Lobbying for Power: A Structural Model of Lobbying in the Energy Sector*

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November 21, 2011

JOB MARKET PAPER

Abstract

Firms systematically lobby the U.S. Congress to influence policy-making. To what extent do lobbying expenditures affect the probability that a policy is enacted? What are the private returns from lobbying expenditures? To answer these questions, I construct a novel dataset comprised of federal energy legislation and lobbying activities by the energy sector during the 110th Congress (2007–2008). A unique feature of this dataset is that it focuses on specific policy issues rather than entire pieces of legislation (bills). I develop and estimate a game-theoretic model where heterogeneous players choose lobbying expenditures to affect the probability that a policy is enacted. I find that the effect of lobbying expenditures on a policy’s equilibrium enactment probability is small. However, the average returns from lobbying expenditures are estimated to be large. As the estimated average value of a policy is quite large, even a small change in its enactment probability can lead to large returns.

*I am greatly indebted to my advisor, Antonio Merlo, and my dissertation committee members, Kenneth I. Wolpin, Hanming Fang, and Flávio Cunha for their guidance, support, and insight. I have greatly benefited from discussions with Xu Cheng, Camilo García-Jimeno, Âureo De Paula, Holger Sieg, Xun Tang, and Petra Todd. I thank the participants of the 2011 Asian Meeting of the Econometric Society, the 25th Annual Meeting of European Economic Association, the 10th World Congress of the Econometric Society, and Penn’s Empirical Micro Seminar and Empirical Micro Lunch. I also thank John Chwat of Chwat & Company and the staff in the Center for Responsive Politics, especially Jihan Andoni. Lastly, I thank Douglas Hanley for computerizing policy identification and also thank Mahluu Attenoukon, Audrey Boles, Eric Sun, Jennifer Sun, and Yi Yi for providing excellent research assistance for data collection. The research reported here was supported by the National Science Foundation through Grant SES-1023855. All errors are mine.

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1 Introduction

Government policies often benefit certain firms at the expense of others. Environmental regulations, for example, may give a competitive advantage to firms with cleaner production technologies. Hence, many firms actively engage in lobbying activities to influence the policy-making process. At the same time, most policies affect not only firms’ profitability but also the general public. Therefore, the issue of political influence by private interests is of great concern to any democratic society. This raises the central question addressed in this paper: To what extent does lobbying influence public policy?

In this paper, I study lobbying activities by firms that have heterogeneous and often competing interests in public policies. The main goal of the paper is to quantify the extent to which lobbying expenditures affect policy enactment in the U.S. Congress. To achieve this goal, I construct a novel dataset that contains detailed information on policy enactment and lobbying activities in the 110th Congress (2007–2008). I then specify a game-theoretic model of lobbying and estimate it using this dataset.

To focus the analysis, I restrict attention to energy policies. The energy sector is a crucial component of the U.S. economy, and energy is a major issue in elections. Also, the energy sector is heavily involved in lobbying. For example, in recent years, lobbying expenditures by energy firms account for about 12% of total lobbying expenditures. Moreover, energy policies generally have well-defined winners and losers among energy firms. At the same time, they often address issues of great concern to the general public (e.g., environmental quality). While the empirical results of this study may be specific to energy policies, the method I propose in this paper is general, and can be readily applied to any types of policies.

A novel feature of this study is that policies, not entire pieces of legislation (bills), are the unit of analysis. I define a policy as part of a bill that addresses one unique issue. Existing studies on the influence of interest groups on legislation have focused on bills as the fundamental unit of analysis.¹ However, a bill usually contains multiple policies, which may or may not be related to each other, and the same policy may appear in multiple bills. Consider, for example, a bill that was introduced for consideration by Congress in 2008 to promote domestic energy production (H.R. 6566). This bill contained several different policies (e.g., allowing natural gas production in the outer Continental Shelf and extending the solar energy property tax credit) and was not enacted. However, the solar energy tax provision was later inserted into the financial industry bailout bill (H.R. 1424), which was enacted. If a researcher were to focus only on the fate of the energy bill, she would potentially

¹One notable exception is Baumgartner et al. (2009). They study 98 randomly selected policy issues in which interest groups were involved and then followed those issues across two Congresses. For each issue, they conducted detailed interviews of lobbyists and supplemented them with extensive document searches.
mismeasure the effect of lobbying by ignoring the fact that the solar energy tax policy was ultimately enacted as part of the financial industry bill. More importantly, energy firms care about the enactment of the tax policy, not in which bill it was included.

I construct a unique dataset of 539 distinct energy policies appearing in 445 bills. This represents the universe of all energy policies considered by the 110th Congress. Among these policies, 293 of them (54%) appear in more than one bill. By tracking each policy’s movement through bills, I determine whether the policy was enacted or not. There are 45 policies that were ultimately enacted, 40 of which also appear in bills that failed to pass.

For each policy, I collect information on lobbying activities. The data is sourced from the lobbying reports mandated by the Lobbying Disclosure Act of 1995. This act stipulates that for every contract with a client, a lobbyist must submit a periodical report that records the total amount of income or expenses related to lobbying activities and disclose which issues were lobbied, such as bills or bill sections. I group the energy firms and trade associations in the data into multiple lobbying coalitions based on their interests with respect to energy policies. For each lobbying coalition and each policy, I determine whether the coalition lobbied for or against the policy or did not lobby at all based on the lobbying reports and other auxiliary sources of information. Though I do not observe policy-specific lobbying expenditures, I observe the total expenditures over all policies for each lobbying coalition.

The lobbying coalitions are the players in the lobbying game I specify and estimate. For each policy, players know the initial level of support in the legislature in the absence of lobbying and the values to all players. They have heterogeneous valuations of a policy, which determines their position on the policy. For each policy, players simultaneously decide whether to lobby or not and incur an entry cost if they do. Then the participants simultaneously decide the amount of lobbying expenditures. The lobbying expenditures by each player and the initial probability of enactment determine the equilibrium probability that the policy is enacted. The expected payoff of a player who lobbies the legislature on a policy is the value of the policy multiplied by the equilibrium enactment probability minus total lobbying costs.

There are three fundamental components of the model that I estimate: (i) the enactment production function; (ii) the distribution of the initial enactment probability; and (iii) the distribution of the value of a policy to each player. There are two main empirical challenges to identifying the structural parameters of the model from the data. First, the initial enactment probability is not observed, and theory implies that it is correlated with the lobbying

\[2^{The lobbying reports were retrieved from the website of the U.S. Senate (www.senate.gov/legislative/Public_Disclosure/LDA_reports.htm). The frequency of reporting was initially semi-annual but was amended to be quarterly in 2007.}
decisions of players. Second, only total lobbying expenditures are observed in the data, rather than policy-specific expenditures. I overcome both of these challenges by exploiting both the structure of the model and exclusion restrictions. The model has a unique equilibrium in lobbying expenditures given any observed lobbying participation profile. Therefore, the unobserved, policy-specific lobbying expenditures can be expressed as a function of the exogenous variables in the model and the observed lobbying participation profile. In addition, exclusion restrictions and the fact that total expenditures are observed help separately identify the level of the policy valuations and the effectiveness of lobbying expenditures.

I find that the average difference between the final enactment probability and the initial probability is estimated to be less than 0.04 percentage points. This finding is the result of two effects. First, the effect of lobbying expenditures on the policy enactment probability is very small. For example, I estimate it would cost $200 million for one lobby to change the enactment probability from 50% to 51% if no one else lobbied. Second, the effects of expenditures by both supporting and opposing lobbies partially cancel each other out. I find that 57% of the direct effects of lobbying are canceled out by competing lobbies. However, the average returns to lobbying expenditures are estimated to be 102% – 113%. Because the average value of a policy is estimated to be $400 million, even a small change in its enactment probability can lead to large private returns.

There is a large empirical literature that tries to assess the influence of interest groups on policy-makers via campaign contributions. A strand of this literature focuses on the voting behavior of individual legislators on bills. Another strand, pioneered by the theoretical work of Grossman and Helpman (1994), estimates the effect of campaign contributions by special interests across industries on the level of trade protection. As pointed out above, in this paper I focus instead on the enactment of policies (as opposed to bills), and on lobbying expenditures by firms (as opposed to campaign contributions).

A recent empirical literature uses the lobbying disclosure data to address a variety of issues, such as establishing the relationship between lobbying expenditures and campaign contributions by individual interest groups (Tripathi et al., 2002), exploring the determinants of political organization across U.S. industries (Bombardini and Trebbi, 2009), or assessing the relative importance of issue expertise and connections in lobbying (Bertrand et al., 2011). In a closely related paper, de Figueiredo and Silverman (2006) estimate the return to lobbying by universities regarding academic earmarks. However, they do not account for competition among multiple players, and their analysis would not extend to environments where the

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3 See Grossman and Helpman (2001) for a review of the theoretical literature on interest groups’ political influence and Ansolabehere et al. (2003) for a survey of the empirical literature.
4 Hall and Wayman (1990) also consider the behavior of legislators in committees.
5 See e.g. Goldberg and Maggi (1999), Gawande and Bandyopadhyay (2000), and Gawande et al. (2005)
private values of specific policies to individual players are not observable. I address both of these issues in my paper.

The remainder of the paper is organized as follows. The next section describes the main features and construction of the dataset. Section 3 describes the model. Section 4 presents the econometric specification. Section 5 discusses the identification and estimation strategy. Section 6 contains the results of the empirical analysis. Section 7 concludes.

2 Background and Data

I construct a novel dataset on energy policies considered in the 110th Congress and the lobbying activities targeting these policies by energy firms and trade associations. The main dataset is based on lobbying reports mandated by the Lobbying Disclosure Act (1995), which are available at the Senate Office of Public Records, and on legislative information available in the Library of Congress. I describe the main features of the construction of the dataset and show summary statistics of the key variables.

2.1 Bills vs. Policies

I define a policy as the smallest self-contained part of a bill or a joint resolution that addresses one unique issue. Existing studies have focused on legislative bills as the fundamental unit of analysis. However, it is more reasonable to consider that the objective of a lobbying entity is to help or block the passage of a certain part of a bill rather than the entire bill. A bill often addresses multiple issues; this is especially the case for omnibus legislation, which is more likely to pass than other types of legislation. Furthermore, some parts of a bill can be dropped from the bill or inserted into another bill over the course of the legislative process.

The approach of having a policy as the unit of my analysis has a unique advantage in that the outcome of lobbying—i.e., success or failure to enact a policy—is measured accurately. To obtain the enactment information of the policy, I track each policy across bills. In tracking a policy, it is crucial to define and measure the distance between two different texts. I use a metric designed by Salton et al. (1975) and adopt a set of rules to determine if two policies included in respective bills are considered identical. In the dataset, a policy is included, on average, in 3 different bills.

There are four types of legislation: bills, joint resolutions, concurrent resolutions, and simple resolutions. Bills and joint resolutions require the approval of both the House and the Senate and the signature of the president to be enacted into law. Concurrent resolutions and simple resolutions are not submitted to the president and therefore do not have the force of law.
The dataset covers all policies that were both considered in the 110th Congress (2007–2008) and that create, extend, or repeal a federal financial intervention or regulation whose main statutory subjects are coal, oil, nuclear or renewable energy companies, or electric and gas utilities. Examples are tax incentives for renewable energy sources, loan guarantees to construct energy-efficient power lines, and regulation of mercury emission from coal-fired power plants. Note that not all policies that affect the energy sector are included in the analysis because their statutory subject might be a different sector. For example, a policy to enhance competition in the railroad industry affects the coal mining industry and the electric utilities that mainly use coal to generate electricity, but it is not in the sample because the statutory subjects are the firms in the railroad industry. In the dataset, there are 539 policies which are included in 445 bills.

A policy is considered to have been enacted if the policy is included in the final version of an enacted bill. By this definition, 45 policies (8.35%) were enacted into law. Table 1 shows the final the status of the policies. Note that the average enactment rate of all bills and joint resolutions in the 110th Congress is 4.10%. The reason why the enactment rate is higher for the dataset is mainly due to the fact that, as discussed previously, the ratio of policies to bills is not 1:1, and an enacted bill often includes many policies. Out of 445 bills that included the policies in the dataset, only 5 bills (1.12%) were enacted.

2.2 Lobbying Disclosure Data

Lobbyists can be categorized into two groups by their professional arrangement: in-house (or internal) lobbyists and external lobbyists. In-house lobbyists are hired by a firm, a trade association, or a citizens’ group as an employee. External lobbyists have a contract with a client and often work for multiple clients simultaneously. Most lobbyists, whether in-house or external, are required to register and file a report to disclose their lobbying activities by the Lobbying Disclosure Act of 1995.

This act mandates that any lobbyist or lobbying firm whose lobbying income (for external lobbyists) or expenditure (for self-lobbying entities) exceeds a certain threshold during the filing period must file a report. The content of the report includes: (i) all relevant lobbyists’ name, address, and previous official position; (ii) the client’s name, address, and general business description; (iii) the total amount of income or expenditures related to lobbying activities; (iv) a list of general issue areas (such as Agriculture, Energy, etc.); (iv) a list of

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7 According to Bertrand et al. (2011), about 40% of registered lobbyists are in-house lobbyists.
8 The cutoff amount is $5,000 for external lobbyists and $20,000 for self-lobbying entities. The frequency of filings was originally semi-annual, and after the Honest Leadership and Open Government Act (2007) was enacted, it became quarterly. This amendment also strengthened the registration criteria and the enforcement rules.
the specific issues including a list of bill numbers and references to specific executive branch actions; and (vi) a list of contacted houses of Congress or federal agencies. I have obtained the original disclosure reports from the website of the Senate Office of Public Records.

One of the most interesting parts of the lobbying reports is the specific issue section. Lobbyists are supposed to describe their specific lobbying targets, by specifying bill numbers, titles, and sections. However, lobbying expenditures are not itemized by targets or policies; only the total amount is listed. I discuss how I overcome this shortcoming in the data in Section 5.

2.3 Lobbying Coalitions by Energy Sub-sectors

In total, there are 559 firms and associations in the energy sector which filed at least one lobbying report in 2007-2008. The total amount of their lobbying expenditures during this period is about $607.9 million. The distribution of individual firm or trade association’s lobbying expenditures is very skewed; the median amount of lobbying expenditures is $160,000, while the average is over $1,087,000. When ranked by lobbying expenditures, the top 10% of firms and trade associations in this sector—55 entities in total—spent about $462.7 million. This accounts for 76.11% of the total amount of lobbying expenditures by the sector.

The energy sector is politically organized by sub-sectors. Among these top 55 lobbying spenders, there are 8 trade associations that represent energy sub-sectors. For example, the American Petroleum Institute represents the U.S. oil and natural gas industry and has members including major oil and natural gas companies such as Exxon Mobil, BP, and

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9 I merged my dataset with the dataset compiled and cleaned by the Center for Responsive Politics (CRP) to determine the industry in which a client is involved and to figure out parent-subsidiary relationships. I also did my own research on firms and trade associations by checking their website and the website of Bloomberg Businessweek (investing.businessweek.com) when the information in the CRP dataset is not sufficient. Note that identifying entities correctly is not always straightforward. First, there is no company or organization identifier in the lobbying reports, so one must resort to the name of entities and general business description in the reports. Second, parent and subsidiary firms can be considered as one entity, since their interests mostly coincide. Third, entities change over time by mergers and acquisitions.

10 I exclude the following firms and associations which can be considered as in the energy sector in the analysis: (i) community-owned electric utilities, rural electric cooperatives and public power districts (93 entities), (ii) foreign energy companies (9 entities), (iii) independent power providers (26 entities), and (iv) firms that are only involved electric transmission (10 entities).

11 This is the list of the trade associations which are among the top 55 lobbying spenders in the energy sector: (1) National Mining Association (coal mining industry); (2) American Coalition for Clean Coal Electricity (coal industry and electric utilities that mainly use coal to generate electricity); (3) American Petroleum Institute (oil and natural gas industry); (4) Nuclear Energy Institute (nuclear industry and electric utilities that mainly use nuclear energy to generate electricity); (5) Edison Electric Institute (investor-owned electric utilities); (6) American Wind Energy Association (wind energy industry); (7) Solar Energy Industries Association (solar energy industry); and (8) National Biodiesel Board (biodiesel industry).
Chevron. All energy companies among the top lobbying spenders are a member of at least one trade association.

I categorize energy firms and trade associations in the dataset into 4 groups: (i) the coal mining industry and investor-owned electric utilities or independent power providers that mainly use coal for power generation; (ii) the oil and natural gas industry, (iii) the nuclear industry and investor-owned electric utilities or independent power providers that mainly use nuclear energy for power generation; and (iv) the renewable energy industry (such as bio, solar, wind, geothermal, and hydro-kinetic) and investor-owned electric utilities or independent power providers that mainly use renewable energy for power generation.

I designate certain firms and trade associations as strategic or major in lobbying the legislature on the energy policies in the dataset. I assume that these strategic firms and trade associations lobby cooperatively according to the 4 groups mentioned above. In the model, these lobbying coalitions are the players of a lobbying game. Entities are selected as strategic based on the fraction of their individual lobbying expenditures to the total lobbying expenditures by the group to which they belong. The threshold for inclusion is 2.5% for all groups except for that of renewable energy, whose threshold is 1.5%. Based on the criterion, 42 firms and trade associations are considered as strategic, with 8 to 12 belonging to each group. The total amount of lobbying expenditures by these strategic entities accounts for 66.02% of that of the energy sector as a whole. Table 2 lists the entities, and Table 3 shows some descriptive statistics by group. Table 4 shows the total lobbying expenditures in 2007–2008 by the strategic firms and associations by group. For each group, the table also shows an estimate of the amount spent on lobbying specifically on the energy policies included in the dataset for this paper.

For each firm or trade association in each lobbying coalition, I extract from lobbying reports and other auxiliary sources the following information for each policy: (i) whether or not the entity lobbied the legislature on the policy and (ii) whether the entity supports or opposes it. I assume that when a bill is listed as a lobbying target in the report, all policies in the bill are lobbied on by the respective entity. The position of a firm or a trade association on a policy is determined by exploiting a variety of sources of information.

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12 The renewable energy group is relatively more heterogeneous than other groups. I use a lower threshold so that all major renewable energy sources are represented.

13 The estimates are based on the information on targeted bills listed in the lobbying reports. The estimates are calculated as follows for each group: first, I count the number of the bills that include at least one energy policy in the dataset and that each strategic firm or trade association lobbied on; second, I calculate the ratio of the number to that of the total bills that the entity lobbied; and then I sum over each entity’s lobbying expenditures multiplied by the obtained ratio within the group.

14 However, it is possible that the resulting lobbying participation frequency in the dataset is greater than the actual participation frequency. In the next version of the draft, the results of a robustness check will be included.
Note that the position information is needed for all relevant firms and trade associations regardless of lobbying participation. In most cases, guesswork is straightforward based on the business of an entity and the content of each policy. I also collect and use relevant documents available online to arrive at these determinations, such as the letters sent to the Congress by interest groups and statements in news articles and the groups’ own websites.

The lobbying participation and policy position of the entities within a lobbying coalition are aggregated as follows. A coalition is assumed to have lobbied the legislature on a policy if any of the strategic firms or trade associations within the coalition lobbied on the policy. The position of individual strategic firms or trade associations mostly align within a coalition, but when there are disagreements, I take the policy position of the majority of the entities in the coalition as the coalition’s position.

3 Model

There is a finite set of lobbying coalitions, denoted as $\mathcal{L}$. Each lobbying coalition represents a unique interest. These lobbying coalitions are the players of the lobbying game. Consider a specific policy $p$. Each player values the policy heterogeneously, and the value of policy $p$ to player $\ell$ is denoted as $v_{\ell,p}$. Some players have positive values and others have negative values from the enactment of the policy. I denote the set of players that support policy $p$ as $\mathcal{L}_{F,p} \subset \mathcal{L}$ and those that oppose it as $\mathcal{L}_{A,p} \subset \mathcal{L}$. For simplicity, it is assumed that the legislative process regarding a policy does not interfere with that of any other policy.

The model is a game of complete information, consisting of two stages. For each policy, players first simultaneously decide whether or not to lobby the legislature on the policy. Upon participation, a player pays an entry cost. The initial level of support for the policy in the legislature, the value of the policy to all players, and the entry costs of lobbying on the policy for all players are common knowledge. Second, knowing the identities of other participants, players simultaneously decide how much to spend in order to affect the chances that the policy will be enacted. The initial level of support for the policy in the legislature and the lobbying expenditures of each player determine the probability that the policy is enacted. This second stage game is modeled as an all-pay group contest in the sense that the lobbying expenditures are sunk costs and the rent is a public good shared amongst all groups on the same side of a policy.

The early papers on the rent-seeking behaviors, such as Tullock (1967) and Krueger...
(1974), have been extended in various directions (see Nitzan 1994 for a summary) and this
rent-seeking literature has studied lobbying as an application. One extension that is relevant
to my paper is that the rent is a group-specific public good. This type of rent-seeking contests
are studied by many papers including Katz et al. (1990), Ursprung (1990), Nitzan (1991),
Baik (1993, 2008), Riaz et al. (1995), and Dijkstra (1998). They differ by the assumptions on
the asymmetries in the players’ valuation of the rent and how the probability of each group
winning the rent is determined by players’ efforts (the contest success function), amongst
others.

As discussed in Konrad (2007), the following contest success function is typically at-
tributed to Tullock (1980) and is extensively used in the literature. The probability of group
$i$ winning the rent given expenditures $(s_1, s_2, ..., s_L)$ is:

$$
\begin{cases}
\frac{s_i^\gamma}{\sum_{j=1}^L s_j} & \text{if } \max\{s_1, s_2, ..., s_n\} > 0, \\
\frac{1}{L} & \text{otherwise.}
\end{cases}
$$

The parameter $\gamma > 0$ in the function is important for the marginal impact of an increase in a
player’s expenditure. In my model, the contest success function, which I refer to as the policy
enactment production function, has a few features that differ from this function. First, noise
or randomness affects the determination of the winner. Second, an initial advantage to a
certain group is allowed in the sense that the initial support of a policy in the legislature
affects the equilibrium enactment probability.

The policy enactment production function is specified as follows: policy $p$ is enacted if

$$
\omega_p + \left\{ \sum_{i \in \mathcal{L}_F,p} g(s_{i,p}) - \sum_{j \in \mathcal{L}_A,p} g(s_{j,p}) \right\} - \epsilon_p > 0,
$$

where the random variable $\epsilon_p$ follows a cumulative density function $F_{\epsilon}$. This randomness in
the outcome of lobbying represents unexpected changes in the environment, such as economic
and electoral conditions, that could affect the legislators’ votes. $\omega_p$ summarizes the initial
level of support for policy $p$ in the legislature, and hence $F_{\epsilon}(\omega_p)$ is the probability that the
policy is enacted in the absence of lobbying. $s_{\ell,p}$ stands for the amount of money that player
$\ell \in \mathcal{L}$ spends to lobby the legislature on policy $p$. Function $g$ is increasing and strictly
concave in the amount of spending. As a player supports (or opposes) the policy and spends
money for (or against) its enactment, the enactment probability increases (or decreases).
However, the change in the probability decreases as the spending level increases.

Given the policy enactment production function specified above, the expected payoff of
a player is delineated as follows. Players are assumed to be risk-neutral.\textsuperscript{16} If player $\ell$ spends $s_{\ell,p}$ to lobby for policy $p$ given other players’ spending $s_{-\ell,p} \equiv \{s_{\ell',p}|\ell' \in \mathcal{L} - \{\ell\}\}$, the expected payoff is:

$\mathbb{E} u_\ell(\text{In}, s_{\ell,p}|\{\omega, s_{-\ell,p}\}) = F_\epsilon \left( \omega'_{p,-\ell} + g(s_{\ell,p}) \right) v_{\ell,p} - s_{\ell,p} - c_{\ell,p},$

where $\omega'_{p,-\ell} = \omega_p + \left\{ \sum_{i \in \mathcal{L}_{F,p} - \{\ell\}} g(s_{i,p}) - \sum_{j \in \mathcal{L}_{A,p}} g(s_{j,p}) \right\}$ and $c_{\ell,p}$ is the entry cost. Note that if the player lobbies against the policy, the expected payoff can be similarly defined. If the player does not participate,

$\mathbb{E} u_\ell(\text{Out}|\{\omega, s_{-\ell,p}\}) = F_\epsilon \left( \omega'_{p,-\ell} \right) v_{\ell,p}.$

Players do not have a budget constraint.\textsuperscript{17}

The equilibrium concept in this game is the Subgame Perfect Nash Equilibrium. In the second stage, a pure strategy equilibrium is unique if it exists under the following conditions:

\textbf{Proposition 1.} Suppose the following conditions hold: (i) $g(x) = \beta x^\gamma$, $0 < \gamma \leq \frac{1}{2}$; (ii) $\epsilon$ has a finite support $(\lambda_L, \lambda_U)$ and $\omega \in (\lambda_L, \lambda_U)$; (iii) the pdf $f_\epsilon$ is concave and uni-modal at $\lambda_0 \in (\lambda_L, \lambda_U)$. Then if a pure strategy equilibrium exists in the second stage, it is unique.

\textbf{Proof.} The proof is constructive. Suppose player $\ell$ lobbies for policy $p$. For notational ease, I will drop the subscript for a policy, $p$, in the notations in the proof. The player solves the following maximization problem given $\{\omega, s_{-\ell}\}$:

$$\max_{s_{\ell}} \mathbb{E} u_\ell(\text{In}, s_{\ell}|\{\omega, s_{-\ell}\}).$$

If $s_{\ell}^*$ maximizes player $\ell$’s expected payoff, $s_{\ell}^*$ must satisfy the first order condition.

$$f_\epsilon(\omega'_{-\ell} + g(s_{\ell}^*))g'(s_{\ell}^*)v_\ell = 1.$$

Let us denote the equilibrium probability index as $\omega^* \equiv \omega + \left\{ \sum_{i \in \mathcal{L}_{F}} g(s_i^*) - \sum_{j \in \mathcal{L}_{F}} g(s_j^*) \right\}$. The optimal spending for player $\ell$ is characterized by:

$$s_{\ell}^* = g'^{-1} \left( \frac{1}{f_\epsilon(\omega^*)v_\ell} \right).$$

\textsuperscript{16}If players are risk-averse, $v_{\ell,p}$ can be interpreted as $u_\ell(v_{\ell,p}^*)$ where $v_{\ell,p}^*$ is the value of policy $p$.
\textsuperscript{17}Baik (2008) studies the rent-seeking contest with group-specific public goods when players are budget-constrained. He finds that the free-rider problem within group is alleviated compared to the base model without budget-constraints.
Note that as \( g(\cdot) \) is strictly concave, the inverse of \( g'(\cdot) \) exists. Similarly, if player \( \ell' \) lobbies against the policy, his optimal spending is characterized by:

\[
    s^*_\ell = g'^{-1}\left(\frac{-1}{f_{\ell}(\omega^*)v_{\ell'}}\right).
\]

Based on the equations above, the equilibrium probability index is characterized by:

\[
    \omega^* = \omega + \sum_{\ell \in I_L} g'^{-1}\left(\frac{1}{f_{\ell}(\omega^*)|v_{\ell}|}\right) - \sum_{\ell \in I_A} g'^{-1}\left(\frac{1}{f_{\ell}(\omega^*)|v_{\ell}|}\right),
\]

where \( I_L \) is a set of players who participate in lobbying for the policy and \( I_A \) are a set of those who participate in lobbying against it. Note that the above equation is a necessary condition for an equilibrium. By showing that there exists a unique solution to the above equation, the proof is completed. The uniqueness of an equilibrium hinges on the functional form of \( g(\cdot) \) and \( f_{\ell}(\cdot) \). Given the specification of \( g(\cdot) \), the above equation can be rewritten as follows:

\[
    \omega^* = \omega + f_{\ell}(\omega^*)^{\frac{1}{1-\gamma}} \cdot c,
\]

where \( c = (\beta \gamma)^{\frac{1}{1-\gamma}} \left\{ \sum_{i \in I_L} |v_i|^{\frac{1}{\gamma}} - \sum_{j \in I_A} |v_j|^{\frac{1}{\gamma}} \right\} \). If \( c = 0 \), then the solution is unique, \( \omega^*_p = \omega_p \). Now consider when \( c \neq 0 \). Let us denote \( h(\omega^*; c) \equiv \omega^* - \omega \). Then the above equation can be written as:

\[
    h(\omega^*; c) = f_{\ell}(\omega^*)^{\frac{1}{1-\gamma}}.
\]

Suppose \( c > 0 \). First, if \( h(\lambda_0) < f_{\ell}(\lambda_0)^{\frac{1}{1-\gamma}} \), then there exists a unique solution \( \omega^* > \lambda_0 \). When \( x \leq \lambda_0 \), \( h(x) < f_{\ell}(x)^{\frac{1}{1-\gamma}} \) and therefore there is no solution. When \( x > \lambda_0 \), there is a unique solution because \( h(x) \) is strictly increasing and \( f_{\ell}(x)^{\frac{1}{1-\gamma}} \) is strictly decreasing. Second, if \( h(\lambda_0) \geq f_{\ell}(\lambda_0)^{\frac{1}{1-\gamma}} \), then there exists a unique solution \( \omega^* < \lambda_0 \). When \( x > \lambda_0 \), \( h(x) > f'(x)^{\frac{1}{1-\gamma}} \) and therefore there is no solution. Note that as long as \( 0 < \gamma \leq \frac{1}{2} \), \( f_{\ell}(x)^{\frac{1}{1-\gamma}} \) is concave and both \( h(x) \) and \( f_{\ell}(x)^{\frac{1}{1-\gamma}} \) are strictly increasing and concave for \( x < \lambda_0 \). \( h(\lambda_L) < f_{\ell}(\lambda_L)^{\frac{1}{1-\gamma}} \) by the assumption that \( \omega > \lambda_L \), and this guarantees a unique solution. When \( c < 0 \), we can similarly show that there exists a unique solution. Note that given \( \omega^* \), the equilibrium amounts of lobbying spending by players are uniquely determined.

The existence and the uniqueness of a pure strategy equilibrium in the second equilibrium is guaranteed. However, in the first stage a mixed-strategy equilibrium exists but it may not be unique.
4 Empirical Specification

I use the model described in Section 3 to empirically analyze the lobbying behavior of coalitions of energy firms and to quantify the effect of lobbying expenditures on policy enactment. In this section, I describe the specification of the model that I structurally estimate using policy-level data as well as aggregate-level data.

In the data, policies differ in several observed dimensions. First, the general public has different opinions on each policy. I measure the public opinion on a policy by using the polling data obtained from the Roper Center for Public Opinion Research. I include all polling questions in the polling dataset which were asked about energy policy issues to U.S. national adult samples during 2007−2008 and these polling questions are matched with the policies in my dataset. Not all policies in the dataset have corresponding polling questions. Based on the polling data, I create two variables for each policy: (i) one dummy variable that indicates whether a relevant polling question exists in the polling dataset (salience), and (ii) the estimated fraction of supporters for the policy (public opinion).

Second, each policy heterogeneously affects each of the lobbying coalitions defined in Section 2 in two observed aspects. For each coalition, one is whether the policy favors or disfavors the coalition; and the other aspect is whether or not the policy directly affects it. For instance, a tax credit policy for capturing and sequestrating carbon dioxide from coal-fired power plants directly benefits coal industry while it indirectly affects other energy industries.

A third way in which policies differ is that the congressional committees that have jurisdiction over a policy vary. The members of these committees play an important role in moving the policy through the lawmaking process. When a bill is introduced, it is referred to one or multiple committees in whichever chamber of Congress it was submitted in. The receiving committees may (cooperatively or separately) consider and approve the bill, with or without amendments or recommendations, and send it to the full House or Senate. The committee may also rewrite the bill entirely, reject it, or simply refuse to consider it. Most bills die in the committee action stage. In the 110th Congress, over 84.07% of bills were killed there. As Oleszek (2010) describes in detail, which committees receive what kinds of bills is determined by precedent, public laws, memoranda of understanding between committee chairs, turf battles, and the rules of the House and Senate. I determine jurisdictional committees for a particular policy based on the referrals of bills in which the policy and its similar policies appear.\footnote{The similarity is determined based on the policy issue. For example, there are multiple policies that amend the renewable electricity production tax credit and these policies are considered to be similar to each other. Tax policies are often under the jurisdiction of House Ways and Means and Senate Finance.}
In the model, policies differ with respect to three dimensions: (i) the initial level of support in Congress; (ii) the value to each lobbying coalition; and (iii) the entry cost for each coalition to lobby the legislature. These characteristics are not observable to the researchers. Hence, to carry out the empirical analysis, I specify the distributions of these characteristics in the population, and the way they relate to individual policy characteristics that are observable.

The initial level of support for a particular policy in Congress is related to the factors that weigh into legislators’ choices of policy positions. Prominent factors include the preferences of their constituents, their own personal policy preferences, and the preferences of their party leaders. All of these preferences are closely related to how the policy affects each energy industry. The index of the initial probability that policy $p$ is enacted in the absence of lobbying, denoted as $\omega_p$ in the model section, is allowed to depend on two variables regarding the public opinion (salience, public opinion) and five variables regarding the identity of lobbying coalitions that are directly favored or disfavored (pro-coal, pro-oil, pro-nuclear, anti-coal/nuclear, and anti-oil). Let us denote the vector of a constant and these seven variables by $Z_p$. I assume that $\omega_p$ is distributed over the support of $(\lambda_L, \lambda_U) \subset \mathbb{R}$ and is additively separable into a linear index of $Z_p$ and an unobserved random variable $\xi_p$:

$$\omega_p = Z_p \delta + \xi_p.$$ 

In estimation, I focus on the lobbying behaviors of strategic or major energy firms, which I define in Section 2. However, other nonstrategic firms, trade associations, and citizens’ groups also attempt to influence legislators. I assume that their activities of political influence happen before the lobbying coalitions in the dataset make lobbying decisions. As a result, $\xi_p$ includes the omitted variables regarding these activities of political influence.

The value of policy $p$ to lobbying coalition $\ell$, known as $V_{\ell,p}$, is allowed to depend on the direct relevance of the policy to the coalition (relevance). I denote the vector of a constant and this variable as $X_{\ell,p}$. Though I do not observe $V_{\ell,p}$, I observe its sign. $I_{\ell,p}$ is a random variable that takes value 1 if lobbying coalition $\ell$ is for policy $p$ ($V_{\ell,p} > 0$) and -1 if the coalition is against the policy ($V_{\ell,p} < 0$). Note that $|V_{\ell,p}| = V_{\ell,p}I_{\ell,p}$. I assume that $\log |V_{\ell,p}|$ is additively separable into a linear index of $X$ and an unobserved random variable $\eta_{\ell,p}$:

$$\log |V_{\ell,p}| = X_{\ell,p} \alpha_{\ell} + \eta_{\ell,p}.$$ 

Note that the variables on public opinion are excluded to affect the value of a policy to an

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19Fenno (1973) argued that legislators are motivated by three basic goals: reelection, good public policy, and influence within the legislature.
industry.

The entry cost for lobbying coalition $\ell$ to lobby the legislature on policy $p$, denoted as $C_{\ell,p}$, in the model section, represents the minimal administrative or informational cost to embark on lobbying activities. Examples of such costs could include the costs of initial research and surveys on the economic, social, or environmental effects of the proposed policy as well as related existing policies. These costs may vary by both policy and lobbying coalition. I allow the entry cost to depend on the extent to which a lobbying coalition is connected to the members of the committees that have jurisdiction over a policy (connection).

The degree of connection is measured by the fraction of the congressional committee members whose ex-staffers are hired by the lobbying coalition as lobbyists to the total number of committee members. In calculating the fraction, I weigh each committee differently based on the observed likelihood that it has jurisdiction over the policy. I obtain the dataset on the career history of registered lobbyists from Lobbyists.info, a division of Columbia Books & Information Services.\textsuperscript{20} I denote lobbying coalition $\ell$’s degree of connection related to lobbying the legislature on policy $p$ by $R_{\ell,p}$. I assume that $C_{\ell,p}$ is linear in $R_{\ell,p}$:

$$C_{\ell,p} = \kappa_0 + \kappa_1 R_{\ell,p}.$$  

Wright (1996), Ainsworth (1997), and Hall and Deardorff (2006), amongst other papers, discuss the cooperative relationship between lobbyists and legislators. Lobbyists, particularly those who have broad access, can acquire and provide information on other legislators’ positions and plans to like-minded legislators. As Wright (1996) noted, the knowledge about what legislators are planning and thinking is an important resource that can be used to shape perceptions about the viability of various policy options. Empirically, there is a recent study by Blanes i Vidal et al. (2010) examining how staffer-turned-lobbyists benefit from the personal connections acquired during public service. They find that lobbyists with experience in the office of a U.S. Senator suffer a 24% drop in generated revenue when that Senator leaves office.

The ex-post shock that affects the outcome of lobbying, denoted as $\epsilon_p$ for policy $p$ in Section 3, is assumed to follow the Triangular distribution with the finite support of $(\lambda_L, \lambda_U) \subset \mathbb{R}$. The distribution has a unique mode of $\lambda_0 \in (\lambda_L, \lambda_U)$. $g(\cdot)$ is parametrized as:

$$g(s) = \beta s^\gamma,$$

where $0 < \gamma \leq \frac{1}{2}$.

Table 7 presents the summary statistics of the variables.\textsuperscript{20}

\textsuperscript{20}The address of the company’s website is www.lobbyists.info.
5 Identification and Estimation

5.1 Identification

There are four components of the model that I estimate: (i) the enactment production function, (ii) the distribution of the initial enactment probability, (iii) the distribution of the value of a policy to each player, and (iv) the entry cost of lobbying on a policy to each player. In the data, I observe for each policy whether or not it was enacted and which lobbying coalitions lobbied for or against it. I also observe the total expenditures over all policies for each coalition.

There are two empirical challenges to identifying the structural parameters of the model from the data. First, the initial enactment probability is not observed and theory implies that it is correlated with the lobbying decisions of interest groups. Second, policy-specific lobbying expenditures are not observed. I overcome these challenges by exploiting both functional form restrictions and exclusion restrictions.

Given the model specification in Section 4, the observed equilibrium outcome variables—namely policy enactment, lobbying participation, and average lobbying expenditures—can be expressed as a function of exogenous variables observable and unobservable variables specified in the previous section. I introduce notations for the observed equilibrium outcome variables. Let $Y_p$ denote a random variable that takes value 1 if policy $p$ is enacted and 0 otherwise. $D_{\ell,p}$ is a random variable that takes value 1 if lobbying coalition $\ell$ lobbies the legislature on the policy; $\bar{S}_\ell$ is the average lobbying expenditure per policy by coalition $\ell$.

First, the policy enactment outcome is expressed as:

$$Y_p = 1 \left\{ Z_p \delta + \xi_p + \beta \sum_{\ell \in \mathcal{L}} D_{\ell,p} I_{\ell,p}s_{\ell,p} - \epsilon_p \geq 0 \right\}, 
\tag{5.1}$$

Whether or not lobbying coalition $\ell$ participates in lobbying the legislature on policy $p$ given other coalitions’ strategies is determined by:

$$D_{\ell,p} = 1 \left\{ (F_\ell(\omega_{p,\ell} + \beta I_{\ell,p}s_{\ell,p}^\gamma) - F_\ell(\omega_{p,-\ell})) \exp(X_{\ell,p} \alpha_\ell + \eta_{\ell,p}) I_{\ell,p} \geq s_{\ell,p} + \kappa_0 + \kappa_1 R_{\ell,p} \right\},
\tag{5.2}$$

where $\omega_{p,-\ell}'$ is the index of the probability that policy $p$ is enacted when player $\ell$ does not participate and other coalitions’ entry decisions are held the same. Lastly, the average lobbying expenditure by lobbying coalition $\ell$ is expressed as:

$$\bar{S}_\ell = \frac{1}{n} \sum_{p=1}^n (s_{\ell,p} + \kappa_0 + \kappa_1 R_{\ell,p}) D_{\ell,p},
\tag{5.3}$$
where \( N \) is the total number of policy observations in the dataset.

I do not observe lobbying expenditures for each policy \((\{s_{\ell,p}\}_{\ell \in \mathcal{L}})\) in the data, but the model has a unique prediction on them given the observed lobbying participation profile. Therefore, \( s_{\ell,p} \)'s can be substituted with a function of observable variables \((D_p, Z_p, X_p, I_p)\), unobservable variables \((\{\xi_p, \{\eta_{\ell,p}\}_{\ell \in \mathcal{L}}\}\), and parameters. The equation (5.1) can be rewritten as follows:

\[
Y_p = \left\{ \omega_p^* - \epsilon_p \geq 0 \right\},
\]

\[
\omega_p^* = Z_p \delta + \xi_p + \sum_{\ell \in \mathcal{L}} I_{\ell,p} D_{\ell,p} \left( \gamma f_\ell(\omega_p^*) \beta^{\frac{1}{\gamma}} V_{\ell,p}(X_{\ell,p}, \eta_{\ell,p}) \right)^{\frac{1}{1-\gamma}},
\]

where \( V_{\ell,p}(X_{\ell,p}, \eta_{\ell,p}) \equiv \exp(X_{\ell,p} \alpha_{\ell} + \eta_{\ell,p}) \). Proposition 1 proves that under the specifications of the model, there exists unique \( \omega_p^* \) that satisfies the above equation.

The equations (5.2) and (5.3) can also be written as:

\[
D_{\ell,p} = \left\{ \kappa_0 + \kappa_1 R_{\ell,p} \leq \left( F_\ell(\omega_p^*) - F_\ell(\omega_{p,-\ell}) - \left( \gamma f_\ell(\omega_p^*) \beta^{\frac{1}{\gamma}} V_{\ell,p}(X_{\ell,p}, \eta_{\ell,p}) \right)^{\frac{1}{1-\gamma}} \right) V_{\ell,p}(X_{\ell,p}, \eta_{\ell,p}) \right\},
\]

\[
S_\ell = \frac{1}{n} \sum_{p=1}^{n} \left( (\beta \gamma f_\ell(\omega_p^*) V_{\ell,p}(X_{\ell,p}, \eta_{\ell,p}))^{\frac{1}{1-\gamma}} + \kappa_0 + \kappa_1 R_{\ell,p} \right) D_{\ell,p}.
\]

In sum, the unobserved lobbying expenditures for each policy are recovered by the functional form restrictions that guarantee unique equilibrium in the spending game. I argue that under the following assumptions (A1–A9), the parameters of the model and the distribution of \((\xi, \eta_A, \eta_B)\) are identified. Note that \( Z \) includes \( X \) and \( I \) by construction of certain variables in \( Z \).

However, it does not include \( R \).

A1. We have a random sample of observations \((Y_p, D_p, Z_p, R_p), p = 1, \ldots, n \). Let \( n \to \infty \).

A2. The rank of the \( n \times (K + 1) \) data matrix, \((Z, R)\), is \((K + 1)\) with probability 1.

A3. \( R \) is independent of \( Z \).

A4. \( \delta_1 > 0 \), and for almost every value of \( z_{-1,p} \), \( \Pr(Z_{1,p} \in (a_1, a_2) | z_{-1,p}) > 0 \) for all open intervals \((a_1, a_2)\) in \((-\infty, \infty)\). \( Z_1 \) is not included in \( X \).

A5. \( \kappa_1 < 0 \), and for all \( \ell \in \mathcal{L} \), for almost every value of \( r_{-\ell,p} \), \( \Pr(R_{\ell,p} \in (a_1, a_2) | r_{-\ell,p}) > 0 \) for all open intervals \((a_1, a_2)\) in \((-\infty, -\frac{a_0}{\kappa_1})\).

\[\text{The initial level of support in the legislature for a particular policy will depend on any variable that affects the value of the policy to lobbying coalitions, as long as the variable is both easily observable to the legislators and the legislators care about their constituents' preferences.}\]
A6. The cdf of $\epsilon$, $F_\epsilon(\cdot)$ is known. I normalize $(\lambda_L, \lambda_0, \lambda_U)$ as $(-1, 0, 1)$.

A7. $\epsilon$, $\xi$, and $\{\eta_\ell\}_{\ell \in L}$ have mean zero, are mutually independent, and are independent of the observable variables, $(Z, R)$.

A8. $\kappa_0$ is known.

A9. The equilibrium selection rule is known.

I illustrate this argument using an example with two players, $A$ and $B$, but a similar argument can be made for a case with more than two players. This argument is made in four steps that I delineate as follows.

**Step 1**

Consider the policy enactment probability when $D = (0, 0) \equiv d_{00}$:

$$Pr(Y = 1|D = (0, 0), z, r) = Pr(z\delta + \xi - \epsilon \geq 0|D = (0, 0), z, r)$$

Note that using the identification at infinity argument, $Pr(Y = 1|D = (0, 0), z, r) \to Pr(z\delta + \xi - \epsilon \geq 0|z)$ as $r_A \to -\infty$ and $r_B \to -\infty$. By A6 and A7, $Z$ and $\xi - \epsilon$ are independent, $F_\epsilon(\cdot)$ is known, and the mean of $\xi - \epsilon$ is zero. Therefore, exploiting A3 and A4, I identify $\delta$ and the distribution of $\xi$ up to scale. That is, I identify $\left(\frac{\delta_0}{\delta_1}, 1, \frac{\delta_2}{\delta_1}, ..., \frac{\delta_{K-1}}{\delta_1}\right)$ and the distribution of $\frac{\xi}{\delta_1}$.

**Step 2**

Let us consider the probability of $D = (1, 0) \equiv d_{10}$. This probability is closely related to the policy enactment probability given the entry profile:

$$Pr(Y = 1|D = (1, 0), z, r) = Pr(\Phi_A(\bar{x}_A, z, \eta_A, \xi) - \epsilon \geq 0|D = (1, 0), z, r),$$

where $\bar{x}_A = x_{-1, A}$, $\phi_A(\bar{x}_A) \equiv \beta^\frac{1}{2} \exp(\alpha_0^A + \alpha_1^A \bar{x}_A)$, and $\Phi(\phi^A(\bar{x}_A), z, \eta_A, \xi)$ denotes the equilibrium enactment probability index, that is, $\omega^* = \Phi(\phi^A(\bar{x}_A), z, \eta_A, \xi)$ if and only if

$$f_\epsilon(\omega^*) = \frac{(i_A(\omega^* - z\delta - \xi))^{\frac{1}{2}}}{\phi_A(\bar{x}_A) \exp(\eta_A)}.$$

Now the probability of $D_A = 1$ given $D_B = 0$ can be written as follows:

$$Pr(D_A = 1|D_B = 0, z, r) = Pr(\kappa_0 + \kappa_A r_A - u_A \leq 0|D_B = 0, z, r_A)$$
where

\[ u_A \equiv \Psi(\phi^A(\bar{x}_A), z, \eta_A, \xi) \exp(\alpha_0^A + \alpha_1^A \bar{x}_A + \eta_A), \]

\[ \Psi(\phi_A(\bar{x}_A), z, \eta_A, \xi) \equiv (F_e(\Phi(\phi_A(\bar{x}_A), \eta_A, \xi)) - F_e(z\delta + \xi)) i_A - \left( (\gamma f_e(\Phi(\phi_A(\bar{x}_A), \eta_A, \xi))) \frac{1}{2} \phi_A(\bar{x}_A) \right)^{\frac{1}{2}}. \]

If \( r_B \rightarrow -\infty \), \( \Pr(D_A = 1|D_B = 0, z, r) \rightarrow \Pr(\kappa_0 + \kappa_1 r_A - u_A \leq 0|z, r_A) \). Note that \( u_A \) and \( R_A \) are independent by A3 and A7 and \( \kappa_0 \) is known. Therefore, we identify the sign of \( \kappa_1 \) and the distribution of \( \tilde{u}_A \equiv \frac{u_A}{\kappa_1} \) conditional on \( Z \). Using similar arguments, the distribution of \( \frac{u_B}{\kappa_1} \) is identified.

**Step 3**

Taking the log of \( \tilde{u}_A \):

\[ \log \tilde{u}_A = (\alpha_0^A - \log \kappa_1) + \alpha_1^A \bar{x}_A + \log \Psi(\phi^A(\bar{x}_A), z, \eta_A, \xi) + \eta_A. \]

As the log transformation is monotone, we know the distribution of \( \log \tilde{u}_A \) conditional on \( Z \). Note that \( \log \Psi(\phi^A(\bar{x}_A), z, \eta_A, \xi) \) is increasing in \( \eta_A \) given any realization of \( (\xi, Z) \). Hence, there exists a one-to-one mapping of \( (\xi, \log \tilde{u}_A) \) to \( \eta_A \) for any given \( Z \). Note also that we know the marginal distributions of \( \frac{\xi}{\delta_1} \) and \( \log \tilde{u}_A \) and by A7, we can recover the joint distribution of \( (\frac{\xi}{\delta_1}, \log \tilde{u}_A) \). Given this joint distribution, the distribution of \( \eta_A \) is identified up to finite parameters, \( (\alpha_0^A, \alpha_1^A, \beta, \gamma, \delta_1, \kappa_1) \). Similarly, the distribution of \( \eta_B \) is identified up to finite parameters, \( (\alpha_0^B, \alpha_1^B, \beta, \gamma, \delta_1, \kappa_1) \).

**Step 4**

For any \( (z, r, d) \), \( \Pr(Y = 1|D = d, z, r) \) can be characterized by \( (\alpha_0, \alpha_1, \beta, \gamma, \delta_1, \kappa_1) \) given the partially recovered distribution of \( (\xi, \eta_A, \eta_B) \) in the previous steps and the known equilibrium selection rule by A9. Further, the unconditional expectation of lobbying expenditures of each player can also be characterized by \( (\alpha_0, \alpha_1, \beta, \gamma, \delta_1, \kappa_1) \). By varying \( (z, r) \), we have a system of nonlinear equations where the number of equations greatly exceeds the number of the unknown parameters. I argue that these parameters can be identified and in particular, it can be shown that the unconditional expectation of lobbying expenditures help separately identify \( \alpha_0 \) and \( \beta \).  

Key assumptions in the above identification argument are the exogeneity of the observable variables and the exclusion restrictions. First, I assume that there exists a variable that

\footnote{The proof will be complete if I show that there exists a unique solution to this problem. For example, if the Jacobian matrix of the non-linear equations satisfies certain conditions suggested by Gale and Nikaido (1965), then the uniqueness can be guaranteed. However, it is extremely difficult given that the equilibrium objects do not have a closed-form solution.}
affects the initial enactment probability and which can vary while other components of the initial enactment probability, valuations of policy, and entry costs of lobbying are fixed. Second, I assume there exists a variable that affect the entry cost of one player while the initial enactment probability, the other players’ entry costs and the value of the policy to all players remain fixed.

In estimation, I assume that variables regarding public opinion (salience, public opinion) do not affect the distribution of the value of policy. I also assume that the variable representing the extent to which a player is connected to the members of the committees that have jurisdiction over a policy (connection) does not affect the initial enactment probability, valuations of policy, and the entry cost of other players. The argument that the variable connection does not affect the initial enactment probability or valuations of policy is based on timing and information assumptions about hiring lobbyists. Lobbying contracts are often long-term and the formation of new contracts in the middle of a congressional session is uncommon. If lobbying contracts are made before policies are proposed in Congress and firms have limited ability to anticipate policy proposals and initial support, this exclusion restriction can be justified.

Another key assumption in the identification argument is that $\kappa_0$ is known. I claim that $\kappa_0$ is consistently estimated by looking at the smallest lobbying expenditures undertaken by entities that lobbied for one policy and did not hire lobbyists with connections. The observed expenditure of an entity $\ell$ that lobbied only one policy with no connection regarding the lobbied policy is

$$S^o_\ell = \kappa_0 + \tilde{S}_\ell,$$

where $\tilde{S}_\ell$ stands for the lobbying expenditures after entry. Because the support of $\tilde{S}_\ell$ is $(0, \infty)$ given the model, the lower bound of $S^o_\ell$ is $\kappa_0$.

I employ identification at infinity arguments, which have been extensively used in econometrics (see, for example, Heckman (1990)). However, variation in excluded exogenous variables in the dataset may not be large enough to point-identify the parameters of the model. To help resolve this issue, I make distributional assumptions in the estimation; I assume that $\xi$ follows $Unif(-\sigma_\xi, \sigma_\xi)$ and $\eta_\ell$ follows $N(0, \sigma_\ell)$. Further, I impose an equilibrium selection rule. Specifically, when there are multiple equilibria, I select the equilibrium that maximizes the sum of the payoffs of all players.\footnote{There is an active literature on estimating discrete-choice games that explicitly addresses this issue (Tamer 2003; Ciliberto and Tamer 2009; Bajari et al. 2010, for example). Ciliberto and Tamer (2009) do not impose an equilibrium selection rule and their inference methods are robust to non-point-identification. However, it is not practical to employ their method given the size of my dataset.}

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5.2 Estimation

I have the individual policy-level data (enactment and lobbying participation profile) and the aggregate player-level data (total lobbying expenditures). Both types of data are necessary to identify the parameters in the model as discussed in the previous section. I use an extremum estimator where the scalar objective function $Q_N(\theta)$ is defined as:

$$Q_n(\theta) = \frac{1}{n} \sum_{p=1}^{n} \ln f(y_p, d_p|w_p; \theta) - \sum_{\ell=1}^{L} \tau_\ell \left\{ \frac{1}{n} \sum_{p=1}^{n} (s_{\ell,p} - \mathbb{E}(s_{\ell,p}|w_p; \theta)) \right\}^2,$$

for any given positive $(\tau_1, ..., \tau_L)$, where $f(y_p, d_p|w_p; \theta)$ is the likelihood of observing $(y_p, d_p)$ given $w_p \equiv (z_p, \{x_{\ell,p}, i_{\ell,p}, r_{\ell,p}\}_{\ell \in L})$.

The log likelihood for policy $p$, $f(y_p, d_p|w_p; \theta)$, is defined as:

$$f(y_p, d_p|w_p; \theta) = y_p \log \Pr(Y = 1, D = d_p|w_p; \theta) + (1 - y_p) \log \Pr(Y = 0, D = d_p|w_p; \theta),$$

where $\Pr(Y = 1, D = d_p|w_p; \theta)$ can be written as:

$$\Pr(Y = 1, D = d_p|w_p; \theta) = \int \Pr(Y = 1, D = d_p|w_p, \xi, \eta, \theta) dH(\xi, \eta; \theta)$$

$$= \int \Pr(Y = 1|D = d_p, w_p, \xi, \eta, \theta) \Pr(D = d_p|w_p, \xi, \eta, \theta) dH(\xi, \eta; \theta)$$

$$= \int F_\epsilon \left( z_{\ell\delta} + \xi + \beta \sum_{\ell \in L} i_{\ell,p} s_{\ell}(w_p, d_p, \xi, \eta; \theta)^{\gamma} \right) \Pr(D = d_p|w_p, \xi, \eta, \theta) dH(\xi, \eta; \theta),$$

$\textit{24}$Alternatively, as Imbens and Lancaster (1994) suggest, I can use the following conditions based on the model:

$$\left[ \begin{array}{c} \partial L(\theta)/\partial \theta \\ s - \mathbb{E}(s; \theta) \end{array} \right] = 0.$$

Let us denote $\tilde{L}_p(\theta)$ as the simulated log-likelihood for $p$th observation, and $\tilde{S}(\theta)$ as the simulated value of $\mathbb{E}(s; \theta)$. The method of simulated moments estimator

$$\hat{\theta} = \arg \min_{\theta \in \Theta} g_P(\theta)' \Omega g_P(\theta),$$

where

$$g_N(\theta) = \left[ \frac{1}{N} \sum_{p=1}^{N} \partial \tilde{L}_p(\theta)/\partial \theta \right] \left[ \frac{1}{N} \sum_{p=1}^{N} s_p - \tilde{S}(\theta) \right],$$

can also be used. This estimator is more computationally intensive than the suggested estimator in this paper, but is an efficient estimator. I will employ this estimator in addition to the current estimator and the estimation results will be presented in the next version of this draft.
and \( \Pr(Y = 0, D = d_p|w_p; \theta) \) can be similarly delineated.

\((\bar{s}_1, \ldots, \bar{s}_L)\) is the average lobbying spending vector for all players, where \( \bar{s}_\ell \equiv \frac{1}{n} \sum_{p=1}^{n} s_{\ell,p} \) for any \( \ell = 1, \ldots, L \). The expected value of the lobbying expenditure of player \( \ell \) given observable variables, \( \mathbb{E}(s_{\ell,p}|w_p; \theta) \), can be characterized as:

\[
\mathbb{E}(s_{\ell,p}|w_p; \theta) = \int \sum_{d'} (s_{\ell}(w_p, d', \xi, \eta; \theta) + (\kappa_0 + \kappa_1 r_{\ell,p})d'_\ell) \Pr(D = d'|w_p, \xi, \eta, \theta)dH(\xi, \eta; \theta)
\]

It can be shown that this estimator is consistent and asymptotically normally distributed under regularity conditions. Note that the choice of weights, \((\tau_1, \ldots, \tau_L)\), does not affect the consistency of this estimator as long as the weights are strictly positive. In practice, I do not have an analytical form for \( \Pr(Y = 1, D = d_p|w_p; \theta) \) or \( \mathbb{E}(s_{\ell,p}|w_p; \theta) \), so I simulate in order to obtain these objects. Let us denote \( \tilde{f}_p(\theta) \) as the simulated likelihood for \( p \)th observation, and \( \tilde{s}_{\ell,p}(\theta) \) as the simulated value of \( \mathbb{E}(s_{\ell,p}|z, x, w_p; \theta) \). For any choice of \( \tau > 0 \), the simulated estimator, \( \hat{\theta}_{SIM} \) is defined as:

\[
\hat{\theta}_{SIM} = \arg\max_{\theta \in \Theta} \frac{1}{n} \sum_{p=1}^{n} \log \tilde{f}_p(\theta) - \sum_{\ell=1}^{L} \tau_\ell \left( \frac{1}{n} \sum_{p=1}^{n} (s_{\ell,p} - \tilde{s}_{\ell,p}(\theta)) \right)^2.
\]

6 Empirical Results

Table 8 shows the estimation results. The asymptotic standard errors are provided in parentheses.

6.1 Model Fit

Using the estimated parameters, I simulate the data and calculate the following moments displayed in Tables 9–11. The overall fit of the simulated data to the actual data is good in both the level and the trend. Table 9 shows the predicted enactment probabilities conditional on the detailed final status of the policy, which is not exploited in the estimation.\textsuperscript{25}

The further a policy was pushed in the legislative process, the larger the predicted enactment probability is. On average, the predicted enactment probability is 9.63\% and the actual enactment probability in the data is 8.35\%. The predicted probability for policies which have never been considered on the floor is 6.75\%, and that for those which were enacted is 16.36\%. Table 10 shows both the actual and the predicted probabilities of lobbying participation by each lobbying coalition. The second and third rows show the unconditional participation

\textsuperscript{25}In the estimation, I use the enactment information only.
probabilities. The predicted unconditional participation probability of each lobbying coalition is slightly larger than the actual unconditional participation probability, but the rank of lobbying coalitions in terms of lobbying participation probability is preserved. The lobbying participation probability conditional on the position of the coalitions can be found in the rest of the table, and the fit in general is good. Lastly, Table 11 shows each lobbying coalition’s total lobbying expenditures and average lobbying expenditures conditional on participation. In the estimation, the moment conditions on the unconditional average lobbying expenditures are used and hence the fit in terms of total lobbying expenditures is good. The predicted average lobbying expenditures conditional on participation are slightly less than the counterpart in the data, but the overall trend is very similar.

### 6.2 Effect of Lobbying Expenditures on Policy Enactment

Based on the estimates, I find that the effect of lobbying expenditures on the equilibrium policy enactment probability is very small. This assessment is based on the following exercise. First, I simulate the equilibrium enactment probability and the initial enactment probability for each policy conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. Second, I calculate the difference between the two probabilities. If lobbying were not allowed, the initial enactment probability would be the final enactment probability. Therefore, the difference in these two probabilities is due to lobbying expenditures by both supporting and opposing lobbying coalitions. This measure of the effect of lobbying expenditures on the enactment probability for policy \( p \) conditional on the participation profile \( d_p \) and observable characteristics \( w_p \) can be mathematically expressed as:

\[
\text{Effect}(d_p, w_p) = E \left[ F\left(z_p\delta + \xi_p + \beta \sum_{\ell \in L} i_{\ell,p} s_{\ell}(w_p, d_p, \xi_p, \eta_p)^\gamma\right) - F\left(z_p\delta + \xi_p\right) | d_p, w_p \right].
\]

Based on this measure, I find that the difference is on average 0.032 percentage points and is 0.037 percentage points conditional on lobbying at the estimated parameters. Figure 1 shows the distribution of the effect of lobbying expenditures on the policy enactment probability.

The finding that lobbying expenditures hardly affect policy-making is striking, and results

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\(^{26}\)The weights for the moment conditions of the unconditional average lobbying expenditures, \((\tau_1, ..., \tau_L)\), affect the fit in terms of total lobbying expenditures. The weights that I use in the estimation are proportional to the observed average lobbying expenditures. Note that these weights determine the relative contribution of each moment condition to the value of the objective function, compared to that of the likelihood. In the estimation, I choose these weights so that the contributions of the likelihood and moment conditions are balanced. As mentioned in Section 5, the choice of these weights does not affect the consistency of the estimator, but it affects the efficiency of the estimator.
from the following two channels. First, the estimated enactment production function is such that the marginal effect of lobbying expenditures on the policy enactment probability is very small. Second, the effects of lobbying expenditures by competing interests partially cancel each other out. I discuss these two channels in detail and show how this estimation result is derived from the data.

6.2.1 The Enactment Production Function

Based on the estimates of $\beta$ and $\gamma$, I conclude that the marginal effect of lobbying expenditures on the policy enactment probability is very small. To illustrate this point, I calculate the effect of additional lobbying expenditure ($\Delta s$) by lobbying coalition $\ell$ on the probability that a policy is enacted, which can be mathematically represented as:

$$F_\epsilon(\omega_{-\ell} + \beta(s_\ell + \Delta s)\gamma) - F_\epsilon(\omega_{-\ell} + \beta s_\ell\gamma),$$

where $\omega_{-\ell}$ is the index of the enactment probability determined by the initial enactment probability and the lobbying expenditures by all other lobbying coalitions except $\ell$. Note that this effect depends on $\omega_{-\ell}$ and $s_\ell$. Given the assumption that $\epsilon$ is symmetric and has a unique mode at zero, the closer $\omega_{-\ell}$ is to zero, the larger this effect is. Further, the smaller $s_\ell$ is, the larger this effect is, because the contribution of lobbying expenditures by a lobbying coalition to the policy enactment probability is strictly concave in its expenditures. Therefore, this effect is the largest when $s_\ell = 0$ and $\omega_{-\ell} = 0$, or $F_\epsilon(\omega_{-\ell}) = 50\%$. When $\Delta s$ is $1,000$, the change of the enactment probability is at most [0.005, 0.015] percentage points at 90% confidence level; when $\Delta s$ is $66,000$, which is the average per-policy lobbying expenditure by the renewable energy lobbying coalition, it is at most [0.046, 0.054] percentage points; and when $\Delta s$ is $3$ million, which is over ten times as much as the average per policy lobbying expenditures by the coal lobbying coalition, it is at most [0.18, 0.24] percentage points.

This finding immediately raises two questions. First, what in the data derives this result? Second, given this very small effect, why do firms spend money in lobbying the legislature on interested policies? These two questions are closely related to each other. As described in the identification argument, the effect parameter $\beta$ and the distribution of value of a policy to each lobbying coalition are not separately identified without observing lobbying expenditures. That is, if a certain profile of $\beta$ and value distribution of each lobbying coalition generates a certain lobbying participation profile probability and policy enactment probability, conditional or unconditional on observable variables, then a new profile of $\beta$ and value distribution can also generate the same probabilities by increasing $\beta$ and decreasing the
level of value distribution, or vice versa. However, the observed total lobbying expenditures by each lobbying coalition over all policies help separately identify \( \beta \) and value distribution.

To illustrate this point, I fix \( \beta \) to be \( \tilde{\beta} = 8.1642 \times 10^{-4} \), which is much larger than the estimated value of \( \hat{\beta} \) (6.9312E-06, with standard error 4.1115E-06), and estimate the model with this constraint that \( \beta = \tilde{\beta} \). I reject the null hypothesis that the constraint on \( \beta \) is true with \( p \)-value less than 0.001 based on the Likelihood Ratio test.\(^{27}\) Based on the simulation results given these parameters, I find that the levels of simulated total lobbying expenditures and average lobbying expenditures conditional on lobbying participation are much different from their counterparts in the data, while the overall fit in other dimensions such as the enactment probability and the participation probability is relatively good. In Table 12, I show the unconditional enactment probability, lobbying participation probability for each lobbying coalition, and average lobbying expenditures conditional on participation in the actual data and the simulated data for both sets of parameters.

Based on the simulation results given the estimated parameters outlined above, the average effect of lobbying expenditures on the policy enactment probability is 5.0 percentage points. Given that the average enactment probability in the data is 8.35\%, this effect can be considered large; it is certainly much larger than 0.04 percentage points, which is the effect of lobbying expenditures simulated at the originally estimated parameters. The estimated average value of a policy under the constraint that \( \beta = \tilde{\beta} \) is $4.85 million for the oil and gas lobbying coalition and $2.87 million for the renewable energy coalition. On the other hand, the estimated average value of policy without the constraint is $808.45 million for the oil and gas lobbying coalition and $474.97 million for the renewable energy coalition. Figure 2 shows the estimated distribution of value of a policy for each lobbying coalition, and Table 13 shows summary statistics of the value distributions.

This stark contrast in the estimated value distribution suggests that one way to validate my estimates is to compare the estimated value distribution to the actual value distribution. However, the private valuation of a specific policy to each lobbying coalition is mostly unavailable. In particular, the economic impact of an environmental or market regulation on the targeted industry, as well as non-targeted industries which may be indirectly affected, is very hard to measure. In my dataset, there are 27 policies in which the federal government

\(^{27}\)The value of the objective function at the originally estimated parameters, \( Q_n(\hat{\theta}) \), is -2.412, and that at the newly estimated parameter with the constraint that \( \beta = \tilde{\beta} \), \( Q_n(\tilde{\theta}) \), is -2.43163. The LR statistic is defined as

\[
2n \cdot (Q_n(\hat{\theta}) - Q_n(\tilde{\theta})),
\]

and it can be shown that this statistic converges in distribution to \( \chi^2(1) \) under the null hypothesis that \( \beta = \tilde{\beta} \). The value of this LR statistic is 20.96; therefore, I reject the null hypothesis with \( p \)-value less than 0.001.
directly spends money for private entities and the authorized amount of money to be appropriated is listed. Among these policies, 22 of them are grants, R&D subsidies or loan or loan guarantees for bio and other renewable energy industries, and the rest are directed towards new nuclear power plants, coal-to-liquid projects, etc. The average government spending authorized by these policies is $736 million. The average value of a policy which is specific to the renewable energy lobbying coalition is estimated to be $706 million. This is anecdotal evidence for validating my estimates.

However, we have some evidence that may suggest that the average value of an energy policy will be much larger than several million dollars. For example, one policy in the dataset is designed to limit or cap the volume of certain greenhouse gases emitted from electricity-generating facilities and from other activities involving industrial production and transportation. A Congressional Budget Office estimate for government revenue increase due to this policy is about $1.19 trillion over the 2009-2018 period.\textsuperscript{28} Also, according to a report by the Energy Information Administration, federal energy subsidies in 2007 were $16.6 billion in total.\textsuperscript{29} The point is that the effect of lobbying expenditures on policy-making cannot be large because to rationalize a large effect, the value of a policy should be very small compared to the size of government spending for the energy industry and the potential economic impact of tax or regulatory policies on the industry.

### 6.2.2 Competing Interests

The average difference between the equilibrium enactment probability and the initial enactment probability conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions is 0.04 percentage points for those policies on which at least one of the lobbying coalitions lobbied. Out of 539 policies in the dataset, 461 policies were lobbied by at least one of the lobbying coalitions. Table 14 shows the effect of lobbying expenditures on the equilibrium enactment probability conditional on the following cases: (i) when only the supporting lobbying coalitions lobbied; (ii) when only the opposing lobbying coalitions lobbied; and (iii) when both sides lobbied. Specifically, for 167 policies in the dataset, both supporting and opposing lobbying occurred and the lobbying efforts by both sides partially canceled each other out. In order to quantify the canceled-out effect, I obtain the effect of lobbying expenditures by each side on policy enactment probability by simulating the difference in the enactment probability due to each lobby. One measure of the canceled-out effect is the ratio of twice the minimum of these two effects by each side.

\textsuperscript{28} Source: www.cbo.gov/ftpdocs/91xx/doc9120/s2191.pdf.

\textsuperscript{29} Source: www.eia.gov/oiaf/servicert/subsidy2/. The report was released in April 2008 and a response to a request from Senator Lamar Alexander of Tennessee to provide an estimate of the size of each current subsidy.
to the sum of them. Based on this measure, I find that about 57% of the effect of lobbying expenditures by both sides canceled each other out when both sides lobbied.

6.3 Average Returns to Lobbying

I define the conditional expectation of the average returns to lobbying coalition $\ell$ from lobbying on policy $p$ as:

$$E\left(\frac{u_{\ell,p}(d_{p,\ell} = 1|d_{p,-\ell}) - u_{\ell,p}(d_{p,\ell} = 0|d_{p,-\ell})}{s_{\ell,p}}|z_p, r_p\right).$$

In words, the average return from lobbying on the policy is the ratio of the difference in the equilibrium payoffs with and without lobbying, given other lobbying coalitions’ strategies, to the coalition’s lobbying expenditures on the policy. Because the policy-specific value to a lobbying coalition and its lobbying expenditures on the policy are not observed, I take the expectation conditional on the observed lobbying participation profile and observable characteristics of the policy and the lobbying coalitions. For each lobbying coalition, I calculate the average return from lobbying on each policy, conditional on participation. Table 15 and Figure 4 show the distribution of the average return from lobbying a policy. I find that the mean of average returns to lobbying are similar among the lobbying coalitions and are above 100%.

Ansolabehere et al. (2003) discuss the puzzle described by Tullock (1972). The amount of campaign contributions by interest groups is relatively very small compared to the extremely large costs and benefits that are levied and granted by government. Ansolabehere et al. (2003) provide their perspective that campaign contributions should be viewed primarily as a type of consumption good rather than as a market for buying political benefits. In my paper, lobbying expenditures are assumed to be made as an economic investment. However, analogously, the average lobbying expenditures in the data are very small compared to the estimated value of policies. This is because the marginal effect of lobbying expenditures on the policy enactment probability is very small.

7 Conclusion

In this paper, I have presented a novel approach to the empirical analysis of political influence by interest groups based on the specification and estimation of an all-pay contest with heterogeneous interest groups over policies considered in the U.S. Congress. One of the main contributions of this paper is that I provide a novel unit of analysis: policies, which are
parts of bills, rather than bills themselves as in previous works. and I track each policy to determine whether or not it was enacted. This is particularly relevant for studying lobbying behaviors because the content of a bill can and often does change throughout the whole legislative process. Using a newly constructed dataset that contains information on policies and lobbying activities, I have quantified the effect of lobbying expenditures on the probability that a policy is enacted, and estimated the average returns to lobbying expenditures for or against a policy. In this study, I focus on energy policies and lobbying activities targeting these policies by energy firms. Although it may not be possible to extrapolate from the empirical results of this study to general conclusions, the but the methodology used in this paper can be applied in studying other policy issues.

While the analysis extends the existing empirical literature on the study of political influence, there are several important issues I have neglected to address in this paper which represent possible directions for future research. One issue is that lobbying expenditures can be a long-term investment which may only bear fruit after several congressional sessions. Since this study uses a dataset collected from only one congressional session, progress on incorporating this issue critically hinges on the collection of new data on the multiple Congresses. Another important issue concerns the mechanism through which lobbying influences policy-making. An extension of my model, which incorporates this issue, could be used to address the welfare implication of the regulation of lobbying.

References


Baumgartner, F. R., J. M. Berry, M. Hojnicki, D. C. Kimball, and B. L. Leech


Table 1: The Final Status of Policies in the Data

This table shows the final status of energy policies in the dataset. The policies whose final status is *not reported* have never been sent to the floor of the House or Senate. The policies whose final status is *reported and not enacted* were reported by the committee(s) or were directly put to a vote on the floor without committee reports, but not were enacted into law. As can be seen, only 8.35% of the policies considered in the analysis were enacted into law. The figures in this table are computed by the author based on the bill status information available at the Library of Congress (THOMAS).

<table>
<thead>
<tr>
<th>Final Status</th>
<th>Number of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Reported</td>
<td>388 (71.99%)</td>
</tr>
<tr>
<td>Reported, Not Enacted</td>
<td>106 (19.66%)</td>
</tr>
<tr>
<td>Enacted</td>
<td>45 (8.35%)</td>
</tr>
<tr>
<td>Total</td>
<td>539</td>
</tr>
</tbody>
</table>
Table 2: List of Entities in the Energy Lobbying Coalitions

<table>
<thead>
<tr>
<th>Lobbying Coalition</th>
<th>List of Entities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil/Gas (8)</td>
<td>American Petroleum Institute, BP, Chevron Corp, Conocophillips, Exxon Mobil, Koch Industries, Marathon Oil, Shell Oil</td>
</tr>
</tbody>
</table>
Table 3: Descriptive Statistics of Entities in the Energy Lobbying Coalitions

This table shows the descriptive statistics of the firms and associations in the dataset that are categorized as members of strategic or major lobbying coalitions on energy policies. For each coalition, Total Asset is the sum of the asset value of each firm within the coalition at the end of 2007 and Total Sales is the sum of the revenue of each firm within the coalition in 2007. Note that these figures do not include information on firms that were not on the U.S. stock market at the end of 2007. The figures in this table are computed by the author based on the lobbying reports mandated by the Lobbying Disclosure Act of 1995 and the Compustat dataset.

<table>
<thead>
<tr>
<th></th>
<th>Assns</th>
<th>Firms</th>
<th>Total Asset</th>
<th>Total Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>3</td>
<td>7</td>
<td>$253.35b</td>
<td>$71.68b</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>1</td>
<td>7</td>
<td>$1,116.92b</td>
<td>$1,443.73b</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1</td>
<td>11</td>
<td>$195.06b</td>
<td>$87.78b</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>6</td>
<td>6</td>
<td>$41.04b</td>
<td>$14.69b</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10</td>
<td>32</td>
<td>$1,606.33b</td>
<td>$1,617.88b</td>
</tr>
</tbody>
</table>
Table 4: Lobbying Expenditures by the Energy Lobbying Coalitions

The third column shows the total lobbying expenditures by each lobbying coalition. The fraction of the lobbying spending of the major entities that belong to a lobbying coalition to that of all the entities in the respective group is in parentheses. The fourth column shows an estimate of the amount of lobbying spending that was directed to the energy policies that are analyzed in the paper. The figures in this table are computed by the author based on the lobbying reports mandated by the Lobbying Disclosure Act of 1995.

<table>
<thead>
<tr>
<th></th>
<th># of Entities</th>
<th>Total Spending</th>
<th>Energy Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>10</td>
<td>$139.56m (65.01%)</td>
<td>$77.85m</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>8</td>
<td>$160.63m (61.33%)</td>
<td>$73.22m</td>
</tr>
<tr>
<td>Nuclear</td>
<td>12</td>
<td>$70.65m (92.24%)</td>
<td>$33.92m</td>
</tr>
<tr>
<td>Renewable</td>
<td>12</td>
<td>$30.44m (55.64%)</td>
<td>$22.11m</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>$401.28m (66.01%)</td>
<td>$207.10m</td>
</tr>
</tbody>
</table>


Table 5: Lobbying Participation by the Energy Lobbying Coalitions

This table shows the pattern of lobbying participation by each lobbying coalition. Policies are categorized based on the position of each lobbying coalition. *Pro-renewable* policies promote or support the renewable energy industry and *Pro-fossil/nuclear* policies promote or support the coal, oil and gas, and/or nuclear energy industry. If any of the coalitions is negatively affected by a policy, it is considered as *With-dispute*, and if none of them are negatively affected by the policy, then it is considered as *No-dispute*. The figures in this table are computed by the author based on the lobbying reports mandated by the Lobbying Disclosure Act of 1995 and the Compustat dataset. The unit in this table is in %.

<table>
<thead>
<tr>
<th></th>
<th>Obs.</th>
<th>Enactment Prob.</th>
<th>Coal</th>
<th>Oil/Gas</th>
<th>Nuclear</th>
<th>Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>539</td>
<td>8.35%</td>
<td>49.54%</td>
<td>66.79%</td>
<td>48.98%</td>
<td>61.97%</td>
</tr>
<tr>
<td><em>Pro-renewable &amp; No-dispute</em></td>
<td>196</td>
<td>9.70%</td>
<td>51.53%</td>
<td>62.24%</td>
<td>48.98%</td>
<td>76.02%</td>
</tr>
<tr>
<td><em>Pro-renewable &amp; With-dispute</em></td>
<td>180</td>
<td>8.89%</td>
<td>44.44%</td>
<td>76.11%</td>
<td>47.78%</td>
<td>55.00%</td>
</tr>
<tr>
<td><em>Pro-fossil/nuclear</em></td>
<td>152</td>
<td>5.92%</td>
<td>53.95%</td>
<td>62.50%</td>
<td>51.32%</td>
<td>50.66%</td>
</tr>
</tbody>
</table>
Table 6: Lobbying Position of the Energy Lobbying Coalitions

This table shows the correlation pattern of position of the energy lobbying coalitions. The figures in this table are computed by the author based on the lobbying reports mandated by the Lobbying Disclosure Act of 1995.

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Oil/Gas</th>
<th>Nuclear</th>
<th>Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1.000</td>
<td>0.888</td>
<td>0.852</td>
<td>0.431</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>-</td>
<td>1.000</td>
<td>0.766</td>
<td>0.356</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-</td>
<td>-</td>
<td>1.000</td>
<td>0.503</td>
</tr>
<tr>
<td>Renewable</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Table 7: Summary Statistics of Variables

This table shows the summary statistics of the observable variables used in the estimation.

<table>
<thead>
<tr>
<th></th>
<th>Obs.</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy-specific variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Opinion</td>
<td>539</td>
<td>0.3753</td>
<td>0.3555</td>
<td>0.0000</td>
<td>0.9100</td>
</tr>
<tr>
<td>Salience</td>
<td>539</td>
<td>0.5436</td>
<td>0.4986</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pro-Coal</td>
<td>539</td>
<td>0.1763</td>
<td>0.3814</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pro-Oil/Gas</td>
<td>539</td>
<td>0.2301</td>
<td>0.4213</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pro-Nuclear</td>
<td>539</td>
<td>0.1596</td>
<td>0.3665</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Anti-Coal/Nuclear</td>
<td>539</td>
<td>0.1095</td>
<td>0.3125</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Anti-Oil/Gas</td>
<td>539</td>
<td>0.2672</td>
<td>0.4429</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Policy-player-specific variables</strong></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>Relevance (Coal)</td>
<td>539</td>
<td>0.2690</td>
<td>0.4439</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Relevance (Oil/Gas)</td>
<td>539</td>
<td>0.4972</td>
<td>0.5005</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Relevance (Nuclear)</td>
<td>539</td>
<td>0.2022</td>
<td>0.4020</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Relevance (Renewable)</td>
<td>539</td>
<td>0.4675</td>
<td>0.4994</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Connection (Coal)</td>
<td>539</td>
<td>0.2319</td>
<td>0.0682</td>
<td>0.0000</td>
<td>0.6935</td>
</tr>
<tr>
<td>Connection (Oil/Gas)</td>
<td>539</td>
<td>0.1940</td>
<td>0.0533</td>
<td>0.0408</td>
<td>0.5410</td>
</tr>
<tr>
<td>Connection (Nuclear)</td>
<td>539</td>
<td>0.1378</td>
<td>0.0386</td>
<td>0.0000</td>
<td>0.2968</td>
</tr>
<tr>
<td>Connection (Renewable)</td>
<td>539</td>
<td>0.1240</td>
<td>0.0397</td>
<td>0.0000</td>
<td>0.3420</td>
</tr>
</tbody>
</table>

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Table 8: Estimation Results

This table shows the parameter estimates. The asymptotic standard errors are provided in parentheses. The asterisks marks represent the statistical significance of the estimates: * significant at 10%; ** significant at 5%; and *** significant at 1%.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Parameter</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>6.93E-06*(4.11E-06)</td>
<td>$\alpha_0$(Oil/Gas)</td>
<td>18.9123***(0.5777)</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.3812***(0.0473)</td>
<td>$\alpha_0$(Nuclear)</td>
<td>18.6493***(2.0005)</td>
</tr>
<tr>
<td>$\delta_0$</td>
<td>-0.7036***(0.0779)</td>
<td>$\alpha_0$(Renewable)</td>
<td>18.9259***(0.5509)</td>
</tr>
<tr>
<td>$\delta_1$(Public Opinion)</td>
<td>0.1312 (0.0811)</td>
<td>$\alpha_1$(Coal)</td>
<td>1.4755 (2.5908)</td>
</tr>
<tr>
<td>$\delta_2$(Salience)</td>
<td>-0.0118 (0.0250)</td>
<td>$\alpha_1$(Oil/Gas)</td>
<td>1.2095 (1.8821)</td>
</tr>
<tr>
<td>$\delta_3$(Pro-Coal)</td>
<td>0.0832 (0.1448)</td>
<td>$\alpha_1$(Nuclear)</td>
<td>1.4377 (1.4954)</td>
</tr>
<tr>
<td>$\delta_4$(Pro-Oil/Gas)</td>
<td>-0.0401 (0.0577)</td>
<td>$\alpha_1$(Renewable)</td>
<td>1.0132 (1.3140)</td>
</tr>
<tr>
<td>$\delta_5$(Pro-Nuclear)</td>
<td>0.0200 (0.0328)</td>
<td>$\sigma_\eta$(Coal)</td>
<td>1.6097**(0.7490)</td>
</tr>
<tr>
<td>$\delta_6$(Anti-Coal/Nuc)</td>
<td>-0.0339 (0.0536)</td>
<td>$\sigma_\eta$(Oil/Gas)</td>
<td>1.2666 (1.2116)</td>
</tr>
<tr>
<td>$\delta_7$(Anti-Oil/Gas)</td>
<td>0.0540 (0.0609)</td>
<td>$\sigma_\eta$(Nuclear)</td>
<td>1.2367 (1.1210)</td>
</tr>
<tr>
<td>$\sigma_\xi$</td>
<td>0.4270***(0.0905)</td>
<td>$\sigma_\eta$(Renewable)</td>
<td>0.9342 (1.1411)</td>
</tr>
<tr>
<td>$\alpha_0$(Coal)</td>
<td>18.1777***(1.6582)</td>
<td>$\kappa_1$(Connection)</td>
<td>-14,128.6***(2,928.5)</td>
</tr>
</tbody>
</table>
Table 9: Model Fit–Predicted Enactment Probability by Final Status

In this table, the policies in the data are divided into three groups: (1) those which have never been considered on the floor; (2) those which were reported by committee(s) or were directly put to a vote on the floor without committee reports but not enacted into law; and (3) those which were enacted. Using the estimated parameters, I calculate the conditional enactment probability for each policy via simulation. The numbers in the second column represent the average of the conditional enactment probabilities of the policies in each group.

<table>
<thead>
<tr>
<th>Data</th>
<th>Predicted Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Reported</td>
<td>6.75%</td>
</tr>
<tr>
<td>Reported, Not Enacted</td>
<td>14.77%</td>
</tr>
<tr>
<td>Enacted</td>
<td>16.36%</td>
</tr>
<tr>
<td>Total</td>
<td>9.13%</td>
</tr>
</tbody>
</table>
Table 10: Model Fit–Predicted Lobbying Participation

This table shows the pattern of lobbying participation by each lobbying coalition in the data. The categorization of the policies is based on the position of each coalition. *Pro-renewable* policies promote or support the renewable energy industry and *Pro-fossil* policies promote or support the coal, oil and gas, and/or nuclear energy industries. If any of the coalitions is negatively affected by a policy, it is considered as *With-dispute*, and if none of them are negatively affected by the policy, then it is considered as *No-dispute*. The units in this table are in %. 

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Oil/Gas</th>
<th>Nuclear</th>
<th>Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Data</td>
<td>49.54</td>
<td>66.79</td>
<td>48.98</td>
</tr>
<tr>
<td></td>
<td>Predicted</td>
<td>52.32</td>
<td>67.43</td>
<td>51.95</td>
</tr>
<tr>
<td><em>Pro-renewable &amp; No-dispute</em></td>
<td>Data</td>
<td>51.53</td>
<td>62.24</td>
<td>48.98</td>
</tr>
<tr>
<td></td>
<td>Predicted</td>
<td>52.35</td>
<td>63.89</td>
<td>51.65</td>
</tr>
<tr>
<td><em>Pro-renewable &amp; With-dispute</em></td>
<td>Data</td>
<td>44.44</td>
<td>76.11</td>
<td>47.78</td>
</tr>
<tr>
<td></td>
<td>Predicted</td>
<td>50.25</td>
<td>72.72</td>
<td>51.95</td>
</tr>
<tr>
<td><em>Pro-fossil/nuclear</em></td>
<td>Data</td>
<td>53.95</td>
<td>62.50</td>
<td>51.32</td>
</tr>
<tr>
<td></td>
<td>Predicted</td>
<td>54.82</td>
<td>66.12</td>
<td>52.12</td>
</tr>
</tbody>
</table>
Table 11: Model Fit–Predicted Lobbying Expenditures

The total lobbying expenditures by each lobbying coalition, both actual and predicted, can be found in the second and the third column. For each lobbying coalition, the average lobbying expenditures conditional on participation, both actual and predicted, can be found in the fourth and the fifth columns.

<table>
<thead>
<tr>
<th></th>
<th>Total Spending ($ million)</th>
<th>Average Spending ($ thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data</td>
<td>Predicted</td>
</tr>
<tr>
<td>Coal</td>
<td>77.85</td>
<td>75.34</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>73.21</td>
<td>74.10</td>
</tr>
<tr>
<td>Nuclear</td>
<td>33.91</td>
<td>31.25</td>
</tr>
<tr>
<td>Renewable</td>
<td>22.11</td>
<td>22.81</td>
</tr>
</tbody>
</table>
Table 12: Model Fit Comparison

This table shows the model fit in terms of the three sets of moments: the unconditional policy enactment probability, lobbying participation probability, and average lobbying expenditures conditional on participation. The second column shows these statistics calculated using the data, and the third column shows the simulated statistics using the originally estimated parameters, denoted as $\hat{\theta}$. The unit for the average lobbying expenditures conditional on participation is $1,000. In order to illustrate how the effect parameter $\beta$ is separately identified from the distribution of policy value, I re-estimate the model with the constraint that $\beta$ is $8.1642E-04$, which is much larger than $\hat{\beta} = 6.9312E-06$. As explained in Section 6.2.1, the Likelihood Ratio test rejects the null hypothesis that $\beta$ is $8.1642E-04$ with $p$-value less than 0.001. In the fourth column, I show the simulated statistics using the newly estimated parameters with the constraint, denoted as $\tilde{\theta}$. As can be seen, the fit with respect to the enactment probability and participation probability is more or less comparable to that of the originally estimated parameter ($\hat{\theta}$), but the fit with respect to the level of lobbying expenditures is much worse.

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Predicted at $\hat{\theta}$</th>
<th>Predicted at $\tilde{\theta}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enactment rate</td>
<td>8.35%</td>
<td>9.13%</td>
<td>10.78%</td>
</tr>
<tr>
<td>Participation by Coal</td>
<td>49.53%</td>
<td>52.33%</td>
<td>53.89%</td>
</tr>
<tr>
<td>Participation by Oil/Gas</td>
<td>66.79%</td>
<td>67.43%</td>
<td>69.79%</td>
</tr>
<tr>
<td>Participation by Nuclear</td>
<td>48.98%</td>
<td>51.95%</td>
<td>52.55%</td>
</tr>
<tr>
<td>Participation by Renewable</td>
<td>61.97%</td>
<td>64.27%</td>
<td>64.00%</td>
</tr>
<tr>
<td>Expenditures by Coal</td>
<td>291.59</td>
<td>278.98</td>
<td>233.78</td>
</tr>
<tr>
<td>Expenditures by Oil/Gas</td>
<td>203.38</td>
<td>193.96</td>
<td>160.69</td>
</tr>
<tr>
<td>Expenditures by Nuclear</td>
<td>128.47</td>
<td>109.98</td>
<td>99.34</td>
</tr>
<tr>
<td>Expenditures by Renewable</td>
<td>66.02</td>
<td>65.73</td>
<td>60.42</td>
</tr>
</tbody>
</table>
Table 13: The Distribution of the Simulated Value of a Policy

Based on the parameter estimates, I simulate the expected value of each policy conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. The following table shows the summary statistics of the distribution of simulated absolute value of policy to each lobbying coalition. The specification of the value distribution is

$$\log |v_{\ell,p}| = \alpha_{0,\ell} + \alpha_{1,\ell} \times (Relevance)_{\ell,p} + \eta_{\ell,p},$$

where $\eta_{\ell,p}$ is normally distributed with mean zero and variance $\sigma^2_{\eta_{\ell,p}}$. $Relevance_{\ell,p}$ is a binary variable regarding how specific policy $p$ is to lobbying coalition $\ell$. The unit in this table is $\$ million.

<table>
<thead>
<tr>
<th></th>
<th>Not Specific ($Relevance = 0$)</th>
<th>Specific ($Relevance = 1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>Coal</td>
<td>78</td>
<td>286</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>163</td>
<td>365</td>
</tr>
<tr>
<td>Nuclear</td>
<td>126</td>
<td>270</td>
</tr>
<tr>
<td>Renewable</td>
<td>166</td>
<td>265</td>
</tr>
</tbody>
</table>
Table 14: Effect of Lobbying Expenditures on Policy Enactment and Competing Interests

This table shows the effect of lobbying expenditures on the equilibrium probability that a policy is enacted conditional on the three mutually exclusive events: (i) when only the supporting lobbying coalitions lobbied; (ii) when only the opposing lobbying coalitions lobbied; and (iii) when both sides lobbied. Out of 539 policies in the dataset, 461 policies were lobbied by at least one lobbying coalition. The unit in this table is percentage points and the numbers in parenthesis are standard deviations. *Net Effect* is calculated by simulating the difference in the equilibrium enactment probability and the initial enactment probability conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. *Effect by Supporters (or Opposers)* is calculated by simulating the conditional expectation of the difference in the enactment probability due to the supporting (or opposing) lobbying expenditures. *Total Effect* is the sum of *Effect by Supporters* and *Effect by Opposers*. *Canceled-out Effect* is defined as twice the minimum of these two effects.

<table>
<thead>
<tr>
<th></th>
<th>Obs.</th>
<th>Effect by Supporters</th>
<th>Effect by Opposers</th>
<th>Total Effect</th>
<th>Net Effect</th>
<th>Canceled-out Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>461</td>
<td>0.0347</td>
<td>0.0161</td>
<td>0.0374</td>
<td>0.0508</td>
<td>0.0155</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0323)</td>
<td>(0.0243)</td>
<td>(0.0304)</td>
<td>(0.0372)</td>
<td>(0.0250)</td>
</tr>
<tr>
<td>Lobbied by Supporters Only</td>
<td>226</td>
<td>0.0434</td>
<td>-</td>
<td>0.0434</td>
<td>0.0434</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0372)</td>
<td>(0.0372)</td>
<td>(0.0372)</td>
<td>(0.0372)</td>
<td></td>
</tr>
<tr>
<td>Lobbied by Opposers Only</td>
<td>68</td>
<td>-</td>
<td>0.0152</td>
<td>0.0152</td>
<td>0.0152</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0198)</td>
<td>(0.0198)</td>
<td>(0.0198)</td>
<td>(0.0198)</td>
<td></td>
</tr>
<tr>
<td>Lobbied by Both</td>
<td>167</td>
<td>0.3685</td>
<td>0.0383</td>
<td>0.0751</td>
<td>0.0384</td>
<td>0.0428</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0209)</td>
<td>(0.0253)</td>
<td>(0.0252)</td>
<td>(0.0168)</td>
<td>(0.0235)</td>
</tr>
</tbody>
</table>
Table 15: Average Returns from Lobbying Expenditures on a Policy

This table shows the summary statistics of the distribution of the conditional expectation of average returns from lobbying expenditures on a policy. I define the conditional expectation of the average returns to lobbying coalition $\ell$ from lobbying on policy $p$ as:

$$\mathbb{E}\left(\frac{u_{\ell,p}(d_{p,\ell} = 1|d_{p,\ell} = 0|z_p, r_p)}{s_{\ell,p}}\right).$$

The second column shows the mean of the conditional expectation of average returns from lobbying a policy over lobbied policies for each lobbying coalition. The third column shows the standard deviation.

<table>
<thead>
<tr>
<th>Coalition</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>112.91%</td>
<td>15.53%</td>
</tr>
<tr>
<td>Oil/Gas</td>
<td>115.56%</td>
<td>17.10%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>101.82%</td>
<td>14.07%</td>
</tr>
<tr>
<td>Renewable</td>
<td>103.10%</td>
<td>18.61%</td>
</tr>
</tbody>
</table>
This histogram shows the distribution of the effect of lobbying expenditures on the equilibrium probability that a policy is enacted over all policies on which there were lobbying activities in the data. Out of 539 policies in the dataset, there were lobbying activities on 461 policies. The effect of lobbying expenditures on policy enactment probability is calculated by simulating the difference in the equilibrium enactment probability and the initial enactment probability conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. On average, the effect of lobbying expenditures on the policy enactment probability is 0.037 percentage points.
Figure 2: The Distribution of the Simulated Absolute Value of a Policy

Based on the parameter estimates, I simulate the expected absolute value of each policy conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. The following histograms show the distribution of the simulated absolute value of a policy to each lobbying coalition. The value distribution has two modes due to the specification that the mean value is different depending on the binary variable regarding how specific a policy is to the lobbying coalition.
Based on the parameter estimates, I simulate the expected lobbying expenditures for each policy conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions. The following histograms show the distribution of simulated policy-specific lobbying expenditures given participation for each lobbying coalition.
Figure 4: The Distribution of Average Returns to Lobbying Expenditures on a Policy

This histogram shows the distribution of the conditional expectation of average returns from lobbying expenditures on a policy. I define the conditional expectation of the average returns to lobbying coalition $\ell$ from lobbying on policy $p$ as:

$$
E \left( \frac{u_{\ell,p}(d_{p,\ell} = 1|d_{p,-\ell}) - u_{\ell,p}(d_{p,\ell} = 0|d_{p,-\ell})}{s_{\ell,p}} \bigg| z_p, r_p \right).
$$

The estimated kernel density using the Epanechnikov kernel function is drawn over the histogram for each coalition.