Policy Influence and Private Returns from Lobbying in the Energy Sector

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June 23, 2015

Abstract

In this paper, I quantify the extent to which lobbying expenditures by firms affect policy enactment. To achieve this end, I construct a novel dataset containing all federal energy legislation and lobbying activities by the energy sector during the 110th Congress. I then 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 to be statistically significant but very small. Nonetheless, the average returns from lobbying expenditures are estimated to be over 130 percent.

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. As a result, many firms actively engage in lobbying activities in hopes of influencing the policy-making process. The issue of political influence by private interests is therefore of great concern to any democratic society, since most policies affect not only firms' profitability but also the general public. This gives rise to 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 the probability that a policy, as introduced in legislation,

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is ultimately enacted into law by the United States Congress. To achieve this goal, I construct a novel dataset that contains detailed information on policy enactment and lobbying activities during the 110th Congress (2007–2008). Information on lobbying activities is obtained from the lobbying reports mandated by the Lobbying Disclosure Act of 1995. I then specify and estimate a game-theoretic model of lobbying where interest groups choose lobbying expenditures with the goal of influencing the probability that certain policies are enacted. To focus the analysis, I restrict attention to energy policies. While the empirical results of this study may be specific to energy policies, the empirical framework in this paper is general, and can be readily applied to any type of policies.

In the estimation, I find that the average difference between the initial and final enactment probability of a policy is small: only 0.05 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, based on the estimation, it would cost $3 million or more for one lobbying group to change a policy's enactment probability by 1.2 percentage points if no other groups also lobby. Second, the effects of expenditures by both supporting and opposing lobbies partially cancel each other out. I find that 20 percent of the direct effects of lobbying are canceled out by competing lobbies. However, although the effect of lobbying expenditures on the policy enactment probability is very small even without the canceling-out effect, the average returns to lobbying expenditures are estimated to be 137–152 percent. Because the average value of a policy to a particular group is estimated to be over $500 million, even a small change in its enactment probability can lead to large private returns.

To the best of my knowledge, this is the first paper that structurally estimates a rent-seeking model of lobbying. A structural approach is essential for three main reasons. First, explicitly modeling interest groups' decisions may help overcome the empirical challenges to studying lobbying. As discussed in de Figueiredo and Richter (2014), the main statistical challenges include omitted-variable bias and endogenous selection bias. Although instrumental variables can be used to address these challenges, as in de Figueiredo and Silverman (2006), it is very difficult to obtain the instrumental variables and justify their exogeneity. Second, in the data, policy-specific lobbying expenditures are not observed, while total lobbying expenditures across policies are observed for each lobbying group. Instead of arbitrarily dividing the total lobbying expenditure into policy-specific expenditures, I use the equilibrium condition derived from the model that the marginal benefit of lobbying is equal to the marginal cost at equilibrium. Third, the structural approach enables me to calculate private returns from lobbying expenditures. The private returns to an interest group are defined as the difference in the expected payoffs with and without lobbying expenditures. To calculate the expected payoff when an interest group chooses not to lobby, I consider the strategic reaction of other interest groups characterized by the model, as well as the initial probability that the targeted policy is enacted into law. This point has been ignored in previous studies.[1]

This paper provides a new method of defining and measuring the outcome of lobbying. A key feature in this method is that *policies*, not entire bills, are the unit of analysis. I define a policy as a part of a bill that addresses one unique issue. Most existing studies regarding

[1]For example, de Figueiredo and Silverman (2006) estimate the elasticities of the amount of academic earmarks to universities with respect to lobbying expenditures, implicitly assuming that if a university does not lobby, it will receive no earmarks. Having this assumption may result in overestimating the returns from lobbying. They also assume that there is no competition between universities for earmarks, which may further bias the results.

the influence of interest groups on legislation have focused on bills as the fundamental unit of analysis.[2] 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 a bill (H.R. 6566) from the 110th Congress that was intended to promote domestic energy production. This bill contained several different policies, such as one allowing natural gas production on the outer Continental Shelf and one extending the solar energy property tax credit. The bill was not enacted, but 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 mismeasure the effect of lobbying by ignoring the fact that the solar energy tax policy was ultimately enacted as a part of the financial industry bill. Even more importantly, in practice, energy firms care about the enactment of the tax policy, not about which bill it was included in. This paper provides a systematic method of tracking each policy's movement through bills when studying large sets of policies.

Lastly, this paper expands the scope of the analysis to *all* energy policies that were ever introduced as a part of non-appropriations legislation during the period of the study. This is in contrast to most existing empirical studies, which only focus on legislative voting behavior regarding certain subsets of bills considered salient.[3] However, most bills die in committee before they reach the House or Senate floor for a vote. Moreover, interest groups may affect the contents of a bill that is brought to a vote, not just the result of the vote itself. This paper includes policies that are not even seriously considered in committees, which enhances the generality of the results. In that regard, this paper is similar to Hall and Wayman (1990), Baumgartner, Berry, Hojnacki, Kimball, and Leech (2009), and Igan and Mishra (2014).[4]

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 discusses the identification and estimation strategy. Section 5 contains the results of the empirical analysis. Section 6 concludes.

2 Background and Data

I construct a 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 of 1995, which are

[2]Some exceptions include studies whose unit of analysis is industries. These study the influence of industry interests on the level of trade protection, pioneered by the theoretical work of Grossman and Helpman (1994). See, for example, Goldberg and Maggi (1999), Gawande and Bandyopadhyay (2000), and Gawande, Krishna, and Olarreaga (2012). Another notable exception is Baumgartner, Berry, Hojnacki, Kimball, and Leech (2009), in which the authors study 98 randomly selected policy issues in which interest groups are involved, and then follow those issues for four years (1999–2002). The main difference is that they rely on interviews with lobbyists to obtain policy issues, while I look directly at the text of the bills.

[3]This literature seeks to estimate the effect of campaign contributions on the voting behavior of individual legislators. See Ansolabehere, de Figueiredo, and Snyder (2003) for a survey of this strand of the literature.

[4]Hall and Wayman (1990) study the influence of interest groups on the participation of committee members, using data drawn from staff interviews and markup records of three House committees on three bills. In Baumgartner, Berry, Hojnacki, Kimball, and Leech (2009), policy issues are randomly selected regardless of their legislative status. Igan and Mishra (2014) study the relationship between the political influence of the financial industry and financial regulation during 2005–2006, and their analysis includes bills that did not reach the voting stage. In measuring the position of the members of Congress on financial regulation, they use both voting and (co)sponsorship records.

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

Existing studies have focused on legislative bills as the fundamental unit of analysis. However, a bill often addresses multiple heterogeneous issues, and some parts of a bill can be dropped from the bill or inserted into another bill over the course of the legislative process. Given these two facts, there can be a few problems when applying the "bill approach" to studying the effects of lobbying. First, the unit of analysis may be different from the units actually being targeted by interest groups. When an interest group lobbies on a bill, its targets are specific policy issues, which may be addressed in a certain part of the bill, not necessarily in its entirety. Second, the outcome of the lobbying efforts can be misrepresented because it is possible for the fate of an entire bill to be different than that of each bill section. Third, it is not always easy to clearly assess how successful lobbying efforts are when an interest group supports some bill sections while opposing others. These problems can be mitigated if the research is focused on one specific policy issue, but in order to generalize research findings, studying a large number of policy issues is key. In this paper, I therefore propose a method to systematically determine the unit of analysis and its final legislative status in practice.

A natural place to start is with the sections of a bill, as defined in the bill text. A section of a bill often represents a policy proposal regarding a unique issue. To obtain the enactment information, I track each section across bills by adhering to the following procedures.[5] First, I use a vector space model to represent bill sections by corresponding vectors based on word frequency, and measure the distance between the vectors by calculating the cosine of the angle between them.[6] Second, based on the measured distances among the vectors, I create a graph of the bill sections. Third, I group the sections using an algorithm to find connected components in the graph. Using the unique bill sections as the unit of analysis helps resolve the aforementioned problems.

However, this approach presents a potential problem: for any given policy issue, there can be multiple policy proposals. Using the method proposed in this paper, I obtain a list of the unique policy proposals regarding an issue and the final legislative status of each unique proposal. Of these policy proposals and the existing status quo policy, only one is eventually chosen during the legislative process. Therefore, the effect of lobbying on one policy proposal may not be independent from that on another policy proposal. This can cause a problem in assessing the effect of lobbying. For example, consider a specific policy issue: whether or not, and to what extent, to extend a status quo tax credit policy for certain investments. Policy proposal A extends the tax credit by one year, and proposal B extends it by three years. Suppose proposal A is enacted. If proposals A and B are considered separately, the supportive lobbying efforts for A are recorded as successful and those for B as unsuccessful. However, it is possible that the lobbying efforts for B may have affected the probability that proposal A is enacted. To resolve this issue, I adjust the definition of the unit of analysis by combining the unique bill sections into one group if they address the same policy issue and

[5] A more detailed description of these procedures can be found in Appendix A.1. and A.2.

[6] Vector space models are used in information filtering, information retrieval, indexing, and relevancy rankings. For references, see Salton, Wong, and Yang (1975) and Raghavan and Wong (1986).

Table 1

Final legislative status of policies

Final Status	Number of Obs.
Not Reported	387 (71.9)
Reported, Not Enacted	106 (19.7)
Enacted	45 (8.4)
Total	538

Note: The numbers in parentheses show relative frequencies (percentage).

affect the interest groups in the same direction, either positively or negatively.[7] I call each group of bill sections a *policy*, and set it as the unit of analysis in this paper. In the dataset, a policy appears in 3 different bills on average.

The dataset covers all policies that were both considered in the 110th Congress (2007–2008) and that create, modify, 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 emissions from coal-fired power plants. Note that not all policies that affect the energy sector are included in the analysis because their statutory subjects might be from 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 538 policies which are included in 445 bills.[8]

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 (8.4 percent) were enacted into law.[9] Table 1 shows the final the status of the policies. Over 70 percent of the policies died even before being sent to the floor of the House or the Senate (denoted as "Not Reported" in the table), and about 20 percent of the policies reached the floor, but were not enacted into law (denoted as "Reported, Not Enacted" in the table).

2.2 Lobbying Disclosure Data

Lobbyists can be categorized into two groups by their professional arrangements: in-house (or internal) lobbyists and external lobbyists.[10] In-house lobbyists are hired by a firm, a trade association, or a citizens' group as employees. 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

[7] I adopt a set of rules to combine the unique bill sections into one group. These rules are described in Appendix A.2.

[8] In Appendix A.1, I describe how these 538 policies were selected to be in the analysis.

[9] Note that the average enactment rate of all bills and joint resolutions in the 110th Congress is 4.1 percent. The enactment rate of a policy in the dataset is higher than that of a bill because on average, an enacted bill includes more policies than a rejected bill. Out of 445 bills that included the policies in the dataset, only 5 bills (1.1 percent) were enacted.

[10] According to Bertrand, Bombardini, and Trebbi (2015), about 40 percent of registered lobbyists are in-house lobbyists.

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.[11] The content of the report includes: (i) all relevant lobbyists' names, addresses, and previous official positions; (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.); (v) a list of 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.

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 during 2007–2008.[12] The total amount of their lobbying expenditures during this period is about \$607.9 million. The distribution of an 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 percent of firms and trade associations in this sector—55 entities in total—spent about \$462.7 million. This accounts for 76.11 percent of the total amount of lobbying expenditures by the sector.

The energy sub-sectors are often politically organized. Among the top 55 lobbying spenders, there are 8 trade associations that represent energy sub-sectors.[13] 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 Chevron. All energy companies among the top lobbying spenders are members 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 that mainly use coal for power generation; (ii) the oil and natural gas industry; (iii) the nuclear industry and investor-owned electric utilities that mainly use nuclear energy for power generation; and (iv) the renewable energy industry (such as bio, solar, wind, geothermal, and hydro-kinetic energy) and investor-owned electric utilities 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.[14] I assume that these strategic firms and

[11] 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 of 2007 was enacted, it became quarterly. This amendment also strengthened the registration criteria and the enforcement rules.

[12] See Appendix A.3 for a detailed description on how I identified these 559 entities from the lobbying disclosure reports.

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

[14] In this paper, environmental groups are not considered as *strategic* or *major* in energy policy lobbying.

Table 2

Energy lobbying coalitions

	Num. of Associations	Num. of Firms	Asset ($ billion)	Sales ($ billion)	Lobbying ($ million)
Coal	3	7	253.35	71.68	139.56
Oil/Gas	1	7	1,116.92	1,443.73	160.63
Nuclear	1	11	195.06	87.78	70.65
Renewable	6	6	41.04	14.69	30.44
Total	10	32	1,606.33	1,617.88	401.28

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 designated as strategic based on the fraction of their individual lobbying expenditures to the total lobbying expenditures of the group to which they belong. The threshold for inclusion is 2.5 percent for all groups except for that of renewable energy, whose threshold is 1.5 percent.[15,16] Based on the criterion, 42 firms and trade associations are considered as strategic, with 8 to 12 belonging to each group.[17] The total amount of lobbying expenditures by these strategic entities accounts for 66 percent of that of the energy sector as a whole.

Table 2 shows some descriptive statistics for the lobbying coalitions. The second and third columns show the number of associations and firms that are included in each coalition respectively. The fourth column shows the sum of the asset value of each firm within the coalition at the end of 2007, and the fifth column displays the sum of the revenue of each firm within the coalition in the same year.[18] The table shows that in comparison to other coalitions, the oil and natural gas lobbying coalition consists of much larger firms in terms of total asset and sales. However, lobbying expenditures are not necessarily proportional to the size of the coalition. The last column of the table lists the total lobbying expenditures in 2007–2008 by each coalition, and it is notable that the rest of the lobbying coalitions spend much more in proportion to their size for lobbying activities than the oil and natural gas coalition does.

This is because their lobbying spending is very small compared to that by the energy sector. During the period of this study, environmental groups spent $35.2 million dollars in total, which accounts for only 6 percent of the total lobbying expenditures by the energy sector. Moreover, much of the lobbying of these groups is focused on issues outside the energy sector.

[15] There are two reasons why only large and active firms and trade associations are included in the analysis. First, small firms and large firms may take different positions on a policy even though they belong to the same industry. They are often treated differently in public policies. The goal is to have a coalition consisting of homogenous interests. Second, small firms are more likely to lobby private policies such as an earmark for a specific product.

[16] The renewable energy group is relatively more heterogeneous than other groups. I use a lower threshold so that all all large firms and trade associations in the renewable energy industry that tend to lobby public policies. Alternatively, I could have constructed three separate lobbying coalitions (solar, wind, and bio-based energy), but some firms in this coalition are involved in various renewable energy sources, which makes it difficult to determine which coalition these firms should belong to.

[17] See Table 17 in the Appendix for a list of the 42 entities in the dataset.

[18] These figures are based on the Compustat dataset and do not include information on firms that were not on the U.S. stock market at the end of 2007.

2.4 Lobbying Participation and Position

For each firm or trade association in each lobbying coalition, I extract from lobbying reports and other auxiliary sources two pieces of 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 energy 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. Note that the position information is needed for all relevant firms and trade associations regardless of lobbying participation. In most cases, classification is straightforward, based on the business of an entity and the content of each policy.[19] I also collect and use relevant documents available online to arrive at these determinations, such as letters sent to the Congress by interest groups and statements in news articles and the groups' own websites.

The lobbying participation and policy positions of the entities within a lobbying coalition are aggregated as follows. A coalition is considered 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 coalitions, but when there are disagreements, I take the policy position of the majority of the entities within it as the coalition's position.[20]

Table 3 shows some patterns of participation by each lobbying coalition. Lobbying participation is selective in the sense that not all policies are lobbied by all coalitions. The second column of the table shows the average frequency of lobbying participation on a policy. The oil and natural gas coalition participates the most frequently, followed by the renewable energy coalition. The renewable energy coalition participates relatively often compared to its total lobbying expenditures, which is less than one-tenth of that of the oil and natural gas coalition. The other columns show the correlation of lobbying participation among lobbying coalitions. It can be seen that lobbying participation is positively correlated.

2.5 Policy Passage and Lobbying

Table 4 shows the relationship between the enactment of a policy and the lobbying activities on the policy. As can be seen in Panel A in the table, among the 538 energy policies in the dataset, 350 policies were lobbied on either by none of the lobbying coalitions or by some, but not all, of them. The enactment rate of these policies is less than 1 percent. On the other

[19] It is possible that even if a policy is favorable (unfavorable) to a firm, it may not necessarily support (oppose) the policy. For example, if enactment of a favorable policy may dampen the prospect of another favorable, potentially more beneficial, policy, the firm may lobby against the former policy. Similarly, if an unfavorable policy is the only feasible alternative to another much worse policy, the firm may lobby for the former policy. Therefore, the position variable that I construct may contain a misclassification error. In Appendix D.7, I show that the scope in which this potential misclassification error may affect the main results of this paper is very small.

[20] The classifications are straightforward for 80.2 percent of the policies. For the remaining 20.8 percent, there is potential for disagreement among the entities within a coalition on the policy position. Note that I specifically call out the possibility of "potential" disagreements because I do not have statements or documents that show actual disagreements for any of these policies. Nevertheless, I acknowledge the possibility because the firms within a coalition do compete in the same market. For example, it is unclear what position each oil company took regarding biofuel policies without a specific policy statement because the investment portfolios, including biofuel, vary across the firms.

Table 3

Lobbying participation by the energy lobbying coalitions

	Average	Correlation among lobbying coalitions			
		Coal	Oil/Gas	Nuclear	Renewable
Coal	0.50	1.00	0.38	0.71	0.42
Oil/Gas	0.67	-	1.00	0.45	0.34
Nuclear	0.49	-	-	1.00	0.45
Renewable	0.62	-	-	-	1.00

Table 4

Policy enactment and lobbying

	Obs.	Enactment (percentage)
Panel A		
Not lobbied by all	350	0.6
Lobbied by all	188	22.9
Supporters are dominant	122	25.4
Opposition is dominant or equal	66	18.2
Panel B		
Not lobbied	78	0.0
Lobbied by supporters only	225	8.4
Lobbied by opposition only	68	4.4
Lobbied by both sides	167	13.8
Total	538	8.4

hand, when a policy was lobbied by all of the lobbying coalitions, the enactment rate increases to about 23 percent. Furthermore, when the number of supporting lobbying coalitions exceeds that of opposing lobbying coalitions, the enactment rate is greater (about 25 percent) than that of the opposite case (about 18 percent). This does not necessarily imply that lobbying is effective because lobbying participation is endogenously determined. It can be seen in Panel B that when both supporting lobbying coalitions and opposing coalitions lobby, the enactment rate is much higher (about 14 percent) than when only supporting coalitions lobby (about 8 percent).

To quantify the effect of lobbying participation on the probability that a policy is enacted, it is necessary to control for the selection in lobbying participation. This is complicated by the fact that both the outcome variable (the enactment of a policy) and the endogenous explanatory variable (the participation in lobbying on the policy) are discrete. In this paper, I quantify the effect of lobbying expenditures on the enactment probability of a policy, controlling the endogeneity of lobbying decisions and exploiting the structure of the model described in the next section.

2.6 Observed Characteristics of Policies

In the data, policies differ in several observed dimensions. First, the general public has different opinions on each policy. I measure public opinion on a policy by using polling data obtained from the Roper Center for Public Opinion Research. I include all polling questions in the polling dataset, which asked a national sampling of U.S. adults about energy policy issues during 2007–2008. These polling questions are matched with the policies in my dataset.[21,22] 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*).[23]

Second, the policies can be categorized into two groups: regulatory and fiscal. I create three variables for each policy: (i) one dummy variable that indicates whether the policy is intended to strengthen the existing regulations or create new ones (*more regulation*); (ii) a second dummy variable that indicates whether the policy is intended to loosen or repeal the existing regulations (*less regulation*); and (iii) a third dummy variable that indicates whether the policy is intended to decrease or repeal existing taxes or to create new government spending programs such as subsidy and loan guarantee (*more government spending*).

Third, each policy heterogeneously affects each of the lobbying coalitions in two observed aspects. For each coalition, one aspect is whether the policy favors or disadvantages the coalition (*pro-coal, pro-oil/gas, pro-nuclear*, and *pro-renewable*). The other aspect is whether or not the policy directly affects that coalition (*relevant-coal, relevant-oil/gas, relevant-nuclear,* and *relevant-renewable*). For instance, a tax credit policy for capturing and sequestrating carbon dioxide from coal-fired power plants directly benefits the coal industry while it indirectly affects other energy industries.

Table 5 presents the summary statistics of the variables.

2.7 Lobbying as a Long-term Investment?

Lobbying can be a long-term investment that plays out over several years or longer. Even if policy advocates may not achieve an immediate policy response, they may have managed to get some of their ideas into the policy community. Furthermore, it should be noted that regardless of whether or not a policy is enacted during a certain Congress, the following Congresses may revisit that policy with new but related policies. An enacted tax credit may be adjusted in the next Congress, for example.

To gauge the extent of the long-term effect of lobbying on policy outcomes, I track the policies in my dataset for four more years, i.e., through the terms of the 111th and the 112th Congresses. To track these policies, I use the same method described in Section 2.1. The results of this additional four years of tracking are represented in Table 6, on which I base the following discussion of three interesting trends.

First, 65.5 percent of the policies that failed to be enacted in the 110th Congress were not re-introduced in bills during the following four years. To complement the policy approach

[21] There are 1,331 national polls on energy and environmental issues available at the Roper Center for Public Opinion Research during the period in question. Among them, I find that 158 polls are directly relevant to the energy policy issues in the data. The subjects of these polls include miner safety standards, renewable portfolio standards, windfall profit taxes on oil and gas companies, etc. The average sample size is 1,294, and the sample sizes range from 817 to 18,018. These 158 polls are matched to 293 policies in the data.

[22] Because there are not many state or district level polls on energy issues, I focus on national level polls.

[23] When a policy does not have a corresponding polling question, it may be considered to have a missing observation for the *public opinion* variable. However, I interpret this case as "no opinion," which may be due to certain characteristics of the policy, such as being too technical for the general public to form an opinion. For this reason, I construct a variable called *salience*, instead of imputing values for the *public opinion* variable.

Table 5
Summary statistics of variables

Variable	Obs.	Mean	SD	Min	Max
Public Opinion	538	0.3747	0.3556	0.0000	0.9100
Salience	538	0.5428	0.4986	0	1
More Regulation	538	0.2862	0.4524	0	1
Less Regulation	538	0.1561	0.3633	0	1
More Gov Spending	538	0.4572	0.4986	0	1
Pro-Coal	538	0.6914	0.4623	0	1
Pro-Oil/Gas	538	0.6190	0.4861	0	1
Pro-Nuclear	538	0.6970	0.4599	0	1
Pro-Renewable	538	0.6970	0.4699	0	1
Relevant-Coal	538	0.2695	0.4441	0	1
Relevant-Oil/Gas	538	0.4981	0.5005	0	1
Relevant-Nuclear	538	0.2026	0.4023	0	1
Relevant-Renewable	538	0.4665	0.4993	0	1

used here, I also look at all energy bills that were either enacted into law or passed by one House during the four years, which confirm that mostly new policies were discussed during the period. More detailed results are presented in Appendix A.4.

Second, among the 170 of policies that were re-introduced, only two became law. Both of these were measures aimed at the prevention of oil spills, and their enactment in 2010 was prompted by the Deepwater Horizon oil spill that occurred earlier that year.[24] Put somewhat differently, of the 493 policies that were not enacted in the 110th Congress, only two were enacted in the two successive Congresses and they were the result of an extraordinary external event. This new finding is of interest in its own right in suggesting that policies that fail in a given Congress have dim prospects in subsequent Congresses.

Third, the data does not seem to show a significant relationship between lobbying in the 110th Congress and policy status in the following two Congresses. Those policies lobbied only by supporters have relatively low rate of being re-introduced compared to the others, and the two later-enacted policies were lobbied only by opposition in the 110th Congress. Note, however, that this is only suggestive of insignificant dynamic effects of lobbying because it does not consider potential endogeneity issues and lobbying activities during the 111th and the 112th Congresses.

Why do we observe this apparent disconnect between the 110th Congress and the following two Congresses? First, a legislator may not find the information transferred by lobbyists in the past pertinent to her policy decisions. For example, she may not find the survey results on oil drilling provided by a lobbyist in 2008 useful for her policy decisions after the Deepwater Horizon oil spill in 2010. Furthermore, the composition of the Congress changes every two years, which may require different legislative strategies and information for policy-making.

Second, the current empirical research does not directly support the existence of dynamic

[24]They were enacted as as a part of the Coast Guard Authorization Act of 2010 (H.R. 3619). See a report from the Congressional Research Service, "Deepwater Horizon Oil Spill: Highlighted Actions and Issues," written by Curry L. Hagerty and Jonathan L. Ramseur in May 2011.

Table 6

Policy enactment and lobbying during three Congresses (110th–112th)

		110th	111th–112th	
	Obs.	Enacted	Reappeared[a]	Enacted
Not lobbied	78	0	32 (41.0)	0
Lobbied by supporters only	225	19	52 (25.2)	0
Lobbied by opposition only	68	3	26 (40.0)	2
Lobbied by both sides	167	23	60 (41.7)	0
Total	538	45	170 (34.5)	2

[a] "Reappeared" policies were re-introduced as a part of at least one bill during the 111th–112th Congresses. The numbers in parentheses show the relative frequencies (percentage) among the not-enacted policies in the 110th Congress in each row.

effects of lobbying on policy enactment.[25] There is a line of empirical research that highlights the importance of a long-term relationship between lobbyists and legislators. However, the benefits of this relationship may be directed to the lobbyists, not necessarily to the interest groups that hire them. For example, Blanes i Vidal, Draca, and Fons-Rosen (2012) examine how staffers-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 percent drop in generated revenue when that Senator leaves office. This implies that cultivated trust and relationships with politicians are valued in the market, and that the interest groups hire their lobbyists accordingly.

Based on the above reasoning and my finding that only two of 493 policies that failed in the 110th congress were subsequently enacted, I conclude that a framework that does not encompass spillovers in lobbing from one Congress to the next is viable. Therefore, I use a static framework to analyze two years of lobbying activities and their outcomes in this paper.

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 in the lobbying game. Consider a specific policy. In the absence of lobbying, the policy will be enacted into law with probability π. Each player values the policy heterogeneously, and the value of the policy to player ℓ is denoted as v_ℓ. Some players have positive values and others have negative values from the enactment of the policy. I denote the set of players who positively value the policy as $\mathcal{L}_f \subseteq \mathcal{L}$ and those who negatively value it as $\mathcal{L}_a \subseteq \mathcal{L}$. 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.[26] 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 entry cost represents the minimal

[25] There is evidence of long-term considerations in another context–interest group contributions to Political Action Committees. See, for example, Snyder (1992). This finding, however, may not necessarily extend to lobbying because lobbying expenditures are made to hire lobbyists, and by law cannot go directly to politicians or their campaign funds.

[26] This complete information assumption does not necessarily exclude the possibility that lobbying affects politicians' decisions by providing them with information.

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 player. 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.[27]

The earliest papers on rent-seeking behaviors, such as Tullock (1967) and Krueger (1974), have been extended in various directions, and rent-seeking literature has studied lobbying as an application.[28] One extension that is very relevant to this paper is that rent is a group-specific public good.[29] An important modeling issue is to determine a policy enactment production function, denoted as $p(\mathbf{s}_f, \mathbf{s}_a; \pi)$. This function defines how the probability that a policy is enacted, p, is determined by the initial enactment probability, denoted as π; and by a profile of supporting players' spending, $\mathbf{s}_f \equiv (s_i)_{i \in \mathcal{L}_f}$, and opposing players' spending, $\mathbf{s}_a \equiv (s_j)_{j \in \mathcal{L}_a}$. I assume the following production function:

$$p(\mathbf{s}_f, \mathbf{s}_a; \pi) = \frac{\pi + \beta_f \sum_{i \in \mathcal{L}_f} s_i^\gamma}{1 + \beta_f \sum_{i \in \mathcal{L}_f} s_i^\gamma + \beta_a \sum_{j \in \mathcal{L}_a} s_j^\gamma}, \tag{3.1}$$

where $\beta_f > 0$, $\beta_a > 0$, $\gamma \in (0, 1)$. There are a few notable features in this specification. First, $p(0, 0; \pi) = \pi$, which is consistent with the definition of π. Second, this specification allows a prior advantage or disadvantage to each group such that when only the supporting (opposing) group lobbies, the probability that a policy is enacted is not necessarily one (zero). This is consistent with the data, but in the literature on contests, it is often assumed that when only one player participates, his winning probability is one.[30] Third, by assuming that $\gamma < 1$, the number of lobbying participants matters in determining the probability that the policy

[27]By taking a rent-seeking contest approach, the mechanism through which lobbying activities affect the policy choices of the legislature is not specifically modeled. There are two types of economic models of interest group influence, and it is not easy to pick one model over another based on the data on lobbying. Papers in the the first category assume that interest groups offer legislators money or resources in exchange for legislative favors (e.g., Snyder 1991, and Groseclose and Snyder 1996). Although by law lobbying expenditures may not directly benefit legislators, lobbyists often act as bundlers of campaign contributions, and they may provide other politically valuable resources. Papers in the second category assume that interest groups may affect policy outcomes by providing relevant information to the lawmaker (e.g., Austen-Smith and Wright 1996, and Bennedsen and Feldmann 2002). As discussed in Bertrand, Bombardini, and Trebbi (2015), lobbyists may have technical expertise on specific policy issues, and/or they may act as a credible or trusted transmitter, from the view of legislators, of valuable information possessed by the firms or organizations that hire them.

[28]For a survey on the rent-seeking literature, see Nitzan (1994), Konrad (2007), or Corchon (2007). As for the applications of the literature to lobbying, see Baye, Kovenock, and de Vries (1993), Che and Gale (1998), and Cotton (2009), for example.

[29]See, for example, Katz, Nitzan, and Rosenberg (1990), Nitzan (1991) , Riaz, Shogren, and Johnson (1995), Dijkstra (1998), and Baik (2008).

[30]For example, Tullock's standard contest success function is that the winning probability of player i given spending vector $(s_1, ..., s_n)$ is $s_i^\gamma / \sum_{j=1}^n s_j^\gamma$ where $\gamma > 0$, if at least one player spends non-zero amount of money, and otherwise, is $1/n$. Note that if $s_i > 0$ and $s_j = 0$ for all $j \neq i$, then $p_i = 1$.

becomes law: If the same amount of money is spent on one side, the more participants there are, the more effective the money is.[31]

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 and without budget constraints.[32] If player ℓ spends s_ℓ to lobby for a policy given other players' spending $(\mathbf{s}_{-\ell,f}, \mathbf{s}_a)$, then the expected payoff is $p(\mathbf{s}_f, \mathbf{s}_a; \pi)v_\ell - s_\ell - c_\ell$, where c_ℓ 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, the expected payoff is $p(\mathbf{s}_{-\ell,f}, \mathbf{s}_a; \pi)v_\ell$.

The equilibrium concept in this game is a subgame perfect Nash equilibrium. The following proposition establishes the existence and uniqueness of a pure-strategy equilibrium in the second stage of the game, and the proof is in Appendix B.

Proposition 1 In the second stage of the game, a pure-strategy Nash equilibrium exists and is unique.

Since a unique equilibrium in pure strategies exists in the second stage, a payoff matrix in the first stage can be uniquely determined. As a result, the first stage game boils down to a finite normal-form game. It is well known that every finite normal-form game has a mixed-strategy equilibrium. Therefore, in the first stage, a (mixed-strategy) equilibrium exists but may not be unique.

We do not observe the initial enactment probability, the values, and the entry costs. For each policy k, I make the following parametric assumptions. First, I assume that the initial enactment probability, π_k, depends on the sum of a linear index of $\mathbf{Z}_k$ and an unobserved random variable ξ_k:

$$\pi_k = F(\mathbf{Z}_k\delta + \xi_k), \tag{3.2}$$

where $F(\cdot)$ is a cumulative density function of the standard normal distribution. $\mathbf{Z}_k$ is a vector of a constant, the variables regarding public opinion (*salience*, *public opinion*), and the content (*more regulation*, *less regulation, more government spending*). ξ_k includes the omitted variables regarding other activities of political influence that are not considered in this model.[33] I assume that ξ_k is distributed with $N(0, \sigma_\xi)$. Second, I assume that the log of the valuation of policy k to player ℓ, $\log|V_{\ell,k}|$, is additively separable into a linear index of $\mathbf{X}_{\ell,k}$ and an unobserved random variable $\eta_{\ell,k}$:

$$\log|V_{\ell,k}| = \mathbf{X}_{\ell,k}\alpha_\ell + \eta_{\ell,k}, \tag{3.3}$$

where η_ℓ follows $N(0, \sigma_{\eta_\ell})$. $\mathbf{X}_{\ell,k}$ is the vector of a constant and the direct relevance of the policy to the coalition (*relevance*). Lastly, I assume that ξ_k and $(\eta_{\ell,k})_{\ell\in\mathcal{L}}$ are mutually independent.

[31] This assumption is data-driven. In the data, there are multiple lobbying participants from the same side. However, when the lobbying expenditures by two different players are perfect substitutes ($\gamma = 1$) and budget constraints do not exist, there is only one participant from each side.

[32] Baik (2008) studies a rent-seeking contest with group-specific public goods when players are budget-constrained. He finds that the free-rider problem within a group is alleviated compared to the base model without budget constraints.

[33] In particular, 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.

4 Identification and Estimation

4.1 Identification

4.1.1 Relationship between the Data and Model

The following four equations succinctly represent how the observed variables in the data are related to the objects in the model. To simplify the argument, let us focus on the case where there are two interest groups on the supporting side of a specific policy. For cases with more than two interest groups and different sides, the argument here can still be easily applied.

The first equation is on the policy enactment probability. Whether or not policy k is enacted is represented by an indicator variable, Y_k, which takes 1 when the policy is enacted and 0 otherwise. The enactment probability is $p(s_{1,k}, s_{2,k}, \pi_k)$ given the lobbying expenditures of interest groups 1 and 2 $(s_{1,k}, s_{2,k})$ and the initial enactment probability (π_k). Therefore,

$$y_k = 1\{\epsilon_k < p(s_{1,k}, s_{2,k}, \pi_k)\}, \tag{4.1}$$

where $\epsilon_k \sim Unif[0, 1]$.

The second equation is the participation rule of an interest group. Whether or not interest group ℓ decides to lobby for policy k is represented by an indicator variable, $D_{\ell,k}$, which takes 1 when the group participates in lobbying for the policy and 0 otherwise. The participation rule involves comparing the benefit of lobbying, which is the difference in the enactment probabilities multiplied by the value of the policy, with the cost of lobbying, which is the sum of the effective spending $(s_{\ell,k})$ and the entry cost $(c_{\ell,k})$. This is expressed as for $\ell = 1, 2$,

$$d_{\ell,k} = 1\{[p(s_{\ell,k}, s_{-\ell,k}, \pi_k) - p(s_{\ell,k} = 0, s_{-\ell,k}, \pi_k)]v_{\ell,k} > s_{\ell,k} + c_{\ell,k}\}. \tag{4.2}$$

The next equation pins down the amount of the lobbying expenditures by an interest group if it participates. Given any participation profile, the vector of the optimal expenditures by all interest groups is unique according to Proposition 1. Let us denote the optimal lobbying expenditure of group ℓ given participation profile $(d_{1,k}, d_{2,k})$ by $\varphi_\ell(v_{1,k}, v_{2,k}, \pi_k; d_{1,k}, d_{2,k})$. Suppose both groups lobby (i.e., $d_{1,k} = 1$ and $d_{2,k} = 1$). Then $\varphi_1(\cdot)$ and $\varphi_2(\cdot)$ satisfy the first order conditions:

$$\frac{\partial}{\partial s_{1,k}} p(\varphi_1, \varphi_2, \pi_k)v_1 = 1, \text{ and } \frac{\partial}{\partial s_{2,k}} p(\varphi_1, \varphi_2, \pi_k)v_2 = 1.$$

Although a closed-form expression for $\varphi_\ell(\cdot)$ does not exist, the proof of Proposition 1 in Appendix B guides the computation. If one group does not lobby, say group 1, then $\varphi_1(\cdot)$ is zero.

Now, given the equilibrium condition that the lobbying expenditures are optimal, we have the following equation for $\ell = 1, 2$:

$$s_{\ell,k} = \varphi_\ell(v_{1,k}, v_{2,k}, \pi_k; d_{1,k}, d_{2,k}). \tag{4.3}$$

Lastly, we observe the total lobbying expenditures for each interest group.[34] Let $s_\ell \equiv$

[34] Specifically, s_ℓ is the sum of lobbying expenditures by player ℓ on all energy policies. In the data, I observe the sum of lobbying expenditures on *all* policies for each player. Therefore, it is crucial to determine the energy lobbying expenditures from the total lobbying expenditures for each player. In doing so, I use information on lobbying participation at the bill level, which I describe in detail in Appendix D.6. Furthermore, based on the sensitivity analyses in Appendix D.6, I find that the key results are robust to variation in the breakdown of the total lobbying expenditures.

$\sum_{k=1}^{n}(s_{\ell,k} + c_{\ell,k})d_{\ell,k}$ denote the total lobbying expenditures by interest group ℓ. Thus,

$$s_\ell = \sum_{k=1}^{n} \{\varphi_\ell(v_{1,k}, v_{2,k}, \pi_k; d_{1,k}, d_{2,k}) + c_{\ell,k}\} \, d_{\ell,k}, \tag{4.4}$$

where n is the total number of policies in the data.

4.1.2 Identifying Assumptions

The main empirical challenge in identifying the structural parameters of the model from the data is twofold. First, the initial enactment probability, π_k, is not observed and is correlated with the lobbying decisions of interest groups, as shown in equations (4.2) and (4.3). This problem is well-acknowledged in the literature of political influence. Second, policy-specific lobbying expenditures are not observed, although the total lobbying expenditures are observed.

To address these challenges, the structure of the model and the functional form assumptions play a crucial role. All assumptions used in this analysis are listed as follows.

Assumption 1 We have a random sample of $(y_k, d_{1,k}, ..., d_{L,k}; \mathbf{w}_k)_{k=1}^n$ for large n, and observe $(s_1, ..., s_L)$. $\mathbf{w}_k$ is a vector of the attributes of policy k.

This assumption is made in most cross-sectional analyses. Relaxing this assumption requires that some specific conditions on the relationship among different policies are satisfied.[35]

Assumption 2 The enactment production function, $p(\cdot)$, and the joint distribution of the unobservable variables in the model, $(\pi_k, v_{1,k}, ..., v_{L,k})$, conditional on policy attributes $\mathbf{w}_k$, are known up to finite-dimensional parameters.

The parametric assumptions in the main estimation are presented in equations (3.1), (3.2), and (3.3). Nonparametric identification of the enactment production function and the distribution of the unobserved variables is impossible because the observed output variable related to the enactment production function, Y_k, is binary and we do not observe the policy-specific expenditures. Note that the production function is inevitably nonlinear because its range is bounded, i.e., $[0, 1]$, while its domain is not. When presenting the key findings, I discuss how certain features of the policy enactment production function may affect the results.

These parametric assumptions also play an important role in addressing the endogeneity issue that the initial enactment probability, π_k, is correlated with the lobbying activities. Note that instrumental variables, which affect the lobbying decisions but do not affect the initial enactment probability, are very difficult to obtain. Instead, I exploit the model prediction on the lobbying decisions. These lobbying decisions are tightly tied to the enactment production function, as demonstrated in equations (4.2) and (4.3). Therefore, the only structure that I impose on the data, in addition to the parametrization of the enactment production function and the joint distribution of the unobservable variables, is that the lobbying decisions are an

[35] For example, in assessing the impact of chain retail stores on the other retailers and local community, Jia (2008) exploits the supermodularity of the entry games in multiple locations/markets by two chain stores.

equilibrium outcome where the expected marginal returns to lobbying to interest groups are equal to one for each policy. One issue, however, is that there can be multiple equilibria in the first stage of the game when the interest groups decide whether to participate in lobbying. To obtain a unique prediction for lobbying participation, I impose an equilibrium selection rule.[36] When estimating the model, I select the equilibrium that maximizes the sum of the payoffs of all players.

Assumption 3 When there exist multiple Nash equilibria, the equilibrium that maximizes the sum of the payoffs of all players is chosen.

Note that we have three pieces of information in the data (enactment, lobbying participation, and total lobbying expenditures), while we have four key components in the model (lobbying effectiveness, mean and variance of policy value, and entry cost). In resolving this problem, I make the following assumption.

Assumption 4 The entry costs to interest groups are observed by the econometrician.

In the estimation, I fix the value of the entry cost to be the same across policies and interest groups, and set it to be the smallest lobbying expenditure undertaken by entities that lobbied for one policy in the data.[37]

Because these assumptions are not testable, I perform extensive sensitivity analyses. For Assumption 1, I estimate the model when the unit of a policy is defined differently (see Appendix D.1). For Assumption 2, I estimate a model with an alternative policy enactment production function (see Appendix D.2). For Assumption 3, a different equilibrium selection rule is assumed (see Appendix D.3). Lastly, I choose two different entry costs and estimate the model to understand how Assumption 4 may affect the results (see Appendix D.4). I find that the results are robust to these sensitivity analyses.

4.2 Estimation

I have the individual policy-level data (enactment and lobbying participation profiles) and the aggregate player-level data (total lobbying expenditures). Both levels of data are needed to identify the parameters in the model as discussed in the previous section. Therefore, I use an estimator that combines the likelihood of observing the individual policy-level data and the moment condition related to the aggregate player-level data.

Let the vector of the parameters of the model be denoted by θ. I propose and use a penalized likelihood estimator where the scalar objective function $Q_n(\theta)$ is defined as:

$$Q_n(\theta) \quad = \tfrac{1}{n}\sum_{k=1}^{n} \ln f(y_k, \mathbf{d}_k | \mathbf{w}_k; \theta) - \tfrac{\lambda}{n}\sum_{\ell=1}^{L}\left\{1 - \tfrac{\sum_{k=1}^{n}\tilde{\varphi}_\ell(\mathbf{w}_k;\theta)}{s_\ell}\right\}^2, \tag{4.5}$$

[36] There is an active literature on estimating discrete-choice games that explicitly addresses this issue (Tamer 2003, Ciliberto and Tamer 2009, or Bajari, Hong, and Ryan 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.

[37] Had policy-specific lobbying expenditures been observed, the entry cost could have been identified from the minimum of the policy-specific lobbying expenditures.

for any given $\lambda > 0$, where $\tilde{\varphi}_\ell(\mathbf{w}_k; \theta)$ is the expected lobbying expenditures by interest group ℓ for policy k with attributes $\mathbf{w}_k$ for any $\ell = 1, ..., L$:

$$\tilde{\varphi}_\ell(\mathbf{w}_k; \theta) \equiv \int \varphi_\ell(\mathbf{v}_k, \pi_k, \mathbf{d}_k^*(\mathbf{v}_k, \pi_k); \theta) dG(\mathbf{v}_k, \pi_k | \mathbf{w}_k; \theta),$$

where $\mathbf{d}_k^*(\mathbf{v}_k, \pi_k)$ denotes the equilibrium lobbying participation profile given $(\mathbf{v}_k, \pi_k)$.[38] By Assumption 3, there is a unique $\mathbf{d}_k^*$ for any given $(\mathbf{v}_k, \pi_k)$.

The first part of the objective function is the average of the log-likelihood of observing $(y_k, \mathbf{d}_k)$ given $\mathbf{w}_k$ over each policy k. The second part of the objective function is the weighted average of the squared difference between the observed total lobbying expenditures and the model-predicted total lobbying expenditures by each player conditional on $\{\mathbf{w}_k\}_{k=1}^n$. Note that the equilibrium objects, $\Pr(Y = 1, \mathbf{D} = \mathbf{d}_k | \mathbf{w}_k; \theta)$ and $\tilde{\varphi}_\ell(\mathbf{w}_k; \theta)$, do not have a closed-form solution. Therefore, I simulate in obtaining the value for $Q_n(\theta)$ for any θ. These two parts of the objective function are weighted by λ.

Let $\hat{\theta}_n \in \arg\max_{\theta \in \Theta} Q_n(\theta)$ where $Q_n(\theta)$ is as defined in (4.5). Under some regularity conditions, this proposed estimator is consistent and asymptotically normally distributed. Intuitively, the estimator is consistent because as $n \to \infty$, the second part of the objective function converges to 0 and the first part is maximized at the true parameter. The choice of λ determines the efficiency of this estimator, but the consistency of the estimator holds for any positive value of λ. For more discussion on this estimator, see Appendix C.

5 Empirical Results

Table 7 shows the parameter estimates. The asymptotic standard errors are provided in parentheses.[39]

5.1 Model Fit

Using the estimated parameters, I simulate the data and calculate some key moments displayed in Table 8. The overall fit of the simulated data to the actual data is good in both the level and the trend. The table shows the actual and predicted moments regarding policy enactment, lobbying participation, and total lobbying expenditures.

In addition to the first order moments of the marginal distributions of policy enactment and lobbying participation, some first order moments of their joint distribution are also reported in the table. One set of such moments are the lobbying participation patterns of all four players by their lobbying positions. The other set of moments are the average enactment rate conditional on these lobbying participation patterns. Note that the enactment rate for the policies that were not lobbied is over-predicted (5.39 percent as opposed to zero), as is the frequency of lobbying by the supporters only (53.13 percent as opposed to 41.82 percent). This is related to the specification of the enactment production function in equation (3.1), where the marginal effect of supportive lobbying on the final enactment probability decreases as the initial enactment probability increases.

[38]A computation procedure of $\varphi_\ell(\mathbf{v}_k, \pi_k, \mathbf{d}_k^*(\mathbf{v}_k, \pi_k); \theta)$ is described in Appendix C.3.

[39]The reported standard errors of the parameters are based on the asymptotic variance matrix defined in Appendix C.1. The parameters are estimated at $\lambda = 50$. The sensitivity analyses in Appendix D.5 show that the results in Tables 7 and 8 are robust to a wide range of values of λ.

Table 7

Estimation results

Parameter	Estimate	Parameter	Estimate
β_f	6.73E-6*** (1.62E-6)	α_0*(Oil/Gas)*	18.8535*** (0.9510)
β_a	1.63E-4** (6.97E-5)	α_0*(Nuclear)*	18.4490*** (0.8818)
γ	0.2885*** (0.0350)	α_0*(Renewable)*	18.7940*** (0.9147)
δ_0	-1.2735*** (0.3123)	α_1*(Coal)*	1.4129* (0.7212)
δ_1*(Opinion)*	0.7297 (16.9400)	α_1*(Oil/Gas)*	1.0208* (0.5944)
δ_2*(Salience)*	-0.4342 (10.0442)	α_1*(Nuclear)*	1.1350 (0.8266)
δ_3*(More Reg.)*	-0.5851* (0.3038)	α_1*(Renewable)*	0.7538 (0.9688)
δ_4*(Less Reg.)*	-0.9364* (0.4829)	σ_η*(Coal)*	1.8333*** (0.5682)
δ_5*(More Spend.)*	-0.3380 (0.2811)	σ_η*(Oil/Gas)*	1.4468*** (0.4887)
σ_ξ	1.1578*** (0.3540)	σ_η*(Nuclear)*	1.5982*** (0.5570)
α_0*(Coal)*	18.2287*** (1.1985)	σ_η*(Renewable)*	1.3158*** (0.5216)

Note: Asterisk marks represent the statistical significance: 10 (*), 5(**), and 1(***) percent.

Table 8

Model fit

	Observed	Predicted
Policy Enactment (percent)		
All	8.35	8.43
By lobbying participation patterns		
Not lobbied	0.00	5.39
Lobbied by supporters only	8.44	7.32
Lobbied by opposition only	4.41	6.47
Lobbied by both sides	13.77	11.72
Participation (percent)		
By players		
Coal	49.63	49.02
Oil/Gas	66.73	65.17
Nuclear	49.07	51.27
Renewable	61.90	61.09
By lobbying participation patterns		
Not lobbied	14.50	4.28
Lobbied by supporters only	41.82	53.13
Lobbied by opposition only	12.64	12.81
Lobbied by both sides	31.04	29.77
Total Spending ($ million)		
Coal	77.85	77.15
Oil/Gas	73.21	73.76
Nuclear	33.91	32.66
Renewable	22.11	22.36

Table 9

Average value of a policy

($ million)	Not Directly Relevant	Directly Relevant
Coal	443.05 (373.31)	1,820.05 (1,692.59)
Oil/Gas	439.09 (333.52)	1,218.73 (1,021.51)
Nuclear	368.91 (336.69)	1,147.76 (1,143.16)
Renewable	362.18 (241.54)	769.64 (528.12)

Note: The asymptotic standard errors are provided in parenthesis.

Table 9 shows the estimated average value of a policy to each lobbying coalition. In the model, the policy value distribution depends on whether or not the policy is directly relevant to the lobbying group. When a policy is directly relevant to the group, the average value of the policy is estimated to be much higher than when it is not directly relevant. For example, a typical policy that directly affects the coal lobbying coalition, such as a clean coal subsidy, is estimated to be worth $1.8 billion, while other energy policies that target other coalitions are estimated to be valued at $443 million by the coal coalition on average.

One way to validate my estimates is to compare the estimated value distribution to the actual value distribution. However, private valuations of specific policies to each lobbying coalition are mostly unavailable, and therefore are not included in the estimation. In particular, the economic impact of an environmental or market regulation on the targeted industry, as well as on 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 directly spends money for private entities, and the authorized amount of money to be appropriated is listed. Among these policies, 22 are grants, R&D subsidies, or loans 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, and the standard deviation is $579 million. The average value of a policy which is directly relevant to the renewable energy lobbying coalition is estimated to be $770 million, as can be seen in Table 9.

5.2 The 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 absolute 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 k, conditional on participation profile $\mathbf{d}_k$ and observable characteristics $\mathbf{w}_k$, can be mathematically expressed as:

$$E\left[\left|\frac{F(\mathbf{z}_k\delta+\xi_k)+\beta_f\sum_{i\in\mathcal{L}_f}\phi_i(\mathbf{w}_k,\xi,\eta,\mathbf{d}_k;\theta)^\gamma}{1+\sum_{j\in\mathcal{L}}\beta_j\phi_j(\mathbf{w}_k,\xi,\eta,\mathbf{d}_k;\theta)^\gamma}-F(\mathbf{z}_k\delta+\xi_k)\right| |\mathbf{d}_k,\mathbf{w}_k\right].$$

Table 10

Effect of lobbying expenditures on policy enactment

(unit: percentage points)	Average Effect
All	0.054 [0.021, 0.415]
Enacted policies	0.091 [0.029, 0.642]
Not enacted policies	0.042 [0.017, 0.340]

Note: The numbers in brackets are 95 percent confidence intervals.

Based on this measure, I find that the difference is on average 0.054 percentage points with a 95 percent confidence interval $[0.021, 0.415]$.[40] As can be seen in Table 10, on average, neither enacted nor not-enacted policies were largely affected by lobbying expenditures. I find that even the largest effect of lobbying in the data is estimated to be 0.4 percentage points. The finding that lobbying expenditures hardly affect policy-making results from the following two channels. First, the effects of lobbying expenditures by competing interests partially cancel each other out. Second, the estimated enactment production function is such that the marginal effect of lobbying expenditures on the policy enactment probability is very small. I discuss these two channels in detail.

5.2.1 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 0.05 percentage points for those policies on which at least one of the lobbying coalitions lobbied. Out of 538 policies in the dataset, 460 policies were lobbied by at least one of the lobbying coalitions. Table 11 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. The second and the third columns show the effects of lobbying by supporting and opposing groups respectively, and each effect is calculated by simulating the expectation of the difference in the enactment probability due to the supporting (or opposing) lobbying expenditures, conditional on the observed participation profile and observable characteristics of the policy and lobbying coalitions.

Both supporting and opposing lobbying occurred for 167 policies in the dataset, and the lobbying efforts by both sides partially canceled each other out. To quantify this canceled-out effect, I use a measure as defined as the ratio of twice the minimum of these two effects by each side to the sum of these effects. For example, suppose that supporting groups increased the enactment probability of a policy by 2 percentage points and opposing groups decreased it by 8 percentage points, resulting in a 6-percentage-point decrease in the end. In this scenario, by adding the absolute value of each group's effects, we have a potential total change in the enactment probability of 10 percentage points, while 4 percentage points of the probability changes are wasted. Based on the aforementioned measure, 40 percent of the lobbying effects are canceled-out here. Using this measure, I find that when both sides lobbied, about 20

[40] These statistics are based on the simulation of the equilibrium enactment probability of 460 policies for which at least one of the lobbying coalitions in the data engaged in lobbying activities.

Table 11

Average effect of lobbying expenditures by lobbying positions

Lobbied by:	Effect by Supporters	Effect by Opposition
Supporters Only	0.027 [0.009,0.059]	-
Opposition Only	-	-0.050 [-0.538,-0.012]
Both	0.019 [0.007, 0.042]	-0.099 [-1.000,-0.014]

Note: Units are in percentage points and the numbers in brackets are 95 percent confidence intervals.

percent of the effects of lobbying expenditures by each side canceled each other out, with a 95 percent confidence interval [9.79, 23.26] percent.

5.2.2 Enactment Production Function

Based on the estimates of β and γ, I conclude that the effect of lobbying expenditures on the policy enactment probability is very small even without the canceling-out effect. To illustrate this point, I calculate the effect of additional lobbying expenditures ($\triangle s_{\ell,k}$) by lobbying coalition ℓ on the probability that policy k is enacted, assuming ℓ is the only coalition which is interested in the policy. If the lobbying coalition favors the policy, the effect (or the change in the enactment probability) can be mathematically represented as:

$$\triangle Pr(Enactment|\triangle s_{\ell,k}, s_{\ell,k}, \pi, \ell \in \mathcal{L}_f, \mathbf{s}_{-\ell,k} = \mathbf{0}) = \frac{\pi + \beta_f (s_{\ell,k} + \triangle s_{\ell,k})^\gamma}{1 + \beta_f (s_{\ell,k} + \triangle s_{\ell,k})^\gamma} - \frac{\pi + \beta_f s_{\ell,k}^\gamma}{1 + \beta_f s_{\ell,k}^\gamma},$$

where π is the initial enactment probability and $\mathbf{s}_{-\ell}$ is the vector of lobbying expenditures by all other lobbying coalitions. Similarly, if ℓ opposes the policy, the effect can be represented as:

$$\triangle Pr(Enactment|\triangle s_{\ell,k}, s_{\ell,k}, \pi, \ell \in \mathcal{L}_a, \mathbf{s}_{-\ell,k} = \mathbf{0}) = \frac{\pi}{1 + \beta_a (s_{\ell,k} + \triangle s_{\ell,k})^\gamma} - \frac{\pi}{1 + \beta_a s_{\ell,k}^\gamma}.$$

Note that this effect, regardless of the position of lobbying coalition ℓ, depends on $s_{\ell,k}$ and π. First, in both cases, the smaller $s_{\ell,k}$ is, the larger the change in the enactment probability is, given $\triangle s_{\ell,k}$. Second, if ℓ lobbies the government for the policy, the change in the enactment probability is the largest when $\pi = 0$. On the other hand, if ℓ is in opposition to the policy, the change in the enactment probability is the largest when $\pi = 1$.

In Table 12, the changes in the enactment probability are shown when the sole lobbying player either supports or opposes the policy, as a function of the change in lobbying spending by player ℓ ($\triangle s_{\ell,k}$). As discussed earlier, the change in the enactment probability depends on $s_{\ell,k}$ and π, and I set $s_{\ell,k}$ and π such that the effect of the additional lobbying expenditures is the largest. The choices of $\triangle s_{\ell,k}$ are closely related to the data: \$66,000 is the average per-policy lobbying expenditure by the renewable energy lobbying coalition, and \$3 million is over ten times as much as the average per policy lobbying expenditures by the coal lobbying coalition. There are two notable trends in the results: First, the effect of lobbying expenditures is fairly small even when only one player lobbies and spends a large amount of money (such as \$3 million); and second, the effect of lobbying expenditures is much larger when players lobby against a policy than when they lobby in favor of it.

Table 12

Change in enactment probability as lobbying spending increases

$\triangle s_{\ell,k}$	$\triangle Pr(Enactment)$	
	ℓ in Support	ℓ in Opposition
	$(\pi = 0, s_{\ell,k} = 0, \mathbf{s}_{-\ell,k} = 0)$	$(\pi = 1, s_{\ell,k} = 0, \mathbf{s}_{-\ell,k} = 0)$
\$1,000	0.005 [0.005,0.005]	-0.120 [-0.126,-0.113]
\$66,000	0.017 [0.017,0.017]	-0.399 [-0.507,-0.291]
\$3,000,000	0.050 [0.049,0.051]	-1.191 [-2.476,0.095]

Note: Units are in percentage points and the numbers in brackets are 95 percent confidence intervals.

5.2.3 Status Quo Bias

The finding that the effect of lobbying expenditures is very small even when there is no lobbying by opponents may run counter to conventional wisdom. However, this finding is consistent with the findings in most papers that focus on the causal relationship between campaign contributions and the voting behavior of legislators.[41] Among the empirical studies on lobbying, Baumgartner, Berry, Hojnacki, Kimball, and Leech (2009) reach similar conclusions. To my knowledge, this is the only study in the literature, aside from my paper, that focuses on lobbying activities regarding various policy issues. The authors study 98 randomly selected policies from the years 1999–2002, conducting multiple, extensive interviews with key advocates. They find that lobbying in general has a very small effect on policy-making.

They also find a modest correlation between the resource advantage of a lobbying organization and its lobbying success when the organization is in favor of the status quo. They argue that there are various ways in which the opponents of a proposed policy are at an advantage. First, governmental and public attention are limited. As a result, the proponents of a policy change often struggle to drum up interest in a specific issue. Second, there are multiple veto points in the policy-making process, from committee actions to final approval by the president. For the proponents of a proposed policy to be ultimately successful, they must be successful at all veto points. However, a policy's opponents need only be successful at any one of the various veto points to achieve their policy goals. Third, opponents often have a very compelling and easily-constructed lobbying argument: they can simply focus on the uncertainty following and unknown consequences of a possible change in policy.

The large asymmetry in the estimated effect of lobbying arises from particular features of the data and the policy enactment production function. Given the policy enactment production function specified in equation (3.1), for a supporter (opponent), the benefit of lobbying participation decreases (increases), ceteris paribus, as the initial enactment probability increases:

$$\frac{\partial \left\{ \Pr(Enact. | s_{\ell,k}, \mathbf{s}_{-\ell,k}; \pi) - \Pr(Enact. | s_{\ell,k} = 0, \mathbf{s}_{-\ell,k}; \pi) \right\}}{\partial \pi} < 0 \quad \text{if } \ell \in \mathcal{L}_f,$$
$$\frac{\partial \left\{ \Pr(Enact. | s_{\ell,k} = 0, \mathbf{s}_{-\ell,k}; \pi) - \Pr(Enact. | s_{\ell,k}, \mathbf{s}_{-\ell,k}; \pi) \right\}}{\partial \pi} > 0 \quad \text{if } \ell \in \mathcal{L}_a.$$

Therefore, the lower the initial probability of enactment is, the more likely it is for a supporter to lobby and the less likely it is for an opponent to lobby. This feature is consistent with

[41] See Ansolabehere, de Figueiredo, and Snyder (2003) for a summary.

the evidence presented by Baumgartner, Berry, Hojnacki, Kimball, and Leech (2009). Based on their interviews, the authors find that for the policy proposals that have little chance of success, supporters are active while opponents often find little need to assert themselves or even to register their disagreement.

Given the policy enactment production function, the final enactment probability for policies with supporting lobbying only would, on average, be much smaller than that for policies with opposing lobbying only if (i) the effect parameters for the supporting and opposing lobbying were the same, and (ii) the supporters and opponents have the same policy value distributions (in magnitudes). In the data, as can be seen in Table 4, the difference between the final enactment probabilities when there was supporting lobbying only and when there was opposing lobbying only is not statistically significant. Therefore, it must be the case that either condition (i) or (ii) was not satisfied. Based on the average number of directly benefited and harmed players, condition (ii) seems to be satisfied: For the policies with supporting (opposing) lobbying only, the average number of directly benefited (harmed) lobbying coalitions is 1.44 (1.33), while the average number of those directly harmed (benefited) is 0.07 (0.25). This leaves us one possibility, which is that the effect parameters for supporting and opposing lobbying are not the same. In particular, opponents must be more effective than supporters to rationalize their lobbying participation even when the initial enactment probability is small.[42]

5.2.4 Caveats

In interpreting the findings here, one may consider the following issues. First, this study is focused on energy policies in legislation and energy industry lobbying during the 110th Congress. Therefore, one should not generalize the findings here to a different policy issue or a different Congress.[43] Second, the results in this paper do not imply that the policy-making outcomes would be more or less unchanged should lobbying be completely banned. The reason for this is that some part of the lobbying activities may be directed towards shaping the pool of policies to be discussed in the Congress. Because these are not documented in the lobbying reports in general, I take the list of policies as exogenously given. It is also possible that the mere presence of the interest groups in Washington, which are often well-equipped with other political instruments such as public advertising and grassroots mobilization, may deter certain policies from being on the agenda in the Congress. What the findings in this paper *can* say is that once a policy is formally introduced to Congress in a piece of legislation, the effect of lobbying on its enactment is very small.

5.3 Average Returns to Lobbying

To calculate the average returns to lobbying, I first consider the expected net benefit to lobbying coalition ℓ from spending $s_{\ell,k}$ to lobby on policy k. The expected net benefit depends on the lobbying expenditures of all coalitions ($\mathbf{s}_k$), the initial enactment probability of the

[42]When estimating a similar model with a different enactment production function, this asymmetry may disappear. This is related to how the benefit of lobbying participation is related to the initial enactment probability. In Appendix D.2, I discuss the estimation results based on the alternative enactment production function, and explain why the asymmetric effects disappear.

[43]However, the model fit exercises in Appendix E indicate that the estimates of the model based on the 110th Congress can explain policy enactment and lobbying in the subsequent two Congresses reasonably well.

Table 13

Average returns from lobbying expenditures

	Average Value of Policy (million dollars)	Average Returns to Lobbying (percent)
Coal	802.30 [195.12, 5,296.90]	145.80 [80.28, 318.62]
Oil/Gas	823.53 [221.76, 4,700.12]	151.86 [93.79, 273.16]
Nuclear	522.08 [130.06, 3,932.33]	139.24 [72.76, 248.80]
Renewable	549.02 [250.92, 2,188.14]	136.99 [87.08, 288.99]

Note: The numbers in brackets are 95 percent confidence intervals.

policy (π_k), and the policy values to the coalitions ($\mathbf{v}_k$). I denote the expected net benefit by $b_{\ell,k}$:

$$b_{\ell,k}(\mathbf{s}_k, \pi_k, \mathbf{v}_k) \equiv \{\Pr(Enact.|s_{\ell,k}, \mathbf{s}_{-\ell,k}, \pi_k) - \Pr(Enact.|s_{\ell,k} = 0, \tilde{\mathbf{s}}_{-\ell,k}, \pi_k)\} v_{\ell,k} - s_{\ell,k} - c_{\ell,k},$$

where $\tilde{\mathbf{s}}_{-\ell,k}$ is the vector of the optimal lobbying expenditures by the other coalitions if coalition ℓ does not lobby, which can be solved as a function of $(\pi_k, \mathbf{v}_k)$.[44] Here, an important component is the counter-factual enactment probability, $\Pr(Enact.|s_\ell = 0, \tilde{\mathbf{s}}_{-\ell,k}(\pi_k, \mathbf{v}_k), \pi_k)$. In the existing literature, this counter-factual enactment probability is ignored, which may lead to over-estimation of the average returns.

If we observed all arguments in $b_{\ell,k}(\cdot)$, the average returns to lobbying would be simply defined as $b_{\ell,k}(\mathbf{s}_k, \pi_k, \mathbf{v}_k)/s_{\ell,k}$. However, we observe none of the arguments in the expected net benefit. Instead, we observe policy attributes ($\mathbf{w}_k$) and lobbying participation profile ($\mathbf{d}_k$). Therefore, I construct the expectation of average returns to lobbying conditional on $(\mathbf{w}_k, \mathbf{d}_k)$:

$$E\left(\frac{b_{\ell,k}(\mathbf{s}_k, \pi_k, \mathbf{v}_k)}{s_{\ell,k}} \mid \mathbf{w}_k, \mathbf{d}_k\right),$$

where the expectation is taken over $(\pi_k, \mathbf{v}_k)$ conditional on $(\mathbf{w}_k, \mathbf{d}_k)$. Based on the estimated parameters of the model, I calculate the above returns for each policy, and report the average values in Table 13. Note that the structural approach in this paper allows me to calculate this object.

As can be seen in Table 13, I find that the returns to lobbying are similar among the lobbying coalitions, and that they range from about 137–152 percent. Although the effect of lobbying on the enactment probability in equilibrium is estimated to be small, the average returns to lobbying are estimated to be large because the average value of a policy is very large. In the table, I also show the estimated average value of a policy to each lobbying coalition. For example, to the coal coalition, the average value of a policy is estimated to be $802 million, while the average lobbying expenditure by the coalition per policy upon lobbying participation is $291,588.

[44]An alternative counter-factual enactment probability is $\Pr(Enact.|s_\ell = 0, \mathbf{s}_{-\ell,k})$. However, this is not consistent with the model where lobbying participation decisions are made before making lobbying expenditure decisions.

Table 14
Bill content and lobbying

(unit: percent)	With Unique Policies Only		With Policies in Other Bills	
	Single-Policy	Multi-Policy	Single-Policy	Multi-Policy
Num. of Obs.	80	14	179	172
Enacted	0.0 (0.5)	0.0 (0.0)	0.6 (0.6)	2.3 (1.2)
Lobbied by coal	7.5 (3.0)	7.1 (7.1)	58.1 (3.7)	89.5 (2.3)
Lobbied by oil/gas	38.8 (5.5)	28.6 (12.5)	78.2 (3.1)	95.9 (1.5)
Lobbied by nuclear	12.5 (3.7)	14.3 (9.7)	65.4 (3.6)	90.1 (2.3)
Lobbied by renewable	33.8 (5.3)	38.6 (12.5)	68.2 (3.5)	95.3 (1.6)

Note: The numbers in parentheses are standard errors.

5.4 Gains from Policy-Level Analysis

In understanding and quantifying how effective interest group lobbying is on legislation, a popular empirical approach has been to focus on a particular bill and study the causal relationship between politicians' votes on that bill and interest group pressure. For example, Caldeira and Wright (1998) study the U.S. Senate votes on three supreme court nominations, and Mian, Sufi, and Trebbi (2010) study the U.S. House Representatives votes on the historic financial industry bailout bill, the Emergency Economic Stabilization Act of 2008.[45]

One implicit assumption used in this literature is that the content of a bill is taken as exogenously given. However, it has been documented that lobbyists assist legislators in the writing of bills (Hall and Deardorff (2006)); and that they affect the participation behavior of members in committees where bills are discussed and amended before a floor vote (Hall and Wayman (1990)).

To study the relationship between lobbying and bill content, I construct bill-level moments on enactment and lobbying participation computed over four exclusive subsets of the 445 bills in the data, as presented in Table 14. The divisions are based on (i) whether a bill includes a single policy or multiple ones, and (ii) whether any of the policies contained in the bill appear in other bills or not. One notable feature in the table is that the enactment rate is much lower in the bill-level data (1.1 percent) than in the policy-level data (8.4 percent). This difference is explained by the fact that 87 bills out of the 440 failed bills (19.8 percent) contain policies that were later enacted. Another feature seen in the table is that bills containing policies that appear in other bills are more likely to be enacted and are more heavily lobbied than those without such policies.

By taking policies as the unit of analysis, I take into account the potential effects of lobbying on the composition of bills, which eventually affects enactment. Bill-level analyses, on the other hand, are limited in incorporating such effects. This may lead to either positive or negative bias in the estimated effects of lobbying expenditures on bill enactment. To see this, consider a typical enactment outcome equation for a bill, which consists of observed bill characteristics, lobbying expenditures on that bill, and an error term. In that equation, lobbying expenditures on other related bills are omitted. However, they may affect the enactment of the bill and are potentially correlated with bill characteristics. Furthermore, any observed bill

[45]Note that this bill is also included in my dataset. It was originally entitled "Paul Wellstone Mental Health and Addiction Equity Act of 2007." In response to the subprime mortgage crisis in 2008, the bill was later enacted as a financial industry bailout bill with additional, unrelated provisions such as energy policies.

Table 15

Comparison of estimation results at the bill level

	Bill-level Analysis	Policy-level Analysis
Effect of lobbying (percentage points)		
All	0.144 [0.043, 0.774]	0.054 [0.021, 0.808]
Enacted bills	0.251 [0.007, 0.767]	0.075 [0.022, 0.592]
Non-enacted bills	0.126 [0.375, 0.681]	0.054 [0.021, 0.812]
Average value of a bill ($ million)		
Coal	324.3 [125.1, 1,598.3]	2,255.2 [536.2, 15,412.4]
Oil/Gas	385.2 [155.5, 1,356.8]	1,555.4 [424.6, 9,107.0]
Nuclear	197.4 [46.76.1, 1,409.9]	1,427.8 [343.8, 10,978.0]
Renewable	182.9 [65.2, 420.0]	1,509.0 [666.0, 6,552.6]

Note: The 95 percent confidence intervals are in brackets.

characteristics related to the content of the bill are potentially correlated with the error term in the enactment equation because bill contents are endogenously determined. In sum, the bill-level estimation results may be biased due to the combination of omitted variables such as lobbying expenditures on other related bills and endogenous selection of the bill content.

To quantify the degree of such bias, I estimate the model using the bill-level data. In doing so, the specification of the model is slightly adjusted so that the initial enactment probability of a bill in equation (3.2) and the value of the bill to a lobbying coalition in equation (3.3) are allowed to depend on the characteristics of the policies contained in the bill.[46] To compare these estimation results with those using the policy-level data, I simulate the original model at the policy level and aggregate the results to the bill level to construct the moments in Table 15.[47] As can be seen in the table, the effects of lobbying expenditures on the probability that a bill is enacted are estimated to be much larger in the bill-level analysis than those in the policy-level analysis, while the value of a typical bill in the data is estimated to be much lower.

Additionally, one could utilize the bill-level data to analyze the process by which policies are bundled into bills. Legislative bargaining and agenda setting have long been theoretically studied (see, for example, the seminal work of Baron and Ferejohn (1989)), but empirical research in this area is scant. Unpacking the process by which lobbying efforts are converted into political outcomes in such a manner would allow one to gain a better understanding of the mechanisms at play. This topic is left for future research.

[46]Specifically, I allow that the initial enactment probability of a bill may depend on an indicator variable that takes 1 if the bill includes at least 15 energy policies and 0 otherwise, as well as the maximum values of the public opinion variables (*salience* and *public opinion*) and the dummy variables on the policy content (*more regulation*, *less regulation*, *more government spending*) over all the policies contained in the bill. The value of a bill to a lobbying coalition is defined as the sum of the values of the policies contained in the bill, where the absolute value of each policy is log-normally distributed as in equation (3.3).

[47]When aggregating the results to the bill-level, I use the composition of the bills in the data. The effect of lobbying expenditures on the enactment of a bill is defined as the average of such effects on the policies contained in that bill.

6 Conclusion

In this paper, I have presented a unique 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 debut a novel unit of analysis: policies, which are parts of bills, rather than bills themselves as in previous works. This is particularly relevant for the study of lobbying behaviors because the content of a bill can and often does change throughout the entirety of the legislative process. I show that bill-level analyses which take the content of a bill as exogenously given can generate biased estimates of the effects of lobbying expenditures on policy changes.

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. I find that the effect of lobbying expenditures on a policy's equilibrium enactment probability is very small. Nonetheless, the average returns from lobbying expenditures are estimated to be over 130 percent. In this study, I focus on energy policies and lobbying activities targeting these policies by energy firms. Given that lobbying expenditures by the energy sector comprise 12 percent of all lobbying expenditures, these findings are interesting in their own right, though it remains to be seen whether the results for lobbying in the energy sector will extend to lobbying in other domains. The approach developed in this paper can however be applied to study the effects of lobbying in other policy domains.

The findings are closely related to the puzzle that the total amount of lobbying expenditures is relatively small when compared to the value of the government policies they are intended to influence. A similar observation regarding campaign contributions was made by Tullock (1972) and Ansolabehere, de Figueiredo, and Snyder (2003). If lobbying is a part of the economic activities of interest groups, one potential explanation for the puzzle is that the average returns to lobbying are small. However, I find that the average returns are much larger than normal market returns. Furthermore, papers that look at lobbying expenditures and stock returns, such as Hill, Kelly, Lockhart, and Ness (2013), find that shareholders value lobbying activities. This implies that lobbyists could charge the interest groups much more, but they do not.

This suggests that significant frictions may exist in the market for policy influence. One such friction is limited access to the market. Granted, in this paper, I impose very minimal market frictions on the four energy lobbying coalitions. The only friction in the model is that the coalitions are supposed to incur the minimum initial lobbying costs. However, this almost unrestricted access to the market may be available only to certain firms and trade associations. Another friction in the market is related to political organization as described by Olson (1965). A further study on these potential frictions in the market can be very important to our understanding of the policy-making process and the welfare implications of the regulation of lobbying.

Appendix

A. Data Construction

A.1. Sample Selection Rule

The dataset covers all bill sections that create, modify, or repeal a federal financial intervention or regulation whose main statutory subject is coal, oil, nuclear or renewable energy companies, or electric and gas utilities. The challenge is to effectively winnow out all relevant bill sections from the pool of over 11,000 bills and joint resolutions that were introduced during the 110th Congress. By employing the following procedure, I select 2,279 bill sections that are contained in 445 bills and joint resolutions.

First, I divide all versions of bills and joint resolutions into sections as defined in the text.[48] Then, I select 9,613 bill sections based on the words in the title of the bill section. With a program I coded for this specific purpose, I check each section to determine if its title includes at least one word related to the energy industry. The number of the words I include in my search is over 500; all words are related to various energy sources (coal, oil, natural gas, nuclear, and renewable energy), electricity, and environmental regulations. Lastly, I read each section in order to exclude the sections whose main statuary subjects are not coal, oil, nuclear, or renewable energy companies, or electric and gas utilities. For example, a bill section regarding energy-efficient government buildings may include the term "energy-efficient," but it is not directly related to the energy industry that I study in this paper.

A.2. Bill Sections vs. Policies

Here, I describe the procedures to determine the unit of analysis–a policy–and its final legislative status, namely, whether or not it was enacted. First, based on a vector space model, I represent the sections by corresponding vectors based on word frequency, and measure the distance between the vectors by calculating the cosine of the angle between them. When the cosine measure is 0, the sections have no similarity because it means that there are no words that exist in both sections. On the other hand, when the measure is 1, the sections are equal because it means that all words used in one section are also used in the other section with the same frequency. Although the ordering of the words may be different, this is of less concern because bills are written in a formulaic manner.

Second, I group the bill sections based on the measured distances. I consider two texts whose distance is greater than or equal to 0.985 as the same, or *connected*, as defined in the graph theory. With this cutoff, it is reasonable to consider that the two connected texts are essentially the same. Third, using a Matlab routine to find connected components in graph (graphconncomp.m), I group the 2,279 bill sections into 962 components. On average and based on the metric, 2.4 bill sections are considered to be the same. For example, creating a production tax credit for electricity produced from marine renewable resources appeared in 32 different bill sections in the exact same terms. The distribution of the number of bill sections that are categorized as one component is shown in Figure 6.1.

[48] The text of each version of a bill or a joint resolution is available on the website of the Government Printing Office. Note that a bill or a joint resolution may have multiple versions as it goes through the legislative process.

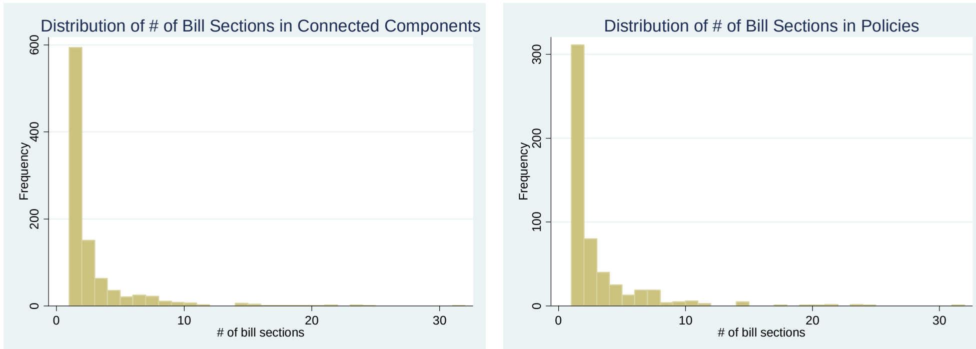

Figure 6.1
Bill Sections vs. Policies

Table 16
Movement of policies across bills

Status of First Bill	Status of Last Bill	Obs.	# of Bills	
			Mean	SD
Introduced	Introduced	387	1.92	1.66
	Reported, Not Enacted	76	6.03	5.29
	Enacted	30	8.67	6.14
Reported, Not Enacted	Reported, Not Enacted	30	2.90	2.44
	Enacted	15	5.14	4.31
Total		538	3.01	3.56

Lastly, I combine some components if (i) they address the same policy issue and (ii) they affect each of the lobbying coalitions in the same direction, either positively or negatively. Two different policy proposals or bill sections are considered to address the same policy issue if they either amend the same section(s) of the United States Code, or create a new section with the same or a very similar title. After this procedure, the 962 components are re-grouped into 538 groups, with each group representing a policy in the analysis. On average, each policy appeared in about 3 different bills. The distribution of the number of bill sections that are categorized as one policy is shown in Figure 6.1. Table 16 shows the average and the standard deviation of the number of bills across which a policy moved during the two-year term of the Congress, conditional on the legislative status of the first bill and the last bill. The legislative status of the last bill determines the final status of the policy. Most policies (494 policies) began with a bill when it was introduced to the Congress, while the remainder were inserted into bills after they were initially introduced. Typically, a new section can be added to an original bill as the bill goes through the committee(s) and the floor of House and Senate. Most policies (388 policies) did not pass or were not reported by the committee(s), although they were often reintroduced as a part of another bill. It can also be seen that those policies which were finally enacted were included in about 6 bills on average.

Table 17

List of of entities in the energy lobbying coalitions

Lobbying Coalition	List of Entities
Coal (10)	Ameren Corporation, American Coalition for Clean Coal Electricity, American Electric Power, Duke Energy, Edison Electric Institute, Energy Future Holdings Corporation, National Mining Association, Peabody Energy, Southern Company, Xcel Energy
Oil/Gas (8)	American Petroleum Institute, BP, Chevron Corporation, ConocoPhillips, ExxonMobil, Koch Industries, Marathon Oil, Shell Oil
Nuclear (12)	Areva Group, Constellation Energy, Dominion Resources, EnergySolutions Inc., Entergy Corporation, Exelon Corporation, FPL Group (now NextEra Energy), General Atomics, Nuclear Energy Institute, Pinnacle West Capital, Public Service Enterprise Group, USEC Inc.
Renewable Energy (12)	American Wind Energy Association, Archer Daniels Midland, Climatemaster Inc., Covanta Energy Corp, Farmers Educational Cooperative Union (known as National Farmers Union), National Biodiesel Board, National Hydropower Association, New Generation Biofuels, PG&E Corporation, Poet LLC, Renewable Fuels Association, Solar Energy Industries Association

A.3. Energy Firms in the Lobbying Disclosure Data

In total, there are 559 firms and associations in the energy sector which filed at least one lobbying report during 2007–2008.[49] In identifying firms or associations in the energy sector, one of the main challenges is that there is no standard identifier for companies or organizations. To overcome this challenge, I merge my dataset with the dataset compiled and cleaned by the Center for Responsive Politics (CRP) to determine the industry in which a lobbying client is involved and to figure out parent-subsidiary relationships and the changes in the names of companies, due for example to mergers and acquisitions. I also did my own research on firms and trade associations by checking their websites and the website of *Bloomberg Businessweek* (investing.businessweek.com) when the information in the CRP dataset was not sufficient.

In the analysis, I designate certain firms and trade associations as *strategic* or *major* in lobbying the legislature on energy policies, and assume that they lobby cooperatively as *lobbying coalitions.* The members of lobbying coalitions are listed in Table 17.

[49] I exclude the following firms and associations which can be considered as in the energy sector: (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).

Table 18

Energy bills in the 111th–112th Congresses (2009–2012)

Congress	Final Status	Total # of Bills	# of Bills Not Containing Similar Issues in the 110th
111	Enacted	4	3
111	Passed One House	15	9
112	Enacted	2	2
112	Passed One House	16	11
Total		37	24

A.4. Energy Bills in the 111th and the 112th Congresses

To provide additional validity to my finding that most of the energy policies discussed in the 110th Congress were not discussed again in the following two Congresses, I look at all bills during the period that (i) were either enacted or passed by one House, (ii) were categorized as "Energy" or "Environmental" by the Congressional Research Service, and (iii) contain policies that directly affect the energy industry.

This analysis is complementary to the policy tracking because I record whether or not a bill contains a similar policy issue discussed in the 110th Congress by actually reading the text, not by calculating the numerical distance between texts. Because this analysis requires careful reading of bill texts, not all bills were studied; only those that satisfy the aforementioned conditions were read and compared to the policies discussed during the 110th Congress.

As can be seen in Table 18, 65 percent of the energy bills that were enacted or passed by either House during the four-year period contain only the issues that were never discussed during the 110th Congress. Examples of these bills are S. 3473 on the Deepwater Horizon oil spill, which was enacted during the 111th Congress, and H.R. 1938 on the Keystone XL pipeline project, which was passed by the House but not by the Senate during the 112th Congress.

B. Existence and Uniqueness of Pure-strategy Equilibrium in the 2nd Stage

Proof. The proof is constructive and is similar to the arguments in Szidarovszky and Okuguchi (1997). Suppose the set of the participants are given in the first stage: $\mathcal{L}_f^E \subset \mathcal{L}_f$ and $\mathcal{L}_a^E \subset \mathcal{L}_a$. Let me define the following variables: $t_i \equiv \beta_i s_i^\gamma$, where β_i is either β_f or β_a depending on i's position; $T_f \equiv \sum_{j\in\mathcal{L}_f^E} t_j$; $T_a \equiv \sum_{j\in\mathcal{L}_a^E} t_j$; and $T_{-i,f} \equiv \sum_{j\in\mathcal{L}_f^E-\{i\}} t_j$. Suppose player i lobbies for a policy. The player solves the following maximization problem given $\{\pi, T_{-i,f}, T_a\}$:

$$\max_{t_\ell} \frac{\pi + t_i + T_{-i,f}}{1 + t_i + T_{-i,f} + T_a} v_i - \left(\frac{1}{\beta} t_i\right)^{\frac{1}{\gamma}}.$$

If t_i^* maximizes player i's expected payoff , t_i^* must satisfy the first order condition:

$$\frac{1 - \pi + T_a^*}{(1 + T_f^* + T_a^*)^2} |v_i| - \frac{1}{\beta_f \gamma} \left(\frac{1}{\beta_f} t_i^*\right)^{\frac{1-\gamma}{\gamma}} = 0, \tag{6.1}$$

where T_f^* and T_a^* are equilibrium outcomes. Using the definition that $T_f^* \equiv \sum_{j\in\mathcal{L}_f} t_j^*$ and (6.1), we can derive the following equation:

$$T_f^* = \sum_{i\in\mathcal{L}_f^E} \beta_f \left(\frac{\beta_f\gamma|v_i|(1-\pi+T_a^*)}{(1+T_f^*+T_a^*)^2}\right)^{\frac{\gamma}{1-\gamma}}. \tag{6.2}$$

Similarly, using the first order condition of opposing players, we can derive the following equation:

$$T_a^* = \sum_{j\in\mathcal{L}_f^E} \beta_a \left(\frac{\beta_a\gamma|v_i|(\pi+T_f^*)}{(1+T_f^*+T_a^*)^2}\right)^{\frac{\gamma}{1-\gamma}}. \tag{6.3}$$

Note that the payoff functions are concave, so the first order conditions are sufficient and necessary for optimality.

Now, let S^* denote $T_f^*+T_a^*$. Then equations (6.2) and (6.3) can be rewritten as:

$$S^* - T_a^* = c_f\left(\frac{1-\pi+T_a^*}{(1+S^*)^2}\right)^{\frac{\gamma}{1-\gamma}}, \tag{6.4}$$

$$S^* - T_f^* = c_a\left(\frac{\pi+T_f^*}{(1+S^*)^2}\right)^{\frac{\gamma}{1-\gamma}}, \tag{6.5}$$

where $c_f \equiv \sum_{i\in\mathcal{L}_f} \beta_f\left(\beta_f\gamma|v_i|\right)^{\frac{\gamma}{1-\gamma}}$ and $c_a \equiv \sum_{j\in\mathcal{L}_a} \beta_a\left(\beta_a\gamma|v_j|\right)^{\frac{\gamma}{1-\gamma}}$. Based on equation (6.4), we can derive T_a^* as a function of S^*, denoted as $\psi_a(S^*)$. Similarly, based on equation (6.5), we can derive T_f^* as a function of S^*, denoted as $\psi_f(S^*)$. Note that $0 \le \psi_f(S) \le S$ if and only if $S \ge S_{0f}$ where S_{0f} satisfies $S_{0f}(1+S_{0f})^{\frac{2\gamma}{1-\gamma}} = \pi^{\frac{\gamma}{1-\gamma}} c_a$. Similarly, $0 \le \psi_a(S) \le S$ if and only if $S \ge S_{0a}$ where S_{0a} satisfies $S_{0a}(1+S_{0a})^{\frac{2\gamma}{1-\gamma}} = (1-\pi)^{\frac{\gamma}{1-\gamma}} c_f$. Let me define the following function, $\Psi(S)$:

$$\Psi(S) \equiv \psi_f(S) + \psi_a(S) - S. \tag{6.6}$$

Note that the proof is done if $\Psi(S) = 0$ has a unique solution. By differentiating equations (6.4) and (6.5) with respect to S, we obtain

$$\psi_f'(S) = \left(1+\frac{2\gamma}{1-\gamma}\frac{S-T_f}{\pi+T_f}\right) \Big/ \left(1+\frac{\gamma}{1-\gamma}\frac{S-T_f}{\pi+T_f}\right),$$
$$\psi_a'(S) = \left(1+\frac{2\gamma}{1-\gamma}\frac{S-T_a}{1+S}\right) \Big/ \left(1+\frac{\gamma}{1-\gamma}\frac{S-T_a}{1+\pi+T_a}\right).$$

Note that $\psi_f'(S) \ge 0$ and $\psi_f'(S) \ge 0$ as long as $S \ge S_0 \equiv \max\{S_{0f}, S_{0a}\}$. Note also that $\psi_f'(S) \ge 1$ if and only if $\frac{\pi+T_f}{1+S} \ge \frac{1}{2}$; and $\psi_a'(S) \ge 1$ if and only if $\frac{1-\pi+T_a}{1+S} \ge \frac{1}{2}$. Therefore, $\psi_f'(S) \ge 1$ if and only if $S \ge S_f$ where $\psi_f(S_f) = \frac{1}{2}S_f - \pi + \frac{1}{2}$. Similarly, $\psi_a'(S) \ge 1$ if and only if $S \ge S_a$ where $\psi_a(S_a) = \frac{1}{2}S_a + \pi - \frac{1}{2}$. Without loss of generality, let us assume that $S_f \le S_a$. Now there are three possible cases: (Case I) $S_f \le S_0 \le S_a$; (Case II) $S_0 \le S_f \le S_a$; and (Case III) $S_f \le S_a \le S_0$. I show that in each case, a unique solution S^* exists. In (Case I), $S^* \in [S_0, S_a]$. First, if $S < S_0$, then either $\psi_f(S)$ or $\psi_a(S)$ is negative. Second, $\Psi(S_0)$ is

$\psi_f(S_0) - S_0$ if $S_0 = S_{0a}$, and is $\psi_a(S_0) - S_0$ if $S_0 = S_{0f}$. In either case, $\Psi(S_0) \leq 0$. As for $\Psi(S_a)$,

$$\begin{aligned}
\Psi(S_a) &= \psi_f(S_a) + \psi_a(S_a) - S_a \\
&= \psi_f(S_a) + \left(\frac{1}{2}S_a + \pi - \frac{1}{2}\right) - S_a \\
&\geq \left(\frac{1}{2}S_a - \pi + \frac{1}{2}\right) + \left(\frac{1}{2}S_a + \pi - \frac{1}{2}\right) - S_a = 0.
\end{aligned}$$

The second equality results from the definition of S_a, and the third equality results from the fact that $S_f \leq S_a$. Third, for any $S \geq S_0$, $\Psi(S)$ is strictly increasing because $\psi_f(S) \geq 1$ and $\psi_a(S) > 0$. Note also that if $S > S_a$, then $\Psi(S) > \Psi(S_a) \geq 0$. In (Case II), $S^* \in [S_0, S_f]$, and the argument is similar. In the last case, (Case III), $S^* \geq S_0$ because $\Psi(S_0) \leq 0$, and $\Psi(S)$ is strictly increasing in $S \geq S_0$ as $\psi_f'(S) \geq 1$ and $\psi_a'(S) \geq 1$. □

C. Estimator

C.1. Asymptotic Variance of the Estimator

One can show that under regularity conditions as described in Theorem 4.1.3 in Amemiya (1985), $\sqrt{n}(\hat{\theta}_n - \theta_0) \to N(0, B(\theta_0)^{-1}A(\theta_0)B(\theta_0)^{-1})$, where

$$\begin{aligned}
A(\theta_0) &= E\left(\frac{\partial \ln f(y_k, \mathbf{d}_k|\mathbf{w}_k;\theta_0)}{\partial\theta} \cdot \frac{\partial \ln f(y_k, \mathbf{d}_k|\mathbf{w}_k;\theta_0)}{\partial\theta'}\right), \\
B(\theta_0) &= -A(\theta_0) - 2\lambda \sum_{\ell=1}^{L} \frac{1}{E(s_{\ell,k})} E\left(\frac{\partial\varphi_\ell(\mathbf{w}_k;\theta_0)}{\partial\theta}\right) E\left(\frac{\partial\varphi_\ell(\mathbf{w}_k;\theta_0)}{\partial\theta'}\right).
\end{aligned}$$

C.2. Comparison with an Efficient GMM Estimator

Alternatively, one can use a generalized method of moments (GMM) estimator, as suggested by Imbens and Lancaster (1994), based on the moment conditions that (i) the expectation of the first derivative of log-likelihood, or the score, is zero; and (ii) the expectation of the difference between the observed total lobbying expenditures and the model-predicted total lobbying expenditures by each player is zero. The weighting matrix of the GMM estimator can be likened to the weight of the estimator used in this paper, λ. While there exists a theoretical guidance for an optimal weighting matrix for the GMM estimator so that the efficiency of the estimator is guaranteed, I do not have a counterpart for the estimator used in this paper. Let us denote the efficient GMM estimator as $\tilde{\theta}_n$. It can be seen that the difference between the asymptotic covariance matrix of $\sqrt{n}(\tilde{\theta}_n - \theta_0)$, denoted as $\tilde{\Sigma}_n$, and the asymptotic covariance matrix of $\sqrt{n}(\hat{\theta}_n(\lambda) - \theta_0)$, denoted as $\hat{\Sigma}_n(\lambda)$, is positive-definite for any choice of $\lambda > 0$. Therefore, the issue is whether a researcher can find a weight λ such that $\hat{\Sigma}_n(\lambda)$ is close enough to $\tilde{\Sigma}_n$ that the information in the data is fully used for making statistical inferences. As can be seen in the section on empirical results, the key parameters of the model are estimated with a high degree of precision. Furthermore, compared to this GMM estimator, the estimator used in this paper is computationally less intensive.

C.3. Computation of $\varphi_\ell(\cdot)$

The scalar objective function $Q_n(\theta)$ includes $\tilde{\varphi}_\ell(\mathbf{w}_k;\theta)$, which denotes the expected lobbying expenditures by interest group ℓ for policy k with attributes $\mathbf{w}_k$ for any $\ell = 1, ..., L$:

$$\tilde{\varphi}_\ell(\mathbf{w}_k;\theta) \equiv \int \varphi_\ell(\mathbf{v}_k, \pi_k, \mathbf{d}_k^*(\mathbf{v}_k, \pi_k);\theta) dG(\mathbf{v}_k, \pi_k|\mathbf{w}_k;\theta),$$

where $\mathbf{d}_k^*(\mathbf{v}_k, \pi_k)$ denotes the equilibrium lobbying participation profile given $(\mathbf{v}_k, \pi_k)$. In the above equation, $\varphi_\ell(\cdot)$ denotes the optimal amount of the lobbying expenditures of group ℓ given policy values to all groups $(\mathbf{v}_k)$ and initial enactment probability (π_k).

To obtain $\varphi_\ell(\cdot)$ for any given $(\mathbf{v}_k, \pi_k)$, I first consider all possible lobbying participation profiles. If there are L interest groups, the total number of the profiles is 2^L. For each lobbying participation profile, I solve for the equilibrium lobbying spending profile. When solving the equilibrium, I use an algorithm derived from the proof for the existence and uniqueness of the second-stage equilibrium in Appendix B. There is no closed-form solution, but the proof is instrumental to compute the equilibrium. For each lobbying participation profile, I calculate the sum of the equilibrium payoffs of all interest groups. Then I find the participation profile with the largest sum of the payoffs. This is denoted as $\mathbf{d}_k^*(\mathbf{v}_k, \pi_k)$. The equilibrium spending by interest group ℓ given $\mathbf{d}_k^*(\mathbf{v}_k, \pi_k)$ is $\varphi_\ell(\mathbf{v}_k, \pi_k, \mathbf{d}_k^*(\mathbf{v}_k, \pi_k))$.

D. Robustness of the Results

In sections D.1–D.4, I present sensitivity analyses regarding each assumption for identification, discussed in Section 4. In section D.5, the empirical role of the weight (λ) in the penalized likelihood estimator used in this paper is discussed. Lastly, two sets of sensitivity analyses regarding the assumptions that I impose when constructing the data are presented in sections D.6 and D.7.

D.1. Definition of a Policy (Assumption 1)

The key part of Assumption 1 is that the lobbying activities regarding one policy are assumed not to affect the enactment of another policy. To evaluate how sensitive the results are to this assumption, I group some policies as "related" in the sense that the lobbying activities regarding one policy may affect the enactment of other policies in the group. To effect this grouping, I rely on (i) the broad issue and (ii) the positions of each energy lobbying coalition. There are 58 unique broad issues, ranging from air pollution regulation of stationary sources to oil spill management. Based on this grouping exercise, I identify 146 policy groups. I assume that each lobbying coalition decides its lobbying decisions on a policy group as a whole. Furthermore, if any of the policies within a group is enacted, the policy group itself is recorded to be enacted. As a result, the enactment probability (21.2 percent) for the policy group is much larger than that of individual policies (8.4 percent).

Using these 146 policy groups, instead of 538 policies in the main estimation, I estimate the model, and present the results in the third column in Table 19. As can be seen in the table, the estimated effectiveness of lobbying is is proportionately much larger but still relatively small in magnitude. Moreover, the effect of and the returns to lobbying are estimated to be within the 95 percent confidence interval of the respective estimates of the main estimation.

D.2. Parametric Assumptions (Assumptions 2)

I make specific parametric assumptions on the enactment production function. To understand how sensitive the results are to these assumptions, I estimate the model with a different specification of the enactment production function. The following specification of a policy enactment production function is based on the idea that the difference in lobbying efforts by both sides determines the probability that a policy is enacted, so that policy k is enacted if

$$\mathbf{Z}_k\delta + \xi_k + \beta_f \sum_{i\in\mathcal{L}_{\mathcal{F},k}} s_{i,k}^{\gamma} - \beta_a \sum_{j\in\mathcal{L}_{\mathcal{A},k}} s_{j,k}^{\gamma} - \epsilon_k > 0,$$

where the random variable ϵ_k follows a cumulative density function F_ϵ.[50] This randomness in the outcome of lobbying represents unexpected changes in the environment, such as economic and electoral conditions, that could affect the legislator's votes. $\mathbf{Z}_k\delta + \xi_k$ summarizes the initial level of support for policy k in the legislature, and thus $F_\epsilon(\mathbf{Z}_k\delta + \xi_k)$ is the probability that the policy is enacted in the absence of lobbying.

The distribution of ϵ_k determines how the marginal benefit of one's lobbying spending depends on the initial enactment probability. If the probability density function f_ϵ is single-peaked, then the marginal benefit of lobbying is also single-peaked. In the specification considered in the main text, the marginal benefit of lobbying is monotone in the initial enactment probability. Here, I assume that ϵ_k follows a triangular distribution with the finite support of (λ_L, λ_U) with a unique mode of $\lambda_0 \in (\lambda_L, \lambda_U)$.[51]

In Table 19, the estimation results based on this alternative specification are shown in the fourth column, headed as "Alternative (2)." As can be seen in the table, the results are very similar to those under the base specification except that the difference between the lobbying effect parameters from each side, (β_f, β_a), is not statistically significant. Unlike the specification considered in the main text, the relationship between the benefit of lobbying participation and the initial enactment probability is the same for both supporters and opponents. As a result, given this alternative specification, the initial enactment probability when there was only supporting lobbying is predicted to be similar to that when there was only opposing lobbying, if the effect parameters are symmetric.

D.3. Equilibrium Selection Rule (Assumption 3)

In the main estimation, I assume a specific equilibrium selection rule, where the equilibrium that maximizes the sum of the payoffs of all players is chosen if there exist multiple equilibria. In Table 19, I show the estimation results based on a different equilibrium selection rule, where the equilibrium that *minimizes* the sum of the payoffs is chosen. As can be seen in the table, the results are very similar to those in the main estimation.

D.4. Entry Cost Parameter (Assumption 4)

I assume that the entry cost is observed by the econometrician. In the estimation, I plug in the smallest lobbying expenditures undertaken by entities that lobbied the Congress regarding

[50] This specification was considered and estimated in earlier versions of this paper.

[51] Both scale and location normalizations are necessary. When estimating the model, I normalize λ_0 to be 0 and $|\lambda_U - \lambda_L|$ to be 2. In addition, I assume that ϵ_k is distributed symmetrically around λ_0. As a result, I estimate the parameters of the model under the assumption that $(\lambda_L, \lambda_0, \lambda_U)$ is $(-1, 0, 1)$.

one policy, which is \$5,000. This estimate of the entry cost may not be a consistent estimate for two reasons. First, the data is potentially truncated because an entity with small lobbying expenditures or revenues is not required to register and report to the government if certain conditions are met. However, this problem is mitigated by the fact that once registered, an entity is supposed to report its lobbying activities regardless of the amount of its total lobbying costs or revenues. Second, the lobbying entry cost for a player in the analysis may be different from that of an entity. For these reasons, I show how the results may change as I change the value of the entry cost. I perform two analyses, where the entry cost is \$100 and \$50,000 respectively. Note that the average per-policy lobbying expenditure by the renewable energy lobbying coalition is \$66,000, which is close to \$50,000.

In Table 19, I show the estimation results of the two analyses in the last two columns, headed as "Alternative (4)" and "Alternative (5)." First, the estimates of the parameters of the enactment production function are larger as the entry cost is set to have larger values. This is an expected result because to maintain the same participation rate given higher entry costs, the marginal benefit of lobbying should be larger. Second, the average effect of lobbying expenditures on the enactment probability of a policy is very small in all cases, while on average, higher entry costs lead to higher effects. Lastly, the returns of lobbying expenditures to all lobbying coalitions are around 100 percent or more, while a higher entry cost is related to lower returns.

D.5. Weight in the Objective Function of the Estimator

As discussed earlier, the estimator $\hat{\theta}_n$ maximizes the following objective function, $Q_n(\theta)$:

$$Q_n(\theta) = \frac{1}{n}\sum_{k=1}^{n} \ln f(y_k, \mathbf{d}_k|\mathbf{w}_k;\theta) - \frac{\lambda}{n}\sum_{\ell=1}^{L}\left\{1 - \frac{\sum_{k=1}^{n}\tilde{\varphi}_\ell(\mathbf{w}_k;\theta)}{s_\ell}\right\}^2.$$

$\hat{\theta}_n$ is consistent for any choice of $\lambda > 0$. With a finite sample, the choice of λ does affect the results. As the value of λ decreases, the average log-likelihood plays a more important role in pinning down the estimated parameters. The estimation results shown in the main text are based on $\lambda = 50$. In the main estimation, the first part of the objective function, the average log-likelihood, is estimated to be -2.79573 and the second part of the objective function is -0.00015. Given these values, I choose two alternative values for λ, 0.005 and 5,000, to see how sensitive the results are. The estimation results can be found in Table 20. Note that the key findings under λ being 0.005 or 5,000 are within the 95 percent confidence regions of those under λ being 50.

In Table 21, I document how the choice of λ affects the estimated values of log-likelihood and total expenditures. At $\lambda = 0.05$, the absolute value of the average log-likelihood is the smallest among the three cases, but the predicted total lobbying expenditures are the furthest away from the observed total lobbying expenditures.

D.6. Total Lobbying Expenditures on Energy Policies

To estimate the model, the sum of lobbying expenditures by each player on all *energy* policies is needed. However, in the data, I observe the sum of lobbying expenditures on *all* policies for each player. To determine the fraction of lobbying expenditures spent on energy policies, I

Table 19

Sensitivity analyses regarding identification assumptions

	Base	(1)	(2)	(3)	(4)	(5)
Parameter Estimates						
β_f	6.73E-6***	5.39E-5	7.02E-6**	6.42E-6**	1.42E-6**	2.26E-5***
	(1.62E-6)	(4.35E-5)	(1.56E-6)	(3.21E-6)	(5.68E-7)	(2.57E-6)
β_a	1.63E-4**	2.67E-4	8.02E-6*	3.72E-4	1.57E-4*	3.49E-4**
	(6.97E-5)	(2.12E-4)	(1.81E-6)	(4.69E-4)	(9.31E-5)	(1.64E-4)
γ	0.289***	0.300***	0.380***	0.300***	0.2996***	0.285***
	(0.035)	(0.028)	(0.033)	(0.052)	(0.1000)	(0.018)
Effect of Lobbying (percentage points)						
All	0.05	0.33	0.04	0.34	0.02	0.13
	[0.02,0.42]					
Returns to Lobbying (percent)						
Coal	145.8	169.1	113.2	146.0	160.0	113.1
	[80.3,318.6]					
Oil/Gas	151.9	168.1	116.2	153.9	163.7	108.7
	[93.8,273.2]					
Nuclear	139.2	158.6	102.2	134.2	154.4	75.6
	[72.8,248.8]					
Ren.	137.0	152.1	103.2	142.6	161.9	58.5
	[87.1,288.9]					
Average Log-Likelihood						
	-2.79573	-2.74341	-2.41752	-2.26651	-2.79807	-2.81955
Objective Function						
	-2.79589	-2.74370	-2.41917	-2.26832	-2.79837	-2.82941

Note: The numbers in parentheses are asymptotic standard errors, and those in brackets are 95 percent confidence intervals. In *Alternative (1)*, I use a different categorization of policies as described in section D.1. In *Alternative (2)*, I use a different policy enactment production function, whose specification can be found in section D.2. In *Alternative (3)*, a different equilibrium selection rule, as explained in section D.3, is utilized when multiple equilibria occur during estimation. Lastly, in *Alternative (4)*, the entry cost is assumed to be \$100, and in *Alternative (5)*, \$50,000. For the base estimation, the entry cost is assumed to be \$5,000. See section D.4. for a more detailed discussion on the choice of entry cost.

Table 20

Sensitivity analyses regarding weight (λ) and data assumptions

	Base	(6)	(7)	(8)	(9)	(10)
Parameter Estimates						
β_f	6.73E-6***	2.14E-5***	7.23E-6***	1.42E-6***	6.12E-6***	1.90E-6*
	(1.62E-6)	(3.75E-6)	(1.70E-6)	(2.58E-7)	(2.09E-6)	(1.24E-6)
β_a	1.63E-4**	7.56E-4*	1.58E-4	4.56E-5***	2.01E-4	3.47E-4***
	(6.97E-5)	(4.01E-4)	(2.97E-4)	(3.03E-5)	(1.26E-4)	(1.33E-6)
γ	0.289***	0.300***	0.298***	0.300***	0.2097***	0.239***
	(0.035)	(0.031)	(0.047)	(0.033)	(0.064)	(0.033)
Effect of Lobbying (percentage points)						
All	0.05	0.28	0.06	0.01	0.02	0.15
	[0.02,0.42]					
Returns to Lobbying (percent)						
Coal	145.8	124.9	134.9	129.0	220.8	209.5
	[80.3,318.6]					
Oil/Gas	151.9	158.0	138.4	135.1	237.2	218.3
	[93.8,273.2]					
Nuclear	139.2	122.3	126.9	121.1	212.3	192.5
	[72.8,248.8]					
Ren.	137.0	151.8	124.0	103.3	215.9	196.1
	[87.1,288.9]					
Average Log-Likelihood						
	-2.79573	-2.77964	-3.24715	-2.80223	-2.85667	-2.08397
Objective Function						
	-2.79589	-2.78208	-3.24736	-2.80367	-2.85740	-2.08685

Note: The numbers in parentheses are asymptotic standard errors, and those in brackets are 95 percent confidence intervals. In *Alternative (6)* and *Alternative (7),* I use different values for the weight (λ) in the objective function of the estimator, 0.05 and 5,000, respectively. In the base estimation, the weight is set at 50–see section D.5 for further explanation. In *Alternative (8)*, the energy lobbying expenditures are assumed to be 20 percent of the total lobbying expenditures. In *Alternative (9)*, the results of a similar exercise, except that the ratio is 100 percent, are shown. See section D.6 for more detailed discussions on these two exercises. In *Alternative (10)*, I use a different rule for determining the policy positions for each lobbying coalition, which I explain in detail in subsection D.7.

Table 21

Role of weight (λ) in the estimation

	$\lambda = 50$	$\lambda = 0.05$	$\lambda = 5{,}000$
Average Log-Likelihood	-2.79573	-2.77964	-3.24715
Lobbying expenditures ($ million)			
Data-Model: Coal	0.70	35.50	0.03
Data-Model: Oil/Gas	-0.54	-260.35	-0.27
Data-Model: Nuclear	1.26	3.22	-0.05
Data-Model: Renewable	0.25	-80.87	-0.06

Note: The last four rows show the difference between the total expenditures in the data and those predicted by the model at the estimated parameters for each coalition.

Table 22
Total lobbying expenditures by lobbying coalitions

	Number of Entities	Total Lobbying Expenditures ($ million)	Energy Lobbying Expenditures ($ million)
Coal	10	139.56	77.85
Oil/Gas	8	160.63	73.22
Nuclear	12	70.65	33.92
Renewable	12	30.44	22.11

use information on lobbying participation at the bill level. First, for each entity that belongs to a player, I multiply its total lobbying expenditures by the ratio of the number of energy bills that the entity lobbied to the total number of bills that it lobbied. Then, I sum the obtained energy lobbying expenditures over all entities that belong to the player. For each lobbying coalition or player, Table 22 shows both the total lobbying expenditures and the calculated total energy lobbying expenditures. Based on the records on bill lobbying, the renewable energy coalition is more focused on lobbying regarding energy issues (73 percent) than other coalitions such as oil and gas (46 percent) or nuclear energy (48 percent). This is consistent with the size of firms and organizations in each coalition: The bigger the firm or the organization is, the more likely that it is involved in lobbying a variety of issues such as general taxation and labor issues. As shown in Table 2, the average assets held by a member of the oil and gas coalition at the end of 2007 are $159.57 billion, which is much larger than the total assets held by the whole renewable energy coalition ($41.04 billion).

Although the bill-level lobbying information is the best available information for inferring energy-specific lobbying expenditures, it does not provide the exact amount of money spent on energy lobbying. To see how the way I determine the energy lobbying expenditures affects the results, I conduct two sensitivity analyses where the energy lobbying expenditures are respectively assumed to be 20 percent and 100 percent of the total lobbying expenditures. In Table 20, the estimation results based on both methods are shown, and they are very similar.

D.7. Policy Position

The position of a lobbying coalition on a specific policy is not always observed in the data, so I construct the position variable based on a variety of auxiliary sources of information. As discussed earlier, this variable may contain a misclassification error. To address this issue, I construct an alternative position variable such that the estimated effect of lobbying can be maximal, and then re-estimate the model using this variable instead of the originally constructed position variable.

It can be seen that the effect of lobbying would be estimated to be the largest if all participating players' lobbying was successful.[52] Given this argument, I construct an alternative position variable such that if a player lobbied on an enacted (rejected) policy, its position

[52]This is especially the case given the enactment production function used in the analysis. The change in the enactment probability due to supporting (opposing) lobbying is decreasing (increasing) in the initial enactment probability. Therefore, if there is supporting (opposing) lobbying only, the initial enactment probability is likely to be low (high), which will lead to a higher estimated effect of lobbying if the lobbied policy passes (fails).

Table 23
Frequency of taking supportive lobbying position

(unit: percent)	Base	Alternative
Coal	69.20	40.33
Oil/Gas	61.97	31.60
Nuclear	69.76	42.19
Renewable	69.76	31.78

Table 24
Model fit in the 111th and 112th Congresses

	111th		112th	
	Observed	Predicted	Observed	Predicted
Policy Enactment (percent)				
All	1.26	6.02	0.00	6.17
Participation (percent)				
By players				
Coal	51.57	50.50	50.00	50.03
Oil/Gas	64.15	65.47	63.64	67.62
Nuclear	33.96	51.37	39.39	51.25
Renewable	30.82	55.59	42.42	54.63
By participation patterns				
Not lobbied	18.24	4.82	18.18	5.15
Supporters only	43.40	47.14	30.30	38.90
Opposition only	15.09	14.04	19.70	18.07
Both sides	23.27	34.00	31.82	37.88

Note: The moments are calculated over 159 policies for the 111th Congress, and 66 policies for the 112th.

is recorded as supporting (opposing). Table 23 shows the frequency of taking a supportive position regarding a policy for each player, under both methods of constructing the position variable. Since most of the policies in the dataset failed to be enacted, the frequency is lower under the alternative method.

In Table 20, the estimation results based on both policy position variables are shown. It can be seen that the lobbying effect parameter for opponents, β_a, is estimated to be higher under the alternative policy positions. Furthermore, the aggregate effect of lobbying is estimated to be 0.15 percentage points, which is much higher than the original estimate of 0.04 percentage points. However, the difference between the estimates under both scenarios is not statistically significant. In addition, the extent of the estimates of the lobbying effects is relatively small even if I estimate the model with data where the policy positions are recorded such that the lobbying effects would be estimated to be the largest.

E. Can We Generalize the Results to Other Congresses?

To understand the extent to which we can generalize the estimation results to other Congresses, I simulate the model using the estimated parameters in Table 7 and the data on the policies that were considered during the 110th Congress and then re-considered during either of the subsequent two Congresses. There are 159 policies that appeared during both the 110th and the 111th Congresses, and 66 policies that were considered during both the 110th and the 112th. While the observable characteristics of these policies are invariant between Congresses, data on public opinion does change from year to year and is incorporated here. For some policies, polling data changes dramatically over the period of the study. For example, there are no polling questions on oil spill regulation during the 110th Congress in my data, while there are many questions on that policy issue during the 111th.

Table 24 represents the simulated moments as well as the corresponding observed moments. Overall, the model fits the data well. For example, the model predicts the level of lobbying participation by the coal and the oil and gas coalitions reasonably well. Although the rates of lobbying participation by the nuclear and the renewable energy coalitions are over-predicted, the lobbying participation patterns broken down by policy positions match well both in terms of the level and the trend.

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