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Universalism and the Value of Political Power

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Abstract: While legislatures typically use majority rule to allocate a budget in distributive legislation, unanimous consent over the broad allocation of benefits is pervasive. I develop a game-theoretic model where members strategically interact in a universal coalition to determine allocations, with non-cooperative bargaining as a threat point for the breakdown of cooperation. To quantify the effects of political power on the agreed-upon allocation, I structurally estimate the model using the "Bridge Bill Capital Budget" in 1992. I find that 16.73 percent of the budget would be allocated differently if allocations were determined only based on actual needs.

Keywords: Universalism, Distributive legislation, Legislative bargaining, Local public goods, and Transportation infrastructure.

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1 Introduction

In economics, the allocation of resources is often rationalized by games with conflicting interests. This is particularly true in legislatures, where politicians compete to win more money for their districts. To study these situations, non-cooperative legislative bargaining games have often been used. However, there is greater room for cooperation and compromise in certain types of bills. For distributive legislation, near unanimous consent over the broad allocation of benefits is pervasive. Weingast (1994) defines an ideal type of distributive legislation as an expenditure policy which is an omnibus of divisible projects. For instance, there were 62 distributive bills on capital projects passed in the Pennsylvania State Legislature from 1981 to 2014 following this definition. 85.5 percent and 62.9 percent of these bills received unanimous support in the Senate and the House respectively. For the bills that did not receive unanimous agreement, average support rate was 93.6 percent in the Senate and 92.4 percent in the House. Universal cooperation over broad allocation of benefits is also commonly found in other contexts. Previous literature finds evidence that various distributive legislations on rivers and harbors, military procurement, categorical grants-in-aid, and public works have passed with unanimous support.[2]

This phenomenon is commonly referred to as "universalism." The two main questions that I address in this paper are the following. First, what determines allocation of money across local public projects under universalism? Second, do political factors affect the allocations and, if so, to what extent? I study both theoretically and empirically how a legislature allocates a budget to fund local public projects in an omnibus bill, one in which many small appropriations are packaged into a large bill. I develop a game-theoretic model

[2]See Weingast (1979) and Shepsle & Weingast (1981) for an overview.

where allocations which are strategically determined to sustain unanimous support arise as the unique equilibrium outcome. Previously, Shepsle and Weingast (1981) studied why universalism emerges. The idea is that under majority rule, politicians face uncertainty over the composition of winning coalition and this can induce ex-ante preferences for universalism. The theoretical innovation of this paper is that I explain what determines allocations under universalism by combining the insight of Shepsle and Weingast (1981) with the insight of Baron and Ferejohn (1989) in the non-cooperative bargaining game. To my best knowledge, given a budget and a legislative protocol, how politicians cooperate yet strategically interact to allocate resources under universalism has not been modeled.

In the model, there is a legislature which consists of members. Each member represents a district. Members are heterogeneous in both political power and their needs for local public projects. There is a stock of local public projects in a district, where each project differs in attributes and political importance. Given an exogenous budget, members need to pass a distributive omnibus bill of local public project grants. I build a model where members first consider cooperating as a universal coalition as in Shepsle and Weingast (1981). In the event that any member disagrees to cooperate, members would play a non-cooperative bargaining game as in Baron and Ferejohn (1989). Once money is allocated across districts, I model how portfolios of projects are chosen within districts following Nevo, Rubinfeld, and McCabe (2005).

On top of the theoretical innovation, this paper is the first to structurally estimate a model of universalism to quantify the effects of political power and needs on the agreed-upon allocations. In the empirical application, I focus on a particular bill which granted funds for bridge repair and replacement. In U.S., the state of Pennsylvania has the second largest stock of deficient bridges, which is about 4,783 bridges or equivalently 20.99 percent of its total stock.[3] Since 1982, the Pennsylvania General Assembly has passed bills, collectively called the Bridge Bill Capital Budget, to authorize grants for the replacement and repair of bridges in Pennsylvania. Almost all of these bills received unanimous consent and allocated funds broadly across bridges in Pennsylvania.[4] I construct a unique data set using one of these bills, passed in 1992, along with bridge-level data from the National Bridge Inventory (NBI) and the Pennsylvania Manual. Using this data set, I structurally estimate the model to rationalize how the state legislature allocated $371 million across 844 out of 6,232 possible local bridges in Pennsylvania.

I find that political power, measured by representation in chambers, committees, and party, has a significant impact on budgetary allocation. Moreover, bridges located in areas of politicians' residence are favored. Using the structurally estimated model, I conduct two counterfactual experiments. First, I simulate the budgetary allocation determined by a non-cooperative bargaining game to compare the distribution of benefits. I find that a non-cooperative bargaining game yields highly uneven distribution of money, as the proposer on average takes about 85.92 percent of the budget. The largest share given to a member in universalism was 10.01 percent of the budget. Second, I quantitatively assess the extent to which political factor affects allocations under universalism. In the model, political power in the legislature may influence geographical allocation of the budget by diverting more resources to better represented districts. Moreover, given the budgetary allocation, political importance of projects may affect how funds are granted across projects within each district. To analyze the extent of these effects, I simulate a

[3]Source: U.S. Department of Transportation, Federal Highway Administration (https://www.fhwa.dot.gov/bridge/deficient.cfm)

[4]Since 1982, 13 bills were passed. 11 bills received unanimous consent in both chambers and 1 bill received one nay vote.

benchmark outcome where allocations are determined based only on actual needs. I find that 16.73 percent of the aggregate budget would be allocated differently across districts. Moreover, there is a great heterogeneity across districts in the extent to which political factors affect how bridges are prioritized.

The remainder of this paper is organized as follows. The next section contains the literature review. Section 3 contains the model. Section 4 describes the solution and estimation methods. Section 5 contains the background of the Bridge Bill Capital Budget. Section 6 contains the description and construction of the data set. Section 7 discusses the empirical specification and Section 8 contains the empirical results. Section 9 discusses the counterfactual analysis and Section 10 concludes.

2 Literature Review

Former studies predicted that benefits would be restricted to a minimum winning coalition for distributive legislation under majority rule (Buchanan and Tullock, 1962; Riker, 1962). Studies in the non-cooperative bargaining literature also concluded that the incentive to concentrate the distribution of benefits results in a minimum winning coalition (Baron, 1991; Baron and Ferejohn, 1989; Eraslan, 2002; Eraslan and Merlo, 2002). With such a framework, impact of proposal power could be assessed but unanimous agreement under majority rule was difficult to explain. On the other hand, papers in the universalism literature established general conditions under which rational individual legislators ex-ante prefer universalism over a strict majority-rule system (Weingast, 1979; Shepsle and Weingast, 1981; Niou and Ordeshook, 1985)[5]. However, previous works do not explain how legislators may end up with heterogeneous allocations under universalism given a

[5]See Weingast (1994) and Collie (1988) for an overview of universalism literature.

budget. Ex-ante preference for universalism does not necessarily mean that legislators' preference is aligned. The conflicting incentives to win a greater budgetary share still persists even under universal cooperation. The framework in previous studies is based on legislators' individual calculation of net benefits to decide whether to follow universalism norm or not. Therefore, a new model is needed to study how legislators strategically interact to allocate a budget while maintaining universal cooperation. I address this lacuna by building a model that incorporates a non-cooperative bargaining framework in a model of universalism. I also add to the previous empirical studies on universalism that have focused on collecting evidence or testing the universalism hypothesis (Ferejohn, 1974; Stein and Bickers, 1994; Wilson, 1986).

As this paper focuses on allocation shares agreed upon unanimously, the model generates heterogeneous allocation outcomes but always renders a unanimous coalition in the equilibrium. However, the size of a winning coalition can range anywhere from bare majority to unanimity in reality. There is a literature which focuses on the size of a winning coalition in the equilibrium. For instance, some papers find that super-majority coalitions arise as an equilibrium outcome with vote buying (Groseclose and Snyder 1996; Banks 2000). These papers typically analyze a setting in which legislators vote over two different policy alternatives, rather determining how to divide a budget. An exception is a paper by Martin (2017), who shows that over-sized coalitions can arise when legislators allocate spending given a constrained formula. Although the size of a winning coalition is an interesting issue, I take unanimity as given and focus on allocation outcomes in this paper. Therefore, I do not analyze all possible voting outcomes that may arise, but focus on the case when there is a unanimous agreement.

Lastly, there is also a large literature which focuses on different kinds of inefficiencies in provision of public goods. For example, many theoretical and empirical studies find that shared costs and concentrated benefits of local public goods often lead to overspending by a legislature consisting of multiple districts (Besley and Coate, 2003; Primo and Snyder, 2008; Weingast, Shepsle and Johnsen, 1981). In this application, the budget is fixed so I do not analyze inefficiency arising from excessive public spending.[6] However, I analyze two ways through which political factors can influence allocation outcomes in line with the previous literature. First, there is a large literature that empirically assesses whether the institutional basis of political representation matters in securing higher spendings (Atlas, Gilligan, Hendershott, and Zupan, 1995; Berry, Burden, and Howell, 2010; Knight, 2005, 2008; Levitt and Snyder, 1995; Primo and Snyder, 2010). Second, there are papers which analyze whether allocation of resources are influenced by motives to maximize political returns or electoral benefits (Wright, 1974; Strömberg, 2004, 2008). I quantify the extent of these two channels in the context of universalism.

3 Model

3.1 Environment

There is a legislature consisting of N members. Each member represents a district and these two terms will be used interchangeably. Members are heterogeneous in two dimensions—political power and local public project needs. In each district, there is an existing stock of local public projects. For each project, the member knows the political importance and project attributes. All members have a list of all projects in their districts, in which projects are ranked by net benefits in a strictly monotonic way. As a legislature,

[6]Although inefficiency from overspending is an important topic, I start out with a fixed budget to model universalism in a tractable way. Endogenizing the budget determination process under universalism would require a different model.

members need to pass a distributive omnibus bill of local public project grants. The aggregate budget of the bill is exogenously given as $\bar{M}$. Under majority rule, each member casts one vote. Each member has a linear utility function in money. Everything is complete information.[7]

3.2 Budgetary Allocation: Legislative Bargaining Game

First, consider a standard non-cooperative, sequential, multilateral bargaining game as in Baron & Ferejohn (1989) and Eraslan (2002) to allocate $\bar{M}$ across the districts. Let $M = \{m \in R_{+}^{N} : \sum_{j=1}^{N} m_j \leq \bar{M}\}$ denote the set of feasible budgetary allocations, where m_j refers to the budget share for member j. There are infinitely many discrete sessions $(t = 0, 1, 2, ...)$ and members share a common discount factor, $\delta < 1$.

At $t = 0$, member j is selected as a proposer with probability $\rho_j > 0$, $\sum_{j=1}^{N} \rho_j = 1$. The probability of being selected as a proposer, which is also referred to as the recognition probability, is heterogeneous across members. The recognition probability for member j is:

$$\rho_j = Pr(Y_j\alpha + \xi_j > Y_k\alpha + \xi_k, \forall k \neq j), \forall j. \tag{1}$$

Y_j is a vector of observable characteristics which includes political power and local public project needs in district j. ξ is a random component assumed to be iid type I extreme

[7]The complete information assumption is not in fact stringent in this setting. Ultimately, necessary information about other members is district-level characteristics, which are public and easily observed in reality (for example, overall quantity and quality of the aggregate stock of projects or committee membership in the legislature). The model does not rely on knowing other members' private benefits from individual projects or their prioritized list of projects.

value with scale parameter σ_ξ. The proposer makes an allocation offer in M. Under a closed rule, all members simultaneously decide whether to accept or reject this proposal. Given a simple majority rule, the budget is allocated accordingly if at least a majority including the proposer accepts the proposal. If not, the procedure continues to $t = 1$ and repeats with a new proposer. The process continues until an allocation is accepted. If an allocation $m \in M$ is accepted at session t, member j's payoff is $\delta^t m_j$. If no allocation is ever agreed on, each member receives a payoff of zero.

Let h^t denote the past history of the identity of previous proposers, offers made, and voting outcomes, as well as that information for the current session. Denote a feasible action for member j at session t by $a_j^t(h^t)$, and denote $\Delta(K)$ as the set of probability measures on K. An action for proposer j is $a_j^t(h^t) \in \Delta(M)$, which implies (mixed) proposal offers made at session t. If member j is not the proposer, then a feasible action is $a_j^t(h^t) \in \Delta(\{accept, reject\})$. A strategy profile s is an N-tuple of strategies, where each strategy s_j for member j is a sequence of actions $\{a_j^t(h^t)\}_{t=0}^{\infty}$.

I look for the stationary subgame perfect (SSP) strategies and payoffs of the Legislative Bargaining Game. There are multiple subgame perfect equilibria in multilateral bargaining games. However, focusing on stationary strategy profiles which do not depend on the current date and past history gives us a unique equilibrium. Theorems characterizing SSP equilibria and SSP payoffs can be found in Eraslan (2002).[8] Here, I restate in words. The proposer makes an offer to the cheapest coalition of $\frac{N-1}{2}$ members. Each member in this coalition is offered his or her discounted stationary payoff, the proposer claims the rest of the budget, and the rest are offered zero. Agreement is reached, as the members in the coalition along with the proposer constitute exactly a majority.

More formally, let r be an $N \times N$ matrix whose (j, k)th component is the offering

[8] See Theorem 1 and 2 in Eraslan (2002).

probability that member k is a coalition partner of proposer j. Let v be $N \times 1$ stationary payoff vector. Then a payoff vector v is SSP if and only if there exists r such that satisfies the following two conditions: 1) given v, r is such that every proposer offers discounted stationary payoffs to $\frac{N-1}{2}$ cheapest members; and 2) given r, v is a fixed point of the following operator $A(\cdot;,r)$.

$$A_j(v;r) = \rho_j \Big[\bar{M} - \sum_{k \neq j}^{N} r_{jk} \delta v_k \Big] + \delta v_j \sum_{k \neq j}^{N} \rho_k r_{kj}, \forall j. \tag{2}$$

Eraslan (2002) proved that an SSP equilibrium outcome exists and that the SSP payoff is unique.[9] This implies that even if there are multiple SSP outcomes, they must all yield the same SSP payoff vector v.

3.3 Budgetary Allocation: Universalism Game

Note that in the Legislative Bargaining Game, $\frac{N-1}{2}$ members outside the minimum winning coalition receive zero. As all members would like to avoid the situation of being excluded, they all get together and consider the possibility of a universal agreement by playing the Universalism Game. This is in spirit of Shepsle & Weingast (1981), who argue that due to legislators' uncertainty over the composition of winning coalitions, they have "ex-ante preference for the outcome deriving from a norm of universalism over the expected outcome of hardball MWC politics." However, whereas legislators are risk averse in Shepsle & Weingast's setting, members are implicitly assumed to be risk neutral in this model as they have a linear utility.

At $t = 0$, each member simultaneously demands a share of the budget $\bar{M}$. Member j demands $m_j \in [0, \bar{M}]$, $\forall j$. The demands from all members constitute an $N \times 1$ allocation

[9]See Theorem 3 and 5 in Eraslan (2002).

vector $m = [m_1, m_2, ..., m_N]'$. Each member then decides whether to support universal agreement with the understanding that any dissent would lead to the Legislative Bargaining Game. If no one defects from cooperation and the budget constraint holds (i.e. $\sum_{j=1}^{N} m_j \leq \bar{M}$), then the universal allocation is adopted. Note that each member wants to demand as much as possible. Given a fixed budget, this implies that other members must receive less, else the budget constraint will be violated. The equilibrium of the budgetary allocation game is stated in the following theorem.

Theorem 1. $m^* = [m_1^*, m_2^*, \ldots, m_N^*]'$ *is the unique subgame perfect equilibrium outcome of the budgetary allocation game if and only if the following condition is satisfied:*

$$m_j^* = v_j, \forall j. \tag{3}$$

Proof. Without loss of generality, take member j to see if he or she can make a profitable deviation by changing the demand by a sufficiently small and positive amount ϵ. Suppose member j demands $m_j' = m_j^* - \epsilon$. Trivially, doing so is not profitable. Suppose member j demands $m_j' = m_j^* + \epsilon$. This implies that some other member, say k, must receive $m_k' = m_k^* - \epsilon$, else the budget constraint will be violated. However, member k will not conform to this allocation as the expected payoff from defecting is higher. Lastly, the uniqueness of m^* arises from the uniqueness of the stationary payoff vector v in the Legislative Bargaining Game. □

In sum, the subgame perfect equilibrium implies that members immediately and unanimously agree on the budgetary allocation, such that each member receives a share which induces indifference between cooperating and defecting. The threat-point for the breakdown of cooperation comes from the expected payoffs in the Legislative Bargaining Game; these payoffs are heterogeneous due to the difference in proposal power within the legislature.[10]

3.4 Portfolio Allocation

Once the budget is allocated across districts, members need to select projects to grant funds. As local public projects have geographically concentrated benefits, all members only care about projects in their own districts. How each member selects a portfolio of projects is modeled following Nevo, Rubinfeld, and McCabe (2005). Each member has a list where all projects in his or her district are ranked in a strictly monotonic way. For example, member j ranks all of K projects in district j, where the subscripts are enumerated in order for convenience as follows.

$$X_{1j}\beta + \epsilon_{1j} > X_{2j}\beta + \epsilon_{2j} > \cdots > X_{Kj}\beta + \epsilon_{Kj}. \tag{4}$$

X_{ij} denotes a vector of variables capturing political importance, cost, and other attributes of project i in district j. ϵ_{ij} is unobserved to the econometrician, but known to member j. Given the budgetary allocation and a stock of projects, each member selects the top projects on the ranking list which satisfy the budget constraint.

Note that this method ignores the non-divisibility issue. For example, suppose that the sum of costs for the first w projects exceeds m_j^*, but the sum of costs for the first $(w-1)$ projects and the cost of another project further down the list satisfies the budget.

[10] Here I develop an intuitive and estimable model which generates heterogeneous allocation shares agreed upon unanimously. The empirical implementation of the model is feasible given the tractability of the bargaining framework along with its prediction of unique equilibrium payoffs. One can come up with various theoretical models such as those that allow other types of negotiations, introduce concave utility functions, etc. However, this would greatly complicate structural estimation of the model without changing much of the underlying intuition.

In this case, the model suggests that only the first $(w-1)$ projects are granted funds.[11] Moreover, there is no strategic manipulation in the ranking once the budgetary allocation is determined.

Once all members select portfolios of local public projects, this comprises the distributive, omnibus bill passed in the legislature under universalism. The equilibrium outcome is unique, given strictly monotonic rankings of projects and the unique stationary payoffs from the non-cooperative bargaining game.

4 Solution, Estimation, and Identification

The equilibrium outcome of this model is the budgetary allocation across selected individual projects of an omnibus bill. This is difficult to solve in general, given a large stock of projects and numerous possible ways to select portfolios. However, the implementation of this model is made feasible by the modeling strategy that I adopt to solve it separately. I determine first how the budget is allocated across districts. Then given a budgetary allocation, I determine how each member selects a portfolio of projects within his or her district. The separation arises because benefits are geographically concentrated for local public projects.[12]

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[11]In the estimation, the budget is always exhausted by definition. Non-divisibility issue only arises in the counterfactual simulation and I discuss this in footnote 28. See an alternative model in Appendix A.2, where a member chooses the set that maximizes his or her utility among feasible sets given the budget. Projects are chosen set-wise so that the budget is exhausted up to the cost of the cheapest project. However, this method can only be implemented computationally when the stock of projects is sufficiently small.

[12]For projects with externalities across districts, this separation may not be appropriate and one would need to model how members interact over portfolios of projects.

4.1 Budgetary Allocation

In the budgetary allocation problem, I solve for the stationary payoff vector v in the Legislative Bargaining Game. This requires solving for an equilibrium pair (r, v) which satisfies the equilibrium conditions. I elaborate on the solution method in Appendix A.1. Given the uniqueness of the stationary payoff vector v proved by Eraslan (2002), I just need to find an equilibrium pair. The uniqueness in v has been used in many empirical applications in the non-cooperative bargaining literature due to its advantageous feature (Eraslan, 2008; Adachi and Watanabe, 2008; etc.).

The equilibrium condition of the budgetary allocation game is $m_j^* = v_j$, $\forall j$. The vector of money shares m is observed in the data and the stationary payoff vector v is solved analytically from the theoretical model in a closed form. As observed money shares will not be exactly equal to theoretical solutions in the empirical application, the residual difference will be captured by an $N \times 1$ vector of random shocks denoted as η. The η captures heterogeneous net benefits from avoiding unobserved consequences when universalism breaks down. For example, when universal cooperation breaks down, some members will get nothing. As a result, they will face finger-pointing and how their constituents evaluate the outcome against them will be heterogeneous. The η is known to all members but not observed to the econometrician. The idea is to search for parameters that minimize the difference between m and v.

By definition, $i'm = \bar{M}$ always holds in the data where i is an $N \times 1$ vector of units. Similarly, $i'v = \bar{M}$ always holds in the theoretical model as well. This implies that $i'\eta = 0$. Assume that η is an order-N normal vector of random variables, where each random variable has a mean of 0. Let the covariance matrix of η be $\sigma_\eta^2(I_N - \frac{ii'}{N})$, where I_N is an $N \times N$ identity matrix. Note that matrix $P = (I_N - \frac{ii'}{N})$ is the Moore Penrose inverse of itself and $P = PPP$ holds. The covariance matrix P induces dependence in

η which respects the restriction that $i'\eta = 0$ as $Pi = 0$. Therefore, the log likelihood function can be written as:

$$(5) \qquad logL(\delta, \vec{\alpha}, \sigma_\xi, \sigma_\eta; \vec{Y}, \bar{M}, m) \;=\; -\frac{N}{2}log(2\pi\sigma_\eta^2) - \frac{1}{2\sigma_\eta^2}(m-v)'P(m-v),$$

where the stationary payoff vector v is a function of parameters $(\delta, \vec{\alpha}, \sigma_\xi)$ and data $(\vec{Y}, \bar{M})$.

Another alternative is to estimate as in Adachi and Watanabe (2008). Given the aggregate budget, information contained in N members is equivalent to information contained in any (N-1) members. Therefore, they drop a member and treat (N-1) residuals as independent and identically distributed. However, as the asymmetry issue can arise, papers dealing with restricted likelihoods in other contexts have often used generalized inverse matrix as in this paper.[13] This directly respects the restriction, addresses the singularity problem, and uses all data without arbitrarily dropping one observation.

The parameters for the budgetary allocation problem include (1) the discount factor δ, (2) the recognition probability parameters $\vec{\alpha}$ which interact with the observables $\vec{Y}$, (3) the distribution parameter σ_ξ for the unobservables ξ, and (4) the distribution parameter σ_η for the unobservables η. Note that $v_j - \eta_j$ needs to be non-negative for all j as it is equal to the budget share. In the estimation algorithm, I check that no member ever receives a negative money share.[14]

I discuss how these key parameters are identified. First, the recognition probability parameters $\vec{\alpha}$ are identified from the variation in attributes $\vec{Y}$ and money shares m. Eraslan

[13] An analogous context is estimating a system of demand equations. In this case, the covariance matrix of residuals is singular when predicted values of each commodity is equal to the actuals (Barten 1969; Deaton 1974).

[14] All components of vector v are always positive. As long as σ_η is sufficiently small, $v_j - \eta_j$ will be non-negative for all j.

(2002) proved that the stationary payoffs are monotone non-decreasing in the recognition probabilities when the discount factor is common across all members. For instance, a member with a higher value of an attribute in $\vec{Y}$ will have a higher recognition probability when the corresponding α is larger and the payoff will be monotone non-decreasing, holding all other things constant. With the iid type I extreme value distribution assumption on the ξ-s, $\vec{\alpha}$ is identified up to scale with respect to σ_ξ.

Identification of the discount factor δ comes from information at the extreme ends, given that there is a large variance in the money shares m. Intuitively, a member with the largest money share has a very large stationary payoff. As his or her vote is expensive to buy, it is unlikely that others will include that member as a coalition partner when they are selected as a proposer. Similarly, a member with the lowest money share is always likely to be included as a coalition partner by others. The offering probabilities matrix r that solves the fixed point operator in equation (2) is restricted for stationary payoffs at the extreme ends. Therefore, the functional forms of stationary payoffs at the extremes are different and this helps to identify δ. Note that if there is not much variance in the payoffs, this argument does not hold as the functional forms of stationary payoffs will not differ across members.[15] Lastly, σ_η is identified from the difference between the stationary payoffs and monetary shares.

[15]Mitsutsune and Adachi (2014) discuss identification of parameters in a bargaining game when information on ex-post payoffs are used under unanimity rule. What helps to identify the discount factor δ in their setting is that there is one observed proposer and that functional forms of stationary payoffs differ between proposer and non-proposer.

4.2 Portfolio Allocation

To estimate the portfolio allocation problem, I refer to Nevo, Rubinfeld, and McCabe (2005). Let $\mathcal{P}$ denote a portfolio of chosen projects and let $\#(\mathcal{P})$ be the number of projects in the set $\mathcal{P}$. Denote $\mathcal{S}$ as the aggregate set of projects in a district, so the projects not selected by a member are in the set $\mathcal{S} \backslash \mathcal{P}$. Suppose the ranking of projects is known, and for simplicity, assume subscripts for projects are given by their rankings. Then the probability of ranking projects in such way is:

$$
\begin{aligned}
Pr(ranking) &= Pr(1 \succeq 2 \succeq \cdots \succeq \#(\mathcal{P}) \succeq \mathcal{S} \setminus P) \\
&= \prod_{\mathcal{S}}(1) \times \prod_{\mathcal{S}\backslash 1}(2) \times \cdots \times \prod_{\mathcal{S}\backslash\{1,2,\ldots,\#(P)-1\}} (\#(\mathcal{P})),
\end{aligned} \tag{6}
$$

where $\prod_X(i)$ is the probability that project i is ranked the highest in set X of available projects. This implies that when projects are ranked by their net benefits, then $X_1\beta + \epsilon_1$ is the highest in the set $\mathcal{S}$; $X_2\beta + \epsilon_2$ is the highest in the set $\mathcal{S} \setminus 1$; and so on. Let ϵ-s be independent and identically distributed type I extreme value with scale parameter σ_ϵ. Then $Pr(ranking)$ can be written in a closed-form as the following:

$$
Pr(ranking|\vec{X}; \vec{\beta}, \sigma_\epsilon) = \frac{exp(\frac{X_1\beta}{\sigma_\epsilon})}{\Sigma_{k=1}^{S} exp(\frac{X_k\beta}{\sigma_\epsilon})} \times \frac{exp(\frac{X_2\beta}{\sigma_\epsilon})}{\Sigma_{k=2}^{S} exp(\frac{X_k\beta}{\sigma_\epsilon})} \times \cdots \times \frac{exp(\frac{X_{\#(P)}\beta}{\sigma_\epsilon})}{\Sigma_{k=\#(P)}^{S} exp(\frac{X_k\beta}{\sigma_\epsilon})}. \tag{7}
$$

Although the chosen projects must be ranked higher than those that were not chosen, the actual ranking is not known. Therefore, I sum the probabilities of all possible rankings that yield the observed portfolio, where $\#(\mathcal{P})!$ is the total number of all possible rankings for the portfolio $\mathcal{P}$:

$$
Pr(\mathcal{P}|\vec{X}; \vec{\beta}, \sigma_\epsilon) = \sum_{k=1}^{\#(\mathcal{P})!} Pr(ranking_k|\vec{X}; \vec{\beta}, \sigma_\epsilon). \tag{8}
$$

For districts with a large number of projects, calculating this probability over all possible combinations of rankings is not computationally feasible. In this case, I simulate 50,000 rankings from the set of all possible rankings to compute an estimate of the average probability. The parameters of the portfolio allocation problem are estimated using the simulated maximum likelihood. The parameters of interests are (1) the net benefits parameters $\vec{\beta}$ which interact with $\vec{X}$ and (2) the distribution parameter σ_ϵ for the unobservables ϵ.

$$L = \prod_{j=1}^{N} Pr(\mathcal{P}_j | \vec{X}_j; \vec{\beta}, \sigma_\epsilon). \tag{9}$$

As this method does not require solving for all feasible sets and the likelihood comes out in a closed-form, the computation becomes quite fast.

The likelihood function in equation (5) for the budgetary allocation and that in equation (9) for the portfolio allocation are separately estimated. They are two independent likelihood functions for distinct problems and the sets of parameters do not coincide. Typically, the separation would not be possible as portfolios of projects would need to be chosen with respect to the allocated budget shares. However, the method of Nevo, Rubinfeld, and McCabe (2005) does not explicitly solve for the optimal set of projects given a budget constraint. It simply recovers the preference parameters that determine how projects are ranked. As the model ignores the non-divisibility issue, the underlying ranking of projects does not depend on a budget. In estimation, the budget is exhausted by definition for all districts as the sum of costs for all chosen projects is always equal to the budget share. Therefore, the two likelihoods can be set up and estimated separately with this modeling technique.

5 Background on the Bridge Bill Capital Budget

For the empirical application of this paper, I focus on a specific bill of grants for bridges. As shown in Table 1, Pennsylvania has the second largest stock of structurally deficient bridges in the U.S.[16]

Table 1: National Rankings and State Data

State	Rank	Total No. of Bridges	No. of Structurally Deficient Bridges	Percentage of Total
Iowa	1	24,242	5,025	20.73
Pennsylvania	2	22,783	4,783	20.99
Oklahoma	3	23,049	3,776	16.38
Missouri	4	24,398	3,222	13.21
Nebraska	5	15,341	2,474	16.13
National Totals		611,845	58,791	9.61

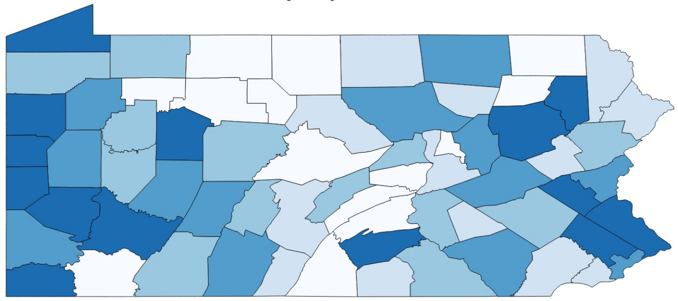
Source: U.S. Department of Transportation, Federal Highway Administration, 2015. (http://www.fhwa.dot.gov/bridge/deficient.cfm)

In 1982, the Pennsylvania General Assembly passed Act 235 (also known as the "Billion Dollar Bridge Bill" or the "Bridge Bill Capital Budget") to authorize funding for repair, rehabilitation, or replacement of public bridges in Pennsylvania. The Bridge Bill Capital Budget (BBCB) is unique to Pennsylvania and serves as the multi-year legal basis for bridge spending. It is an omnibus of bridge grants only, and it itemizes the estimated cost and project type for each bridge in the bill. The bill is financed by the Motor License Fund[17] or by incurring debt. As more bridges deteriorated throughout the years,

[16] A bridge classified as structurally deficient by the Federal Highway Administration implies that it typically requires significant maintenance and repair to remain in service. Moreover, it needs to be eventually rehabilitated or replaced to address deficiencies.

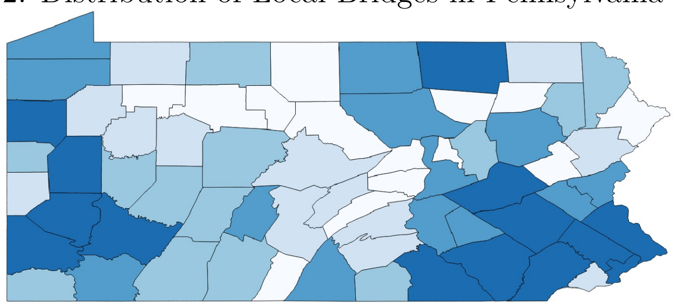
[17] The Motor License Fund is a special state government account which funds the Pennsylvania Department of Transportation projects—construction, maintenance, replacement, and safety measures on highways and bridges in the Commonwealth. It is capitalized through motor fuels taxes, vehicle registra-

Figure 1: Distribution of Money by the BBCB 1992 for Local Bridges



Note: Quintiles are: [$0,$432,600], [$432,601, $2,579,800], [$2,579,801, $5,362,200], [$5,362,201, $8,673,400], and [$8,673,401, $37,137,000].

Figure 2: Distribution of Local Bridges in Pennsylvania in 1992



Note: Quintiles are: [12, 42], [43, 66], [67, 91], [92, 128], and [129,372].

the Pennsylvania General Assembly passed five amendment acts in the 1980s and seven supplemental acts since the 1990s to authorize additional grants.

One striking feature of the BBCB is uncontroversial passage. Excluding legislators who were absent or abstained from voting, almost all of the enacted BBCB bills received unanimous consent in both chambers.[18] Another feature of the BBCB is the broad and heterogeneous allocation of benefits. Figure 1 shows the distribution of money for local

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tion fees, operator's license fees, etc.

[18]There are two exceptions. The first bill in 1982 received two nay votes in the Senate and forty-one nay votes in the House. The other exception is the bill passed in 1986, which received one nay vote in the House. Except for these two bills, all other bills received unanimous legislative agreement in both chambers.

bridges across counties by the BBCB in 1992. Counties are divided into quintiles, where each quintile corresponds to a different shade and the highest quintile is displayed in the darkest shade. The figure shows that money allocation was quite heterogeneous across 67 counties. One reaches the same conclusion with BBCB passed in other years as well. In Figure 2, I similarly show the distribution of local bridges across counties in Pennsylvania.

The BBCB satisfies the ideal-type of distributive legislation, in which it takes the form of an omnibus bill with divisible benefits. Moreover, it is a near-perfect empirical application of the model as it displays the typical features of universalism. Therefore, I use one of the BBCB passed in 1992 in my empirical application. Naturally, there are many empirical applications for this model. One only requires a distributive omnibus bill of local projects which received unanimous legislative consent, and this can be commonly found in many contexts.[19]

6 Data

I construct a data set by combining data from three different sources: (1) BBCB passed in 1992; (2) National Bridge Inventory; and (3) Pennsylvania Manual.

6.1 Bridge Bill Capital Budget of 1992

First, I use the BBCB passed in 1992, which is available from the legislative archive of the Pennsylvania General Assembly website.[20] For each authorized bridge, the BBCB stipulates bridge descriptions (e.g., location, route carried, features crossed, etc.), project

[19]For distributive legislations consisting of heterogeneous types of local public projects, the application of the model would be feasible if one can define the set of available projects and a way to measure benefits.

[20]http://www.legis.state.pa.us/cfdocs/legis/home/bills/

types (e.g., rehabilitation, replacement, reconstruction), and estimated costs. Moreover, information on the aggregate budget, relevant committees involved in referral process, and the vote outcomes in both chambers are available. I focus on the allocations for the local bridges whose benefits are geographically concentrated. Local bridges are defined as those owned by the County Highway Agency, the Town/Township Highway Agency, and the City/Municipal Highway Agency.[21] Theoretically, any BBCB passed with unanimous legislative consent can be used for the empirical application. However, the other data set that I combine with the bill is available only since 1992, so I chose the first one available.[22] The 1992 bill allocated around $371 million across 844 out of 6,232 possible local bridges in Pennsylvania.

6.2 National Bridge Inventory

Along with the BBCB, I combine data from the National Bridge Inventory (NBI). This data is available on the Federal Highway Administration (FHWA) of the U.S. Department of Transportation website.[23] NBI is a bridge-level data set which is annually reported

[21]The BBCB also granted funds to state bridges, which are owned by the State Highway Agency. Given the size, location, and usage, state bridges are likely to have greater externalities than local bridges. The average length of the bridge structure is 39.5m for state bridges and 20.7m for local bridges. State bridges usually lie at the highway intersection or cross rivers, whereas local bridges usually lie at roads and streets, crossing creeks and run. The average daily traffic of state bridges is about 5,331 vehicles, compared to 985 vehicles for local bridges. Moreover, given the large size of Pennsylvania (119,283km^2), local bridges are most likely to be used by nearby residents.

[22]For an external validation analysis, I use the two subsequent bills passed in 1994 and 1999 to see how well estimated parameters from the 1992 bill can predict allocation outcomes. The results are reported in Appendix A.4.

[23]http://www.fhwa.dot.gov/bridge/nbi/ascii.cfm

since 1992. It has information on all public bridges in the U.S., of which there are over 600,000. Around 116 variables are reported for every bridge, including bridge descriptions (location, feature crossed, water facility), usage measures (average daily traffic), technical ratings (condition rating, operating rating, inventory rating), public essentiality measures (historical significance, importance in military defense, detour length), and annual operating status (open, closed, restricted usage, under replacement). This is a technical data set reported by certified technicians. The advantage of such a data set is that it gives the universe of possible bridge projects and objective measures of needs for each individual bridge. I use the information for the universe of 6,232 local bridges in Pennsylvania in 1992. Descriptive statistics on the number of local bridges and average quality measured by the average sufficiency ratings for 67 counties in Pennsylvania are shown in Table 2.[24]

Since the NBI data does not provide any information on whether a bridge was authorized by the BBCB or not, I link the bridges in the bill to the NBI data using the following criteria: (1) county code; (2) place code (township, borough, city); (3) facility carried by bridge (SR/PA/US/TR number or road name); (4) feature crossed (creek, river, lake, railroad); and (5) segment number or other additional location description, if mentioned. The goal of the BBCB is to allocate funds for replacement, reconstruction, and rehabilitation of deteriorated bridges. However, some irrelevant projects such as new bridge construction or painting are included, so I exclude those. Sometimes two or more descriptions for a bridge in the bill could not be distinguished from one another given the information available there. In these cases, I keep the first occurrence and drop any oth-

[24]A sufficiency rating is an overall rating of a bridge's fitness for the duty it performs, derived from multiple dimensions of technical evaluations. It ranges from 0 to 100, where 100 represents an entirely sufficient bridge and 0 represents an entirely insufficient or deficient bridge. It is the common rating formula adopted by the FHWA.

Table 2: Descriptive Statistics of Bridge Characteristics by County

County	No. of Local Bridges	Sufficiency Rating	County	No. of Local Bridges	Sufficiency Rating
Adams	70	75.25	Lackawanna	81	49.28
Allegheny	372	65.52	Lancaster	267	63.55
Armstrong	70	58.47	Lawrence	71	54.81
Beaver	55	65.39	Lebanon	93	79.93
Bedford	86	63.23	Lehigh	113	67.28
Berks	194	72.46	Luzerne	107	53.96
Blair	110	69.36	Lycoming	112	64.08
Bradford	130	63.15	Mckean	83	57.39
Bucks	159	64.22	Mercer	170	79.33
Butler	152	51.56	Mifflin	50	62.57
Cambria	81	61.38	Monroe	56	71.98
Cameron	12	60.43	Montgomery	214	63.88
Carbon	28	68.17	Montour	32	55.82
Centre	60	58.53	Northampton	125	70.11
Chester	153	59.60	Northumberland	97	69.59
Clarion	67	51.08	Perry	50	57.98
Clearfield	76	52.33	Philadelphia	138	62.78
Clinton	21	65.70	Pike	37	71.48
Columbia	91	59.85	Potter	40	58.00
Crawford	125	49.57	Schuylkill	154	68.55
Cumberland	63	67.41	Snyder	34	68.67
Dauphin	105	76.56	Somerset	79	53.15
Delaware	65	64.61	Sullivan	36	58.29
Elk	35	56.84	Susquehanna	59	70.35
Erie	109	65.95	Tioga	100	65.90
Fayette	110	58.75	Union	40	67.12
Forest	14	46.47	Venango	60	46.24
Franklin	96	75.27	Warren	65	53.34
Fulton	24	62.63	Washington	147	48.10
Greene	91	42.11	Wayne	68	44.88
Huntingdon	57	62.61	Westmoreland	145	57.15
Indiana	88	72.18	Wyoming	26	57.06
Jefferson	51	57.22	York	221	73.63
Juniata	42	72.85			

Source: NBI of 1992.

ers. Lastly, some of bridges in the bill have incomplete descriptions, which makes them to be difficult to be identified. After dropping a total of 43 local bridges in the bill for these reasons, I am left with 844 local bridges, of which I match 644 bridges to the NBI data. The matching fails to be perfect as descriptions in the bill are sometimes not sufficient to uniquely match bridges, or lacks additional information that is necessary. Nevertheless, the matching of individual bridges does not affect the budgetary allocation problem, and instead only affects the portfolio allocation problem.

6.3 Pennsylvania Manual

Lastly, I refer to the Pennsylvania Manual to obtain information on the political environment of the Pennsylvania General Assembly in 1992. The Pennsylvania Manual is a comprehensive guide to Pennsylvania's government, which is published biennially by the Department of General Services for the Commonwealth. I collect information on 50 senators and 203 House members, such as representing district, committee membership, party affiliation, and residential address. These variables are used to construct a representation in the legislature which affects the proposal power in the budgetary allocation game or preference in ranking bridges in the portfolio allocation.

In general, legislatures are either unicameral or bicameral, and the model of this paper focuses on a generalized unicameral legislature. The theoretical literature on non-cooperative bargaining is much more advanced in a unicameral setting. Studies on a bicameral legislature mostly rely on indices from cooperative theory such as the Shapley-Shubik index (Shapley and Shubik, 1954), and there are only few studies that take a non-cooperative approach (Diermeier and Myerson 1999; Ansolabehere, Snyder, and Ting 2003). As this is the first study to analyze allocations under universalism, I focus on a general theoretical setting of a unicameral legislature which gives tractable results.

In the empirical analysis, however, a further assumption needs to be made as the Pennsylvania state legislature has two chambers.[25] That is, the two chambers' information needs to be combined at a common district level. I use county as the district unit, as the bill itemizes bridges by counties and the number of counties is feasible for computation.[26] I define a 'member' representing a county as a group of all senators and House members who represent all or a part of this county in his or her legislative district and act together. For example, if a senator represents a part of Beaver county and a part of Lawrence county, I add one senator to these two counties. In this way, I combine representation information from both chambers and incorporate this into the recognition probability.

This assumption is not to suggest that a bicameral legislature in fact operates as a unicameral legislature. Strategic interactions can potentially exist across chambers, but this is difficult to observe in the data and my model does not capture them. Given my assumption, the model focuses on how money is allocated geographically as a group of politicians who commonly represent a county fight together to win more. It does not consider what happens within a county among individual politicians or between politicians across two chambers. With these caveats in consideration, the rest of empirical analysis will be implemented at the county level. At the same time, I further discuss the validity of this assumption by exploring an alternative of using the actual Senate districts in Appendix A.3.

Table 3 summarizes the descriptive statistics of representation in the General Assembly

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[25]The Pennsylvania state legislature was originally unicameral until 1830. One example of a unicameral state legislature in U.S. is the Nebraska state legislature. Unicameral legislatures are also quite common at national and subnational levels in other countries.

[26]If the number of districts is N, the model needs to solve for an inverse of $N \times N$ matrix in the equilibrium. As N grows, it becomes computationally intensive to solve the model.

by county. Overall, we see that the representation of counties is quite heterogeneous. This is true not only in terms of the number of representatives in chambers, but also in terms of party affiliation, committee membership, and seniority of politicians. For example, some counties have no representation in Rules & Executive Nominations committee, whereas counties such as Philadelphia has as many as 9 members. The seniority of politicians representing a county is constructed by adding all the previous terms served by every senator and House member representing that county.

Table 3: Descriptive Statistics of Representation in the General Assembly by County

	Mean	Min	Max	Standard Dev.
No. of senators	1.77	1	8	1.35
No. of House members	4.01	1	29	4.81
No. of Democratic senators	0.59	0	6	1.05
No. of Democratic House members	2.07	0	23	3.92
No. of Transportation committee members	0.95	0	6	1.16
No. of Appropriations committee members	1.40	0	8	1.52
No. of Rules & Executive Nominations members	0.76	0	9	1.38
Seniority in the Senate	8.94	3	45	7.27
Seniority in the House	19.23	1	149	26.23

Source: The Pennsylvania Manual Vol.110.

For each bridge, I also track reported home address of each politician in the Pennsylvania Manual at the place or county subdivision level, such as borough, township, or city. For instance, Adams county is divided into 34 subdivisions. Using the 5-digit FIPS code reported by the U.S. Census Bureau, I link the home address with the location of each bridge. This is to see whether bridges located in the county subdivision of politicians' residence receive preferential treatments given all other things equal. Alternatively, one can think of other indicators that capture political importance of bridges. I elaborate on other political indicators that were specified and estimated in the empirical results section.

7 Empirical Specification

7.1 Recognition probability

In the model, counties are heterogeneous in political power in the legislature and in the actual local bridge needs. This heterogeneity yields different probabilities of being selected as a proposer in the Legislative Bargaining Game. The probability that county j is recognized as a proposer is denoted as ρ_j.

$$\rho_j = Pr(Y_j\alpha + \xi_j > Y_k\alpha + \xi_k, \forall k \neq j), \text{ where} \tag{10}$$

$$\begin{aligned} Y_j\alpha = {} & \alpha_1 \cdot log(number\ of\ legislators_j) + \alpha_2 \cdot I(no\ Democrats_j) \\ & + \alpha_3 \cdot I(Represented\ in\ all\ relevant\ committees_j) \\ & + \alpha_4 \cdot cities_j + \alpha_5 \cdot area_j + \alpha_6 \cdot area_j^2 + \alpha_7 \cdot I(lowest\ county\ class_j) \\ & + \alpha_8 \cdot log(number\ of\ bridges_j) + \alpha_9 \cdot (share\ of\ closed\ bridges_j) \\ & + \alpha_{10} \cdot I(no\ historically\ significant\ bridges_j). \end{aligned} \tag{11}$$

ξ-s are iid type I extreme value with scale parameter σ_ξ.

The first three terms in Y reflect the political features of a county in the legislature. The first variable which interacts with α_1 is the number of all politicians representing county j in the state legislature. The second variable is an indicator which equals to one if there are no Democrats representing county j. The variable which interacts with α_3 is an indicator which equals to one if county j is represented in all the relevant committees for this bill, which are the Transportation, Appropriations, or Rules & Executive Nominations Committees. As the previous literature often finds that having greater representation in the chambers or relevant committees can be advantageous, α_1 and α_3 capture these effects. Also, whether legislators belong in the majority party can affect their proposal power. The majority party of the Senate and the House in the Pennsylvania General Assembly of 1991-1992 were the Republican party and the Democratic party respectively. α_3 captures the effect of having all the representatives from the Republican party when two chambers were occupied by different parties.

The next four terms in Y interacted with parameters α_4 to α_7 are related to county characteristics. They are: the number of cities in a county, area, area squared, and an indicator capturing a county's classification. For the purposes of legislation and the regulation of their affairs, the Pennsylvania General Assembly has an act which divides counties into nine classes based on population and inhabitants. If a county belongs to one of the lowest two county classification, then this indicator is equal to 1. These four variables capture the needs of a county given its population density or geographical size.

The last three terms in Y interacting with parameters α_8 to α_{10} are related to a county's bridge stock characteristics in terms of quantity and quality. They are: the total number of local bridges, share of closed bridges, and an indicator that a county has no historically significant bridges. In the NBI data, a bridge can be classified as having historical significance if it is a particularly unique engineering example, or if the crossing itself is significant, or if the bridge is associated with significant circumstances. If a county has no historically significant bridge at all, the indicator variable equals to one; it is zero otherwise. Given iid type I extreme value assumption on the ξ-s, the recognition probability becomes:

$$\rho_j = \frac{exp(\frac{Y_j \alpha}{\sigma_\xi})}{\sum_{k=1}^{N} exp(\frac{Y_k \alpha}{\sigma_\xi})}. \tag{12}$$

Lastly, one may consider the following caveats. Attributes $\vec{Y}$ are assumed to be exogenous but this assumption may not hold for some features, particularly for political variables. For instance, gerrymandering may cause correlations between political features in $\vec{Y}$ and the error term ξ. Also, it may be possible that districts with greater needs for the BBCB funds joined the relevant committees. In this case, committee affiliation would be endogenous. As for the second issue, the three committees are all involved with many bills other than the BBCB bill. For instance, the Transportation committee also makes decisions for other various types of transportation infrastructures such as roads, railways, transit, and etc. Furthermore, as I control for the quantity and quality of the bridge stock, this may be less of an issue.

7.2 Net benefit from a bridge project

Next, I specify the net benefit from a bridge i in district j, which is denoted as u_{ij}:

$$u_{ij} = X_{ij}\beta + \epsilon_{ij}. \tag{13}$$

X_{ij} is a vector of observable characteristics of bridge i, and ϵ_{ij} is unobserved to the econometrician. It is assumed to be iid type I extreme value with scale parameter σ_ϵ.

$$\begin{aligned} X_{ij}\beta = {} & \beta_1 \cdot rating_i + \beta_2 \cdot I(restricted_i) + \beta_3 \cdot log(cost_i) \\ & + \beta_4 \cdot I(senator_i) + \beta_5 \cdot I(House\ member_i). \end{aligned} \tag{14}$$

The first three variables interacting with β_1 to β_3 are related to the technical attributes of a bridge. They are the sufficiency rating, the indicator of whether a bridge is restricted, and the log of project cost. β_2 is interacted with an indicator which equals to 1 if a bridge is posted for various types of restrictions including speed, load-capacity, number of vehicles, etc.

The last two variables interacting with β_4 to β_5 are related to non-technical attributes which may affect politicians' preferential treatment of bridges. This is captured by whether a bridge is located in an area of politicians' residence. For instance, $I(senator_i)$ is equal to 1 if at least one senator lives in the place or county subdivision of where bridge i is located. Vice versa holds for the $I(House\ member_i)$ variable. Therefore, these variables yield heterogeneous political attributes across bridges located within the same county.

7.3 Cost of a bridge project

The information of bridge costs is obtained from the BBCB. This means that the cost data is only available for bridges that were authorized by the bill, so costs for the rest of bridges need to be imputed. I specify the cost of a bridge denoted by p_i as below. Each variable is technical bridge attribute, which I obtain from the NBI data. I estimate the parameters using Ordinary Least Squares.

$$
\begin{aligned}
(15) \qquad log(p_i) = {} & \kappa_1 + \kappa_2 \cdot structure\ length_i + \kappa_3 \cdot structure\ length_i^2 \\
& + \kappa_4 \cdot I(rating_i = L) + \kappa_5 \cdot I(rating_i = M) + \kappa_6 \cdot lanes\ under_i \\
& + \kappa_7 \cdot area_i + \kappa_8 \cdot area_i^2 + \kappa_9 \cdot I(functional\ class_i = 1) \\
& + \kappa_{10} \cdot deck\ width_i^2 + \kappa_{11} \cdot I(lanes\ on_i = H) \\
& + \kappa_{12} \cdot I(main\ unit\ spans_i = H) + \kappa_{13} \cdot max\ span\ length_i \\
& + \kappa_{14} \cdot I(curb_i = H) + \kappa_{15} \cdot deck\ width_i \\
& + \kappa_{16} \cdot I(historical\ significance_i) + \omega_i.
\end{aligned}
$$

8 Empirical Results

8.1 Budgetary allocation

The estimated parameters and standard errors for the budgetary allocation problem are shown in Table 4. The standard errors are computed by estimating the information matrix, using the outer product of the scores of the likelihood function. The coefficients have signs that align with expectations. Of 13 parameters, 9 of them are statistically significant at 1 percent and 1 of them is statistically significant at 5 percent. I find that the effect of political channels, measured by representation in chambers and party, is still significant even after controlling for various dimensions of county characteristics and actual bridge needs. Having a larger number of legislators and being represented in all relevant committees have a positive impact on securing a larger share of the budget, although committee representation is not statistically significant at standard levels. Having all the representatives from the Republican party has a negative impact given that two chambers were occupied by different parties. On top of political features, the attributes related to scale of counties and their bridge needs also matter. Counties with a larger number of cities, larger area, greater number of local bridges, and greater share of closed bridges receive larger budget shares. The model was estimated with numerous different specifications and joint test was used for model selection.[27]

The discount factor between sessions is estimated to be 0.73. Many empirical studies in the non-cooperative legislative bargaining literature find discount factor to be lower than that typically found for other economic agents (Adachi & Watanabe, 2008; Merlo,

[27]Some variables may have a priori reason to be included based on previous findings in the literature. Multiple dimensions of political features (for example, chairman, party, seniority, committee membership, etc.) were specified in the estimation to see what mattered.

Table 4: Parameter Estimates for the Budgetary Allocation Problem

	Variable	Estimate	S.E.
	⟨Political power⟩		
α_1	Log(Number of legislators)	0.5273	0.1971
α_2	I(No Democrats)	-1.2975	0.6047
α_3	I(Represented in all relevant committees)	0.4113	0.3038
	⟨County characteristics⟩		
α_4	Number of cities	0.3520	0.0793
α_5	Area	0.6618	0.2050
α_6	Area squared	-0.0672	0.0155
α_7	Indicator of lowest county class	-2.6725	1.8569
	⟨Bridge needs⟩		
α_8	Log of number of bridges	0.0840	0.0735
α_9	Share of closed bridges	9.0270	1.6895
α_{10}	I(No historically significant bridges)	-1.4986	0.2893
	⟨Miscellaneous⟩		
σ_ξ	Scale parameter for the ξ distribution	1.5109	0.2371
δ	Discount factor	0.7302	0.1001
σ_η	Standard deviation for the η distribution	0.0071	0.0008
	Log likelihood	236.64	

1997; etc.). The greater impatience of political agents is due to the uncertainty and risk associated with turnover in the legislature. Also, the standard deviation for the η distribution is very small. This implies that the budgetary shares determined under universalism are well captured by the expected payoffs in the Legislative Bargaining Game.

Tables 5 through 7 present evidence on how well the model fits the data. Table 5 compares budget shares by committee membership in the data and those generated by the model. The fit is reasonably close and representation in relevant committees seems to be valuable as it is associated with greater budgetary shares. For example, the aggregate share for seven counties that have no committee member in either chamber is 5 percent of the aggregate budget. However, another seven counties which have at least one chairman

Table 5: Fit of the Budget Shares by Committees (Unit: Percent)

Budget Share of Counties with Membership in:	Data	Model	No. of Counties
Senate committee chair	35.45	39.05	16
Senate Transportation	41.01	47.01	26
Senate Appropriations	62.35	66.67	38
Senate Rules & Executive Nominations	44.07	46.86	19
No Senate committee	32.31	26.55	26
House committee chair	22.20	24.76	7
House Transportation	42.74	43.58	22
House Appropriations	60.45	60.90	26
House Rules & Executive Nominations	40.59	43.06	18
No House committee	21.46	21.77	23
No Senate nor House committee	5.08	3.93	7

Table 6: Fit of the Budget Shares by Representation in the Chambers (Unit: Percent)

No. of Senators	One	Two	Three or More
Data	40.05	24.21	35.74
Model	39.28	25.14	35.58
No. of counties	40	15	12

No. of House Members	One	Two	Three	Four	Five or More
Data	12.76	6.32	16.29	19.63	45.00
Model	11.65	9.17	16.33	15.95	46.90
No. of counties	18	11	14	7	17

in one of the relevant committees in the House collectively receive 22 percent of the budget.

Similarly, I look at the model fit by representation in chambers in Table 6, measured by the number of senators and House members representing a county. The model can fit the fact that counties with greater number of politicians tend to receive larger shares of the budget. Lastly in Table 7, I compare the model fit by criteria not related to political power. Each column represents a quintile given the criteria. Overall, predictions of the model match the outcomes in the data fairly well, even for criteria that were not used in the estimation such as number of vehicles or average daily traffic.

Table 7: Fit of the Budget Shares by Needs (Unit: Percent)

Quintile		1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
No. of local bridges	Data	3.60	13.78	22.06	18.65	41.92
	Model	5.01	14.85	21.61	17.28	41.24
Bridge rating	Data	20.93	11.79	21.63	29.86	15.80
	Model	19.47	14.12	17.09	29.27	20.05
Average daily traffic	Data	7.70	11.93	15.13	22.38	42.87
	Model	8.27	11.16	13.32	24.22	43.03
Population	Data	3.22	11.72	16.07	25.87	43.12
	Model	3.95	11.73	18.48	24.91	40.93
No. of vehicles	Data	5.56	10.58	14.62	26.12	43.12
	Model	5.84	9.97	17.54	25.71	40.93

8.2 Portfolio Allocation

In Table 8, I show the estimated parameters and standard errors for the portfolio allocation problem. As before, the standard errors are computed by estimating the information matrix, using the outer product of the scores of the likelihood function. Among 67 counties, 9 counties received no money for local bridges in the 1992 bill. That leaves 58 counties and I focus on 55 counties which have sufficiently high match rates.

Table 8: Parameter Estimates for the Portfolio Allocation

	Variable	Estimate	S.E.
β_1	Sufficiency rating	-0.0382	0.0050
β_2	I(Restricted)	0.2897	0.0497
β_3	Log of bridge cost	0.2675	0.0352
β_4	I(senator)	0.0274	0.0064
β_5	I(House member)	0.6305	0.0954
σ_ϵ	Scale parameter for type I extreme value	1.7973	0.2155
	Log likelihood	-1575.13	

I estimate how counties rank bridges to choose a set of bridges. Bridges with greater deterioration rating and restricted usage are more likely to receive a higher rank. A bridge with higher sufficiency rating implies less deterioration, so the coefficient for β_1 comes out as negative as expected. β_2 captures various kinds of restrictions including weight and speed limits. In the estimation, the coefficient for cost of bridges, β_3, comes out as positive. One explanation for the positive coefficient is that politicians may prefer projects which have bigger scale in terms of spendings due to their impact on local economy. All other things being equal, a bridge located in a county subdivision where politicians live is favored. This is captured by β_4 and β_5, which are positive and statistically significant at 1 percent. This estimation result shows that beyond the technical attributes of bridges, private returns of politicians also matter in how bridges are prioritized.

Other political measures were also estimated using various specifications. For instance, I looked at whether a group of politicians representing a county which consists of more Republicans prefer bridges located in county subdivisions with greater number of Republican voters. In addition, the number and margin of votes in the 1990 Pennsylvania gubernatorial election were also analyzed. This is to see whether the governor, who has the right to veto the bill passed by the legislature, has influence over the selection of bridges. Although estimate parameters have expected signs showing positive impact of political factors, they were statistically insignificant or ruled out by the joint test.

Table 9: Fit of Portfolio Allocation for Selected Counties

Money by Tertile		1^{st}	2^{nd}	3^{rd}
No. of chosen bridges	Data	2.78	13.11	18.74
	Model	2.48	11.96	23.13
Length of chosen bridges	Data	188.58	167.96	316.49
	Model	225.21	193.89	301.74
Rating of chosen bridges	Data	44.50	46.03	54.89
	Model	22.43	35.04	41.71

In Table 9, I show the model fit for the portfolio problem. Given the estimated parameters and the budget shares, I simulate the portfolio allocation numerous times. To show the model fit, I divide 55 counties into tertiles based on the amount of money received. Then I compare the number, length, and rating of chosen bridges predicted by the model with those observed in the data. For example, the counties in the first tertile of budget shares choose on average of 2.78 bridges in the data, whereas the model predicts about 2.48 bridges. The overall fit is reasonably close for the number and length of chosen bridges. However, the model tends to over-predict the inclusion of deteriorated bridges as the average rating of chosen bridges predicted by the model tends to be lower.[28]

Table 10: Parameter Estimates for Bridge Costs

Variable	Estimate	S.E.
Constant term	4.4908	0.2061
Structure length	0.6185	0.1044
Structure length^2	-0.0378	0.0067
I(sufficiency rating = L)	0.1521	0.0710
I(sufficiency rating = M)	0.2441	0.0687
I(number of lanes under the structure = H)	0.5941	0.2414
Area	-0.0401	0.0100
Area^2	0.0002	0.00004
I(functional classification = rural or other principal arterial)	0.1223	0.0675
I(number of lanes on the structure = H)	-1.0548	0.3293
I(number of spans in main unit = H)	0.9196	0.3200
Length of maximum span	0.1222	0.0485
I(curb width = H)	-0.5026	0.1536
Deck width	0.1588	0.3366
Deck width^2	0.4005	0.1393
I(historically significant)	-0.1750	0.1307
R squared	0.5357	

[28]In simulations, the budget is not exhausted as non-divisibility is ignored. Around $30.7 million is not spent out of $290 million allocated to matched bridges in 55 counties. The average bridge replacement cost in the data is about $440,000, so this equals to an amount for replacing around 70 local bridges.

Table 11: Fit for Bridge Costs (Unit: $1,000)

	Data	Model	No. of Obs.
Closed bridges	392.86	382.96	22
Restricted bridges	371.52	352.18	400
Bridges with a sufficiency rating less than 20	393.90	363.92	75
Bridges with a sufficiency rating between 20 and 40	383.14	354.77	241
Bridges with a sufficiency rating between 40 and 60	407.46	378.86	132
Bridges with a sufficiency rating between 60 and 80	406.32	368.99	106
Bridges with a sufficiency rating between 80 and 100	456.56	390.42	74

Lastly, estimated parameters for the bridge cost are reported in Table 10. To impute costs for bridges that are not included in the bill, I use OLS to estimate bridge costs using bridges that were authorized by the bill. Various technical bridge features from the NBI data are used in the estimation and I report the fit in Table 11.

9 Counterfactual Analysis

In this section, I describe the results of counterfactual experiments designed to compare allocation outcomes in different scenarios. In the first counterfactual experiment, I simulate the budgetary allocation that would arise if universalism were to break down and a minimum winning coalition were formed in the Legislative Bargaining Game for the BBCB of 1992. That is, a proposer who is randomly chosen according to the estimated recognition probability makes an allocation offer to a coalition consisting of cheapest members to secure a majority's consent. The model suggests that payoffs under universalism are equal to the expected payoffs from the Legislative Bargaining Game. When simulated payoffs from the Legislative Bargaining Game are averaged out sufficiently many times, they are indeed almost the same as the payoffs under universalism.

However, the distribution of benefits realized in the Legislative Bargaining Game is very different from that in universalism. In Table 12, I compare the standard deviation of budgetary shares in the Legislative Bargaining game and that in universalism. As exactly $\frac{N+1}{2}$ members in the minimum winning coalition receive positive money shares in the Legislative Bargaining Game, the distribution of benefits is highly concentrated. Among all members, the standard deviation is 1.69 in universalism, whereas it is 10.47 in the Legislative Bargaining Game. Furthermore, the distribution is also quite concentrated within the minimum winning coalition. Among $\frac{N+1}{2}$ members in the minimum winning coalition, the standard deviation of budget shares is 14.66. This is because the proposer extracts as much as possible from the coalition partners. On average, the proposer takes about 85.92 percent of the budget, whereas the shares of the coalition partners range from 0.07 percent to 0.90 percent of the budget. The largest share for a member equals to 10.01 percent of the budget in universalism.

Table 12: Comparison of Budgetary Allocation Distribution

		Standard Dev.
Universalism	Among N members	1.69
Legislative Bargaining Game	Among N members	10.47
	Among $\frac{N+1}{2}$ members in the minimum winning coalition	14.66

The same budget $\bar{M}$ is exogenously given in the counterfactual experiment as in the baseline model. However, the size of a budget can also be closely associated with a voting outcome. For example, if a budget is not large enough to be shared, legislators may be less likely to cooperate universally. To investigate this relationship, I analyze all 62 distributive bills on capital projects passed by the Pennsylvania State Legislature from 1981 to 2014. The size of a budget varies greatly as 10 bills allocated \$0.168 billion on average for less than 5 items and the remaining bills allocated \$2.85 billion on average for a long list of items. Unanimous agreement is more frequently found in bills with larger budgets, although the difference is not quite significant.[29] The number of observations is small to generalize its finding, but the evidence suggests that the size of a winning coalition can differ as the size of a budget changes. With this caveat in mind, the counterfactual experiment should be interpreted as an exercise comparing the dispersion of benefits when the same budget is being allocated by a bare majority rather than by everyone.

Next, I conduct a counterfactual experiment to analyze the political impact on the allocations determined under universalism. In the model, more money may be diverted to districts with better political representation in the legislature, all other things being equal. Also, given the budgetary allocation, political returns may affect the choice of projects for grants within each district. To assess the extent to which political factors influence the budgetary allocation, I first simulate the budgetary allocation that would arise if all political channels in the legislature were shut down. That is, I let the recognition probabilities to only depend on actual needs by setting $\alpha_1 = \alpha_2 = \alpha_3 = 0$.

The results are reported in Tables 13 and 14. Compared to the baseline simulation of the model, I find that 16.73 percent of the aggregate budget, or equivalently $62.07 million, would be allocated differently. For example, the share for counties with no Senate committee membership increases by 24.97 percent, as shown in Table 13. The shares for counties with committee memberships would all decrease, although the extent of the decrease differs depending on committee. The percentage drop for the share of counties with a committee chair in either chamber is large as well. In Table 14, I look at the

[29] 50 percent of the House and 70 percent of the Senate agreed unanimously for the former small budget bills. For the remaining bills, 65 percent of the House and 88 percent of the Senate agreed unanimously. As universalism is pervasive, all of these bills received either unanimous or much larger than a bare majority support.

Table 13: Change in Budgetary Share by Committee (Unit: Percent)

	Baseline	No Political Channels	No. of Counties	Change
No Senate committee	26.55	33.18	26	24.97% ⇑
Senate committee chair	39.05	29.83	16	23.61% ⇓
Senate Rules & Executive Nom.	46.86	36.06	19	23.05% ⇓
Senate Transportation	47.01	39.61	26	15.74% ⇓
Senate Appropriation	66.67	59.83	38	10.26% ⇓
House committee chair	24.76	15.62	7	36.91% ⇓
No House committee	21.77	26.49	23	21.68% ⇑
House Rules & Executive Nom.	43.06	34.82	18	19.14% ⇓
House Appropriation	60.90	50.23	26	17.52% ⇓
House Transportation	43.58	37.32	22	14.36% ⇓
No Senate nor House committee	3.93	7.47	7	90.08% ⇑

Table 14: Change in Budgetary Share by Representation in the Chambers (Unit: Percent)

No. of Senators	One	Two	Three or More
Baseline	39.28	25.14	35.58
No political channels	52.04	25.97	21.98
No. of counties	40	15	12
Change	32.48% ⇑	3.30% ⇑	38.22% ⇓

No. of House Members	One	Two	Three	Four	Five or More
Baseline	11.65	9.17	16.33	15.95	46.90
No political channels	17.93	14.30	18.99	15.96	32.82
No. of counties	18	11	14	7	17
Change	53.91% ⇑	55.94% ⇑	16.29% ⇑	0.06% ⇑	30.02% ⇓

percentage change in budget shares by representation in the chambers. In both chambers, the lowermost and uppermost counties in terms of the number of included legislators would face large changes in their values. The analysis shows that having political power in the legislature translates into considerable additional budgetary gains.

Given the simulated shares of money, I now simulate the portfolio allocation which would arise if bridges only differed in their technical attributes by setting $\beta_4 = \beta_5 = 0$. The selected portfolios change for two reasons. First, the number of bridges granted funds in each county becomes different as budget shares change. Second, which bridges are chosen also becomes different as they are ranked differently. The extent of the first effect was analyzed previously using the percentage change of budget shares, so here I present the extent of the second effect. For each county in a simulation, I calculate the net benefit of bridges given the estimated parameters and again with $\beta_4 = \beta_5 = 0$, added by common simulated shocks. Then I sort these two vectors of net benefits in order to compare how many bridges are ranked differently. Table 15 summarizes the average proportion of bridges whose ranking becomes different when political factors are shut down. I find that the impact is quite heterogeneous across counties. For instance, less than 10 percent of bridges are ranked differently for 35 counties. On the other hand, some counties such as Allegheny have as many as 47 percent of its bridges being ranked differently.

Table 15: Change in Ranking of Bridges

Proportion of Bridges with Different Ranking	No. of Counties
less than 10%	35
between 10% and 20%	5
between 20% and 30%	8
between 30% and 40%	5
between 40% and 50%	2

The structural approach taken by this model is essential for conducting the two counterfactual experiments. In the first counterfactual analysis, suppose one wants to compare allocations from universalism and those from the Legislative Bargaining Game without structurally estimating the model. As an alternative, one can collect bills passed with unanimous or bare majority support and make an inference by comparing the average distribution of benefits. Although this analysis gives a general idea, it may not give a reasonable prediction for the counterfactual outcome of this bill that we are interested in. As the underlying bargaining power can differ greatly across bills, concentration of benefits will be different as well.[30] To analyze counterfactual outcome of this bill, one would first need to structurally estimate the model to recover the underlying power structure.

The structural approach is also necessary for the second counterfactual experiment. As an alternative, suppose one uses a reduced-form analysis to predict allocations without political channels. For instance, one can first regress money shares m on the observable features $\vec{Y}$ and estimate coefficients. Using these coefficients and shutting down the political feature variables, one can simulate money shares. However, this does not answer the question of our interest as the simulated shares do not add up to the aggregate budget. To analyze how the aggregate budget would be allocated differently without the political channels, one would need to structurally estimate the model.

10 Conclusion

In this paper, I present a novel way of modeling universalism in a game-theoretic framework, where a legislature allocates a given budget for a distributive omnibus bill under unanimous consent. One of the contributions of this paper is that I combine the insights from the previous literature on universalism with the non-cooperative bargaining

[30]For instance, Appendix A.4. shows that the estimated parameters from the BBCB in 1992 can reasonably predict the allocation results for the BBCB in 1994, but not so well for the BBCB in 1999. This suggests that the bargaining power can change even among the same set of bills, depending on various circumstances.

literature. The model is general and flexible enough to be empirically applied to any distributive omnibus bill passed with unanimous consent. Using a constructed data set, I structurally estimate the model to rationalize how the Pennsylvania General Assembly allocated funds to deteriorated local bridges in the BBCB in 1992. I find that the distribution of benefits determined by universalism is much more dispersed compared to that generated by a non-cooperative bargaining game. Also, I find that political factors affect the geographical outlay of the budget as well as the choice of bridges granted funds under universalism.

There are several extensions of this paper which can be addressed in the future. First, my focus has been on a static game, but cooperation may be dynamically sustained over time. To the best of my knowledge, this paper is the first attempt to model and structurally estimate how heterogeneous allocations are determined under unanimous agreement. Therefore, a static framework seems to be an appropriate first step, but including dynamics would be interesting for future's work.[31] Second, currently I focus on a typical local public good defined in the public economics literature, where benefits are locally concentrated with diffused costs. However, one could also consider a public project with externalities, in which case there would be coordination across members in selecting projects. Lastly, this paper analyzes the case when there is a unanimous agreement. How-

[31] For simplicity, one can think of modeling universalism in a dynamic setting as the following. Consider an overlapping generation of finitely lived politicians in a deterministic environment. For cooperation to not unravel, politicians in their last term would have to be ensured sufficient budget shares. Politicians remaining in the legislature would cooperate, knowing that they would also be ensured sufficient shares in their last term. However, in reality where the turnover rate is quite high and politicians exit the legislature for many unexpected reasons, it is not clear whether such universal cooperation can be sustained. Moreover, distributive bills with a room for everyone to benefit are often introduced irregularly. Given such high uncertainty, focusing on present may be what is relevant for politicians in the legislature.

ever, over-sized coalitions approaching unanimity can also arise in reality and it would be interesting to allow for different coalitions sizes in the equilibrium.

A Appendix

A.1 Solution Method of the Budgetary Allocation

Eraslan (2002) proved that when $\delta_j = \delta \ \forall j$, then $\rho_j \leq \rho_k$ implies $v_j \leq v_k$. I use this theoretical result to solve the equilibrium object (r, v). For simplicity, I explain the case when $N = 5$. This can be extended to any N greater than five. Given recognition probabilities of all members and a common discount factor, I enumerate the subscripts of members by their ordering of recognition probabilities for notational simplicity.

(16) $$\rho_1 \leq \rho_2 \leq \rho_3 \leq \rho_4 \leq \rho_5.$$

Given the theoretical result, the following relationship holds:

(17) $$v_1 \leq v_2 \leq v_3 \leq v_4 \leq v_5.$$

However, note that the equality sign can not be eliminated as the theoretical result only gives weak monotonicity. First, I guess that there is only a single way to form a minimum winning coalition as the following:

(18) $$v_1 < v_2 < v_3 < v_4 < v_5.$$

Given this relationship, each member has exactly one way of forming a minimum winning coalition. This determines the r matrix, which can be denoted as the following:

(19)
$$r = \begin{pmatrix} 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \end{pmatrix},$$

where r_{jk} refers to the probability that member k is a coalition partner of member j. Using this r, I compute the fixed point for v using equation (2). Then I check whether r is indeed consistent given v. If it is consistent, I found the equilibrium; otherwise, I now search for mixed strategies.

A mixed strategy equilibrium involves the case when there are multiple ways of forming a minimum winning coalition. For example, suppose I guess the following:

(20)
$$v_1 < v_2 = v_3 < v_4 < v_5.$$

Members 1, 2, and 3 have one unique way of forming a minimum winning coalition as before. However, members 4 and 5 have two different ways of forming a minimum winning coalition since the cost of including either member 2 or member 3 is the same. This implies that the r matrix can be written as:

(21)
$$r = \begin{pmatrix} 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & a_4 & b_4 & 0 & 0 \\ 1 & a_5 & b_5 & 0 & 0 \end{pmatrix},$$

where $a_4 + b_4 = a_5 + b_5 = 1$. I discretize the grids for these a-s and b-s and iterate to find (r, v) that satisfies the equilibrium condition.

Some inequality relationships are redundant, such as:

$$v_1 < v_2 = v_3 < v_4 < v_5, \tag{22}$$

$$v_1 < v_2 = v_3 < v_4 = v_5. \tag{23}$$

Excluding a pure strategy case, there are $N^2 + 2N$ cases to consider when there are N members.

A.2 An Alternative Model of Portfolio Allocation

Consider an alternative way of modeling the portfolio allocation as an optimization problem solved over sets. Suppose member j has K projects and the budget is given by m_j^*. The objective of member j is to choose a portfolio of projects to maximize his or her utility given the budget constraint.

$$\max U(B_l), \tag{24}$$

$$s.t. \sum_{h}^{K} p_h \cdot I(h \in B_l) \leq m_j^*. \tag{25}$$

B_l is a portfolio of projects and its utility can be written as:

$$U(B_l) = \bar{X}_l \beta + \epsilon_l. \tag{26}$$

$\bar{X}_l$ is a vector containing average characteristics of projects in B_l. ϵ_l is unobserved to the econometrician but known to member j. It is assumed to be iid type I extreme value with scale parameter σ_ϵ. If B_1 is chosen among W feasible sets, the probability is written as:

$$Pr(portfolio|\bar{X};\beta,\sigma_\epsilon) = \frac{exp(\frac{\bar{X}_1\beta}{\sigma_\epsilon})}{\Sigma_{k=1}^{W} exp(\frac{\bar{X}_k\beta}{\sigma_\epsilon})}. \tag{27}$$

Similarly, the parameters of the model can be estimated by maximizing the likelihood.

$$L = \prod_{j=1}^{N} Pr(portfolio_j|\bar{X};\beta,\sigma_\epsilon). \tag{28}$$

One issue with this framework is that the number of possible sets grows exponentially as the budget or total number of project stock increases. Some feasible sets can be ruled out by concentrating on those sets that exhaust the budget sufficiently. Although feasible sets need to be calculated once, the calculation turns out to be infeasible with a large number of sets. Moreover, this also implies that the probability of choosing a portfolio will become almost zero. For instance, Allegheny county has 372 local bridges. In the data, I observe that 21 bridges were chosen. Simply calculating all possible combinations of choosing 21 out of 372 projects already exceeds a number which has about 35 digits. Although many sets would be dropped which either exceed or do not exhaust budget sufficiently, the number of possible combinations is still very big.

A.3 Estimation using Senate Districts

Instead of combining information from two chambers at the county level, I now use actual Senate districts to estimate the model. Theoretically, one can also use districts for the House of Representatives. However, there are 203 districts for the House of Representatives in Pennsylvania and this makes the computation to be quite intensive. I match all 6,232 local bridges to 50 Senate districts by tracking their location at the township, borough, city, or ward level. The recognition probability now only contains characteristics of the Senate districts and political features of senators. The parameter estimates are shown in Table 16. As less information is available at the Senate district level and political features are now defined for each single senator, the specification is a bit different from that in Table 4. Out of 8 variables, 4 of them are statistically significant at 1 percent, and each one variable is statistically significant at 5 percent and 10 percent respectively. Similar to the estimation results for the baseline model, features related to needs and political representation have positive coefficients which are associated with a higher recognition probability.

Table 16: Parameter Estimates Using Senate Districts

	Variable	Estimate	S.E.
α_1	I(No representation in relevant committees)	-0.0488	0.3747
α_2	Square root of number of Senate terms served	0.6362	0.4948
α_3	Log of number of bridges	1.7148	0.0734
α_4	I(No historically significant bridges)	-0.7675	0.4569
α_5	Square root of number of cities	0.8131	0.3227
σ_ξ	Scale parameter for the ξ distribution	1.5553	0.0103
δ	Discount factor	0.7838	0.0553
σ_η	Standard deviation for the η distribution	0.0141	0.0013
	Log likelihood	143.22	

Next, I show the model fit in Tables 17 and 18. Overall, the model fits the data reasonably well, although the fit is not as good as the baseline model which combines information from the two chambers. For instance, the model tends to over-predict money shares for districts with low population density. Each Senate district has a population of around 237,000 and some districts cover quite large geographical areas that are sparsely populated. The number of bridges can be quite big in a large Senate district. However, this corresponding area is mapped to relatively fewer House districts. Therefore, the shares tend to be over-predicted when the House information is not accounted for. The estimation results based on the Senate information gives a reasonable fit for the budgetary allocation outcome, but at the same time suggests that incorporating features from both chambers improves the model's prediction.

Table 17: Fit of the Budget Shares by Committees (Unit: Percent)

Budget Share of Districts with Membership in:	Data	Model	No. of Districts
Senate Transportation	20.44	24.33	10
Senate Appropriations	33.28	42.11	20
Senate Rules & Executive Nominations	17.31	24.74	15
No Senate committee	42.83	53.21	23

Table 18: Fit of the Budget Shares by Needs (Unit: Percent)

Quintile		1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
No. of local bridges	Data	2.80	20.06	20.65	20.20	36.29
	Model	5.91	18.06	16.31	22.88	36.84
No. of closed bridges	Data	24.63	7.26	14.91	25.91	27.55
	Model	21.92	10.44	16.44	28.36	22.84
No. of restricted bridges	Data	4.75	17.04	20.37	19.50	38.33
	Model	8.33	14.13	18.24	18.07	41.23

A.4 Simulation using BBCB from Other Years

To investigate the extent to which the estimation results can be generalized to other bills, I simulate the model using the estimated parameters in Table 4 and the two subsequent BBCB bills passed after 1992. The BBCB in 1994 and 1999 allocated around \$223 million to 324 local bridges and \$1.35 billion to 1,071 local bridges respectively. Variables capturing political power in the legislature and bridge stock features are different and I incorporate their status in $\vec{Y}$ of the recognition probability.

Table 19: Fit of the Budget Shares by Committees (Unit: Percent)

	1994		1999	
Budget Share of Counties with Membership in:	Data	Model	Data	Model
Senate Transportation	73.62	65.73	75.34	61.68
Senate Appropriations	73.26	65.81	94.51	79.02
Senate Rules & Executive Nominations	66.59	61.93	90.85	72.85
No Senate committee	12.29	19.77	1.72	8.33
House Transportation	53.20	49.51	67.90	50.45
House Appropriations	63.84	61.34	84.12	58.29
House Rules & Executive Nominations	29.05	44.52	82.38	58.65
No House committee	27.37	19.19	7.83	17.21
No Senate nor House committee	7.51	5.78	0.74	3.21

Table 20: Fit of the Budget Shares by Representation in the Chambers (Unit: Percent)

	No. of Senators	One	Two	Three or More
1994	Data	21.53	13.00	64.40
	Model	32.82	16.74	48.70
1999	Data	9.22	16.60	74.08
	Model	31.89	23.59	43.19

	No. of House Members	One	Two	Three	Four	Five or More
1994	Data	8.10	14.77	6.67	3.94	66.53
	Model	10.40	8.54	9.49	10.67	60.90
1999	Data	6.50	3.09	3.58	2.53	84.30
	Model	10.91	6.36	10.12	13.05	59.65

Tables 19 and 20 show the model fit when the budgetary allocations for the BBCB in 1994 and 1999 are simulated. Overall, parameter estimates from the 1992 bill predict the allocations in 1994 reasonably well. The model captures the trend and level given committee membership and number of legislators. The fit is less accurate for the BBCB of 1999. The distribution of benefits is much more concentrated for the bill in 1999 compared to the bills in 1992 and 1994. For instance, Allegheny took around 51.51 percent of the aggregate budget in 1999. Without incorporating additional political features or changing the recognition probability parameters, the simulated model does not match the distribution of benefits well. Therefore, one should be cautious about generalizing the parameter estimates as the underlying bargaining power can greatly differ across bills.

References

The Pennsylvania Manual (Volume 110) (Dept. of General Services for the Commonwealth of Pennsylvania, 1991).

Adachi, T. and Y. Watanabe, "Ministerial Weights and Government Formation: Estimation Using a Bargaining Model," *Journal of Law, Economics, and Organization* 24 (2008), 95–119.

Ansolabehere, S., J. M. Snyder and M. M. Ting, "Bargaining in Bicameral Legislatures: When and Why Does Malapportionment Matter?," *The American Political Science Review* 97 (2003), 471–481.

Atlas, C. M., T. W. Gilligan, R. J. Hendershott and M. A. Zupan, "Slicing the Federal Government Net Spending Pie: Who Wins, Who Loses, and Why," *The American Economic Review* 85 (1995), 624–629.

Banks, J. S., "Buying Supermajorities in Finite Legislatures," *The American Political Science Review* 94 (2000), 677–681.

Baron, D. P., "Majoritarian Incentives, Pork Barrel Programs, and Procedural Control," *American Journal of Political Science* 35 (1991), 57–90.

Baron, D. P. and J. A. Ferejohn, "Bargaining in Legislatures," *The American Political Science Review* 83 (1989), 1181–1206.

Barten, A. P., "Maximum likelihood estimation of a complete system of demand equations," *European Economic Review* 1 (1969), 7–73.

Berry, C. R., B. C. Burden and W. G. Howell, "The President and the Distribution of Federal Spending," *American Political Science Review* 104 (2010), 783–799.

Besley, T. and S. Coate, “Centralized versus decentralized provision of local public goods: a political economy approach,” *Journal of Public Economics* 87 (2003), 2611–2637.

Buchanan, J. M. and G. Tullock, *The Calculus of Consent: Logical Foundations of Constitutional Democracy* (The University of Michigan Press, 1962).

Collie, M. P., “Universalism and the Parties in the U.S. House of Representatives, 1921-80,” *American Journal of Political Science* 32 (1988), 865–883.

Deaton, A. S., “The Analysis of Consumer Demand in the United Kingdom, 1900-1970,” *Econometrica* 42 (1974), 341–367.

Diermeier, D. and R. B. Myerson, “Bicameralism and Its Consequences for the Internal Organization of Legislatures,” *The American Economic Review* 89 (1999), 1182–1196.

Eraslan, H., “Uniqueness of Stationary Equilibrium Payoffs in the Baron-Ferejohn Model,” *Journal of Economic Theory* 103 (2002), 11–30.

———, “Corporate Bankruptcy Reorganizations: Estimates From A Bargaining Model,” *International Economic Review* 49 (2008), 659–681.

Eraslan, H. and A. Merlo, “Majority Rule in a Stochastic Model of Bargaining,” *Journal of Economic Theory* 103 (2002), 31–48.

Ferejohn, J. A., *Pork Barrel Politics: Rivers and Harbors Legislation, 1947-1968* (Stanford University Press, 1974).

Groseclose, T. and J. M. Snyder, “Buying Supermajorities,” *American Political Science Review* 90 (1996), 303–315.

Knight, B., "Estimating the Value of Proposal Power," *The American Economic Review* 95 (2005), 1639–1652.

———, "Legislative Representation, Bargaining Power and the Distribution of Federal Funds: Evidence from the US Congress," *The Economic Journal* 118 (2008), 1785–1803.

Levitt, S. D. and J. Snyder, James M., "Political Parties and the Distribution of Federal Outlays," *American Journal of Political Science* 39 (1995), 958–980.

Martin, G. J., "Dividing the Dollar With Formulas," *Journal of Politics* (Forthcoming).

Merlo, A., "Bargaining over Governments in a Stochastic Environment," *Journal of Political Economy* 105 (1997), 101–131.

Mitsutsune, M. and T. Adachi, "Estimating Noncooperative and Cooperative Models of Bargaining: An Empirical Comparison," *Empirical Economics* 47 (2014), 669–693.

Nevo, A., D. L. Rubinfeld and M. McCabe, "Academic Journal Pricing and the Demand of Libraries," *The American Economic Review* 95 (2005), 447–452.

Niou, E. M. and P. C. Ordeshook, "Universalism in Congress," *American Journal of Political Science* 29 (1985), 246–258.

Primo, D. M. and J. M. Snyder, "Distributive Politics and the Law of 1/n," *The Journal of Politics* 70 (2008), 477–486.

———, "Party Strength, the Personal Vote, and Government Spending," *American Journal of Political Science* 54 (2010), 354–370.

Riker, W. H., *The Theory of Political Coalitions* (New Haven : Yale University Press, 1962).

Shapley, L. S. and M. Shubik, “A Method for Evaluating the Distribution of Power in a Committee System,” *The American Political Science Review* 48 (1954), 787–792.

Shepsle, K. A. and B. R. Weingast, “Political Preferences for the Pork Barrel: A Generalization,” *American Journal of Political Science* 25 (1981), 96–111.

Stein, R. M. and K. N. Bickers, “Universalism and the Electoral Connection: A Test and Some Doubts,” *Political Research Quarterly* 47 (1994), 295–317.

Stromberg, D., “Radio’s Impact on Public Spending,” *The Quarterly Journal of Economics* 119 (2004), 189–221.

———, “How the Electoral College Influences Campaigns and Policy: The Probability of Being Florida,” *The American Economic Review* 98 (2008), 769–807.

Weingast, B. R., “A Rational Choice Perspective on Congressional Norms,” *American Journal of Political Science* 23 (1979), 245–262.

———, “Reflections on Distributive Politics and Universalism,” *Political Research Quarterly* 47 (1994), 319–327.

Weingast, B. R., K. A. Shepsle and C. Johnsen, “The Political Economy of Benefits and Costs: A Neoclassical Approach to Distributive Politics,” *Journal of Political Economy* 89 (1981), 642–664.

Wilson, R. K., “An Empirical Test of Preferences for the Political Pork Barrel: District Level Appropriations for River and Harbor Legislation, 1889-1913,” *American Journal of Political Science* 30 (1986), 729–754.

Wright, G., “The Political Economy of New Deal Spending: An Econometric Analysis,” *The Review of Economics and Statistics* 56 (1974), 30–38.