funds based on formula factors. The Title I-A program includes minimum grant provisions that guarantee each state a certain percentage of available appropriations and ensure no school district receives less than 85% of the funding it received in the prior year. One consequence of these minimum grant provisions is that smaller states receive more per capita funding than larger states. Figure 1 shows the Title I-A grant per child in poverty compared to the logged number of children in poverty in a given state under current law and if the formula contained no minimum grant provisions.

Under current law, states with fewer children in poverty receive substantially more per child than states with higher numbers of children in poverty. When the minimum grant provisions are removed, this relationship goes away.

Figure 1: Title I-A Grant Amounts Per Child in Poverty (FY2016)



Source: Data from the Congressional Research Service (CRS Report R45141)

In practice, many allocation formulas are not particularly effective at targeting grants to areas with the highest need. The Low Income Home Energy Assistance Program (LIHEAP) disproportionately benefits states in the Northeast and Midwest (Kaiser and Pulsipher 2006), while the Title I-A program, provides higher shares of funding to the least poor areas (Moskowitz et al. 1993). Rural areas receive more per capita federal grant spending, but areas with high economic need receive less federal spending per capita (Hall 2010). Many formulas are not responsive to changes in population and have a status quo bias (Larcinese, Rizzo, and Testa 2013). For example, the Vocational Rehabilitation formula negatively affects states with population growth since the mid-1970s because the formula is based, in part, on how much each state received in FY1978 (Szymendera 2008).

3 Related Literature

As allocation formulas determine the share of funding each state or district will receive, a natural starting point when thinking about formula grants is Baron and Ferejohn's (1989) divide-the-dollar game. In the game, legislators bargain over how to divide a budget among themselves. An exogenously chosen legislator proposes an allocation and then legislators vote on the proposal. If the proposal passes, the game ends. If the proposal fails, another proposer is able to offer an allocation. Bargaining continues until a proposal passes and that allocation is enacted. Baron and Ferejohn show that in equilibrium, the proposer receives a disproportionate share of funds. Further, funds are only distributed to legislators that vote for the proposal (the winning coalition). When proposals are brought up under a closed rule, the size of the winning coalition is minimal (i.e., proposals pass by a bare majority).[1] When the repeated nature of the policy process is taken into account, the results are similar. Kalandrakis (2004) shows that a dynamic divide-the-dollar game with an endogenous status quo has an equilibrium in which legislators maximize their current utility. Others have expanded this model to examine the effect of a unanimous voting rule and heterogeneous discount rates (Anesi and Seidmann 2015), persistent agenda setters (Diermeier and Fong 2011), endogenous procedural rules (Duggan and Kalandrakis 2012), and veto players (Nunnari 2018).

Lee (2000) and Martin (2018) both apply Baron and Ferejohn's (1989) divide-the-dollar game to formula grants. Lee argues that an implication of the model is that smaller states are cheaper to include in the winning coalition. Looking at changes to allocation formulas in the Senate, Lee provides empirical evidence that smaller states disproportionately benefit from formula grants. Martin extends the model to examine the constraint that bargaining over formula factors places on legislators. Martin shows that when bargaining over the weights placed on a small number of formula factors, legislators have relatively little latitude in targeting funds to specific districts. Additionally, the model predicts oversized winning coalitions, positive distributions outside of the winning coalition, and stable voting blocs.

A related literature focuses on the role that committees play in distributing federal funding. Distributive theories explain spending as the result of electorally motivated legislators (e.g., Ferejohn 1974; Mayhew 1974; Shepsle and Weingast 1981; Evans 2011;

1. When proposals are brought up under an open rule, there are larger-than-minimal winning coalitions. The size of the winning coalition is determined by the size of the legislature and the discount factor.

Weingast and Marshall 1988). That is, legislators can increase their chances of reelection by bringing funding back to their states or districts. This process is facilitated by the congressional committee system. Specifically, committees are not representative of the whole legislature but rather are composed of preference outliers or high demanders. This is because the committee membership assignment process assigns legislators to those committees they value most highly. Committee members' districts thus receive a disproportionate share of benefits under the jurisdiction of the committee. Knight (2005) illustrates one mechanism for this by explicitly incorporating the committee structure into a divide-the-dollar framework. In Knight's model, the committee acts as an agenda setter and makes the initial proposal considered by the legislature. Another source of committee power may be the conference process in which committees resolve differences between House and Senate proposals. This procedure provides committees with veto power, and the anticipation of this power affects the actions of other legislators earlier in the bargaining process (Shepsle and Weingast 1987).

Distributive theory has received substantial empirical testing. There is evidence that members of key committees and subcommittees able to procure more transportation funding for their districts (Evans 1994; Lee 2003; Knight 2005), research funding for universities in their states (Payne 2003), and military construction funding for military bases in their states and districts (Hammond and Rosenstiel 2020). Looking across multiple policy areas, Clemens, Crespin, and Finocchiaro (2015) find members of Appropriations subcommittees are able to procure more earmarks for their districts. Grimmer and Powell (2013) find that members on certain committees get an electoral subsidy from being on those committees. There is also evidence that it is committee status (e.g., being committee chair), not committee membership, that matters (Berry and Fowler 2018).[2]

Alternatively, under Krehbiel's (1991) informational model, committees provide a division of labor and means for specialization as opposed to facilitating the distribution of pork. Unlike the distributive model, legislators are uncertain about the relationship

2. Berry and Fowler (2016) test distributive theory using formula grant outlays and find no relationship between committee membership and formula spending. However, this null result may be because the authors do not isolate years in which the allocation formula changed.

between policies and their outcomes. By specializing, committees can reduce this uncertainty. However, it seems unlikely that an informational model applies to amending allocation formulas as there is generally no uncertainty about how a formula change will affect the distribution of funds. This is because when legislators propose a new formula, they usually have grant estimates produced that they share with the chamber (National Research Council 2003).

Partisan theories of congressional behavior offer a different explanation. Under partisan theories, party leaders use their agenda-setting power to achieve party goals and legislators can increase their reelection chances by improving the party's reputation or brand (e.g., Cox and McCubbins 1986, 1993, 2005). In the case of formula grants, this would lead legislators to support formula changes that help the party but potentially reduce funding for their states or districts. Consistent with partisan theories, Engstrom and Vanberg (2010) find that members of the majority party receive substantially more funding via earmarks than their minority counterparts. In particular, the majority party tends to target earmarks to members in pivotal agenda-setting positions (Engstrom and Vanberg 2010) and who are electorally vulnerable (Lazarus and Steigerwalt 2009; Engstrom and Vanberg 2010). The majority party may also allot some pork to the minority to avert criticism for pork-barreling (Balla et al. 2002). With respect to formula grants, Levitt and Snyder (1995) find that formula funds are biased toward Democratic voters but parties are only able to target funds to certain types of voters, not to specific districts.

4 A Theory of Congressional Bargaining Over Grants

While existing theories of distributive politics may shed some light on how Congress designs grant programs, they miss the additional constraints formulas impose. To address this gap in the literature, I model congressional bargaining over formula grants as a divide-the-dollar game in which legislators attempt to adjust grant programs to bring as much funding as possible to their states. Though this is not the first attempt to model bargaining over formulas (e.g., Martin 2018), this theory is the first to incorporate a status quo policy and minimum grant provisions.

Similar to Martin (2018), legislators bargain over the weights placed on formula factors. That is, given a formula based on population and poverty, legislators decide the share of funding allocated based on population and the share of funding allocated based on poverty. In line with distributive theories, I endow committee chairs with proposal power. I conceptualize minimum grant provisions as an additional formula factor that provides an equal amount of funding for all states. I first consider a one-period game in which the committee chair proposes a formula and all legislators vote on the committee proposal. If the proposal is enacted, grants are allocated based on this new formula. If the proposal fails, grants are allocated based on the status quo policy. However, in practice, bargaining does not follow this take-it-or-leave-it structure. I therefore also consider an infinite horizon model where legislators bargain until agreement is reached and a new proposer is drawn in each period.

What formula gets enacted depends on which legislator is chair, the status quo formula, and the distribution of formula factors across states. As the proposer, committee chairs are often able to modify formulas to bring additional funding to their states. However, as in Martin (2018), funding is distributed outside of the winning coalition. The model also yields new predictions related to the status quo policy. First, there are cases in which the committee chair retains the status quo formula. And, in the repeated game, if the status quo is very favorable to the chair then there are cases when delay can occur in equilibrium. Second, states doing poorly under the status quo are "cheaper" to include in the winning coalition and thus benefit from formula changes. Third, the winning coalition may be minimal sized or larger-than-minimal sized. The size of the winning coalition depends, in part, on the grants each legislator is receiving under the status quo.

The model also raises questions about formula efficiency—allocating funding based on need. In the case where a formula contains two factors, one measuring need and the other not, the efficient policy is one that allocates all of the funding based on the factor measuring need. Similarly, if both factors measure need then there is a set of efficient policies that allocate all of the funding based on the formula factors and does not include any minimum grant provisions.

4.1 Model Setup

Let $N = \{1, ..., n\}$ be a set of n legislators bargaining over how to allocate a budget. To avoid complications that may arise from ties, I assume n is odd. One of the legislators, the committee chair, is endowed with proposal power. I denote the committee chair with c.

Formula grants, unlike earmarks, are based on formula factors as well as minimum grant provisions. To incorporate this into the model, I allow legislators to bargain over weights placed on formula factors and the minimum grant amount. Each legislator i has two quantifiable attributes or formula factors, $x_i > 0$ and $z_i > 0$. For simplicity, x_i and z_i are measured in share. A legislator's allocation is a function of the weights placed on x and z, η and γ, as well as a fixed amount or minimum that each legislator receives, α:

$$y_i = \eta x_i + \gamma z_i + \alpha \frac{1}{n} \tag{1}$$

where $\eta, \gamma, \alpha \geq 0$.

For example, consider a formula based on population (x) and poverty (z) levels. If a state made up 10% of the total national population and had 25% of the national population living in poverty then $x_i = 0.1$ and $z_i = 0.25$. Further if $\eta = 0.5$, $\gamma = 0.5$, and $\alpha = 0$, then half of the funding would be based on population and the other half would be based on poverty. Under this formula, state i would receive 17.5% of the budget.[3]

What formula can be enacted is constrained by the funding level for the program. That is, legislators bargain over how to divide a budget among themselves but cannot increase the size of the budget. As in other zero-sum games, this budget constraint always binds in equilibrium. For simplicity, I fix the budget to 1. As a result, a legislator's grant amount y_i can be thought of as the share of available funding that her state receives. For an allocation $\mathbf{y} = (y_i)_{i=1}^n$ to be feasible, it must satisfy $\sum_{i=1}^n y_i \leq 1$. And because x_i

3. $0.5 \times 0.10 + 0.5 \times 0.25 = 17.5\%$

and z_i are measured in share, then $\sum_{i=1}^{n} y_i \leq 1$ implies that $\eta + \gamma + \alpha \leq 1$. I denote all feasible combinations of (η, γ, α) with χ where

$$\chi = \{\eta, \gamma, \alpha \in [0, 1] \,|\eta + \gamma + \alpha \leq 1\} \tag{2}$$

In practice, a formula typically remains in effect until it is amended. That is, formula grant provisions generally do not sunset. To incorporate this into the model, I include an exogenously determined status quo policy $(\eta_q, \gamma_q, \alpha_q) \in \chi$. This status quo remains in effect if no formula change is passed. During a program's initial enactment, the status quo formula is $(0, 0, 0)$. I denote legislator i's grant allocated under the status quo policy with q_i.

The sequence of play is as follows. At the start of the game, the committee chair makes a proposal $(\eta, \gamma, \alpha) \in \chi$ and the chamber floor then takes an up-or-down on the committee proposal. If $(n + 1)/2$ legislators vote for the proposal (i.e., majority rule), grants are allocated based on the new formula. If the proposal fails, the status quo policy remains in effect. Utilities are then realized and the game ends.

A player's utility is the allocation they receive from a formula. If a proposal (η, γ, α) is enacted, then the utility for legislator i is

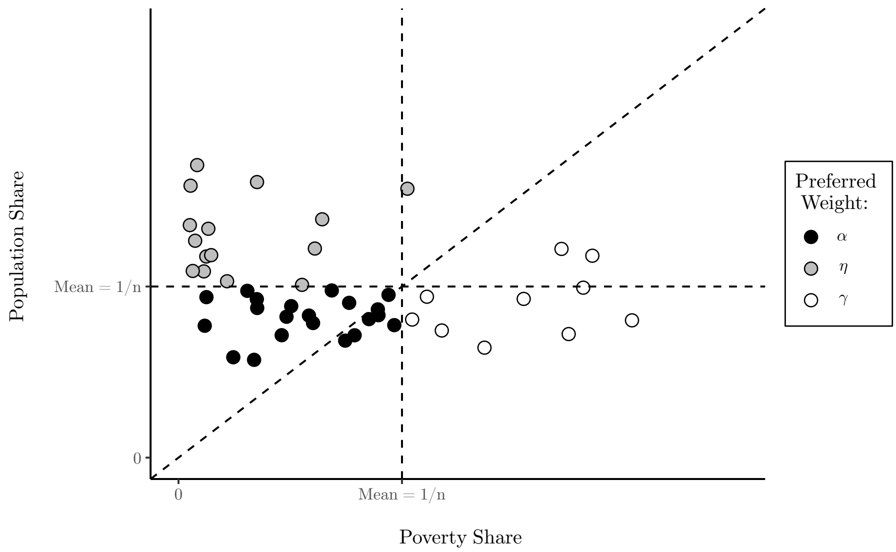
$$u_i = \eta x_i + \gamma z_i + \alpha \frac{1}{n} \tag{3}$$

Note that the largest grant amount a state can receive is equal to its largest formula factor. Let $f_i^1 > f_i^2 > f_i^3$ represent legislator i's rank ordering of x_i, z_i, and $1/n$.[4] When $f_i^1 = x_i$ (i.e., $x_i \geq z_i$ and $x_i \geq 1/n$) then the largest grant i can receive is x_i. And, this allocation occurs when $\eta = 1, \gamma = 0, \alpha = 0$. The intuition for this result is relatively straightforward: a legislator receives the largest grant when all of the weight is placed on her largest formula factor. I refer to legislators whose largest factor is x_i as legislators whose preferred weight is η. I refer to legislators whose largest factors are z_i and $1/n$ as legislators whose preferred weights are γ and α, respectively.

4. For example, if $x_i > z_i > 1/n$ then $f_i^1 = x_i$, $f_i^2 = z_i$, and $f_i^3 = 1/n$.

Returning to the previous example of a formula based on population (x) and poverty (z), Figure 2 shows the preferred weight for each state based on the state's x and z values. Note that because x and z are measured as shares of the total, the mean of x is $1/n$ and the mean of z is $1/n$.[5] If a state has below average population and poverty levels then it prefers α. If a state has above average population and its population share is higher than its poverty share, the state prefers η. Otherwise, the state prefers γ.

Figure 2: Formula Based on Population and Poverty



4.2 Equilibrium Analysis

I focus on equilibria in which the chair proposes an acceptable allocation and no legislator uses a weakly dominated voting strategy. That is, the chair proposes an allocation that defeats the status quo and legislators vote yes if and only if their utility from the proposal not passing is less than their utility from the proposal.[6]

The question for the committee chair is which of the proposals that can pass the floor maximize her grant amount. Because the budget constraint always binds in equilibrium,[7]

5. $\frac{\sum_{i=1}^{n} x_i}{n} = \frac{1}{n}$ because, by definition, $\sum_{i=1}^{n} x_i = 1$.

6. These restrictions rule out uninteresting equilibria in which proposals are best responses solely because they would not pass and voting decisions are best responses solely because a single vote does not change the outcome.

7. See Lemma 1 in the appendix.

the chair's grant is equal to the following:

$$y_c = 1 - \sum_{i \in N-c} y_i \tag{4}$$

Therefore, for the chair to maximize her own grant she should minimize the grants to other legislators provided that a winning coalition (at least $(n-1)/2$ legislators) would vote for the proposal. Let $A_i \subseteq \chi$ be the set of proposals that i would accept. As the alternative to a proposal is the status quo, all legislators accept any proposal that gives them at least their grant amount under the status quo. Thus the set of proposals acceptable to a given winning coalition W is

$$A_W = \bigcap_{i \in W} A_i = \left\{ (\eta, \gamma, \alpha) \in \chi \,\middle|\, \eta x_i + \gamma z_i + \frac{\alpha}{n} \geq q_i \ \forall i \in W \right\} \tag{5}$$

and the social acceptance set is the following set of all proposals that could pass:

$$A = \bigcup_{W \in \mathcal{D}} A_W \tag{6}$$

where $\mathcal{D}$ is the set of all winning coalitions. Thus, the committee chair solves the following:

$$\begin{aligned} \min_{\eta,\gamma,\alpha} \sum_{j \in N-c} \eta x_j + \gamma z_j + \alpha \frac{1}{n} & \\ \text{s.t. } (\eta, \gamma, \alpha) \in A & \\ \text{s.t. } \eta + \gamma + \alpha = 1 & \end{aligned} \tag{7}$$

Due to her proposal power, the chair always weakly benefits when Congress bargains over a formula.[8] That is, if the chair were to ever lose funding from a formula change, she would retain the status quo. And, in many cases the chair is able to increase her grant amount. In particular, whenever the status quo policy does not allocate the entire budget, the chair is always able to increase her grant amount. This is because, at the very least, the chair can increase her most preferred weight, which strictly increases the grant

8. $y_c \geq q_c$.

amounts for all legislators. However, when the budget constraint does bind under the status quo then to increase her own grant amount the chair needs to decrease the grant amount for at least one other legislator. And, it is always be possible for the chair to do this when the chair and the majority of legislators are receiving less under the status quo than they would if all of the funding were allocated based on either their second-most preferred weight or the chair's preferred weight. Proposition 1 summarizes this result.

Proposition 1. There exists a Nash equilibrium in which the chair makes an acceptable proposal. Further, let g_i be the grant legislator i receives when the committee chair sets her preferred weight to 1, G be the set of all legislators for whom $g_i \geq q_i$, and $|G|$ be the number of legislators in G. If either (i) $\sum_{i \in N} q_i < 1$; (ii) $q_i < f_i^2$ for the majority of legislators and the chair; or (iii) $|G| \geq (n+1)/2$ and $q_i < g_c$ then there exists a Nash equilibrium in which a formula is enacted that increases the chair's grant amount.

The underlying logic for this result is that when a legislator is not receiving her maximum grant amount then there is another formula in addition to the status quo formula that provides the legislator at least what she is receiving under the status quo. Thus, except in the case where the chair is receiving her maximum grant under the status quo or when requirements (i), (ii), and (iii) are violated, it is always possible for the chair to construct a formula that provides a majority of legislators at least what they were receiving under the status quo and increases her own grant.[9]

If possible the chair sets her preferred weight to 1 as this provides her state its maximum grant amount. And, it is be possible for the chair to enact this formula when it provides a majority of states at least what they are receiving under the status quo formula. As a result, when the chair sets her preferred weight to 1, there may be an oversized winning coalition. For example, if the chair prefers η and a majority of legislators are receiving grants under the status quo less than or equal to x_i then the size of the winning coalition is equal to the number of states for which $q_i \leq x_i$. However, if the chair is not able to set her preferred weight equal to 1 then any formula change has a winning

9. If the chair is receiving her maximum grant under the status quo then she retains the status quo policy as this is already maximizing her utility.

coalition that is minimal sized. That is, under majority rule, the winning coalition size is $(n+1)/2$. Corollary 1 states this result more formally.

Corollary 1. If $|G| \geq (n+1)/2$ then there exists a Nash equilibrium in which the winning coalition size is $|G|$. If $|G| < (n+1)/2$, then any formula change enacted in equilibrium has a minimal winning coalition.

Notice that if the committee chair prefers the same weight as the majority of legislators then, in equilibrium, the chair always sets her preferred weight to 1. Additionally, when the status quo formula is $(0, 0, 0)$, as would be the case when a program is initially enacted, then the chair sets her preferred weight to 1.

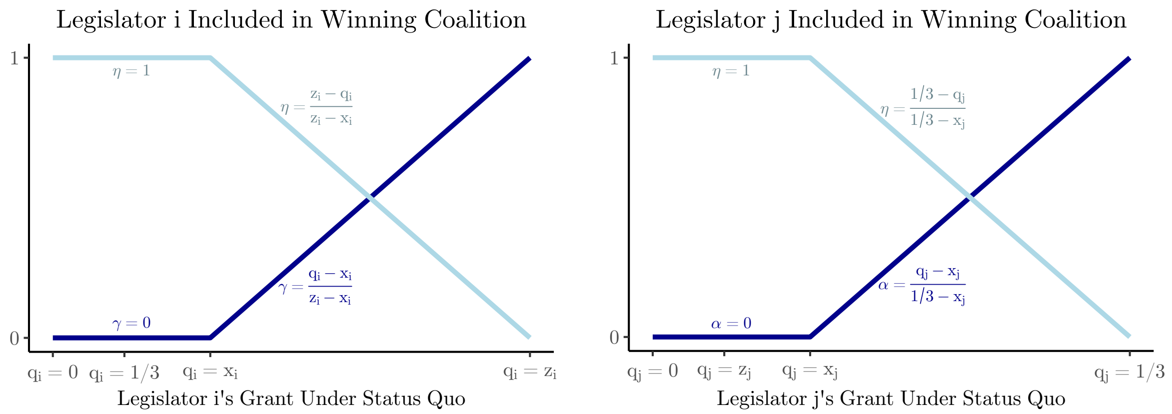
There are, however, cases where there exists an equilibrium in which the committee chair retains the status quo. For example, consider the case where a majority of legislators prefer α and the status quo policy is $(\eta_q, \gamma_q, \alpha_q) = (0, 0, 1)$. In this case all legislators are receiving grants equal to $1/n$, which is the maximum possible grant for the majority of legislators. Thus, any formula change would result in the majority of legislators losing funds. As a result, no matter which legislator is the committee chair, no formula change is enacted in equilibrium.

When proposing a formula, the chair forms the cheapest winning coalition. As equation 7 indicates, the cheapest members of the winning coalition are those that have the lowest status quo grants and those whose inclusion results in the smallest amount of funding being distributed to legislators other than the committee chair.

To illustrate what formula is enacted and which legislators are included in the winning coalition consider a case with three legislators c, i, j where $x_c > 1/3 > z_c$, $z_i > x_i > 1/3$, and $1/3 > x_j > z_j$. Thus, c prefers η, i prefer γ, and j prefers α. Note that when there are only three legislators, the committee chair just needs one other legislator to weakly prefer the committee proposal to the status quo for it to pass.

Figure 3 shows what c would propose to include either i or j in the winning coalition, depending on the status quo policy. Notice that the smaller a legislator's grant is under the status quo, the larger η is in chair's proposed formula. And because the chair prefers η, the smaller a legislator's grant is under the status quo, the larger the chair's grant is under the proposal. However, the rate of change in η, and thus the chair's grant amount, with respect to a legislator's status quo grant is different for i and j. That is, when $q_i > x_i$, a one unit increase in q_i results in a $\frac{1}{(z_i - x_i)}$ decrease in η while, when $q_j > x_j$, a one unit increase in q_j results in a $\frac{1}{(1/3 - x_j)}$ decrease in η.

Figure 3: Proposals By Status Quo Grant



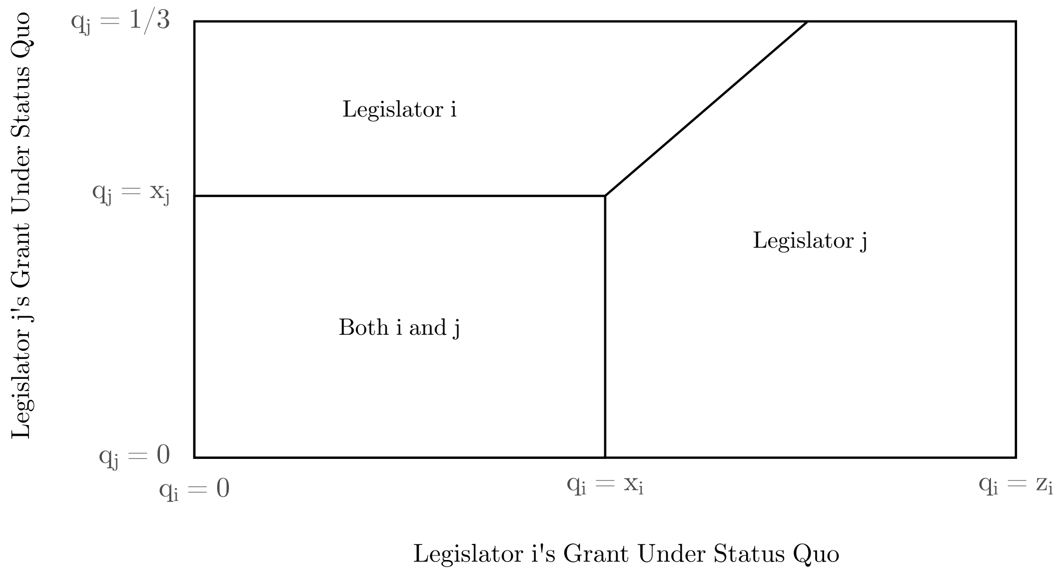
When deciding whether to include i or j in the winning coalition, c chooses whichever formula gives her state the larger grant amount. The solution to this is shown in Figure 4 below. Because η is smaller the larger a state's grant is under the status quo, when a state is receiving less under the status quo it is cheaper to include in the winning coalition.[10] Specifically, when $x_i \geq q_i$ then legislator i is included in the winning coalition. When $x_j \geq q_j$ then legislator j is included in the winning coalition. And, when both $q_i > x_i$ and $q_j > x_j$ then i is included in the winning coalition when the following is true:

$$\frac{z_i - x_i}{x_c - z_c}(q_j - x_j) \geq \frac{1/3 - x_j}{x_c - 1/3}(q_i - x_i) \tag{8}$$

When equation 8 does not hold and $q_i > x_i$ then j is included in the winning coalition. Thus, as q_i increases, legislator i becomes more expensive to include in the winning coalition.

10. It is worth noting that evaluating how a state is doing under the status quo is relative. In this example, j's grant under the status quo is always smaller than i's grant. This is because $z_i > x_i > 1/3 > x_j > z_j$. However, there are times when the chair is better off including i in the winning coalition than j.

Figure 4: Legislator Included in the Winning Coalition



Notice that the formula enacted in equilibrium distributes funding outside of the winning coalition. Unlike the Baron and Ferejohn (1989) model, any formula where at least one of the weights is non-zero provides some funding to every state. The reason for this is that $x_i > 0$ and $z_i > 0$. That is, for example, a formula that allocates funding based on population will provide some funding to every state as every state has a population greater than 0.

This example also illustrates how bargaining over a formula reduces the benefit for the proposer, which in this case is the committee chair. In the Baron and Ferejohn (1989) game, the funds distributed outside of the winning coalition would go to the proposer. Further, in the case where either $q_i < x_i$ or $q_j < x_i$ then the proposer's benefit is further reduced. This is because the chair sets $\eta = 1$, which increases the grant for i and/or j. However, in the Baron and Ferejohn game, the proposer would merely make i or j indifferent rather than increasing their grant amount. And, in equilibrium, the proposer would never include both i and j in the winning coalition.

4.3 Effect of Multiple Proposers

In practice, bargaining does not typically follow this take-it-or-leave-it structure. If the committee proposal is not accepted, other legislators can offer alternate proposals. To highlight the effect of this, I consider an infinite horizon game where a new proposer is randomly selected and payoffs are realized in each period. Specifically, the bargaining protocol is as follows. In the first period, the committee chair makes a proposal $(\eta, \gamma, \alpha) \in \chi$ and the chamber floor then takes an up-or-down on the committee proposal. If $(n+1)/2$ legislators vote for the proposal (i.e., majority rule), then utilities based on the committee proposal are realized in the current period and in every subsequent period. Otherwise grants are allocated based on the status quo policy $(\eta_q, \gamma_q, \alpha_q) \in \chi$ for the current period, a new proposer is selected, and the game repeats. Legislator i is selected as the proposer with probability ρ_i. Legislators discount future payoffs with a common discount rate $\delta \in [0, 1)$. Note that when $\delta = 0$ this is the same as the one-period game.

Following Banks and Duggan (2006), I focus on no-delay stationary equilibria.[11] More formally, I require that legislators' proposals satisfy sequential rationality and that their acceptance sets satisfy weak dominance. In such equilibria, legislators have a continuation value

$$v_i = \sum_{j=1}^{n} \rho_j \int_p y_i(p) \pi_j dp \tag{9}$$

where $y_i(p)$ is legislator i's grant from proposal p and π_j puts probability one on socially acceptable proposals that maximize j's utility and zero otherwise.

As in the one-period model, the question for the committee chair is which of the proposals that can pass the floor maximize her grant amount. From equation 4 it follows that for the chair to maximize her own grant she should minimize the grants to other legislators provided that legislators in the winning coalition W receive a grant at least equal to what they would if they rejected the proposal. If proposal $p = (\eta, \gamma, \alpha)$ is accepted, each player i receives a payoff in the current period equal to $y_i = \eta x_i + \gamma z_i + \alpha \frac{1}{n}$ and a dynamic payoff equal to $\frac{y_i}{1-\delta}$. Therefore, player i supports any proposal that

11. No delay implies that a proposal p is in A.

provides her a grant y_i weakly greater than $(1-\delta)q_i + \delta v_i$ and the set of proposals acceptable to a given winning coalition is

$$A_W = \left\{(\eta, \gamma, \alpha) \in \chi \,\middle|\, \eta x_i + \gamma z_i + \frac{\alpha}{n} \geq (1-\delta)q_i + \delta v_i \;\forall i \in W\right\} \tag{10}$$

The cheapest members of the winning coalition again are the legislators with the lowest grants under the status quo and that allow the chair to distribute the smallest amount of funding to other legislators. However, in addition, a legislator's cheapness is also a function of her continuation value and thus the probability that she becomes the proposer in the future.

This model can be written as a special case of Banks and Duggan (2006). From Theorem 1 of Banks and Duggan I get the following existence result:

Proposition 2. There exists a stationary equilibrium with immediate agreement.

However, for certain values of q_c and distributions of x and z there also exist stationary equilibria with delay.[12] In such an equilibrium, legislators have the following continuation value:

$$v_i = \frac{\sum_{j \in N} \rho_j \left(\int_p y_i(p)\pi_j dp + (1-\delta)q_i \pi_j(\chi - A)\right)}{1 - \delta \sum_{j \in N} \rho_j \pi_j(\chi - A)} \tag{11}$$

where $\pi_j(\chi - A)$ is the probability that legislator j makes a proposal that is not accepted.

Consider a case where $1/3 > x_c > z_c$, $x_i > z_i > 1/3$, $x_j > z_j > 1/3$, and $(\eta_q, \gamma_q, \alpha_q) = (0, 0, 1)$. That is, legislator c prefers α, legislators i and j both prefer η, and the status quo formula places all of the weight on α, providing each legislator with a status quo grant of 1/3. I look for stationary equilibria of the following form: $p_c = (0,0,1), A_c = \{(\eta, \gamma, \alpha) \in \chi | y_c \geq (1-\delta)1/3 + \delta v_c\}, p_i = p_j = (1,0,0), A_i = \{(\eta, \gamma, \alpha) \in \chi | y_i \geq (1-\delta)1/3 + \delta v_i\}$,

12. Model 6 of Banks and Duggan (2006) provides a similar example of a stationary equilibrium with delay.

and $A_j = \{(\eta, \gamma, \alpha) \in \chi | y_j \geq (1-\delta)1/3 + \delta v_j\}$. In such equilibria,

$$\begin{aligned} v_c =& \frac{(\rho_i + \rho_j)x_c + \rho_c \frac{1}{3}(1-\delta)}{1-\delta\rho_c} \\ v_i =& \frac{(\rho_i + \rho_j)x_i + \rho_c \frac{1}{3}(1-\delta)}{1-\delta\rho_c} \\ v_j =& \frac{(\rho_i + \rho_j)x_j + \rho_c \frac{1}{3}(1-\delta)}{1-\delta\rho_c} \end{aligned} \tag{12}$$

Therefore c accepts a proposal when

$$y_c \geq \frac{1}{3} + \frac{\delta(1-\rho_c)(x_c - 1/3)}{1-\delta\rho_c} \tag{13}$$

i accepts a proposal when

$$y_i \geq \frac{1}{3} + \frac{\delta(1-\rho_c)(x_i - 1/3)}{1-\delta\rho_c} \tag{14}$$

and j accepts a proposal when

$$y_j \geq \frac{1}{3} + \frac{\delta(1-\rho_c)(x_j - 1/3)}{1-\delta\rho_c} \tag{15}$$

In this case, i and j always vote to reject c's proposal. And, by construction, all three legislators' acceptance sets satisfy weak dominance. Further, the chair weakly prefers proposing $(0, 0, 1)$ to any other proposal that would get rejected and weakly prefers proposing $(0, 0, 1)$ to making a proposal that either i or j would accept immediately. Thus, c's proposal strategy satisfies sequential rationality. Additionally, as i and j's proposals would both pass and provide them their maximum grant amounts, these strategies also satisfy sequential rationality. Therefore, there exists a stationary equilibrium where delay occurs with probability 1 but after a finite number of periods a proposal other than the status quo is enacted.[13]

13. If the chair were not fixed as the proposer in the first period then delay would occur with probability $\rho_c > 0$.

5 Empirical Analysis

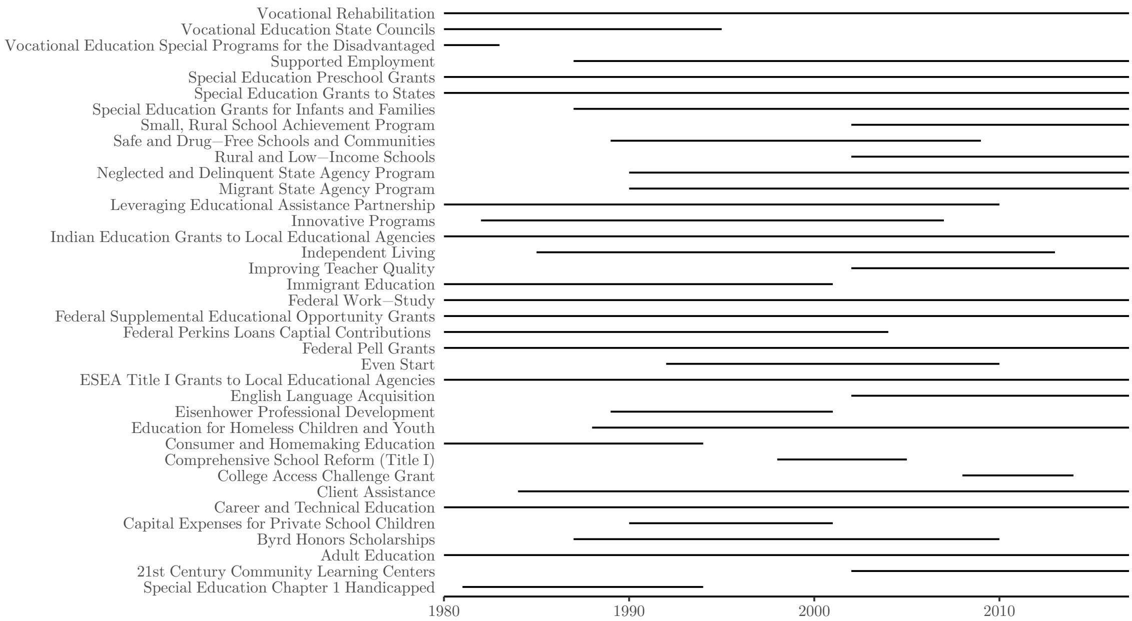
The theory yields predictions about which states will benefit from formula grant programs that can be tested empirically. In this section, I test two of these predictions using data on education grant programs. First, the theory predicts that formula grant proposals will benefit states doing worse under the status quo. To test this prediction, I examine the relationship between a state's grant amount under the status quo formula and whether that state is included in the winning coalition. Consistent with theoretical predictions, I find that states doing worse under the status quo are more likely to benefit from a formula change.

Second, if committees do have proposal power then the state represented by the committee chair should benefit more from formula changes. To test this prediction I use a matched difference-in-differences design to estimate how much formula funding committee chairs are able to procure for their states. Additionally, I test whether committee members as well as committee chairs have an advantage. In the theory, I simplify the role of committees to proposal power for the committee chair. In practice, proposals must be passed in committee before they are considered on the floor. Thus, committee members as well as the committee chair should benefit from formula grant changes. Consistent with these predictions, I find evidence that both committee members and committee chairs are able to procure additional formula funding for their states when programs under their jurisdiction are reauthorized.

5.1 Data

To test the predictions from the model, I examine the distribution of grants to states for education. Education is a particularly good policy area to test the model as there are many education formula grant programs. However, there is no reason to think that these programs are different than formula grant programs in other policy areas. I compile a data set of grant amounts for each state in each year going back to FY1980 for all formula grant programs administered by the Department of Education.[14] For each program in each year, I hand code when the program was last reauthorized. I then match each reauthorization to Stewart and Woon's (2017) and Nelson's (1993) congressional databases to determine authorizing committee membership. As all of the programs in the data set are education programs, they all fall under the jurisdiction of the Health Education Labor and Pensions (HELP) Committee.[15] Figure 5 summarizes which programs are funded in each year in this dataset.

Figure 5: Formula Grants Administered by ED, FY1980 to FY2017



As these data are at the state level, I focus my analysis on the Senate. While there is nothing particular to the theory that applies to the Senate but not the House, there is reason to suspect that senators are more likely to try and alter grant programs to bring more funding to their states than House members. Specifically, because formulas do not allocate grants to congressional districts it is difficult for House members to claim credit for formula changes and know how a formula change will affect funding for their district

14. Data on state grant amounts are available on the Department of Education's website. I exclude the Impact Aid program from this analysis because it has been reauthorized by bills reported out of the Health Education Labor and Pensions Committee and the Armed Services Committee. Thus, it is sometimes unclear what bill last reauthorized the program and who the relevant committee members are.

15. During this time period the HELP Committee was also called the Human Resources Committee and the Labor and Human Resources Committee.

(Lee 2003, 2004). However, because most formula grants allocate funding to states or entities that are nested within states, these same issues do not affect Senators.

5.2 Methodology

To examine winning coalition membership and the committee advantage, I compare how a state does under similar programs within the same year. As the theory makes predictions about what will happen when a formula is amended, I restrict my analysis to the years following a program reauthorization.[16] As formula changes are often phased in over time, I estimate effects immediately following a reauthorization and for each of the three subsequent years. I discuss the methodology for each analysis in more detail below.

5.2.1 Winning Coalition Membership

To examine the relationship between status quo grants and winning coalition membership, I compare whether a state was included in the winning coalition under education programs reauthorized in the same year. That is, I compare whether a state was included in the winning coalition when it was doing poorly under the status quo to winning coalition membership when it was doing well under the status quo in the same year.

I look at the relationship between a state's status quo grant and winning coalition membership immediately following a formula change and for each of the three subsequent years.[17] To measure when a state is included in the winning coalition, I construct a binary indicator for whether the state's grant increased.[18] To measure whether a state is doing poorly under the status quo, I take the log of a state's grant under the status quo.[19] Because funding levels vary by program, I also include a covariate for the funding level

16. I do not look at the initial enactment of programs as all states benefit when a program is initially enacted. This is because, for initial enactments, states are receiving no funding under the status quo.

17. As a result, I only examine reauthorizations in year t where the program is not subsequently reauthorized prior to year $t+4$. I also only examine reauthorizations where the previous reauthorization occurred more than three years prior. This is to reflect the fact that formula grant changes are phased in over time.

18. In the appendix, I include the same analysis but use a state's grant share to determine the winning coalition. The results are very similar. I consider states where there is no change in their grant amounts as members of the winning coalition.

19. As status quo grants are measured in log dollars, this analysis estimates the relationship between the percentage change in a state's status quo grant on its probability of being included in the winning coalition.

for the program. Specifically, I estimate the probability of being included in the winning coalition j years after reauthorization with the following linear model:[20]

$$Pr(y_{ipt+j} \geq q_{ipt} | q_{ipt}, \omega_{it}) = \beta_1 \log(q_{ipt}) + \beta_2 Appropriations_{pt} + \omega_{it} + \epsilon_{ipt} \tag{16}$$

where y_{ipt+j} is state i's grant in year $t+j$; q_{ipt} is state i's grant prior to the reauthorization of program p in year t; $Appropriations_{pt}$ is the funding level for program p under the status quo; ω_{it} is a state-year fixed effect; and ϵ_{ipt} is an error term. As linear probability models suffer from heteroskedasticity, I use robust standard errors.[21]

The advantage of this design is that it accounts for state and legislator characteristics. As the theory illustrates, whether a state is included in the winning coalition depends on state characteristics (e.g., population) and which legislator is the committee chair. And, these factors may also be related to a state's grant under the status quo. Including state-year fixed effects holds both state and legislator characteristics constant. This allows me to isolate the effect of how a state is doing under the status quo.

5.2.2 Committee Advantage

To estimate the committee and committee chair effects, I use a difference-in-differences design that compares state grant amounts within the same year under education programs that have and have not been reauthorized. Specifically, I exploit the fact that programs do not come up for reauthorization at the same time. That is, at the beginning of a legislator's tenure as chair there will be some programs that she has reauthorized (and thus had the ability to change the formulas) and others she has not. Therefore, I can compare how a state does under a program that the current chair has reauthorized to a similar program that has yet to come up for reauthorization. Put differently, each treated observation has its own control set made up of grant amounts in the same year for the same state under similar programs. For example, Senator Ted Kennedy (MA)

20. I fit a linear probability model rather than a logistic regression due to the inclusion of fixed effects. In the appendix, I fit a conditional logistic regression and get similar results.

21. I calculate White (1980) heteroskedasticity-consistent standard errors using the `sandwich` package in R (Zeileis 2004).

became chair of the HELP committee in 2007. In 2008, Congress reauthorized the Higher Education Act (HEA), which is under the jurisdiction of the HELP committee. However, the Workforce Investment Act (WIA), which is also under HELP's jurisdiction, had yet to be reauthorized while Senator Kennedy was chair. To estimate the additional formula funding Senator Kennedy was able to bring to Massachusetts, I compare the change in Massachusetts's HEA grant amounts between 2008 and 2009 to the change in Massachusetts's WIA grant amounts over the same time period.[22]

As formula changes are often phased in over time, I estimate the effect of joining committee and becoming chair immediately following a formula change and for each of the three subsequent years.[23] Let $D_{ipt} \in \{0, 1\}$ represent the treatment status of state i for program p at time t. I compare the change in a committee member/chair's grant amount following reauthorization at time t to a counterfactual of never being reauthorized over the same period. Thus, the vector $\mathbf{D}$ for the treatment (T) and control (C) groups is the following:

	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$
D_T	0	0	0	1	1	1	1
D_C	0	0	0	0	0	0	0

To estimate the treatment effect j years after reauthorization, I compare the change in each treated observation's logged grant amount between $t-1$ and $t+j$ to that of its matched control set. To account for the fact that the same observation may be used in the control group for multiple observations in the treatment group (matching with replacement), I estimate standard errors using a weighted bootstrap (Otsu and Rai 2017).

22. This analysis assumes that chairs do not select which programs to reauthorize based on which formulas they most want to change. This assumption seems reasonable given that a single statute contains multiple formula grant programs as well as other policies. Thus, whether a program gets reauthorized depends on more than just its allocation formula. To test this assumption I compare the chair's state's grant under the status quo under programs reauthorized and not reauthorized in a given year and find no significant difference. Further, this analysis assumes that a state's grant amounts under reauthorized programs would have followed the same trends as non-reauthorized programs had those programs not been reauthorized. To test this assumption, I examine the pre-reauthorization trends in state grant amounts and find the reauthorized and not reauthorized grants are similar. I include these analyses in the appendix.

23. Thus, I only include observations in the treatment group in year t where the treatment status does not change prior to year $t+4$. I also only include observations that remained untreated for at least three years prior to reauthorization.

I discuss the estimation of effect sizes and standard errors further in the appendix.

This differences-in-differences design overcomes two potential issues for estimation. First, as the model illustrates, a state's grant amount depends on it's formula factors or observable attributes. As discussed previously, comparing the same state in the same year holds state attributes, such as population and poverty, constant. Second, as others have noted, a challenge in measuring the committee advantage is constructing the counterfactual as certain legislators may be more likely than others to select onto a committee (e.g., Grimmer and Powell 2013; Berry and Fowler 2016). Thus I cannot compare a committee member's state to all other states. This design sidesteps this issue by exploiting the plausibly exogenous variation in program reauthorizations, as opposed to which state is represented by the chair, to make within-state comparisons.

5.3 Results

Table 1 examines the relationship between a state's grant under the status quo and winning coalition membership when a program gets reauthorized. In line with theoretical predictions, when a state is doing worse under the status quo it is more likely to be included in the winning coalition. Specifically, in the first year following a reauthorization, a 10% increase in a state's grant under the status quo is associated with a 0.15 percentage point decrease in the probability of being included in the winning coalition. If legislators are attempting to allocate funding based solely on need, then a state's grant under the status quo should have no relationship to whether it is included in the winning coalition. These results are more consistent with legislators trying to maximize grants for their states by forming the cheapest winning coalitions.

Table 1: Winning Coalition Membership (OLS)

	DV: Winning Coalition Member			
	t	$t+1$	$t+2$	$t+3$
Status Quo Grant (Log)	-0.016^{***}	-0.022^{***}	-0.016^{***}	-0.020^{***}
	(0.002)	(0.002)	(0.002)	(0.002)
Funding Level (in Billions)	0.028^{***}	0.046^{***}	0.049^{***}	0.053^{***}
	(0.003)	(0.002)	(0.002)	(0.002)
State-Year Fixed Effects	✓	✓	✓	✓
Observations	4,000	4,000	4,000	4,000
Adjusted R^2	0.080	0.132	0.145	0.156

Note: $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$
Robust standard errors in parentheses

Table 2 presents estimates of the of the committee advantage and the committee chair advantage. The analysis suggests that states represented by committee members receive more formula grant funding. Further, there is an additional benefit of becoming the committee chair on top of committee membership.[24] In the first year following a reauthorization, committee members' states receive about 24% more education funding and committee chairs' states receive an additional 5.5%.[25] These results are consistent with the prediction of the theory that committee members benefit more from formula changes and this benefit is not just due to committee members being high demanders. These results are also somewhat in line with work by Berry and Fowler (2018) that argues that legislators see an increase in power when they become committee chairs. However, unlike Berry and Fowler, I find a substantial effect of committee membership as well as being the committee chair.

24. The control group includes programs that have yet to be reauthorized since a legislator became chair. Because committee chairs were on committee prior to being chair, the committee chair effect is primarily comparing how a state does when it was represented by a committee member to when it is represented by the committee chair.

25. As grants are measured in log dollars, $100 \times (\epsilon^{\beta} - 1)$ reflects the percentage change in funding in a legislator's state when that legislator is on committee or is the chair. For small values of β, this can be approximated by $100 \times \beta$.

Table 2: Effect of Committee Position on Formula Grants, Diff-in-Diff Estimates

	DV: *Grant Amount (Log)*			
	t	$t+1$	$t+2$	$t+3$
Committee Chair	0.055*	0.198*	0.106*	0.117
	(0.023)	(0.077)	(0.044)	(0.061)
Committee Member	0.215*	0.1**	0.227***	0.396**
	(0.1)	(0.037)	(0.053)	(0.121)
Observations				
Committee Chair	138	138	138	138
Committee Member	1,014	1,014	1,014	1,014

Note: *p<0.05; **p<0.01; ***p<0.001; standard errors computed based on 1,000 weighted bootstrap samples in parentheses

Taken together these results indicate that formula grants are a divide-the-dollar game where legislators attempt to increase their states' grants and where committees play a key role in the bargaining process. However, this is not to say that other political and institutional factors do not play a role in the distribution of grants. Rather, these results should be taken to mean that at least some of the patterns in grant allocations can be explained by legislators trying to increase their grant amounts and committee members being particularly effective at doing so.

6 Concluding Discussion

In this paper I show how grant programs are shaped by legislators attempting to maximize the funding their states receive. As with earmarks, the committee chair is more successful in procuring additional funding because of the role she plays in the policymaking process. And, consistent with a distributive theory of formula grants, I find empirical evidence that committee members, and particularly the committee chair, are able to procure more funding for their states. However, the structure of a formula places limits the chair's ability to do this. As in Martin (2018), the advantage to the chair is reduced because funding is distributed outside of the winning coalition, winning coalitions may be oversized, and members of the winning coalition may receive a larger share of funding than is required to make them support a proposal. In this paper, I show that the status quo further constrains the chair, in some cases preventing them from enacting a new formula.

The theory also yields new predictions about which states should most benefit from formula grant programs. States doing worse under the status quo benefit more from formulas because they are cheaper to include in the winning coalition. Consistent with this prediction, I find that the larger a state's grant is under the status quo formula, the less likely that state is to be included in the winning coalition. Additionally, as the Title I-A example illustrated, smaller states tend to receive more per capita grant funding than larger states (Lee 2000). This result is consistent with the theory as the distribution of population across states is right skewed. In other words, there are a few states with very high populations (e.g., New York, California, Texas) but the majority of states have population levels below the national average. Thus, if a formula were to include population or factors correlated with population (e.g., poverty) then a large number of states would want to have high minimum grants (i.e., they would prefer α). Because a large number of formulas do include some measure of population, many formulas should end up with higher minimum grant amounts. And, since minimum grants distribute an equal amount of funding to each state, these provisions provide smaller states more per capita funding.

These results have important implications for how efficiently programs distribute funding to areas with the greatest need. What formula gets enacted, and thus which states benefit, depends on the distribution of formula factors across states, the committee chair, and the status quo policy. Committee chairs with high need benefit from efficient formulas. Thus, due to their proposal power, committee chairs with high need typically improve formulas with poor targeting and protect formulas that target effectively. However, for a committee chair to improve the targeting of a formula, she needs to find a majority of legislators who support her proposal. Thus, if the majority of legislators have relatively low need then, depending on the status quo, it may not be possible for the chair to enact a formula that improves targeting.

The chair, status quo, and distribution of need also determine whether a formula is more targeted to one factor over another. Consider again a formula based on population and poverty. If poverty is concentrated in a few states but population is not then population share will be larger than poverty share for a majority of states. Thus, for certain status quos, even if the chair represents a state with a high poverty share then it may not be possible to enact a formula that is only based on poverty. The formula will have to put some weight on population. More generally, if x is greater than z for a majority of legislators then the formula will often place at least some weight on x.

One implication of this theory is that having committee chairs who are high demanders in a certain policy area may actually improve how effectively formulas target need. Weingast and Marshall (1988) show how the committee system in Congress facilitates decision making because it allows for the enforcement of legislative bargains. This is due to both committees' agenda setting power and the fact that committees are made up of high demanders. By a similar argument committee chairs can enact and protect formulas that most benefit their states through their agenda setting power. And, if committee chairs have high need for a program (i.e., they are high demanders) then the formulas they enact and protect are likely to be formulas that target funding toward areas with the greatest need.

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Appendix

A Theory

Maximum Grant Amounts

It is first useful to consider the maximum possible amount each state could receive under a formula. In a typical divide-the-dollar game (e.g., Baron and Ferejohn 1989), the maximum possible allocation for a legislator is 1 (i.e., they take the entire dollar). However, when allocations are constrained by a formula, each type of legislator has a different maximum allocation, which is less than 1 and determined by x_i and z_i. A legislator's "type" is pair $\{x_i, z_i\}$. Thus, legislators with the same values for x_i and z_i are of the same type. Based on these types, legislators fall into the following three categories, which describe their maximum possible allocation and the formula factor from which they most benefit:

1. When $x_i \geq z_i$ and $x_i \geq 1/n$ then $y_i^{\max} = x_i$ and this allocation occurs when $\eta = 1, \gamma = 0, \alpha = 0$. I refer to these legislators as legislators whose preferred weight is η.

2. When $z_i \geq x_i$ and $z_i \geq 1/n$ then $y_i^{\max} = z_i$ and this allocation occurs when $\gamma = 1, \eta = 0, \alpha = 0$. I refer to these legislators as legislators whose preferred weight is γ.

3. When $x_i \leq 1/n$ and $z_i \leq 1/n$ then $y_i^{\max} = 1/n$ and this allocation occurs when $\alpha = 1, \eta = 0, \gamma = 0$. I refer to these legislators as legislators whose preferred weight is α.[26]

The intuition for this result is relatively straightforward: a legislator receives the largest grant when all of the weight is placed on their largest formula factor. More formally,

$$\max_{\eta,\gamma,\alpha} \eta x_i + \gamma z_i + \alpha \frac{1}{n} \tag{17}$$

26. If $x_i = z_i = 1/n$ then that legislator receive their maximum allocation ($1/n$) under any combination of weights so long as $\eta + \gamma + \alpha = 1$.

when $\eta, \gamma, \alpha \geq 0$ and the budget constraint is $\eta + \gamma + \alpha \leq 1$.

In the case where $z_i = x_i = 1/n$, any combination of η, γ, α provides i her maximum grant of $1/n$ so long as $\eta + \gamma + \alpha = 1$. In this case, η, γ, and α are essentially perfect substitutes. However, in all other cases we must consider corner solutions. When $(1, 0, 0)$ is the formula, i receives a grant of x_i. When $(0, 1, 0)$ is the formula, i receives a grant of z_i. When $(0, 0, 1)$ is the formula, i receives a grant of $1/n$. Thus, $(1, 0, 0)$ provides i her maximum grant (equal to x_i) when $x_i > z_i$ and $x_i > 1/n$. That is, when i prefers η. Similarly, $(0, 1, 0)$ and $(0, 0, 1)$ provides i her maximum grant when she prefers γ and α, respectively.

Proof of Proposition 1

Proposition 1. There exists a Nash equilibrium in which the chair makes an acceptable proposal. Further, let g_i be the grant legislator i receives when the committee chair sets her preferred weight to 1, G be the set of all legislators for whom $g_i \geq q_i$, and $|G|$ be the number of legislators in G. If either (i) $\sum_{i \in N} q_i < 1$; (ii) $q_i < f_i^2$ for the majority of legislators and the chair; or (iii) $|G| \geq (n+1)/2$ and $q_i < g_c$ then there exists a Nash equilibrium in which the chair enacts a formula that increases her grant amount.

Proof. By construction, the voting strategy $A_i = \{(\eta, \gamma, \alpha) \in \chi | \eta x_i + \gamma z_i + \alpha/n\}$ satisfies weak dominance. Notice that legislator i's acceptance set A_i contains the status quo formula for all $i \in N$. Thus, A is always nonempty as it will contain the status quo formula. As a result, the chair can always make an acceptable proposal. And, because a non-acceptable proposal results in grants based on the status quo formula, there is always an acceptable proposal that the chair weakly prefers to a non-acceptable proposal. As a result, selecting the proposal in A that maximizes her grant amount, is a best response for the chair. Thus, there exists a Nash equilibrium in which the chair makes an acceptable proposal. □

Define w_i^1, w_i^2, w_i^3 as the value of legislator i's most, second-most, and least preferred weights, respectively, under the status quo.[27]

27. For example, if $f_i^2 = x_i$ then $w_i^2 = \eta_q$

(i) When $\sum_{i \in N} q_i < 1$ this implies $\eta_q + \gamma_q + \alpha_q < 1$. Thus, the proposer can always strictly increase her grant amount and the grant amount for all other legislators by increasing her preferred weight by $1 - \alpha_q - \gamma_q - \eta_q$. $\square$

(ii) Note that when $\eta + \gamma + \alpha = 1$ but legislator i's least preferred weight is 0 then it must be the case that $y_i \geq f_i^2$. Thus, when $q_c < f_c^2$ this implies that $w_c^1 + w_c^2 < 1$. Further, when $q_i < f_i^2$ for the majority of legislators then $w_i^1 + w_i^2 < 1$ for the majority of legislators. Thus the grant for the chair and majority of legislators can be increased by decreasing w_c^3. $\square$

(iii) When $|G| \geq (n+1)/2$ then the formula that sets the chair's preferred weight to 1 is socially acceptable. This is because it provides every legislator with $y_i = g_i$, which weakly increases grants for a majority of legislators. Further, this provides the chair her maximum grant amount ($y_i = y_i^{\max}$), which strictly increases the chair's grant amount provided the chair is not already receiving her maximum. $\square$

Proof of Corollary 1

Let g_i be the grant legislator i receives when the committee chair sets her preferred weight to 1, G be the set of all legislators for whom $g_i > q_i$, and $|G|$ be the number of legislators in G. Further, let A_W^* be the formula in A_W that maximizes the chair's grant amount and $y_i(A_W^*)$ be legislator i's grant amount from this formula.

It is first useful to consider some lemmas to prove the main result. Lemma 1 shows that in equilibrium the budget constraint always binds.

Lemma 1. $\sum_{i \in N} y_i = 1$

Proof. Suppose not and $\sum_{i \in N} y_i < 1$. Note that because $\sum_{i \in N} x_i = 1$ and $\sum_{i \in N} z_i = 1$, then Lemma 1 implies $\eta + \gamma + \alpha = 1$. If it were not to bind then the proposer could always strictly increase her grant amount by increasing her preferred weight by $1 - \alpha - \gamma - \eta$. $\square$

Lemma 2 shows that if the formula proposed in equilibrium does not provide the chair her maximum grant amount then at least one legislator in the winning coalition is indifferent between the proposal and the status quo.

Lemma 2. If $y_c(A^*_W) < y_c^{\max}$ then there exists $i \in W$ such that $y_i(A^*_W) = q_i$.

Proof. From weak dominance,

$$A_i = \left\{ (\eta, \gamma, \alpha) \in \chi \,\middle|\, \eta x_i + \gamma z_i + \frac{\alpha}{n} \geq q_i \right\} \tag{18}$$

If possible, the chair would set her preferred weight to one as it provides her $y_c^{\max}$. Thus, when $y_c(A^*_W) < y_c^{\max}$, it must be the case that $q_i > g_i$ for the majority of legislators. This implies that the majority of legislators do not prefer the same weight as the chair and some of these legislators need to be included in the winning coalition. Further, from Lemma 1, it immediately follows that if the chair cannot set her preferred weight to 1 the formula proposed in equilibrium will put weight on at least one other factor. If $y_i(A^*_W) > q_i$ for all $i \in W$ such that $g_i > q_i$ then the chair can increase her preferred weight and decrease the other weight in the formula, which decreases the grants for these legislators. Further, the chair will continue to do this until $y_i(A^*_W) = q_i$ for at least one legislator. $\square$

Lemma 3 shows that in equilibrium the sum of grants distributed to legislators other then the chair weakly decreases if members are removed from the winning coalition. Further, if the formula proposed in equilibrium does not provide the chair her maximum grant amount then this inequality is strict.

Lemma 3. When $W' \in \mathcal{D}$ and $W' \subset W$ then

1. $\sum_{i \in N-c} y_i(A^*_{W'}) \leq \sum_{i \in N-c} y_i(A^*_W)$
2. If $y_c(A^*_W) < y_c^{\max}$ then $\sum_{i \in N-c} y_i(A^*_{W'}) < \sum_{i \in N-c} y_i(A^*_W)$

Proof. Because the budget constraint binds in equilibrium, the chair's grant is equal to the following:

$$y_c = 1 - \sum_{i \in N-c} y_i \tag{19}$$

Thus for the chair to maximize her grant, she must minimize grants to all other legislators.

As a result,

$$\sum_{i \in N-c} y_i(A^*_{W'}) = \min_{(\eta,\gamma,\alpha)\in A_{W'}} \sum_{i \in N-c} \eta x_i + \gamma z_i + \alpha/n \tag{20}$$

$$\sum_{i \in N-c} y_i(A^*_{W}) = \min_{(\eta,\gamma,\alpha)\in A_{W}} \sum_{i \in N-c} \eta x_i + \gamma z_i + \alpha/n \tag{21}$$

Because $W' \subset W$, it immediately follows that $A_W \subseteq A_{W'}$. As a result, $\sum_{i\in N-c} y_i(A^*_{W'}) \leq \sum_{i\in N-c} y_i(A^*_W)$. As for part 2, note that, from Lemma 2, there exists $j \in W$ such that $y_j(A^*_W) = q_j$. If legislator j is removed from the winning coalition then c can increase her preferred weight and decrease at least one of the other weights. This strictly increases the chair's grant amount, therefore strictly decreasing the sum of grants distributed to other legislators. □

With this, I can now prove the main result.

Corollary 1. If $|G| \geq (n+1)/2$ then the winning coalition size is $|G|$. If $|G| < (n+1)/2$, then any formula change enacted in equilibrium has a minimal winning coalition.

Proof. If possible the chair sets her preferred weight to 1 as this results in her maximum grant amount. It is possible for the chair to enact this formula when a majority of states receive at least what they are receiving under the status quo formula. Thus, the winning coalition size is $|G|$. In all other cases, the winning coalition is minimal sized. Suppose not and c proposes $(\eta,\gamma,\alpha) \in A$ where $y_i > q_i$ for $\hat{n} > (n+1)/2$ legislators. Because, $|G| < (n+1)/2$ the chair cannot set her preferred weight to 1. From Lemma 1 it follows that if the chair cannot set her preferred weight to 1 then in equilibrium at least two weights are non-zero. From Lemma 3, the chair strictly prefers increasing her preferred weight and decreasing at least one of the other weights such that fewer legislators are included in the winning coalition. This results in a minimal winning coalition because if it did not and the other weights could not be decreased any further then this would imply that the chair's preferred weight is 1, which is not possible.[28] And, the chair strictly prefers this formula to (η,γ,α) because it increases the weight on her most preferred factor and weakly decreases the weight on the other two factors. □

28. There are some knifes edge conditions in which two legislators are equally "cheap" to include in the winning coalition and thus, in equilibrium, the chair could have an oversized coalition.

Proof of Proposition 2

To apply Theorem 1 of Banks and Duggan (2006) I must verify six technical conditions:

1. Impose the requirement that $\delta \in [0,1)$ and $\delta_i = \delta \forall i$.

2. The set of possible formulas χ is nonempty, compact, and convex where $\chi = \{\eta, \gamma, \alpha \in [0,1] | \sum_{i \in N} \eta x_i + \gamma z_i + \alpha 1/n \leq 1\}$. $(0,0,0) \in \chi$ so χ is nonempty. Convexity and compactness follow immediately from the linear budget constraint and the non-negativity constraints used to define χ.

3. The status quo policy $(\eta_q, \gamma_q, \alpha_q) \in \chi$. This is true by assumption.

4. Impose the requirement that the recognition probabilities $\rho_1, ..., \rho_n$ are fixed throughout the game. Note that fixing the chair as the proposer in the first period does not conflict with this requirement as we can consider the chair to be the legislator who is chosen as the proposer in the first period.

5. Each legislator's utility u_i is continuous and concave. This is ensured by the linearity of the utility function.

6. Each legislator's utility u_i is strictly quasi-concave and strictly monotonic in the consumption of i's district. Strict quasi-concavity and strict monotonicity follow from the fact that i's utility is strictly increasing in her own district's grant amount.[29]

B Estimating the Committee Advantage

To estimate the committee advantage I use a difference-in-differences design where each treated observation is matched with control observations from the same state in the same time period. Let $D_{ipt} \in \{0,1\}$ represent the treatment status (committee member/committee chair) of state i for program p at time t. I estimate the committee advan-

29. This condition is needed to ensure that Banks and Duggan's requirement of limited shared weak preferences (LSWP) holds. LSWP is similar to, but weaker than, single-peakedness.

tage j years after a reauthorization for $j \in \{0, 1, 2, 3\}$ using

$$\hat{\tau}_j = \frac{\sum_{i \in S} \sum_{t \in T} \sum_{p \in P} W_{ipt} \left(Y_{ipt+j} - Y_{ipt-1} \right)}{\sum_{i \in S} \sum_{t \in T} \sum_{p \in P} D_{ipt} \times W_{ipt}} \tag{22}$$

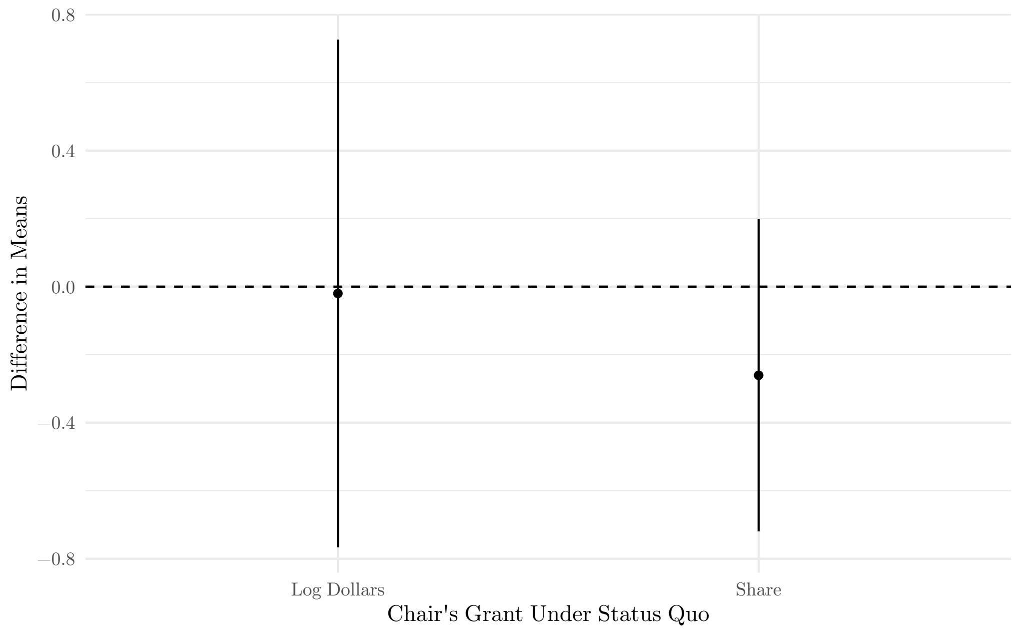
where Y_{ipt+j} is state i's grant amount under program p at time $t + j$; and

$$W_{ipt} = \begin{cases} \frac{-\sum_{p' \in P} \prod_{j'=1}^{3} (1 - D_{ip't-j'}) \prod_{j'=0}^{3} D_{ip't+j'}}{\sum_{p' \in P} \prod_{j'=-3}^{3} (1 - D_{ip't+j'})} & \text{if } D_{ipt+j'} = D_{ipt-j'} = 0 \ \forall \ j' \in \{0, 1, 2, 3\} \\ 1 & \text{if } \prod_{j'=0}^{3} D_{ipt+j'} = \prod_{j'=1}^{3} (1 - D_{ipt-j'}) = 1; \\ & \text{ and } \sum_{p' \in P} \prod_{j'=-3}^{3} (1 - D_{ip't+j'}) > 0 \\ 0 & \text{Otherwise} \end{cases}$$

Note that τ is the average treatment effect on the treated (ATT). The denominator reflects the number of treated observations that have at least one control observation in their matched sets. The numerator is equivalent to taking the change in a state's grant amount for treated observations that have a matched set and subtracting it from the average change in that state's grant amounts over the same time period for programs that have yet to be reauthorized. To achieve this, treated observations with a matched control set receive a weight (W_{ipt}) of 1 and control observations receive a weight based on the number of treated observations they are matched to and the number of other control observations in the matched set. To estimate standard errors, I use the weighted bootstrap procedure proposed by Otsu and Rai (2017). Specifically, I treat the weights as covariates and do not re-estimate them within each bootstrap iteration. Following Imai, Kim, and Wang (2020), I use a block bootstrap procedure to sample state-program units to accommodate the panel nature of my data.

This analysis relies on two assumptions. First, chairs are not strategically selecting programs to reauthorize based on which formulas they want to change. Second, observations in the treatment and control groups follow common trends. Figure 6 shows the difference in means between the chair's grant under the status quo for the treatment and control groups.[30] I measure the chair's status quo grant using both share and log dollars.[31] There does not appear to be any relationship between the status quo grants and whether programs were reauthorized. This suggests that chairs are not selecting bills to reauthorize based on how much grant funding their states are receiving under programs included in each bill. Figure 7 shows the weighted average grant for the committee chair's state under programs that were reauthorized (treatment group) and not reauthorized (control group).[32] The pre-reauthorization trends for the treatment and control units are similar, which supports the common trends assumption required for identification.

Figure 6: Chair's Status Quo Grant Balance Between Treatment and Control

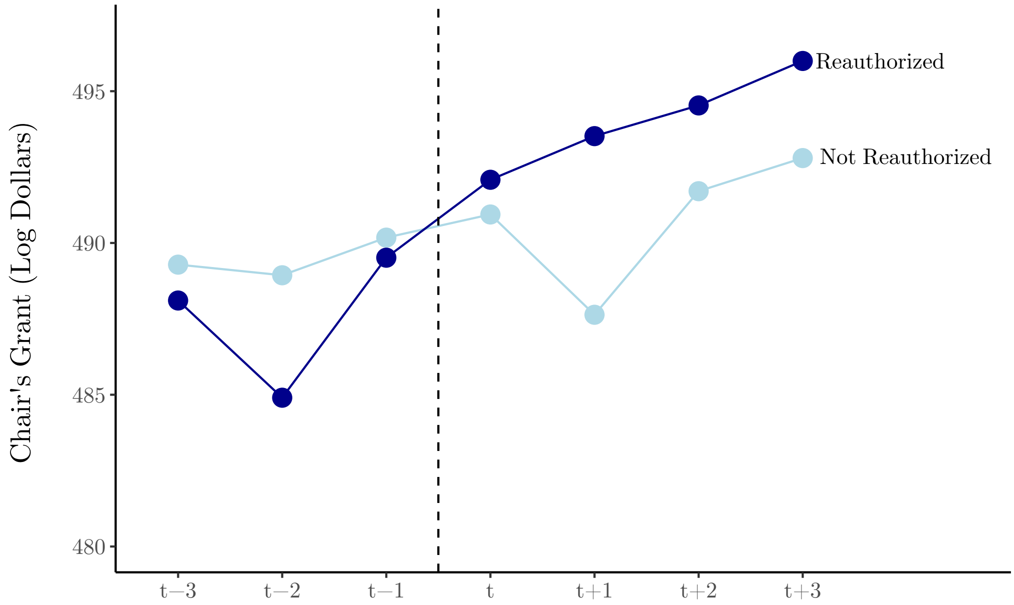


30. The differences in means were weighted using the absolute value of the weights W_{ipt} described above.

31. In order to make the figure easier to read, I multiply share by 100. Thus a share of 15 means that a state is receiving 15% of the funding.

32. Again, I use the absolute value of the weights W_{ipt} described above.

Figure 7: Chair's Grant by Reauthorization Status



C Robustness Checks

Table 3 reexamines which states are included in the winning coalition using a state's grant share opposed to its grant amount to determine winning coalition membership. Similar to using grant amounts, I find that states doing worse under the status quo are more likely to be included in the winning coalition.

Table 3: Winning Coalition Membership (OLS)

	DV: Winning Coalition Member			
	t	$t+1$	$t+2$	$t+3$
Status Quo Grant (Log)	-0.028^{***}	-0.029^{***}	-0.030^{***}	-0.032^{***}
	(0.002)	(0.002)	(0.002)	(0.002)
Funding Level (in Billions)	-0.006^{*}	0.007^{**}	0.006^{*}	0.012^{***}
	(0.003)	(0.003)	(0.003)	(0.003)
State-Year Fixed Effects	✓	✓	✓	✓
Observations	4,000	4,000	4,000	4,000
Adjusted R^2	0.058	0.078	0.080	0.080

*p<0.05; **p<0.01; ***p<0.001
Robust standard errors in parentheses

Table 4 reexamines which states are included in the winning coalition using a conditional logistic regression.[33] Again, I find that states doing worse under the status quo are more likely to be included in the winning coalition.

Table 4: Winning Coalition Membership (Logit)

	DV: Winning Coalition Member			
	t	$t+1$	$t+2$	$t+3$
Status Quo Grant (Log)	-0.118^{***}	-0.152^{***}	-0.127^{***}	-0.209^{***}
	(0.022)	(0.022)	(0.023)	(0.028)
Funding Level (in Billions)	0.156^{***}	0.300^{***}	0.334^{***}	0.450^{***}
	(0.021)	(0.029)	(0.032)	(0.038)
Observations	4,000	4,000	4,000	4,000
Log Likelihood	−1,188.033	−1,199.686	−1,145.007	−1,126.725
Wald Test (df = 2)	59.190^{***}	113.170^{***}	109.880^{***}	137.570^{***}

*p<0.05; **p<0.01; ***p<0.001

33. Note that table 4 reflects raw logit coefficients. I estimate the model using the `survival` package in R (Therneau 2020).