

THEORY AND EVIDENCE ON BUYING POLITICAL INFLUENCE

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ABSTRACT

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This dissertation identifies and addresses contemporary issues in political economy related to how private interests influence elections and government decision making. The three chapters focus on spending in elections by two distinct kinds of organizations and lobbying by firms. The chapters are fundamentally empirical investigations with rigorous theoretical foundations.

Chapter 1: Campaign Finance in the Age of Super PACs

The United States Supreme Court 2010 decision in *Citizens United v. Federal Election Commission* led to a major de-regulation of election campaign finance law. A new political action committee emerged from this case, known as the Super PAC, with a relatively unfettered ability to raise and spend money in elections. How were campaign spending and electoral outcomes affected? I characterize the influence of Super PACs on U.S. Congressional general and primary elections by estimating an election contest model. I exploit variation in donor finances, background information on candidates, and the dynamic model structure to deal with candidate unobservables. Results indicate that Super PACs do not have significant influence on voting outcomes but did increase election spending between 2010-2016. They affect behavior of other committees, with differences across political party and incumbency status. Finally, Super PACs have modest effects on candidate platforms and entry.

Chapter 2: Dark Money in Congressional Elections

Nonprofits in the United States play a unique role in campaign finance. Their tax-exempt status and anonymous donations combined with their recently de-regulated political status allows them to engage in political advertising spending in an unprecedented manner. I study the rise of “dark-money” by 501(c)(4) nonprofits in US Congressional elections by studying the pattern of spending

and the effects on election outcomes. Since 501(c)(4) nonprofits are not legally required to disclose spending to the Federal Election Commission, I exploit raw advertising data to measure their behavior. I find that they do not have significant effects on vote share when accounting for the spending of candidates, parties, PACs, and Super PACs.

Chapter 3: Lobbying for Government Appropriations

This chapter investigates the effect of lobbying on government contract allocation. I consider how lobbying affects both total contract spending and the distribution of contracts between firms. I solve a novel contest model which incorporates these two effects, and then structurally estimate it using a panel of federal contractors. The results suggest that lobbying increases contract spending by \$8.837 billion (3.22%) per year. However, its effects on the observed contract distribution and firm revenues are relatively small. Finally, I find that increasing competition in procurement generally results in less lobbying.

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TABLE OF CONTENTS

LIST OF TABLES	vii
LIST OF FIGURES	x
INTRODUCTION	1
CHAPTER 1 CAMPAIGN FINANCE IN THE AGE OF SUPER PACS	7
1.1 Introduction	7
1.2 Data	11
1.2.1 Voting and Candidate Data	11
1.2.2 Committee Data	13
1.2.3 Donor Data	16
1.3 Model	19
1.3.1 Model Setup	19
1.3.2 Model Parameterization	20
1.3.3 Discussion	26
1.4 Identification and Estimation	28
1.4.1 Estimation Of General Election Voter Preferences	29
1.4.2 Estimation Of General Election for committees	32
1.4.3 Primary Election Estimation	36
1.4.4 Estimation Of Candidate Stages	39
1.4.5 Estimator	43
1.5 Results and Counterfactuals	44
1.5.1 Parameter Estimates	44
1.5.2 Counterfactuals	47
1.6 Conclusion	52
APPENDICES	54
APPENDIX A: Additional Details	55
APPENDIX B: Proofs	68
APPENDIX C: Tables	85
CHAPTER 2 DARK MONEY IN CONGRESSIONAL ELECTIONS	114
2.1 Introduction	114
2.2 Data	117
2.3 Estimation	119
2.4 Results	121
2.5 Conclusion	122
APPENDICES	124
APPENDIX A: Model Extensions	125
APPENDIX B: Tables	127

CHAPTER 3	LOBBYING FOR GOVERNMENT APPROPRIATIONS	136
3.1	Introduction	136
3.2	Contract and Lobbying Data	138
3.3	A Model of Appropriations Lobbying	145
3.4	Identification and Estimation	148
3.5	Parameter Estimates and Model Counterfactuals	160
3.6	Concluding Remarks	167
APPENDICES		169
APPENDIX A:	Tables	170
APPENDIX B:	Proofs	190
APPENDIX C:	Computational Discussion	198
APPENDIX D:	Additional Results	200
APPENDIX E:	Data Details	206
BIBLIOGRAPHY		211

LIST OF TABLES

Table 1.C.1:	Contribution and Spending Regulations	85
Table 1.C.2:	Campaign Contribution Limits	86
Table 1.C.3:	Total General (Ad) Spending (in Millions)	89
Table 1.C.4:	Total Non-Open Race Primary (Ad) Spending (in Millions)	90
Table 1.C.5:	Total Open Race Primary (Ad) Spending (in Millions)	90
Table 1.C.6:	Variation Between Zip Code Income and Committee Finances	92
Table 1.C.7:	General Election Voter Regression: OLS	93
Table 1.C.8:	Voter Parameter Estimates	94
Table 1.C.9:	Illustrating Variation in Primary Moments	95
Table 1.C.10:	Illustrating Variation in Challenger Moments	96
Table 1.C.11:	Committee and Candidate Valuation and Cost Estimates	97
Table 1.C.12:	General Election Voter Controls Estimates	109
Table 1.C.13:	Primary Election Voter Controls Estimates	110
Table 1.C.14:	Parameterization Controls Summary Statistics	110
Table 1.C.15:	Full Committee/Candidate Parameter Estimates	111
Table 1.C.16:	General Election Voter Estimation: Alternative Specifications	112
Table 1.C.17:	General Election Voter Estimation: Heterogeneous Super PAC Effects	112
Table 1.C.18:	General Election Regression All Variables Summary Statistics	113
Table 2.B.1:	Spending Summary Statistics	129
Table 2.B.2:	Controls Summary Statistics	130
Table 2.B.3:	OLS Regressions	131

Table 2.B.4:	OLS Regressions Controls	132
Table 2.B.5:	IV Regressions	133
Table 2.B.6:	IV Regression Controls	134
Table 2.B.7:	Composite IV Regressions	135
Table 3.A.1:	Share of Contracts in a Sector by Lobbying Participation	170
Table 3.A.2:	Lobbying Expenditures by Average Sector Competitiveness	170
Table 3.A.3:	Contract Revenues by Lobbying Participation	170
Table 3.A.4:	Contract Sector Size in Dollars by Mean Lobbying	171
Table 3.A.5:	Contract Revenues Quantiles by Lobbying Participation	171
Table 3.A.6:	Summary Statistics	172
Table 3.A.7:	Reduced Form Regressions	173
Table 3.A.8:	Main Parameter Estimates	180
Table 3.A.9:	Statistics for Observed and Model Firm Lobbying Expenditures per Year . . .	181
Table 3.A.10:	Statistics for Observed and Model Firm Share of Contracts per Sector	181
Table 3.A.11:	Statistics for Observed and Model Firm Lobbying Entry per Sector	182
Table 3.A.12:	Statistics for Observed and Model Total Contracts per Sector	182
Table 3.A.13:	Statistics for Total Contract Spending Induced by Aggregate Lobbying (Endogenous Pool) per Sector	183
Table 3.A.14:	Return to Lobbying per Sector	183
Table 3.D.15:	Robustness Checks 1: Around The Monetary Cutoff	201
Table 3.D.16:	Robustness Checks 2: Around The Year Cutoff	202
Table 3.D.17:	Robustness Checks 3: Around The Approximation Window	203
Table 3.D.18:	Significance Check Around Fixed Effects	204

Table 3.D.19: Bias Corrected Confidence Interval	205
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LIST OF FIGURES

Figure 1.1:	House Election “Outside Committee” Ad Spending (in Millions)	8
Figure 1.2:	Percent Change in Republican General Election Vote Share without SPACs .	49
Figure 1.C.3:	Incumbent Vote Share in General Elections	87
Figure 1.C.4:	Incumbent Vote Share in Primary Elections	87
Figure 1.C.5:	Primary Entry	88
Figure 1.C.6:	Distribution of Candidate Positions	88
Figure 1.C.7:	Candidate Positions, Spending, and Election Outcome	89
Figure 1.C.8:	Super PAC Spending (Millions) Across Donor Financial Measure Bins . . .	91
Figure 1.C.9:	Diagram of Primary FOC Estimation	95
Figure 1.C.10:	Invertibility of Expected Probability in Valence	96
Figure 1.C.11:	Percent Change in General Election Spending Without Super PACs	98
Figure 1.C.12:	Percent Change in Primary Election Spending Without Super PACs	99
Figure 1.C.13:	Percent Change in Committee Entry Without Super PACs	100
Figure 1.C.14:	Percent Change in Republican General Election Vote Share Without Super PACs Across Degrees of Committee Uncertainty	101
Figure 1.C.15:	Percent Change in Republican General Vote Share Without Super PACs by Original Vote Share	102
Figure 1.C.16:	Percent Change in Incumbent Primary Vote Share Without Super PACs . . .	103
Figure 1.C.17:	Percent Change in Challenger Entry Without Super PACs	104
Figure 1.C.18:	Percent Change in Challenger Extreme Position Without Super PACs	105
Figure 1.C.19:	Percent Change in Challenger Moderate Position Without Super PACs	106

Figure 1.C.20: Percent Change in Challenger Extreme Position Without Super PACs: Direct & Indirect Effects	107
Figure 1.C.21: Percent Change in Incumbent Extreme Position Without Super PACs	108
Figure 2.B.1: Reporting Window For Political Advertisements (Source: WMP)	127
Figure 2.B.2: Dark Money Statistics (Source: WMP)	127
Figure 2.B.3: Negative President Obama Issue Advocacy Advertisement	128
Figure 2.B.4: Negative President Obama Express Advocacy Advertisement	128
Figure 2.B.5: Dark Money Spending By Group (Source: CRP)	129
Figure 3.A.1: Distribution of Number of Firms Across Sectors	174
Figure 3.A.2: Distribution of Number of Potential Entrants Across Sectors	175
Figure 3.A.3: Distribution of Number of Total Entrants Across Sectors	176
Figure 3.A.4: Distribution of Nonzero Lobbying Across Firms (Millions)	177
Figure 3.A.5: Total Contracts [Sector Level (Billions)] by Potential Entrants	178
Figure 3.A.6: Average Characteristics by Number of Potential Entrants	179
Figure 3.A.7: Distribution of Endogenous Pool (Billions)	184
Figure 3.A.8: Endogenous Pool Percent by Potential Entrants	185
Figure 3.A.9: Percent Return on Lobbying by Entrants	186
Figure 3.A.10: Mean Percent Return on Lobbying by Year	187
Figure 3.A.11: Lobbying by Market Concentration	188
Figure 3.A.12: Distributions of Log Difference in Lobbying From Removing Other Potential Entrants	189

INTRODUCTION

“Virtually every means of communicating ideas in today’s mass society requires the expenditure of money.”

- Per curiam from *Buckley v. Valeo*, 1976

The role of money in politics is a quintessential political economy topic that dates back to the founding of economics and political science (Mutch 2020). A primary goal of money in politics is to influence the politician. This can be manifested in two distinct, yet linked, ways. First, the set of individuals who become politicians can be influenced by money, and this is the domain of campaign finance and involves money affecting voters. Second, the incumbent politicians can have their own decisions affected by interest groups, beyond having to “pay back” those who helped them get elected, which is broadly defined as lobbying.

This dissertation can be bifurcated into these two themes. Chapters 1 and 2 focus on advertising spending by opaque organizations to affect which candidates voters choose. These chapters fit in the large literature on spending in elections (Green and Krasno 1988; Erikson and Palfrey 2000; Gordon and Hartmann 2016; Klumpp, Mialon, and Williams 2016; Limbocker and You 2020) and the well traversed literature on campaign contributions (Poole, Romer, and Rosenthal 1987; Bonica and Rosenthal 2015; Bouton, Castanheira, and Drazen 2020). The Supreme Court Case decision in *Citizens United v. Federal Election Commission* dramatically changed the campaign finance environment by effectively allowing a new stream of money into elections without limitations. The court case *SpeechNOW v. Federal Election Commission* immediately followed and used the previous case as a precedent. Independent Expenditure Only Political Action Committees, coined Super PACs, emerged out of this case and have no limitations on campaign contributions as long as the spending stemming from those contributions is uncoordinated with the candidates or party. Chapter 1 studies Super PACs in a comprehensive manner; I consider the effects of Super PACs on the general and primary election environments, considering the effects on voting, spending, entry, and candidate policy.

The empirical analysis is founded in a rich game-theoretic model; I estimate a campaign finance model incorporating all of the elements previously described and allow for substantial heterogeneity. I combine aspects from Adams and Merrill (2008), Gordon and Hartmann (2016), Bouton, Castanheira, and Drazen (2020), and other papers for a unique model that can address pertinent empirical questions through counterfactual analysis. The model also contains two distinct and important facets that influence decision making; first, I model election spending between opposing sides as a rent-seeking contest, and second, I model the election spending relationship between different allied groups as a public good. This combination allows for both free-riding and externalities that reflect the real campaign finance environment.

The main identification challenge for this complex empirical setup is dealing with candidate unobservables. Candidates who enter, win primaries, and win general elections likely differ in unobserved ways. I tackle this issue with different strategies for each stage of the game in which these unobservables arise. First, I instrument for spending with exogenous variation in the financial well-being of donors and utilize novel real estate data. Second, I exploit the dynamic structure of the model to uncover unobserved expectations. Third, I proxy for the unobserved selection of candidate entry by comparing entrants and non-entrants based on their State legislature records.

I find that in a world without Super PACs, we likely would see less overall spending in elections with an almost 20% drop in dollars spent. Republicans may suffer slightly without Super PACs and incumbents may benefit, but the effects are noisy and this is largely due to Super PAC spending often being matched by both opposing sides, canceling out competing effects. An absence of Super PACs may also lead to decreased candidate entry and more extreme candidates. The strongest effect is on Democratic incumbents, as the presence of opposition Republican Super PACs pressure them to be more moderate.

Chapter 2 studies another form of money in elections that surged after those court cases, namely “dark money” spending which, like Super PAC spending, has no limits on the contribution amount but earns its name by allowing anonymous donations. 501(c)(4) nonprofit organizations are entities with the capabilities to engage in dark money spending. 501(c)(4) nonprofits are unique in that

they can spend unlimited amounts of money without disclosing their donors; the caveat is that they may only spend on “issue” advocacy ads that do not target candidates as directly as the ads made by candidate committees, Super PACs, and political parties. The advantage of running these potentially less effective ads is the large donor base due to anonymity.

The difficulty in quantifying dark money is due to the lack of reporting. 501(c)(4) nonprofits do not need to report their issue ad spending to the FEC. However one can estimate their spending by looking at raw advertising data at the media market level collected by the Wesleyan Media Project. This captures all political ads on television in major media markets. The sponsor of the ad and the approximate cost is known and I match this with the list of known 501(c)(4) nonprofits. Using this novel data, I study the effects of these groups on general election voters using the framework from Chapter 1; I control for the influence of entities like Super PACs as it is important to allow for heterogeneous effects by these different groups (Sides, Lipsitz, and Grossmann 2010).

I find that 501(c)(4) nonprofit election spending is not particularly effective at changing vote share outcomes in Congressional General elections. Chapters 1 and 2 can be succinctly described as studying the post-2010 campaign finance environment and seeing how the (relatively) unregulated influx of money into elections affected electoral outcomes. Neither chapter explores the welfare implications of all this money being spent in elections through either the opportunity cost of the funds or possible policy outcomes from changes to the composition of winning candidates. As a consequence, I do not take a stand on the normative appeal of the decision in *Citizens United*. My main contribution is to characterize how the campaign finance landscape shifted in the aftermath of this major deregulation. I consider many important effects such as changes in voting outcomes, spending behavior, and candidate decisions.

The second theme of buying political influence that is distinct from election spending is lobbying in Congress and federal agencies. Lobbying is again a thoroughly studied field (Tullock 1967; Grossman and Helpman 1994; de Figueiredo and Silverman 2006; de Figueiredo and Richter 2014b; Kerr, Lincoln, and Mishra 2014; Kang 2016; You 2017). The difficulty in quantifying and estimating the effects of lobbying leaves space in the literature. This is the purview of Chap-

ter 3 and looks at lobbying by government contractors over appropriations, specifically federal government contracts. Lobbying is distinct from election advertising spending as there are fewer regulations on it other than transparency requirements. Firms are allowed to “talk” with politicians on policy and may spend as much as they want hiring lobbying consultants to communicate with politicians to make their case for some policy matter; in the case of defense contractors, this may involve convincing politicians they need to increase the amount of spending on airplane contracts. Thus lobbying is simply money spent on arguing on behalf of some interest group to alter how the (already elected) politician forms policy.

What is novel about Chapter 3 is that it considers how lobbying can affect both the total amount of money spent on contracts and also the distribution of those contracts between firms; this creates unique rent-seeking and public good problems and extends the frameworks from Seim (2006), Hirai and Szidarovszky (2013), and Kang (2016). These aspects mirror the model from Chapter 1 in incorporating two dominant characteristics of many political economy environments: the presence of both rent-seeking and externalities (Tullock 1967; Grossman and Helpman 1994). By incorporating both, I can test the importance of both components so see how they explain observed lobbying and contract outcomes. To do this, I combine the Center for Responsive Politics’ lobbying disclosure database and the federal government’s procurement contract database.

I find that the government spends an additional \$8.8 billion more per year on contracts than it would otherwise due to the lobbying pressure. Lobbying also affects the between-firm contract allocations, with noise, and the return on lobbying participation is large relative to expenditures. I also find that increasing market concentration generally leads to more lobbying. The main take-away from Chapter 3 is that the government spends more per year on contracts than it would otherwise due to the pressure from lobbying. Whether or not this is a mis-allocation of funds (Huneus and Kim 2018) cannot be easily determined without further study. Thus this chapter does not tackle the issue of whether lobbying is welfare improving or not (Cotton and Dellis 2016).

Election spending, campaign contributions, and lobbying are important economic topics in need of further study. Deconstructing the strategic decision-making and equilibrium effects at the

heart of the intersection between private interests and the government is key to understanding why endogenous policy is formulated the way it is. This dissertation studies some of these important aspects but there are additional questions related to Super PACs, dark money, and lobbying by contractors left unanswered. First, exactly why do these wealthy donors spend millions to support the election campaigns of politicians (Bonica & Rosenthal 2015; Rhodes, Schaffner, and La Raja 2018)? Are they seeking an eventual financial boon via favorable legislation and are “buying” their politician? Or are they simply expressing their personal beliefs and have the discretionary income to turn their political opinions into mass media campaigns to buy influence with voters (Ansolabehere, De Figueiredo, and Snyder 2003; Fowler, Garro, and Spenkuch 2020a)? And why do voters respond to political messaging? Is the content adding information to help voters choose (Martin 2019)? These questions are difficult to answer with data and my election analysis is largely agnostic to many of the potential explanations to them. In Chapters 1 and 2, I simply study the effects of election spending on outcomes taking the incentives of the spenders as given. However this approach cannot be completely innocuous as any functional form choice is informed by the theoretical framework that undergirds the empirical analysis.

The informational content of lobbying is perhaps even more important; do lobbying firms update politician’s understanding of policy in a Pareto improving manner or is it just pure rent-seeking (Cotton 2009)? The story becomes more complicated when analyzing actors that engage in both campaign contributions and lobbying: do firms give to politicians with the hopes their lobbying efforts will be more effective? There is the final question of whether campaign contributions, election spending, and lobbying are even the main channels for buying political influence. Some argue there are other distinct strategies utilized by firms (Bertrand, Bombardini, Fisman, and Trebbi 2018; Holburn and Raiha 2018; Raiha 2018).

Given the magnitude of the dollar amounts studied in this dissertation, election spending and lobbying are still likely major avenues for buying political influence. Thus it is still pertinent to study these environments and the incentives behind those spending billions. In the words of Adam Smith, the “dealer” who influences government to affect policy *“comes from an order of men whose*

interest is never exactly the same with that of the public, who have generally an interest to deceive and even to oppress the public” (Smith 1776). This dissertation attempts to model the strategies and quantify the effects of these “dealers” on political outcomes.

CHAPTER 1

CAMPAIGN FINANCE IN THE AGE OF SUPER PACS

1.1 Introduction

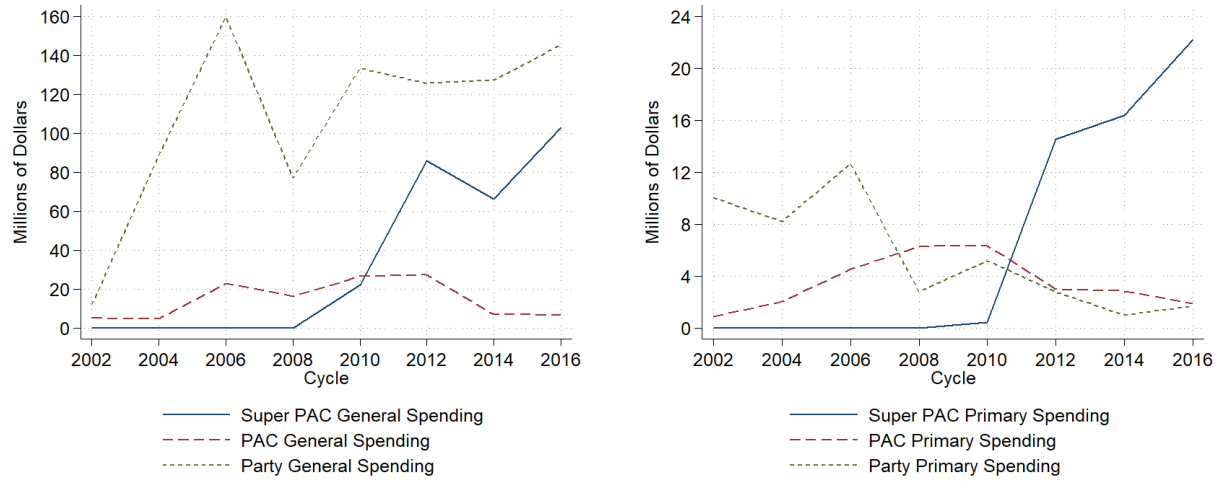
Campaign contributions are an integral part of U.S. elections and allow citizens to support candidates. The rules that govern these contributions, such as limits per donor and restrictions on corporate giving, were upended in the 2010 decisions *Citizens United v. Federal Election Commission* (FEC) and *SpeechNow v. FEC*. The latter case, relying on the former, created a new kind of political action committee (PAC), the “Super PAC”, which could receive unlimited contributions per donor.¹

Super PACs started spending soon after their creation. Long-time Democratic incumbent John Spratt of South Carolina’s fifth district was defeated in his 2010 general election with opposition spending of \$2,839,419, a third of which came from newly formed Super PACs. These groups also spent in primaries, with the Super PAC named “Campaign For Primary Accountability” spending \$136,277 to help defeat Ohio’s second district Republican incumbent Jean Schmidt in her 2012 primary. Super PACs may not only have influenced who won the election but also candidate positions. For example, Republican incumbents post-2010 have been almost twice as likely to position themselves further to the right than to the left, and those who chose a more moderate position faced almost twice as much primary Super PAC opposition spending as others. Super PAC spending habits, shown in Figure 1.1 below, reveal their potential impact; Super PACs have been a major force in general elections and dominate primary spending by non-candidate committees.

Democrats and incumbents have faced the brunt of this new spending, and Democratic members of Congress are looking to get the *Citizens United* decision overturned (Carney 2019). Proponents of both decisions argued that election spending is akin to free speech and that “outside

¹Part of this ruling also allowed them to accept corporate and union donations: any source except foreign nationals, federal contractors, national banks, and federally chartered corporations.

Figure 1.1: House Election “Outside Committee” Ad Spending (in Millions)



The left (right) graph shows total general (primary) election ad spending by Super PACs, PACs, and party committees from 2002-2016.

money” provides a counterweight to established political parties. Opponents feared corporations and wealthy individuals would flood elections with outside money. Both sides have seen their arguments partially materialize. First, Super PACs supported House challengers with more than \$216 million since 2016, but Super PACs helping incumbents have also spent just over \$115 million.² Second, while corporate political spending has not significantly increased since 2010, the substantial spending by Super PACs in Figure 1.1 is largely due to donations by wealthy individuals.

In this chapter, I analyze how Super PACs affect Congressional primary and general elections. I investigate how their spending influences voting behavior, spending by other committees, candidate platforms, and candidate entry decisions. I model a multistage game for the primary and general elections, incorporating the collective efforts of candidates, parties, and Super PACs.³ I allow for heterogeneity along multiple dimensions, such as spending effectiveness and fundraising constraints.⁴ I first estimate the effect of candidate and committee decisions on voters and then estimate the equilibrium conditions for those decisions, using backward induction to incorporate

²They sometimes support the party, fringe groups, or just one candidate (Dwyre and Braz 2015; Chen and Fang 2017; Kolodny and Dwyre 2018; Miller 2018; Herrnson, Heerwig, and Spencer 2018).

³Many analyze only one part of the election with one player per side (Stromberg 2008; Shachar 2009; Gordon and Hartmann 2016; Incerti 2018; Limbocker and You 2020).

⁴I adapt elements from Bouton, Castanheira, and Drazen (2020) to model these constraints through impressionable donors who supply contributions to these committees.

forward-looking behavior. It is vital to include the actions prior to general elections, such as primary elections and candidate entry, as any counterfactual scenario studying Super PACs should not hold these fixed.⁵

A key challenge is to deal with candidate unobservables. The general election winner, general election loser, primary election losers, and potential candidates who did not enter may differ in the eyes of voters in unobserved ways (Dal Bó and Finan 2018). To account for the unobserved heterogeneity across candidates that faced each other in an election, I use exogenous variation in donor finances that affects committee spending. To deal with the unobserved match-ups between candidates that influence forward-looking behavior, I exploit the dynamic model structure. Finally, to proxy for the unobserved selection of candidate entry, I compare Congressional entrants and non-entrants based on their State legislature election records.⁶

Results indicate that Super PACs increase overall spending but with significant heterogeneity. Without Super PACs, total general spending would go down by 18%. While Republicans are slightly helped in general elections, the symmetric spending from both sides largely cancels out the effects in both the general and primary elections. Candidates are also affected, with nontrivial changes to candidate entry and candidate platforms; many are more likely to enter and choose moderate positions if Super PACs are present. Super PACs have differential importance across incumbency status and some effects are imprecise.

I contribute to the literature by estimating a comprehensive campaign finance model that differentiates between candidate and “outside” spending and includes within-election dynamics. I also provide analysis of Super PACs in national elections using novel donor finance variation with counterfactual simulations on the effects of Super PAC presence. This chapter relates to the work on spending in elections, primaries and candidate entry, “outside” influence and donors, and the

⁵Also, the set of candidates in the general election is not random; many races are largely determined in the primaries; ignoring the primaries omits the decision making that precedes and informs spending in the general (Albert, Desmarais, and La Raja 2016; Boatright, Malbin, and Glavin 2016).

⁶Other approaches include using lagged ad price IVs (Stratmann 2009; Chung and Zhang 2020; Gordon and Hartmann 2016), discontinuities of district/media market (Stromberg and Snyder 2010; Spenkuch and Toniatti 2018; Wang 2018), repeat challengers (Levitt 1994), lagged votes/spending (Green and Krasno 1988), and competitiveness measures (Erikson and Palfrey 2000).

new literature on *Citizens United* and Super PACs. There is a rich literature on election spending, primary elections, and political selection (Albert, Desmarais, and La Raja 2016; Carson 2016; Fowler 2016; Dal Bó and Finan 2018); this chapter broadens the literature to include Super PACs and a novel empirical model that considers strategic behavior among political agents and estimates the multiple stages of an election. There is little work on Super PACs in national elections,⁷ and state election evidence suggests the flood of new money helped Republicans win more State legislature seats (Klumpp, Mialon, and Williams 2016). For the State-level elections, state variation prior to 2010 in state campaign finance laws provides identification (Werner and Coleman 2014).⁸ Since my focus is on national elections, that identification strategy is not ideal. My methodology builds upon the structural estimation of election campaigns literature (Kawai and Sunada 2015; Gordon and Hartmann 2016; Sieg and Yoon 2017; Iaryczower, Moctezuma, and Meirowitz 2017; Garcia-Jimeno and Yildirim 2017).

The chapter continues as follows: I start with the data in section 2, detailing the empirical environment and novel donor data. I follow with the model in section 3, describing each stage of the game that will be estimated. I discuss the identification and estimation in section 4. Each stage has parameters that are estimated stage by stage, including the general election voter preferences, committee preferences in the general, primary election voter preferences, additional committee parameters in the primary, and the parameters that govern candidate entry and policy decisions. Section 5 discusses the parameter estimates and delves into a counterfactual that considers how the electoral landscape would change if Super PACs never existed. I run this simulation by solving the model using the estimated parameters but excluding Super PACs from spending in the election. I conclude in section 6.

⁷There is a growing body of descriptive work (Hansen, Rocca, and Ortiz 2015; Baker 2016a; Barutt and Schofield 2016; Miller 2017).

⁸Many use that same variation (Hamm, Malbin, Kettler, and Glavin 2014; Spencer and Wood 2014; Abdul-Razza, Prato, and Wolton 2020; Harvey and Kaslovsky 2019; Petrova, Simonov, and Snyder 2019).

1.2 Data

The two principal groups in this environment are candidates and voters: candidates choose policy platforms and voters choose their preferred candidate. The two broad groups in the background are election committees and donors: committees spend money to help candidates win and the donors supply these committees with campaign contributions. The main committees are the campaign committees, political party committees, traditional Political Action Committees, and Super PACs, each with varying spending and fundraising limitations.⁹

1.2.1 Voting and Candidate Data

One way to measure the spending influence by committees is on the share of votes a candidate receives. The primary, runoff, general, and general runoff election data are from the FEC.¹⁰ Figures 1.C.3 and 1.C.4 show the vote share over time for incumbents in the general and primary elections, where one can see the declining incumbency advantage (Jacobson 2015); note that this trend has slowed down since 2010. In primaries, incumbents win re-election with an over 90% success rate and uncontested primaries were the norm prior to 2010. The number of contested primaries increased during 2010 and stayed high afterwards, as shown in Figure 1.C.5. However, attributing the initial increase to Super PACs is not appropriate because the court case came during the primary cycle. It was largely driven by the “Tea-Party” movement in which establishment Republicans faced a much higher rate of contested primaries.

My measure for candidate position/platform/ideology comes from Bonica (2014).¹¹ It is based on a spatial model of donors where they contribute more to candidates to whom they are more ideologically aligned. To operationalize this, Bonica uses correspondence analysis to construct

⁹For political party committees, I include federal, state, and “Leadership PAC” type committees.

¹⁰They detail votes and parties for all balloted candidates in Congressional elections which had general elections occur on election day. Non-election day special elections are added from the FEC’s non-prepared reports and the CQ election database. The current dataset includes the 2002-2016 cycles for House elections.

¹¹An alternative measure is based on Congressional voting records (DW-NOMINATE scores), and is insufficient for this analysis as it is only observed for incumbents with a voting record. I find that the correlation between DW-NOMINATE and Bonica’s “CF-scores” is 93.34% among House incumbents.

a “common-space” ideology measure based on the whole network of donors and recipients. As described in Bonica (2014), he constructs a contingency table of all donor-recipient committee matches with the dollar values in each cell, then converts the dollars into counts using contribution limits (see Bonica (2014) Appendix A for more details). He then performs a singular value decomposition on the normalized matrix. What Bonica then calls the “ideal points”, which I call the observed position, are then defined based on the eigenvalues of square of that decomposition. Effectively it associates a number per column and a different number per row to find the maximum possible correlation.

These scores are available for all Congressional candidates from 1980-2018. It is well defined for most candidates that received donations. Practically all candidates fit between -3 and 3, where -3 is most liberal, 0 is in the middle, and 3 is most conservative. I report the distribution of these scores in Figure 1.C.6 for pre and post (including) 2010. Note that the distribution is slightly wider in post-2010, indicating higher polarization. The twin peaks around -1 and 1 are due to most candidates not going beyond a moderate position (-1 for Democrats and 1 for Republicans). There is a local trough at 0 as most candidates are at least slightly positioned to one political side.

Republican incumbents who face a primary challenger are slightly more extreme than those who have an unopposed primary. For all Republican candidates, less extreme candidates are generally more likely to win the primary. The average position for Republican incumbent primary winners is higher than for incumbent losers, but there are very few incumbent primary losers. Figure 1.C.7 shows the relationship between candidate position, spending by groups, and the election outcome. It graphs the difference in general election spending by all sources supporting the candidate and opposing the candidate across the absolute value of the candidate’s position (as a measure of extremism), with different markers for whether the candidate won or lost the general election. Candidates that are outspent are more likely to lose and the variance increases with candidate position; for candidates with more extreme positions, large spending gaps may be necessary to win.

1.2.2 Committee Data

Political Action Committees are formal entities regulated under the FEC that can raise and spend money in elections. These committees support candidates through multiple channels: they may donate money to the candidate's campaign committee, rally individuals to support the candidate, and spend on "communications" in support or opposition of a candidate. Direct contributions to a given candidate have strict upper limits that prevent a single PAC from "buying" too much influence with a candidate. Individuals are limited in how much they can donate to a PAC. Between 2002-2010 all PACs had similar fundraising limits on them in that a single individual could only give a few thousand dollars to the PAC in a given election cycle.¹²

Prior to 2010, non-PAC groups such as corporations, nonprofits, unions, and trade associations were limited in their ability to spend in elections. They could form their own PAC, but they could not donate money directly to PACs nor make ads targeting candidates. Ads not coordinated with the candidate or party are called "independent expenditures" (IEs).¹³ The 2010 case *Citizens United v. FEC* allowed these non-PAC groups to make independent expenditures. The following 2010 case *SpeechNOW v. FEC* allowed individuals and now corporations to donate unlimited amounts to IE-only PACs (coined Super-PACs).¹⁴

The FEC provides datasets on committee expenditures with the unit of observation at the transaction level for everything over \$200. The groups engaged in independent expenditures must disclose to which candidate that expenditure was targeted and whether it was for or against the candidate. The date is for when the "communication is publicly distributed or otherwise publicly disseminated" (FEC), and committees often note whether a given expenditure is aimed at the pri-

¹²PACs may end up spending a significant amount in direct contributions but that is by donating to many candidates. Committees may coordinate with a campaign on ads, but this has restrictions.

¹³An independent expenditure (IE) is expenditure for a communication "expressly advocating the election or defeat of a clearly identified candidate that is not made in cooperation, consultation, or concert with, or at the request or suggestion of, a candidate, a candidate's authorized committee, or their agents, or a political party or its agents" [11 CFR 100.16(a)].

¹⁴In Appendix 1.A.1.1 I discuss this case and related campaign finance issues, and provide summaries of the laws and spending limits in Tables 1.C.1 and 1.C.2. Social welfare nonprofit organizations (501(c)(4)s), known as "dark money" groups, also spend in elections however their spending is distinct (again see Appendix 1.A.1.1). As the Center for Responsive Politics reports, they often spend earlier in the election, their spending is not targeted against individual candidates, and most of their spending occurs well before Super PAC spending.

mary or general election. Campaign committee advertising spending is calculated from itemized expenditure reports. I combine ads supporting the candidate and attacking the opponent (see Appendix 1.A.1.6 for a discussion separating them). This file lists every expenditure over \$200. I utilize the self-reported transaction codes and augment that with string-matching in the description field to approximate which transactions are related to ad spending. Summing up all the transactions for each candidate is inappropriate as the IEs are primarily ad-spending and the expenditure files include all forms of spending. The FEC does not have Senate candidate expenditures itemized in a bulk fashion prior to 2010.

I link each “outside” committee (PAC, Super PAC, party) to the campaign they support, combine that with the donor data linking the “in-state” and “out-state” donor variables to the specific district-state in which the committee is active, and merge these with the candidates that are running for election. About 30% of candidates running are not in either dataset, which is not surprising given that most candidates without spending receive trivial votes. Also there are candidates with spending that did not run during the given cycle; those are often post-cycle house-cleaning or early future fundraising (neither of which are large). All dollar values are inflation adjusted to 2015 dollars.

In Table 1.C.3 I detail total general election ad spending in House election pre and post (including) 2010 for four committee types based on the party and incumbency status of the candidate they support.¹⁵ Presidential election cycles often have more Congressional spending as there are donor spillovers, and there are two sets of Presidential and non-Presidential cycles in both pre/post periods. Candidates consistently spend the most, and this is because there is candidate spending in every single race, whereas parties and Super PACs spend sporadically. Total spending increased since 2010 across all committee types, with the new \$277 million in Super PAC spending matching the total increase of \$310 million by candidates and parties. Super PACs spend more on challengers than on incumbents and only Republican incumbents have seen a decrease in total

¹⁵ Average Super PAC spending at the cycle-district-candidate level in post-2010 general elections is \$57.8 thousand with candidate, PAC, party averages of \$192.2, \$13.9, \$110.8 thousand respectively. The largest Super PAC expenditure in a given district is \$5.7 million, with similar levels for candidates and parties.

spending since 2010. While there are more Republican incumbents after 2010, the 2010 Congressional re-districting may have favored Republicans (Royden and Li 2017; Eguia 2020), leading to less competitive districts and hence less spending by incumbents to defend their seat. The large increase in Democratic incumbent spending is mirrored by the increase in Republican challenger spending as that is a common matchup for competitive races. In these races, candidates, parties, and (obviously) Super PACs have large spending expenditures relative to pre-2010.

A major concern for parties, beyond retaining majorities, is re-electing incumbents. Their spending patterns align with these goals and they often focus on competitive races, such as districts with weak opposition incumbents and open seats in swing states. Super PACs are similar in that they spend large amounts in few but highly competitive races. Both will also occasionally spend in a safe race, often to challenge an important incumbent. Parties and Super PACs differ most in primary elections.

Traditional PACs are quite different from parties and Super PACs as they spend relatively little on independent expenditures and their main method is through giving money directly to candidates, especially incumbents. Incumbents receive on average ten times as much in direct contributions as challengers. In addition, PACs often give to incumbents in non-competitive races or even unchallenged incumbents in both primary/general, and they give similar amounts regardless of what others are doing. PACs (often representing an interest group) are a stable funding source for incumbents and may give as an “investment” to keep the incumbent in their pocket of influence. However, their role has not necessarily diminished with the rise of IEs (Baker 2018b), shifting even more away from ads.

In Table 1.C.4 I show total primary election ad spending for elections that have an incumbent and in Table 1.C.5 I report the same for primaries without an incumbent present, known as “open” races. Distinguishing between open and non-open races is important because incumbents almost always win primaries and open Congressional seats often see very high spending. Prior to (and including) 2010, candidate committees dominated primary spending. This changed after 2010, when Super PACs started to spend; while their average is low, they often outspend the candidate they

are supporting or opposing in the races in which they participate. Party and PAC spending have seen a downward trend in primaries, especially in open races. One explanation of this behavior is that parties are relatively ineffective spenders or have high costs in primaries. There may be some substitution from party to Super PAC spending as the decrease in spending to support Democratic incumbents by parties is nearly matched by the increase in Democratic Super PAC spending. Republican Super PACs spend more in primaries than their Democratic counterparts, and there has been an increase in spending across all candidate types. Super PACs play an even larger role in open races as their spending relative to candidates and parties is higher than in non-open races.

The total spending statistics do not tell us about the strategic responses between committees, such as whether or not they mirror each other in which races they enter.¹⁶ When a committee helps a candidate, the opposing committees often match their spending. For example, if at least one Super PAC spends during the general, then in 95% of those races, at least one party committee or PAC would also spend. However parties are the lone non-candidate spenders in 5% of races and PACs are the lone spenders in 38% of the races in which they spend. Also Super PACs outspend parties in 66% of the races in which they spend. In primaries, Super PACs are the lone non-candidate spenders 40% of the time. Prior to 2010, parties were alone 73% of the time, which decreased to 36% after 2010. Thus the primaries are becoming more crowded, but this could be due to either increased levels of participation or simply lower number of primaries spent in. Parties spent in about 8% of primaries before and after, and Super PACs spent in 15% after 2010.

1.2.3 Donor Data

Campaign contribution donors supply committees with the necessary funds to spend on election ads. A committee's ability to spend is affected by how much they raise, which itself is influenced by variation in their donors' financial well-being. Super PACs are especially sensitive to variation in contribution amounts because they can receive large contributions from a single individual;

¹⁶The distribution of candidate spending across different kinds of races indicates that non-zero candidate spending pre-2010 and post-2010 without Super PACs are similar, but candidate spending is drastically different in the races with Super PACs.

contribution limits for candidates/PACs ($\approx \$5,000$) and parties ($\approx \$35,000$) force these committees to have a broader set of donors. However all committees are still vulnerable to downward shocks in the income or wealth of their donor base; the strength of this variation is based on the income elasticity of campaign contributions, and the wealth elasticity of contributions by billionaires is significant (Bonica and Rosenthal 2015).¹⁷ To exploit this source of variation, I construct donor financial well-being measures that affect committee spending.

Donors are known because all political committees (those regulated under the FEC) are required to disclose the identities of their individual donors, including the donation amount, date, name, address, and employment information. I do not observe financial information of donors directly and instead use proxies. I use address level housing characteristics of individual donors (Zhao 2019) and zip code level incomes (Gimpel, Lee, and Kaminski 2006).¹⁸ For the former I use variation in housing values, real-estate prices, taxes, zip code level mortgage information, and other financial indicators that are proxies for financial well-being. The address level real-estate transaction data are from Corelogic's nationwide database on deeds and taxes.¹⁹ The zip code data on mortgage performance and origination are also from Corelogic and the zip code income data are from the Internal Revenue Service.

I track the financial well-being changes for that individual and zip code over time, which may affect how much the donors give. I weight each shock by the amount that the citizens in that zip code gave to same-party candidates in the previous election; since I average the shocks across donors/zip codes for a given committee, equal weight on each means the locations with few donors with a big shocks have a larger effect on the committee than locations with many donors with small shocks. This is likely not the case and may weaken the instrument.

¹⁷See Appendix 1.A.1.3 for more details on using variation of wealthy donors.

¹⁸I also consider Billionaire donors' wealth (Bonica and Rosenthal 2015), however many groups do not receive any money from a billionaire, so there are too many zeros to rely on this measure alone. This was validated by scraping the Forbes billionaire list; see Appendix 1.A.1.4 for details. Industry performance of donor profession is another possibility however one would need to classify donors' industry through their self-reported occupation, but this does not work for some donors, such as the retired.

¹⁹Corelogic's database (via Princeton's Data and Statistical Services) on deeds contains every assessment from county offices dating back to the 1990s; the tax data goes back to 2005; the residential mortgage performance data are for 65% of all active mortgages with their originations back to 1998.

One issue is how to define the instrument when there is zero spending, as we do not observe the identity of a Super PAC that was interested in spending but did not. Endorsement data could be useful to identify such groups (Grossmann and Dominguez 2009) but many committees do not report this information; in addition, some that do report endorsements fund each candidate. I use the average for Super PACs that are aligned with the same party-incumbency status in that state and use their income variation for this hypothetical “potential” entrant Super PAC. I average across the country if there are none in the state.

I differentiate between donors in the state in which the committee is spending, as within-district donor variation may affect a given district’s electoral outcome, and out-of-state donors, which may be less related to the characteristics of a given district (Gimpel, Lee, and Pearson-Merkowitz 2008; Rhodes, Schaffner, and La Raja 2018). In Figure 1.C.8, I graph Super PAC spending across 100 bins of the various donor financial measures.²⁰ For zip code level income, there is a general increase in spending for higher income changes, especially for positive changes. For changes in house assessment values, among donors who have had assessments, there is again a position correlation. There is also a negative correlation between increases in the mortgage interest rates and Super PAC spending, again driven by reductions in donations.

In Table 1.C.6, I consider the variation induced by zip code level income changes. The first column regresses contributions at the zip code level on their lagged contributions, lagged income, and change in income. The income change positively correlates with donations. In column 2, I consider the perspective of the committee and how much they receive from donors in that zip code based on the income; the effect is similar. In column 3, I aggregate up to the year level for the committee to see whether the average income variation by the donors affects the overall budget; the effect is similar but weaker due to aggregation. Finally, I consider the spending level in a given election, and look at out-of-state donor income variation, and find that those income changes are fairly predictive of spending.

²⁰I consider the change in: zip code level income, house sale price, house value, house tax, zip mortgage balance, zip mortgage interest rate, zip foreclosure rate, zip days delinquent, and zip max days delinquent.

1.3 Model

A theoretical framework is useful to estimate the effects of Super PACs on electoral competition and analyze the counterfactual of how the elections outcomes could change without Super PACs existing. This model should capture the different direct and indirect channels through which Super PACs could influence the election, including the within-election dynamics of each stage of the election, from the initial entry and policy-platform decisions by candidates to the general election voters' decisions. I will estimate the various parameters from the model, such that the endogenous decisions can be re-solved for in the counterfactual, holding these estimated parameters fixed.

1.3.1 Model Setup

The game environment is as follows: There are two sides, Republican and Democrat, fighting to win a Congressional seat. Candidates make policy and entry decisions prior to the election and committees raise and spend money to help the candidates win. For exposition, let Republicans be the party in power.

There are four classes of players: First candidates: $\{R_1, R_2, D_1, D_2\}$, where R_1 is the Republican Incumbent, R_2 is the Republican Primary Challenger, D_1 is the first Democratic Primary Challenger, and D_2 is the second Democratic Primary Challenger. Let $c \in \{R_1, R_2, D_1, D_2\}$ denote an arbitrary candidate.

Second there are committees (campaign, parties, and Super PACs) aligned to each candidate: let $i_c \in N_c$ refer to a committee aligned with candidate c ; N_c is the set of committees aligned to candidate c . Next, there are many voters v for each side in the primary and the general, and finally donors $j \in J$ that donate to committees based on fundraising.²¹

The actions take place over four main stages. All actions from previous stages are observed by players. First, the incumbent chooses a position in a discrete one-dimensional space with $d_I \in \{0, \dots, \Theta\}$ and $d_I = 0$ indicates they will not seek re-election. The positions can be interpreted as

²¹In Appendix 1.A.1.2 I consider an extension with an additional player: an investment PAC P_I aligned with the incumbent that helps build the incumbent's war-chest to discourage entry during the "shadow primary".

either a political scale of left-to-right or moderate-to-extreme per party. These positions capture how voters and donors perceive candidates, such as “a moderately liberal Democrat” versus “an extremely liberal Democrat”. Second, the challengers decide whether to enter the election or not and choose a policy position $d_c \in \{0, \dots, \Theta\}$. Non-entry is $d_c = 0$. Let $\mathbf{d} = \{d_{R_1}, d_{R_2}, d_{D_1}, d_{D_2}\}$.

Third, committees (other than the candidate’s committee) make primary entry decisions $a_{i_c}^P \in \{0, 1\}$. Let $\mathbf{a}^P = \{a_{i_c}^P \forall i_c\}$. Then the committees decide how much effort to exert in raising money in the primary election $e_{i_c}^P \in \mathbb{R}_+$ (zero for non-entrants). Then, donors make their primary election donations $y_{j_{i_c}}^P \in \mathbb{R}_+$, which gets converted into spending (ads) $S_{i_c}^P$. Then, the primary voters (on each side) vote and a winner is decided $w_c^P \in \{0, 1\}$ for both Republican and Democratic primaries; let $\mathbf{w}^P$ denote the set of primary winners.

Fourth, the committees (including those who may not have entered the primary) make general entry decisions $a_{i_c}^G$. Let $\mathbf{a}^G = \{a_{i_c}^G \forall i_c\}$. Then they choose fundraising efforts for the general election $e_{i_c}^G$. Then donors make their general election donations $y_{j_{i_c}}^G$, which gets converted into spending $S_{i_c}^G$. Finally, voters vote to determine a general election winner w_c^G .

I describe the payoffs in the next section. I focus on equilibria where agents only condition on the set of actions that are payoff relevant to them; the purpose is to ease the notation.²²

1.3.2 Model Parameterization

Consider the final stage; a general election voter v chooses candidate R , D , or not to vote. Their utility from voting for candidate c , U_{vc} , is given in equation (1.3.1) and inspired by Gordon and Hartmann (2016). It is a function of campaign spending, exogenous observables, and private information. The spending $S_{i_c}^G \geq 0$ is by committees $i_c \in N_c$ supporting the candidate c and has corresponding effectiveness parameters $\beta_{i_c} \geq 0$ and $\phi \in (0, 1)$. The $\phi = 1$ case leads to perfect substitutability; only one player per side ever spends. The term X_c^{G1} is composed of exogenous

²²To clarify: recall that I allow players to observe all actions from previous stages (hidden actions complicate defining the PBE). Thus for example, voters observe fundraising effort and an equilibrium might exist with voters conditioning on effort. However committee effort is not payoff-relevant to voters conditional on spending, and thus I focus on equilibria in which voters (all players for that matter) do not condition on payoff-irrelevant actions. The concise conditioning notation implies this.

characteristics that allow for heterogeneous spending effects. The mapping $h_c^G: \mathbb{R}^k \times d_c \rightarrow \mathbb{R}$ is a function of k observed exogenous district-candidate characteristics $X_R^G \in \mathbb{R}^k$, the position choice d_c , and parameters $\delta \in \mathbb{R}^{k+1}$. The unobservables include unobserved candidate-election characteristics $\xi_c^G \in \mathbb{R}$ and voter private information idiosyncrasies $\varepsilon_{vc} \in \mathbb{R}$. The utility of abstention is $U_{v0} = \varepsilon_{v0}$.

$$U_{vc} = \underbrace{\sum_{i_c \in N_c} \beta_{i_c} (S_{i_c}^G)^\phi \cdot (1 + X_c^{G1} \alpha) + h_c^G(X_c^{G2}, d_c, \delta) + \xi_c^G}_{u_c^G} + \varepsilon_{vc} \quad (1.3.1)$$

Voters observe everything except other voters' idiosyncrasies. Committees do not observe $\{\xi_c^G, \varepsilon_{vc}\}_{\forall v,c}$, but know their distributions. Voters observe ξ_c^G because this term incorporates how voters perceive candidates and shocks that occur during the election up to election day that affect the voter's decision. While an individual voter does not know exactly what their neighbor thinks, captured in the private information ε_{vc} , it is reasonable to assume they know the district-candidate level local information. Committees and candidates make their spending and policy decisions early enough in the election cycle such that ξ_c^G is not exactly known at the time.

The voter has priors on each candidate via $\{h_c^G, \xi_c^G, \varepsilon_{vc}\}$, and the spending gives them new information.²³ To transform this from the voter's perspective to the committee's, construct the share of votes and then the probability of winning. The voter's private idiosyncrasies ε_{vc} are distributed iid Type 1 Extreme Value with location zero and scale one.²⁴ Then the share of votes s_c^G is the following for $\aleph$ number of candidates (see Lemma 1 for details):

$$s_c^G = \frac{\exp(u_c^G + \xi_c^G)}{1 + \sum_{\iota=1 \dots \aleph} \exp(u_\iota^G + \xi_\iota^G)}. \quad (1.3.2)$$

Then candidate c wins if $s_c^G > s_n^G \forall n \neq c$. For two candidates, write out the win indicator

²³Effectiveness does not vary between support and attack ads; this simplification is not innocuous as voters may be differentially affected by the type of ad (Sides, Lipsitz, and Grossmann 2010).

²⁴The Type 1 Extreme Value distribution (special case of Gumbel distribution) is a continuous distribution with pdf $f(x) = \exp(x) \exp(-\exp(x))$. It is commonly used in discrete choice (Train 2009), and thus is appropriate in this context, and the difference in two T1-EV follows a logistic distribution.

function for candidate R as follows:

$$\mathbb{1}[s_R^G > s_D^G] = \mathbb{1} \left[\frac{\exp(u_R^G + \xi_R^G)}{1 + \exp(u_R^G + \xi_R^G) + \exp(u_D^G + \xi_D^G)} > \frac{\exp(u_D^G + \xi_D^G)}{1 + \exp(u_R^G + \xi_R^G) + \exp(u_D^G + \xi_D^G)} \right].$$

The above is equivalent to the expression $\mathbb{1}[u_R^G + \xi_R^G > u_D^G + \xi_D^G]$. Now committees may not perfectly know how voters will perceive candidates and thus have beliefs over the unobserved candidate shocks. Let $\xi_c^G \sim \text{iid Type 1 EV with location } \psi_c^G \text{ and scale } \sigma_\xi$. Rewrite ξ_c^G in terms of a standard T1-EV random variable $\xi_c^* = (\xi_c^G - \psi_c^G)/\sigma_\xi$, meaning $\xi_c^G = \xi_c^* \sigma_\xi + \psi_c^G$, then rewrite the indicator: $\mathbb{1}[u_R^G + \xi_R^* \sigma_\xi + \psi_R^G > u_D^G + \xi_D^* \sigma_\xi + \psi_D^G] \implies \mathbb{1}[(u_R^G + \psi_R^G)/\sigma_\xi - (u_D^G + \psi_D^G)/\sigma_\xi > \xi_D^* - \xi_R^*]$. Then the expected value of this indicator function is the win probability $P(w_R^G = 1 | \mathbf{w}^P)$ from the committee's perspective:²⁵

$$P(w_R^G = 1 | \mathbf{w}^P) = \frac{\exp((u_R^G + \psi_R^G)/\sigma_\xi)}{\sum_{c \in \{D, R\}} \exp((u_c^G + \psi_c^G)/\sigma_\xi)}. \quad (1.3.3)$$

To construct the payoff for the committee, I model the donors and derive the fundraising production function. That maps committee fundraising efforts e_{ic}^G into spending S_{ic}^G , specifically $S_{ic}^G = \sum_{j \in J} \gamma_{j,ic} e_{ic}^G$, where $\gamma_{j,ic}$ is the fundraising yield (inverse cost) from donor j for committee i_c .

The general election donor $j \in J$ maximizes the utility from giving to the political causes they support. Their program is given in (1.3.4) and they choose how much to give to committee i_c with $y_{ji_c}^G$. Whether or not they give is primarily based on the donor's political alignment with the committee to which they are donating, $\alpha_{ji_c} : d_c \rightarrow [0, 1]$, which is function of the candidate's policy platform. The benefit is also a function of how much they give and the committee fundraising effort e_{ic}^G . This setup is inspired by the “naive” donors specification from Bouton et al. (2020).²⁶

²⁵Note this is the “contest success function” for the general election. Also, this is only for a plurality voting rule. A majority rule would use a CSF such as $P = \exp(-\exp(s_c - 0.5))$ with a runoff, and a top-two primary CSF would be the density of the 2nd order statistic for winning. Two states have majority rules for the general; 11 have it for the primary. Three states (varying across time) use open primaries. I exclude the races with unique designs (like Louisiana) and use the run-off as the “main” election when applicable.

²⁶In their main model, donors internalize their influence over the election outcome. If I did that, the donors and

Their costs are a function of their donation, weighted by their wealth $\alpha_j^0 > 0$ and how limited the committee i_c is in fundraising ability $\alpha_{i_c}^F$.²⁷

$$\max_{y_{ji_c}^G \in \mathbb{R}_+} \alpha_{ji_c} y_{ji_c}^G e_{i_c}^G - \frac{(y_{ji_c}^G)^2}{2\alpha_j^0 \alpha_{i_c}^F} \quad (1.3.4)$$

Solving program (1.3.4) and regrouping leads to the following interpretation: the donor supplies campaign contributions $y_{ji_c}^G$ to political committees i_c by choosing their contribution level based on their preference/ability $\gamma_{ji_c} = \alpha_{ji_c} \alpha_j^0 \alpha_{i_c}^F$ and the political committee's fundraising efforts $e_{i_c}^G$. Their optimal donation function can be thought of as the fundraising production technology (from that donor) for the committee as shown in equation (1.3.5):

$$y_{ji_c}^G = \gamma_{ji_c} e_{i_c}^G \quad (1.3.5)$$

To make this model of spatial donors that are also influenced by fundraising efforts consistent with Bonica (2014), an interpretation is that the individual donor is not influenced by fundraising (only policy), and rather just the number of donors is affected by fundraising efforts. The donations are translated into spending with a simple setup shown in equation (1.3.6). This assumes that donations are race-specific and that groups spend all they raise.²⁸

$$S_{i_c} = \sum_{j \in J} y_{ji_c}^G \quad (1.3.6)$$

committees would effectively be interchangeable. My approach also differs from Schnakenberg and Turner (2020), who model the donor's decision between two kinds of candidates based on policy preference.

²⁷The weighting by fundraising limits is an alternative to a strict limit per donor. The interpretation is clearer once one looks at the donation production function and think of these donors as classes of donors. It is easy for a Super PAC to raise a lot of money with little effort: they can get \$1 million from one wealthy donor. For a candidate to raise that much, they would have to raise the maximum of \$5,000 from 200 people.

²⁸To simulate public financing of campaigns (Klumpp, Mialon, and Williams (2015)), add a constant. As an aside, one could generalize the model to allow for the fundraising efforts to vary at the donor level, meaning player i chooses e_{ij} for every j . This prevents one from constructing a one-to-one transformation between S_i and e_i , but it would not substantively change the outcome of the model: solving the spending stage with e_{ij} simply adds more first order conditions which effectively results in just additional players to each side.

The general election program for a committee is given in (1.3.7) in terms of efforts and (1.3.8) in terms of spending. Any entry cost is sunk at this point so I omit it from the program below. A committee's value associated with winning is $V_{i_c} \geq 0$. Let $g_{i_c} = (\sum_{j \in J} \gamma_{ji_c})^{-1} \geq 0$, where g_{i_c} can be interpreted as spending constraints; spending on ads has a marginal cost associated with raising the sufficient funds.²⁹

$$\max_{e_{i_c}^G \in \mathbb{R}_+} V_{i_c} \cdot P(w_c^G = 1 | w_c^P = 1, \mathbf{w}_{-c}^P) - e_{i_c}^G \quad s.t. \quad S_{i_c}^G = \sum_{j \in J} \gamma_{ji_c} e_{i_c}^G \quad (1.3.7)$$

$$\max_{S_{i_c}^G \in \mathbb{R}_+} V_{i_c} \cdot P(w_c^G = 1 | w_c^P = 1, \mathbf{w}_{-c}^P) - g_{i_c} \cdot S_{i_c}^G \quad (1.3.8)$$

Before the general election, the committees make entry decisions. I allow for private information in payoffs (entry costs), $\lambda_{i_c}^G \sim \text{Logistic}(0, \sigma)$. Committees then have beliefs over the entry decisions of other committees. Let $\pi_{i_c}^G = V_{i_c} \cdot P(w_c^G = 1 | \cdot) - e_{i_c}^G$. The expected payoff for a given entry decision conditional on private information, $u_{i_c}^G(a_{i_c}^G | \cdot) - \lambda_{i_c}^G a_{i_c}^G$, integrates over these beliefs. $N = \dim\{N_c\}$. The summation is across all 2^{N-1} combinations of committee decisions $\mathbf{a}_{-i_c}^G$; denote the belief by committee i_c in the probability of committee j choosing a_j^G from the decision profile $\mathbf{a}_{-i_c}^G$ with $p_j(\mathbf{a}_{-i_c}^G)$, where $-i_c$ notation refers to committees except i_c . The entry payoff is below, where $\mathbf{S}^*$ is the vector of optimal spending for a given entry profile. Note that spending in the election has a public good aspect. A committee can have a non-entry positive payoff (the probability of a candidate winning is not necessarily zero if their aligned committee does not enter). This is not innocuous; under a favor-buying framework, the committee who does not support the candidate receives nothing. I am implicitly assuming committees just want the candidate to win

²⁹Note that every different kind of committee has the same payoff structure; this is not innocuous as parties may care about winning majorities, creating more dependence across races. This concern is reduced by recent finds however: Incerti (2018) estimates both majority-seeking and total-seat-seeking models of party spending in House races and finds more evidence for the latter framework.

and they do not care if that is through their spending or others’.

$$\max_{a_{ic}^G \in \{0,1\}} u_{ic}^G(a_{ic}^G | \mathbf{p}_{-ic}) - \lambda_{ic}^G a_{ic}^G \quad s.t. \quad u_{ic}^G = \sum_{\mathbf{a}_{-ic}^G \in \{0,1\}^{2N-1}} \pi_{ic}^G(\mathbf{S}^* | a_{ic}^G, \mathbf{a}_{-ic}^G) \prod_{j \neq ic} p_j(\mathbf{a}_{-ic}^G) \quad (1.3.9)$$

The previous stages are repeated in the primary election, but the committees now use the expected outcome of the general election: $EP(w_c^G = 1) = \sum_{\mathbf{a}^G \in \{0,1\}^{2N}} P_c^G(\mathbf{a}^G) \prod_j p^*(a_j^G)$, where $P_c^G(\mathbf{a})$ is the win probability from equation (1.3.3) evaluated at the equilibrium spending levels $\mathbf{S}^*$ for a given entry profile and $p^*(a_j^G)$ is the equilibrium probability of that entry profile. For the Republican side the payoff is given in equation (1.3.10), where $c \in \{R_1, R_2\}$.

$$\max_{S_{ic}^P \in \mathbb{R}_+} V_{ic} \cdot [P(w_c^P = 1)EP(w_c^G = 1 | w_c^P = 1 \cap w_{D_2}^P = 1) \cdot P(w_{D_2}^P = 1) + P(w_c^P = 1)EP(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1) \cdot P(w_{D_1}^P = 1)] - g_{ic}^P S_{ic}^P \quad (1.3.10)$$

Before the primary election, the committees make entry decisions. Define primary private information $\lambda_{ic}^P \sim \text{Logistic}(0, \sigma_p)$.³⁰ Let $\pi_{ic}^P = V_{ic} \cdot EP(w_c^G = 1 | \cdot) - g_{ic}^P S_{ic}^P$ and $u_{ic}^P - \lambda_{ic}^P a_{ic}^P$ be the expected payoff. Then the program for this entry stage is $\max_{a_{ic}^P \in \{0,1\}} u_{ic}^P(a_{ic}^P | a_{-ic}^P) - \lambda_{ic}^P a_{ic}^P$.

Prior to the primary, the potential challengers make entry decisions alongside discrete policy positions. I write the program for all challengers in equation (1.3.11), based on the probability of winning the overall election minus their costs. Let V_c be the value to candidate c of winning, V_c^0 be the outside option, $\bar{\theta}_c$ be the ideal position point, and κ_c be a cost scaling parameter. Let η_{d_c} be private variation in payoffs per choice, where $\eta_{d_c} \stackrel{iid}{\sim} T1EV(0, \sigma_C)$. The probability of winning the general election from the challenger’s perspective $EP_c^G(d_c)$, is an expectation over both the general and primary election committee equilibrium entry:

³⁰Committees in the primary do not observe the private shock for the general election, and it is assumed that a committee does not observe its own private shock in the general until reaching it.

$$EP_c^G(d_c) = \sum_{\mathbf{a}^P \in \{0,1\}^{4N}} \left[\sum_{\mathbf{a}^G \in \{0,1\}^{2N}} P_c^G(\mathbf{a}^P | \mathbf{a}^G, \mathbf{d}) \prod_j p_j^*(a_j^G) \right] \prod_j p_j^*(a_j^P).$$

$$\max_{d_c \in \{0, \dots, \Theta\}} V_c \cdot EP_c^G + V_c^0 \cdot (1 - EP_c^G) - \kappa_c(d_c - \bar{\theta}_c)^2 \cdot \mathbb{1}[d_c > 0] + \eta_{d_c} \quad \forall c \in \{R_2, D_1, D_2\} \quad (1.3.11)$$

Finally there is the first stage in which the incumbent I chooses a position. The expected win probability is now defined as $EP_I^G(d_I) = \sum_{\mathbf{d}'_C \in \dim\{\Theta\} | \mathbf{d}_C} EP_I^G(d_I | \mathbf{d}'_C) \prod p(\mathbf{d}'_C)$, taking an expectation over the equilibrium distribution of challenger decisions $\mathbf{d}_C$. The notation for valuations and costs is similar, with private information $\eta_{d_I} \stackrel{iid}{\sim} T1EV(0, \sigma_I)$.

$$\max_{d_I \in \{0, \dots, \Theta\}} V_I \cdot EP_I^G + V_I^0 \cdot (1 - EP_I^G) - \kappa_I(d_I - \bar{\theta}_I)^2 \cdot \mathbb{1}[d_I > 0] + \eta_{d_I} \quad (1.3.12)$$

1.3.3 Discussion

I solve the game with backward induction through each stage.

Proposition 1. *There exists a pure strategy Bayesian Nash equilibrium in which all agents condition on payoff relevant actions.*

Proof. See Proof of Proposition 1 in Appendix 1.6. □

The general election spending stage has a solution, but uniqueness is not guaranteed given the convexity of the exp function in the CSF, but the equilibria can be characterized. Existence and uniqueness of the entry stage is easier to demonstrate. Existence of the primary spending stage is straightforward, but uniqueness is not. Existence and uniqueness for the primary entry stage is similar to the general election argument. Challenger decisions are a generalization of the entry stages and the incumbent's decision is straightforward.

Lemma 1. *When voter v 's indirect utility from choosing candidate c is expressed as: $U_{vc} = u_c + \xi_c + \epsilon_{vc}$, where $\epsilon \sim iid$ Type I Extreme Value with location $\psi = 0$, and scale $\sigma = 1$, then the*

share of votes can be written as the following (with utility of abstention $U_{v0} = \epsilon_{vc}$ and number of candidates J): $s_c = \exp(u_c + \xi_c) / (1 + \sum_{k=1 \dots J} \exp(u_k + \xi_k))$.

Proof. See Proof 1 in Appendix 1.6. □

Lemma 2. *The program in equation (1.3.8) has a strictly (finite) positive solution for strictly positive $V_{ic} \forall ic \forall c$, strictly positive $\beta_{ic} \forall ic \forall c$, $\phi \in (0, 1)$, and strictly positive $\sum_{j \in J} \gamma_{jic} \forall ic \forall c$.*

Proof. See Proof of Lemma 2 in Appendix 1.6. □

Lemma 3. *The equations that define whether there is a unique solution for the program (1.3.8) can be expressed as a single equation with two parameters and one variable. Sufficient for a unique solution are magnitude restrictions on the relative sizes of the two parameters.*

Proof. See Proof of Lemma 3 in Appendix 1.6. □

Lemma 4. *The program in equation (1.3.9) has a pure strategy solution for strictly positive $V_{ic} \forall ic \forall c$, strictly positive $\beta_{ic} \forall ic \forall c$, $\phi \in (0, 1)$, and strictly positive $\sum_{j \in J} \gamma_{jic} \forall ic \forall c$, and this solution is unique for a sufficiently large σ .*

Proof. See Proof of Lemma 4 in Appendix 1.6. □

Lemma 5. *The program in equation (1.3.10) has a strictly (finite) positive solution for strictly positive $\{V_{ic}, \beta_{ic}, \sum_{j \in J} \gamma_{jic}\} \forall ic \forall c$ and $\phi \in (0, 1)$.*

Proof. See Proof of Lemma 5 in Appendix 1.6. □

Conjecture 1. *The program in equation (1.3.10) is unique under parameter restrictions.*

Proof. See evidence for Conjecture 1 in Appendix 1.6. □

Lemma 6. *The program in equation (1.3.11) has a pure strategy solution for strictly positive $V_c, V_c^0 \forall c$ and nonnegative $\kappa_c \forall c$. Furthermore, the solution to program in equation (1.3.11) is unique for sufficiently large σ_C .*

Proof. See Proof of Lemma 6 in Appendix 1.6. □

Conjecture 2. *The function $P(w_c^G = 1 | w_c^P)$ is invertible in ψ_c given parameter restrictions.*

Proof. See evidence for Conjecture 2 in Appendix 1.6. □

How does *Citizens United* affect this environment? Under the new paradigm, Super PACs enter the game and they may have differential valuations, costs, and effectiveness. Super PAC spending not only affects others' spending, but can also change the candidates' decisions and the election outcome.³¹ The model also relates to the work on the forces that drive candidates to choose moderate or extreme positions (Boleslavsky and Cotton 2015). Similarly, Baker (2016b) finds that "outside money" makes incumbents less responsive to their district, which in the model can be seen through donor preferences that may differ from voters.

There are distinct aspects of this model: I treat candidates differently from citizen-candidate models like Osborne and Slivinski (1996). I use costs to model contribution limits as opposed to direct constraints (Cotton 2009; Avis, Ferraz, Finan, and Varjao 2019; Maloney and Pickering 2018). I allow for substantial heterogeneity, differing from those that exploit symmetry (Stromberg 2008); sources of asymmetry include parameters, timing, and donors (Meirowitz 2008). The dynamics modeled here can be thought of as an extension of Adams and Merrill (2008), and distinct from other within-election games (Klumpp and Polborn 2006; Denter and Sisak 2015; Roos and Sarafidis 2017; Ellickson, Lovett, and Shachar 2019; Acharya et al. 2018) or between-election dynamic models (Kawai and Sunada 2015; Polborn and Snyder 2017).³² To understand the magnitude and direction of the effects, I estimate the model.

1.4 Identification and Estimation

I estimate the parameters that govern preferences for voters (parameters from equation 1.3.1 for the general and primary elections), committees (parameters from equations 1.3.8 and 1.3.10),

³¹One could also consider the saturation effect: the idea that a Super PAC flooding the market with ads makes a candidate's own ads less effective; this is empirically explored in Baker (2018a).

³²Kawai and Sunada (2015) is an interesting hybrid model with between-election warchest building and some within-election facets (abstracting away from policy, donors, outside spending, and primary-contested incumbents).

and candidates (parameters from equations 1.3.11 and 1.3.12).³³ I must assume that the observed data are in equilibrium and are selected from the same equilibrium across observations.

1.4.1 Estimation Of General Election Voter Preferences

Voter preferences are captured by the spending effectiveness parameters β , observed candidate characteristic parameters δ , and unobserved candidate characteristics ξ ; each of these varies across the general and primary election. The last term captures election day shocks and unobserved heterogeneity, which I collectively call candidate valence, and which committees and candidates know in expectation ψ_C^G for the general and ψ_C^P for the primary.

The influence of campaign spending on votes has been extensively studied in the pre-2010 environment (Carson 2016; Stratmann 2017), and a major source of endogeneity is the unobserved valence which affects the degree of competitiveness.³⁴ To be specific, the main threat to identifying the effects of observables on voter preferences is the unobserved election shock ξ . This influences voters directly and affects committees and candidates through their endogenous choices. Thus identification of spending effectiveness β and candidate characteristics δ is contaminated by ξ . I use instrumental variables to extract the variation in the endogenous variables that exogenously predicts voting behavior.

An ideal instrument for spending would be a shock to a committee's budget unrelated to the election in question; I use variation in the finances of donors from outside the state of the election in question.³⁵ The variation of outside donors is conditionally exogenous as variables that affect

³³I validated the estimation: I simulated the model with pre-specified values for the parameters, drew a sample from this data generating process (by solving the entire game for an equilibrium), and estimated it using the procedure describe in this section; I was able to precisely recover each parameter, and repeated this exercise for a variety of parameter value combinations.

³⁴Races that are not competitive do not exhibit large spending on either side. A weak incumbent combined with a strong challenger often result in a competitive race (Erickson and Palfrey 1998). In such instances, the challenger is able to spend more, so then the incumbent spends more, and outside groups become interested. Failing to isolate these competitive races precisely can result in biased estimates. Evidence for this problem can be seen in Table 1.C.7 with a weak candidate spending effect and a negative Super PAC spending effect.

³⁵A common IV for spending is off-election year average TV ad prices varying across media markets (Stratmann 2009; Chung and Zhang 2020; Gordon and Hartmann 2016); this specific variable does not vary at the committee level. One could also use out-of-district vs out-of-state donors. For price heterogeneity, one could use media market overlap instead of ad prices (see appendix 1.A.1.8).

the overall economy will affect donors across the country. The key is that conditional on the pre-spending controls, the additional variation in finances explained by the instruments is only related to the given election through spending. Consider a donor in West Virginia who is affected by the coal industry; a shock to their industry which affects their income will be correlated with the same shock to an Ohio coal region. If one sufficiently controls for the economic trends in Ohio, then the instrument can be excluded.³⁶

To instrument for candidate position I use lagged Senate incumbent positions from the same state as those correlate with the political environment but, conditional on political controls of the current election, are unrelated to the House race in question (similar to Iarcyzower, Moctezuma, and Meirowitz (2017)).³⁷ Thus, conditional on the controls, the exogenous variation in candidate positions and spending across differential vote shares (accounting for turnout) identify β and δ ; then ξ is the residual.

The spending effectiveness parameters β_{ic} are pooled across committee types (candidate, Super PAC, and party), meaning there are three distinct spending effectiveness coefficients for the general election. To construct the estimating equation, transform equation 1.3.1 with $\alpha = 0$ for simplicity.³⁸ Recall the general election voter utility for choosing candidate c , $U_{vc} = u_c^G + \xi_c^G + \varepsilon_{vc}$, where $u_c = \sum_{ic \in N_c} \beta_{ic} (s_{ic}^G)^\phi + h_c^G$, and the vote shares $s_c^G = \exp(u_c^G + \xi_c^G) / (1 + \sum_{c=1}^C \exp(u_c^G + \xi_c^G))$. The log vote share is $\ln(s_c^G) = \ln(\exp(u_c^G + \xi_c^G)) - \ln(1 + \sum_{c=1}^C \exp(u_c^G + \xi_c^G))$, which is equiv-

³⁶A concern is that some committees do not rely on out-of-state donors; there may be heterogeneity in the strength of the instrument varying across non excludable dimensions such as size and scope of the committee. Across all committees, the median number of states in which they receive donations is 23 and 3.16% have donors from only one state. In terms of dollar amounts, the average share coming from each state is 10%, and the maximum share across all states is on average 52%. One could also use out-of-district donors; this will be stronger for smaller committees but also is less likely to satisfy excludability.

³⁷I choose Senate as that is less sensitive to local district variation and may thus be more indicative of the general attitude in the State; a downside is that it does not vary between districts or candidates within the state. Results are not sensitive to using average outside-of-district by-party lagged position of House candidates within the same state (which addresses both of those variation issues). An alternative is the average exogenous variables for other candidates; this affects candidate c and the share of votes, but is excluded from U_{vc} based on functional form (Iarcyzower, Kim, and Montero 2020).

³⁸One could also use alternative specifications. First, allow $\alpha > 0$ to interact spending with district characteristics (which I consider in the appendix), and second, random coefficients IV Logit to allow for more flexible substitution patterns; Gordon and Hartmann (2016) note that the latter specification does not significantly change results from the simplified one considered in the main text.

alent to $\ln(s_c^G) = u_c^G + \xi_c^G + \ln(s_0^G)$, where s_0^G is the share of absenteeism, and yields the equation below, with normalized $\phi = 1/2$.³⁹ I estimate the moment $E[\mathbf{Z}^\top \xi_c^G] = 0$, in which $\mathbf{Z}$ includes all instruments and exogenous regressors.

$$\xi_c^G = \ln(s_c^G) - \ln(s_0^G) - \left(\sum_{i_c \in N_c} \beta_{i_c} (S_{i_c}^G)^\phi + h_c^G \right) \quad (1.4.1)$$

I let $h_c^G = \mathbf{X}_c^{G2} \delta_1 + d_c \delta_2$, where $\mathbf{X}_c^{G2}$ is a vector of controls that vary at the district-candidate level. I control for the donor income variation within the state as it may correlate with the out-of-state income shocks for a committee and can directly affect voters; I use the zip income shock of within-state donors per committee. I also include economic factors that may affect voters such as district unemployment rate, district income, and district total unemployed. I interact these with incumbency status as the state of the economy affects incumbents and challengers differently. I also include year dummies, percentage of district that graduated high school, district average age, and city precipitation (rainfall inches) on election day (all three interacted with party); the latter has been shown to affect turnout.⁴⁰

Political controls include incumbency status, party, the vote share of the Republican from the last presidential race (interacted with party), the vote share of the last incumbent in the district (interacted with incumbency status), the number of senate candidates running in the state, an open-race dummy, and whether the governor has the same party as candidate. I also include the Cook's political report competitiveness ratings and interact them with incumbency status and party.⁴¹ To account for relative costs of advertising in different markets, I divide expenditures by local ad

³⁹The outside share $s_0^G = 1 - \sum_{c=1}^C s_c^G = 1 - \sum_{c=1}^C \exp(u_c^G + \xi_c^G) / (1 + \sum_{c=1}^C \exp(u_c^G + \xi_c^G))$, which is equivalent to $s_0^G = 1 / (1 + \sum_{c=1}^C \exp(u_c^G + \xi_c^G))$; then taking logs yields $\ln(s_0^G) = -\ln(1 + \sum_{c=1}^C \exp(u_c^G + \xi_c^G))$.

⁴⁰Liao and Junco (2020) also show that news-worthy extreme weather events affect donor/voter behavior.

⁴¹These ratings are based on assessments of incumbency weakness and the "safety" of the seat for the general election. Some years scraped from Cooks website and other years generously shared by Jim Campbell. I have not included polling data given availability (see Appendix 1.A.1.7). News coverage is another measure for implicit competitiveness (Stromberg and Snyder 2010; Balles, Matter, and Stutzer 2018).

prices.⁴² Summary statistics for these variables are reported in Table 1.C.18. Some election structures, such as nonpartisan blanket primaries, are not well approximated with the model framework, and so I drop all districts in Louisiana, California after 2012 and Washington state after 2008.

1.4.2 Estimation Of General Election for committees

The estimated parameters from equation 1.4.1 tell us the elements that influence voters directly. Next I estimate the remaining objects relevant to committees, namely the committee's valuation for winning the overall election and a cost function that may vary across the general and the primary elections. Recall the general election post-entry committee payoff:

$$\pi_{ic}(S_{ic}^G, \mathbf{S}_{-ic}^G) = V_{ic}P_c^G - g_{ic} \cdot S_{ic}^G. \quad (1.4.2)$$

This is a function of V_{ic} : the value to committee i of candidate c winning, P_c^G : the probability of candidate c winning the general election defined in equation (1.3.3) and a function of voter utility u_c^G and expected valence ψ_c^G for all general election candidates, and g_{ic} : the marginal cost of spending (fundraising constraints and donor preferences). I let the committee's expectation of a candidate's valence equal the (estimated) realized valence draw, $\psi_c^G = \hat{\xi}_c^G$, as separately identifying these is difficult (Gordon and Hartmann 2016). The probability of winning P_c^G can then be calculated for the observed pair of candidates in the general election with an additional normalization on the variance of committee uncertainty of candidate quality: I let $\sigma_\xi = 1$ and show sensitivity to alternatives in the results section.⁴³

⁴²Measured as the cost-per-point from SQUAD/SRDS databases. Generously shared by Gregory Martin for 2000-2008 and used in Martin (2019). I use SRDS for 2010 onward and impute some missing years. I use the off-election year lagged prices. There may be variation in prices between committee types (Moshary 2019) and heterogeneous coefficients absorb that. District-media market overlap is another cost proxy.

⁴³With a value for ψ_c^G and σ_ξ , one can simply plug in observed spending and candidate characteristics to calculate the probability of winning. Note that P_c^G is closely linked to the vote share excluding abstention. The probability from the committee's perspective will be biased towards 0.5 (meaning closer to the observed vote share excluding abstention) from above and below if the specified uncertainty (variance) is too high, and biased towards the corners if the specified uncertainty is too low. While the variance of ξ is also identified, and I find that $\text{Var}(\hat{\xi}_c^G) = 0.56$ and $\text{Var}(\hat{\xi}_c^P) = 1.01$, it is likely not equal to σ_ξ^2 (the committee's uncertainty about candidate quality). Gordon

Valuations and costs are not immediately separately identified as low committee spending could signal either low valuations or high costs. Separate identification is achieved by exploiting spending and entry variation.⁴⁴ I let them be functions of data and parameters, allowing the cost to vary across candidate positions: $V_{ic} = \exp(X_{ic}^V \alpha_c)$ and $g_{ic} = \exp(X_{ic}^g \gamma_c + d_c \gamma_\theta + \gamma_{ic}^G)$, where γ_{ic}^G is unobserved cost heterogeneity. The vector X_{ic}^V includes a constant, incumbency status of the candidate, and year fixed effects, with all variables interacted with committee type and party fixed effects. Allowing the coefficients to vary across party is important as there is asymmetry in motivations and behavior (Grossmann and Hopkins 2016).

The vector X_{ic}^g includes a constant, the number of senate candidates in the state (to measure competition for resources and state political activity), and the voting age population of that district (to gauge the pool of local donors and size of region in which to spend), all interacted with committee type and party. I construct a moment from spending variation based on the derivative of equation 1.4.2 for a given set of entrants: $V_{ic} \partial P_c^G / \partial S_{ic}^G - g_{ic} = 0$. I take this first order condition, as shown below, rearrange it to set marginal benefit to marginal cost, and then isolate the marginal probability of winning as a function of the log valuations, log costs, and the error term. The observed candidate decision is a function of the error term γ_{ic}^G and I instrument for it using the lagged Senate position, denoted with Z_c^θ .

$$\log \left(\frac{\partial P_c^G}{\partial S_{ic}^G} \right) = -X_{ic}^V \alpha_c + X_{ic}^g \gamma_c + d_c \gamma_\theta + \gamma_{ic}^G$$

I estimate this equation with the moment in equation 1.4.3 below. The exogenous controls act and Hartmann (2016) estimate σ_ξ via the committee's first order condition rather than from the vote share regression. They estimate committee uncertainty by exploiting pre-spending race competitiveness ratings; however I include those as covariates in the vote share regression given the inclusion of candidate position as a predictor. They also do not estimate a cost function, given their advertising price.

⁴⁴Note: valuations do not change across the general and primary election decisions. If costs were also constant across races, then valuations and costs would be identified as committee-election level fixed effects for those that spent in both races; constant cost is unrealistic however, given that the set of candidates changes, fundraising occurs in both stages, and potential cost heterogeneity (Moshary 2019).

as their own instruments, where $\mathbf{X} = [X_{ic}^V, X_{ic}^g]$. Summary statistics are in Table 1.C.14.

$$E \left[[\mathbf{X}, Z_c^\theta]^\top \left(\log \left(\frac{\partial P_c^G}{\partial S_{ic}^G} \right) + X_{ic}^V \alpha_c - X_{ic}^g \gamma_c - d_c \gamma_\theta \right) \middle| S_{ic}^G > 0 \right] = 0 \quad (1.4.3)$$

The term $\partial P_c^G / \partial S_{ic}^G$ can be shown to be equal to $\beta_{ic}^G \phi(S_{ic}^G)^{\phi-1} P_c^G (1 - P_c^G)$. This moment will identify the ratio of log valuations to log costs with variation in the marginal effect of spending on the probability of winning for different levels of the instruments. In other words, this variation can only identify valuation coefficients that are excluded from costs (and vice-versa), meaning it cannot separately identify variables present in both.

With this identified ratio I can use entry variation to separately identify valuations and costs. The intuition is that if one can identify V/g then another moment that can identify V given g will identify $(V/g)g$ and hence g . In Appendix 1.A.2.3, I consider additional moments for efficiency.⁴⁵ Note that an identification argument relying on the spending conditions introduces a selection issue: the first order conditions do not hold with equality for those who did not spend. Thus there is the implicit assumption, as in Gordon and Hartman (2016), that differential unobserved marginal cost shocks do not primarily explain entry variation.⁴⁶

Next I construct moments from entry variation. Given the private information in entry payoff λ_{ic}^G , committees use the expected payoff when making their entry decisions. The committee's expected payoff for a given entry decision conditional on their private information is denoted with $\mathcal{U}_{ic}^G$, and recall p_j is committee i_c 's belief about what committee j does.

$$\mathcal{U}_{ic}^G(a_{ic}^G | \mathbf{p}_{-i_c}) = \sum_{\mathbf{a}_{-i}^G \in \{0,1\}^{2N-1}} \pi_{ic}^G(\mathbf{S}^* | a_{ic}^G, \mathbf{a}_{-i_c}^G) \prod_{j \neq i} p_j(\mathbf{a}_{-i}^G) + \lambda_{ic}^G a_{ic}^G$$

⁴⁵For an alternative approach, see Erikson and Palfrey (1998), who consider a simultaneous equations model; also see Box-Steffensmeier and Lin (1996) for a dynamic panel approach.

⁴⁶To see this, consider the unconditional zero mean assumption, $E[u] = 0$, which decomposed, with S having nonnegative distribution with mass at zero, equals $E[u|S > 0] \cdot P(S > 0) + E[u|S = 0] \cdot P(S = 0)$. Since $P(S = 0) > 0$, for our identifying assumption above to hold, one necessarily needs $E[u|S = 0] = 0$. Thus if there is selection into spending based on unobservables, this fails. While I can calculate that probability function from entry variation, I do not have an additively separable expression for u in the case of $S = 0$.

Then the probability of entry, where $u_{ic}^G = \mathcal{U}_{ic}^G - \lambda_{ic}^G a_{ic}^G$, is $p_{ic}(a_{ic} = 1) = \text{Prob}[u_{ic}^G(1|\mathbf{p}_{-ic}) + \lambda_{ic}^G > u_{ic}^G(0|\mathbf{p}_{-ic})]$, and with the Logistic distribution leads to conditional choice probabilities.

$$p_{ic} = \frac{\exp(u_{ic}^G(1|\mathbf{p}_{-ic})/\sigma)}{\exp(u_{ic}^G(1|\mathbf{p}_{-ic})/\sigma) + \exp(u_{ic}^G(0|\mathbf{p}_{-ic})/\sigma)} = f(p_{-ic})$$

This system defines a fixed point $\mathbf{p} = f(\mathbf{p})$. I calculate the conditional choice probabilities with $\sigma = 1$, and then compare the observed action a_i to its conditional expectation function p_i . Rather than solving the system for $\mathbf{p}$, I follow Bajari et al. (2010) and use a semi-parametric estimate $\hat{\mathbf{p}}$ (see Appendix 1.A.2.1). Note that either method requires calculating the general election spending stage for all combinations of entry in order to construct u_{ic}^G .⁴⁷ With this in hand, I can write out an entry moment $E[\mathbf{X}^\top (a_{ic} - p_{ic})] = \mathbf{0}$.⁴⁸ In addition, I use the semi-parametric estimate of $\hat{p}_{ic}$ to form the moment $E[\mathbf{X}^\top (\hat{p}_{ic} - p_{ic})] = \mathbf{0}$. This may provide a tighter source of variation than the entry decision alone as to construct $\hat{p}_{ic}$, one uses entry variation and information from the spending stages.

To see the variation that is identifying the parameters, construct the log-odds ratio:

$$\log\left(\frac{\hat{p}_{ic}}{1 - \hat{p}_{ic}}\right) = \log\left[\frac{\exp(u_{ic}^G(1|\mathbf{p}_{-ic}))}{\exp(u_{ic}^G(0|\mathbf{p}_{-ic}))}\right].$$

This can be rewritten, where the expectations for the win probability and spending are over the equilibrium entry profiles: $E[P_{ic}^G|a_i] = \sum_{a_{-i} \in \{0,1\}^{2N-1}} P_{ic}^G(a_1, \dots, a_i, \dots, a_N) \prod_{j \neq i} p_j^*(a_{-i})$.

$$\log\left(\frac{\hat{p}_{ic}}{1 - \hat{p}_{ic}}\right) = V_{ic} \left(E[P_{ic}^G|a_i = 1] - E[P_{ic}^G|a_i = 0] \right) - g_{ic} E[S_{ic}^G|a_i = 1]$$

⁴⁷A direct approach would be to solve for the spending stage equilibrium per entry profile; I semi-parametrically estimate the probability function P_C^G and use the first order condition to get the implied spending; if one knows the equilibrium probability of winning for that given entry profile, spending is the implicit function: $S_{ic}^G = ([V_{ic}/g_{ic}] \beta_{ic} \phi P_C^G (1 - P_C^G))^{1/\phi}$. Using this method only requires assuming that the counterfactual choices based on the same primitives from the observed data use the same equilibrium.

⁴⁸To utilize entry variation, I impose homogeneity assumptions on γ_{ic}^G . It is identified using FOC moments with variation from entrants. For non-entrants, I cannot back this term out and must impute it; I average across party (one could also average across committee type).

The cost function is then separately identified using the variation in entry probabilities and “revenues” for a given value to cost ratio and expenditure, all across levels of $\mathbf{X}$:

$$g_{ic} = \frac{\log [\hat{p}_{ic}/(1 - \hat{p}_{ic})]}{(V_{ic}/g_{ic}) \left(E[P_{ic}^G | a_i = 1] - E[P_{ic}^G | a_i = 0] \right) - E[S_{ic}^G | a_i = 1]}.$$

1.4.3 Primary Election Estimation

Next I proceed to the primary. Using the estimated general election parameters, one can calculate the model prediction for entry, spending, and election outcome for any combination of candidates (conditional on knowing valences). I estimate the primary election analogs to general election parameters, except the valuation for winning the overall election.⁴⁹

For the voter preferences in the Primary election, I use the same approach as for general to estimate spending effectiveness, candidate position effects, and the Primary valence ξ^P (letting $\psi_c^P = \hat{\xi}_c^P$ again). The specification is similar to the general election but I estimate the two primaries (Republican and Democrat) separately.⁵⁰ I also estimate fewer spending effectiveness coefficients given varying instrument strength.

To utilize the committee’s first order condition, one must deal with the unobserved (counterfactual) general election outcomes. For example, the R_1 candidate aligned committee considers both general election outcomes of R_1 facing either D_1 or D_2 when they choose their primary efforts. To be precise, rewrite a Republican committee’s payoff as follows with two candidates per side, where the expected probability of winning the general election for a given set of primary winners is defined as $E[P_c^G | \mathbf{w}^P] = \sum_{\mathbf{a}^G \in \{0,1\}^{2N}} P_c^G(\mathbf{a}^G | \mathbf{w}^P) \prod_j p_j^*(a_j^G | \mathbf{w}^P)$, $E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1)]$ is the expected probability of winning the general election

⁴⁹For committees that did not spend in the general, one can either impute the valuations using the estimated parameters and their observables and then only use primary spending variation to identify primary costs, or separately identify primary valuations by using both spending and entry variation in the primary.

⁵⁰For separate closed primaries, the population to use when measuring turnout is not well approximated with the district total VAP as the voting population is split in two based on political affiliation. I want the voting age population per party to get a better estimate of the relevant population for that party’s primary. I use party affiliation percentages at the state level from Gallup as the estimate.

against D_1 , and $P(w_{D_1}^P = 1)$ is the observed probability of D_1 beating D_2 in their primary:

$$V_{ic}P(w_c^P = 1) \cdot \Omega_c - g_{ic}^P S_{ic}^P \quad s.t. \quad \Omega_c = E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_2}^P = 1)] \cdot P(w_{D_2}^P = 1) \\ + E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1)] \cdot P(w_{D_1}^P = 1) .$$

In the Ω_c expression, only one object is unobserved for candidates that won their primary, namely the general election probability against the candidate on the other side that lost their primary (for example, the general election probability of Trump vs Sanders in 2016). For candidates that lost their primary, both general election probabilities are unobserved. I already backed out the general election expected valence ψ_c^G for candidates in the general election that occurred in the data, but one does not observe it for the primary election losers. This valence term affects the decisions of committees in the primary (and candidates before that), and thus identification of the remaining parameters hinges on recovering it.

I show that one can recover ψ_c^G for primary losers using variation in the general and primary that, by exploiting information revealed by the equilibrium spending behavior, implies a single valence for the primary loser. This approach will rely on inverting the equilibrium win probability to solve for the counterfactual ψ_c^G as a function of observables and parameters.⁵¹ The intuition is that a committee takes the (forward-looking) probability of their preferred candidate winning the general election into account when making the primary spending decision. Consider a committee's spending first order condition in terms of the primary-perspective expected probability of winning the general election $\Omega_c = \frac{\omega_{ic}^P (S_{ic}^P)^\phi}{\phi P_c^P (1 - P_c^P)} \equiv F_c$, where $\omega_{ic}^P = g_{ic}^P / (\beta_{ic}^P V_{ic})$. For committees whose candidates won their primary election, one can rewrite this in terms of the main unobservable: the general election probability of beating the other candidate that lost their primary (let D_1 be the

⁵¹The non-closed form nature of $E[P_c^G | \theta, \mathbf{w}^P]$ makes a direct proof difficult (see conjecture 2 and Appendix 1.A.2.1). Since I estimate the general election parameters first (and $E[P_c^G | \theta, \mathbf{w}^P]$ only depends on these parameters), one can check the inversion condition for each observation beforehand. I illustrate this by graphing the function across the range of estimated general election valences (see Figure 1.C.10) at the values for the estimated general election parameters; it is monotonic on the 100 interval line-space. I do not have a moment condition directly based on inverting the equilibrium spending S in terms of ψ as it is not monotonic. Note that to form a moment around ψ_c^G I have to normalize the unobserved cost γ_{ic}^P . I set it to zero (could also assume it is the same as in the general election). Another approach is to simulate over ψ^P by either assuming $\psi^G = \psi^P$ or imputing on the primary winner valences.

opponent who won their primary):

$$E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_2}^P = 1)] = \frac{F_c - E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1)]P(w_{D_1}^P = 1)}{1 - P(w_{D_1}^P = 1)}.$$

This left hand side probability, denoted shorthand as EP_{CF} , takes into account general election equilibrium committee entry for the hypothetical match-up between candidates R_1 and D_2 , and is thus just a function of the exogenously given objects at the start of the general election, including the unknown valence $\psi_{D_2}^G$. I invert this probability with respect to $\psi_{D_2}^G$, and get the following expression:

$$\psi_{D_2}^G = EP_{CF}^{-1} \left(\frac{F_c - E[P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1)]P(w_{D_1}^P = 1)}{1 - P(w_{D_1}^P = 1)} \right).$$

This approach works when a candidate considers only two potential general election opponents; this is not very restrictive as many races have only two candidates that receive many votes and the vast majority of races only have two that spend non-trivially (for details see Appendix 1.A.1.9). Then a fully contested primary has four candidates: two of them move on to the general election and I only have to recover the general election valences for the two primary losers. As shown above, I recover $\psi_{D_2}^G$ from an R_1 aligned committee's spending first order condition and $\psi_{R_2}^G$ from a D_1 committee first order condition.⁵² I then form the moment around this unobserved valence term, as it is now a function of data and parameters.

$$E[\mathbf{X}^\top \psi_c^G | S_{i_c}^P > 0] = \mathbf{0} \quad (1.4.4)$$

The primary election spending costs parameters are identified in these moments. The confounding influence that the unobserved valences have are dealt with through the inversion. Recall

⁵²If one constructed this equation from D_2 's first order condition, there would be two unknowns as $P(w_{D_2}^G = 1 | w_{D_2}^P = 1 \cap w_c^P = 1)$ is unobserved for both $c = \{R_1, R_2\}$. Thus to use the first order conditions for candidates that did not win their primaries one must first find the missing valence for one from their matchup against a candidate that won their primary and then, using it as now observed, back-out the other candidate's valence.

that I already estimated the voter preferences for the primary and thus the effects of primary spending on election outcomes are known, allowing us to isolate how costs affect spending. The logic of this approach and the sources of variation can be seen in Figure 1.C.9, which shows the inputs to the primary first order condition.

The cost function in the primary, conditional on a known valuation, shifts a committee's willingness to spend, and thus variation in primary spending and observed expected outcomes in the realized match-ups for a given cost implies a single expected probability of winning the general election for the counterfactual match-up. Then, given the probability functional form and exogenous inputs, it implies a single counterfactual valence. Finally, the variation in the cost inputs $\mathbf{X}$, creates the moment to identify the parameters.⁵³ Note this method requires at least one contested primary. In the next section, I describe how to use simulation methods to deal with non-entrants and uncontested races.

1.4.4 Estimation Of Candidate Stages

Now that the general and primary elections are fully characterized, I can calculate the probability of winning for a given candidate for any combination of opponents and positions, and estimate the candidate stages. The only parameters to estimate are candidate-specific that inform their decision. Recall the candidate's objective in equation 1.4.5: V_c : value to candidate c of winning, V_c^0 : outside option, κ_c : marginal cost of deviating from ideal point, $\bar{\theta}_c$: ideal position point, and η_c : private variation in payoffs. The probability of winning is now the expected probability from the pre-primary perspective, where the candidate positions $\mathbf{d}$ are now written as explicit arguments:

$$E[P_c^G | \mathbf{d}] = \sum_{\mathbf{a}^P \in \{0,1\}^{4N}} E[P_c^G | \mathbf{d}, \mathbf{a}^P] \prod_j p_j^*(a_j^P | \mathbf{d}).$$

$$\Pi_c = V_c \cdot E[P_c^G | \mathbf{d}] + V_c^0 \cdot (1 - E[P_c^G | \mathbf{d}]) - \kappa_c (d_c - \bar{\theta}_c)^2 \cdot \mathbb{1}[d_c > 0] + \eta_c(d_c) \quad (1.4.5)$$

⁵³The inclusion of both the observed and unobserved expected probabilities of winning the general (EPG) is key and this can be illustrated in Table 1.C.9; only using primary spending to identify the effect of costs yields a weaker result than if one controls for the observed EPG, which naturally incentives one to increase spending, and this effect is even more pronounced with the inclusion of the unobserved counterfactual match-up EPG. Controlling for this factor leads to a significantly different reduced form cost effect.

The unknowns $\{V_c, V_c^0, \kappa_c, \bar{\theta}_c\}$ are difficult to separately identify as candidate decisions could be rationalized by a variety of parameter combinations; one must parameterize or normalize them (Diermeier et al. 2005, Tillmann 2014; Iarcyzower et al. 2020). I allow the value from office and the outside option value to vary only at the district level. Specifically, $V_c = \exp(W_c\lambda)$, where W_c is a data vector including a constant, number of cycles in which the incumbent retained their seat, and district income. Similarly, $V_c^0 = \exp(W_c^0\lambda^0)$, where W_c^0 includes party and election cycle dummies. All parameters are separately estimated for challengers and incumbents, and I let $\kappa_c = 1$. Summary statistics are in Table 1.C.14.

Without private information, ideal points could be individually identified for candidates that decided to enter as any deviation from the position that maximizes the value discounted probability of winning uncovers the ideal point. With private information, a given decision only reveals the range of information that rationalizes it. I restrict the ideal points to vary at the election cycle-party level for incumbents and set them for challengers to be their observed choices; non-entrant ideal points cannot be separately identified from valuations.

For a given candidate that entered, I observe their entry decision and their policy position, and thus there are two sources of variation to compare across candidates. To estimate the entry stage among candidates, one needs to know the identity of each potential entrant in the event that they do not enter.⁵⁴ I construct potential entrants, with as many potential entrants as there are “empty” spots with two candidates per race: two candidates per side per primary. This approach works because the variables used to predict parameters do not rely on individual characteristics, however there may be selection on unobservables.

The general election and primary election valences of candidates that never ran, meaning the potential entrants that chose $d_c = 0$, are not recoverable from Congressional election data (without more assumptions).⁵⁵ The identification of candidate preferences requires an estimate of these

⁵⁴Tillmann (2014) estimates a Congressional candidate entry model and generates a list of “potential” entrants; because he has the identities of these potential entrants, he uses challenger characteristics to predict entry. A possible IV for entry is filing requirements per state (Ansola-behere and Gerber 1996).

⁵⁵In addition, any valence for a candidate in an uncontested race in which the total number of votes is zero (or party convention where turnout cannot be measured like CT and UT) is also under-identified; this occurs for 20% of primary

valence terms as one needs to calculate their expected probability of winning. I let the committee and candidate expectations of these valences ψ_c for the non-entrants follow a distribution, namely $\psi_c^{NE} \stackrel{iid}{\sim} N(\mu_{NE}, \sigma_{NE})$. The variance σ_{NE} is estimated with maximum likelihood using the variation in estimated entrant valences. The average expected valence for non-entrants, μ_{NE} , is likely different from that of entrants.

To allow for this selection, I use a proxy to estimate the difference in means of the valences for entrants and non-entrants. State legislature members (current or former) are a significant source of the candidate pool for federal Congressional elections (over 40% of current members of Congress since 2010). I compare the State legislature election (general and primary) valences for State legislature incumbents who decided to run for Congress and those who did not. This gives us a sense of how different entrants are from similar non-entrants. I calculate these from state legislature voter regressions, and they provide a proxy for the average difference in valence of the potential entrants, μ_{NE} .⁵⁶

For a given vector of valences for all candidates $(\psi_c^G, \psi_c^P) \forall c$, either estimated or drawn from the proxy distribution, I calculate $E[P_c^G | \mathbf{d}]$ for every combination of candidate decisions. Let $\pi_c = \Pi_c - \eta_{d_c}$. The decision rule for challengers is: $d_c = t$ if $E[\pi_c(d_c = t) | \mathbf{p}_{-c}] + \eta_{d_c=t} > E[\pi_c(d_c = w) | \mathbf{p}_{-c}] + \eta_{d_c=w} \forall w \in \{0, \dots, \Theta\} \setminus \{t\}$. Just as for the committee entry stages, define the system for choice probabilities among challengers, $p_c(d_c = \theta)$, where the expectation is taken over the beliefs about what other challengers will do:

$$p_c(d_c = \theta) = \frac{\exp(E[\pi_c(d_c = \theta | \mathbf{p}_{-c})])}{\sum_{w=0}^{\Theta} \exp(E[\pi_c(d_c = w | \mathbf{p}_{-c})])}.$$

This leads to a simulated moment, shown for a given draw, comparing the observed decision to its conditional equilibrium probability $E\{\mathbf{Z}^\top [d_c - p_c(d_c = \theta)]\} = \mathbf{0}$ using semi-parametric

incumbents and 12% of primary non-incumbents. Since 67% of uncontested primaries still have ballots (albeit with likely distinct voting behavior), I draw valences for those unidentified uncontested primary winners from the estimated primary winner valence distribution from balloted uncontested primaries.

⁵⁶I get the election results for state legislatures from ICPSR, campaign spending from the National Institute on Money in State Politics, and donor records and ideology scores from the state-level election DIME dataset.

estimates for $\mathbf{p}$ (see Appendix 1.A.2.1). I use the semi-parametric approximation to the probability to form another: $E\{\mathbf{Z}^\top [\hat{p}(d_c = \theta) - p_c(d_c = \theta)]\} = \mathbf{0}$. I allow for two position levels beyond non-entry (0), namely “moderate” (1) and “extreme” (2).⁵⁷ To illustrate the identification, consider the expected payoff for a given choice:

$$\begin{aligned} E[\pi_c(d_c|\mathbf{p}_{-c})] &= \sum_{\mathbf{d}_{-c} \in |\theta|^{2N}} \left(V_c P_c^G + V_c^0 (1 - P_c^G) - \kappa_c (d_c - \bar{\theta}_c)^2 \cdot \mathbb{1}[d_c > 0] \right) \prod_j p_j^*(\mathbf{d}_{-c}) \\ &= (V_c - V_c^0) \sum_{\mathbf{d}_{-c} \in |\theta|^{2N}} \left(P_c^G \right) \prod_j p_j^*(\mathbf{d}_{-c}) + V_c^0 - \kappa_c (d_c - \bar{\theta}_c)^2 \cdot \mathbb{1}[d_c > 0]. \end{aligned}$$

The log-odds ratio is then based on the difference, $\Delta_{\theta, \theta'}(\cdot)$, in “revenues” and costs:

$$\log \left(\frac{\hat{p}(d_c = \theta)}{\hat{p}(d_c = \theta')} \right) = (V_c - V_c^0) \cdot \Delta_{\theta, \theta'} \left(\sum_{\mathbf{d}_{-c} \in |\theta|^{2N}} \left(P_c^G \right) \prod_j p_j^*(\mathbf{d}_{-c}) \right) - \Delta_{\theta, \theta'}((d_c - \bar{\theta}_c)^2).$$

Note that the outside option value term V_c^0 is constant across policy choices, so one needs entry and policy to separately identify both valuations. The expected probability is known and thus variation in the probability of a decision across differing levels of $\mathbf{W}$, controlling for differential expected win probabilities, identifies the valuations.⁵⁸

Finally I estimate the incumbent’s decision, and they take the expected actions of the challengers into account. I estimate the parameters on their valuations and the ideal point. The total cost of deviating from the ideal points, $(d_c - \bar{\theta}_c)^2$, is additively separable from the expected win probabilities, which allows for separate identification from the valuations. I use the difference in the semi-parametric probability of the observed and prediction actions, where $\mathbf{W}_I$ includes a constant and the exogenous variables used to predict valuations and ideal points. I use a simulated moment, shown for one draw below, to average across simulated challenger valences. The

⁵⁷I normalize the square of Bonica CF-score positions by dividing by the max of all positions-squared and then set cutoff points at [0,0.25] for moderate (64% of entrants) and (0.25,1] for extreme (36% of entrants).

⁵⁸To illustrate the importance of controlling for the forward-looking nature of candidates, consider Table 1.C.10; it shows regressions of the entry probability on valuations and the EPG. Omitting EPG yields a different estimate for the effect of valuations on entry and a huge improvement in fit.

summation is over policies excluding non-entry.⁵⁹

$$E\left\{\mathbf{W}_I^\top \left[\hat{p}(d_I = \theta) - \frac{\exp(\pi_I(d_I = \theta))}{\sum_{w=1}^{\Theta} \exp(\pi_I(d_I = w))} \right] \right\} = \mathbf{0}$$

1.4.5 Estimator

I estimate the parameters from the equilibrium functions (possibly correspondences) in order to evaluate counterfactual decisions. Let $\mathcal{X}$ be the set of exogenously given observables and $\mathcal{P}$ be the set of parameters (including unobservables). The committee and candidate functions include general spending: $S^G(\mathbf{a}^G, \mathbf{w}^P, \mathbf{d}_C, d_I | \mathcal{X}, \mathcal{P})$, general entry: $Pr[a^G(\mathbf{w}^P, \mathbf{d}_C, d_I | \mathcal{X}, \mathcal{P})]$, primary spending: $S^P(\mathbf{a}^P, \mathbf{d}_C, d_I | \mathcal{X}, \mathcal{P})$, primary entry: $Pr[a^P(\mathbf{d}_C, d_I | \mathcal{X}, \mathcal{P})]$, challenger position: $Pr[d_C(d_I | \mathcal{X}, \mathcal{P})]$, and incumbent position: $Pr[d_I(\mathcal{X}, \mathcal{P})]$. To recap, the main estimation steps are as follows (see Appendix 1.A.2.2 for more details): 1. estimate voter preferences for general and primary elections; 2. estimate valuations and general election costs with general election first order condition and entry moments; 3. estimate primary election costs using primary first order conditions and inverted equilibrium general election win probability; 4. estimate and draw simulated valences for non-entrants, and then estimate challenger valuations and costs using position moments; 5. following step 4, estimate incumbent valuations, costs, and ideal points using position moments. The estimator used in each step is simulated general method of moments (Pakes and Pollard 1989), $\hat{\mathcal{P}} = \arg \min\{[\frac{1}{SNT} \sum m(\mathbf{Y}_{nt}, \mathcal{P}|s)]^\top \mathbf{W} [\frac{1}{SNT} \sum m(\mathbf{Y}_{nt}, \mathcal{P}|s)]\}$, averaging across all district-years NT and simulation draws $s = 1, \dots, S$, with data $\mathbf{Y}$ and identity weight matrix $\mathbf{W}$.

⁵⁹There are very few instances in the data of an incumbent un-expectantly deciding not to re-run (as opposed to a previously announced retirement for example); from 2011-2020, of the 243 non-rerunning incumbents, 70% announced it before election-year and of the remaining 30% who mentioned it during election-year, 65% mentioned it within January and February, well before their primaries (Ballotpedia 2020). Thus I omit their re-entry choice and consider the race open when in the data they do not re-run.

1.5 Results and Counterfactuals

1.5.1 Parameter Estimates

In Table 1.C.8, I report the endogenous variable coefficients from the voter preferences estimation for the general and primary elections of House races from 2010 to 2016.⁶⁰ I report the effect of candidate position and spending on the difference in log share of votes the candidate received and the log share of absentees. For the general election I estimate spending effects by candidates, Super PACs, and parties. I find that candidate and Super PAC spending are not significantly different and party spending is the least effective, but all spending effects are fairly noisy. Super PACs may be more effective than parties because Super PACs are entities that specialize in independent expenditures. The candidate position coefficient reflects how voters respond to more extreme positions, quantified here with a dummy of moderate or extreme measured by binned Bonica scores. The negative coefficient implies voters punish extreme candidates. The controls for this specification are reported in Table 1.C.12.⁶¹ Now the best way to interpret these is in the context of the whole equilibrium, but a reduced form interpretation would be that for a candidate, \$1,000,000 increase in spending at the average advertising price leads to about a 25% [0, 44] increase in relative vote share.

For the Republican primary I consider a bifurcated spending effect (candidate vs non-candidate) and for the Democratic primary I estimate a pooled effect; the first stage F tests for the full specification were insufficient. The spending coefficient in the Democratic primary is small and noisy, indicating that Democratic primary voters are not very responsive to election advertising spending.

⁶⁰Confidence intervals use non-parametric percentile bootstrap with 2010 replications; bias-corrected percentile bootstrap CIs are similar. I use a paired-bootstrap method; resampling over district clusters via a panel bootstrap does not significantly change parameter confidence intervals but does increase outliers in the counterfactuals. I let $S = 100$. Andrews (2000) notes that bootstrap testing the null of $\beta = 0$ if $\beta \geq 0$ and the true effect is zero is inconsistent. In my model, positive spending is only rationalized with a strict $\beta > 0$. The relevant test is whether β is large enough to matter in the election. As a robustness check I directly estimate the coefficient variance-covariance matrix from the inverse of the Hessian matrix from the unconstrained optimization program for the first few estimation steps, and the results are similar.

⁶¹In Table 1.C.17 I consider heterogeneous spending effects for Super PACs across various dimensions including incumbency status, year, state, and party. Few are statistically different across the interactions.

Republican primary spending is larger and more precise for candidates with outside-spending being less effective.⁶² The effects of candidate positioning is the opposite from the general election, indicating that primary voters reward candidates that take more partisan positions. I report the controls for both primaries in Table 1.C.13.

In Table 1.C.11, I report the estimated valuations and costs for committees and candidates, averaged for different committee types, elections, and parties. Candidate committees have the highest valuations, which is driven by the fact that they spend more and they “always” enter whenever their candidate enters. Costs for challengers are typically higher, which may indicate their weaker fundraising abilities. Super PACs have lower valuations than parties but also lower costs; one interpretation is that Super PACs care less about specific races than parties but are able to spend more due to more efficient fundraising. Valuations for Republican challengers are on average 37% larger than Democratic challengers (6.53 [3.93, 12.72] and 4.07 [2.64, 6.04] respectively); this mirrors Gordon and Hartmann (2016) who find a similar result for Presidential candidates. Thus Republicans are willing to spend more in races in which they are more likely to lose, implying Democrats are more risk averse.⁶³ There is a smaller gap in incumbent valuations, but with more heterogeneity across districts. Note that variation in valuations and costs is limited by the covariates used to predict them.

In addition, valuations for Super PACs actually decrease over time, decreasing from 2010-2012 and flattening from 2014-2016. At the same time, costs do not vary significantly across time. The decrease in valuations for the same cost may be a learning process, in which the early Super PACs were willing to spend in elections in which their win probability was low, and later Super PACs were more selective. There is much less temporal variation in candidate and party valuations, which is intuitive given that Super PACs are newcomers.

⁶²Estimating a homogeneous effect if heterogeneous is the correct model, which the general election results allude to, may bias results in that (assuming the same relative sizes from general) I may be overestimating party spending effectiveness in both primaries, underestimating (overestimating) Republican (Democratic) primary Super PAC effectiveness, and underestimating Democratic primary candidate effectiveness. The equilibrium effects are less clear because the bias may be compensated by oppositely biased cost estimates.

⁶³Candidate values are 11.01 [10.23, 34.16] times larger than Super PACs. Republican values across all types are 0.27 [0.05, 1.50] times larger than Democrats.

Table 1.C.15 reports the full list of coefficients that generated these valuation and cost functions. The most notable coefficients here are the cost to committees from the position their candidate takes; this cost coefficient is on average small in magnitude and often positive for Republican committees and negative for Democratic committees, indicating that the latter committees may be more able to raise funds to spend when the candidate they support is more partisan. I also find primary election losers have a lower average and higher variance of general election valences than primary winners. This indicates that the pool of candidates that successfully make it to the general are not necessarily always the highest “quality” in unobserved dimensions, a result that corroborates Tillmann (2014). Finally, I find that State legislature incumbents who did not run for Congress have on average 14% lower quality, conditional on controls, than the State legislature incumbent Congressional race entrants.

The function to predict vote share fits the data with an adjusted R^2 of 0.95. The R^2 for the general election Republican committee entry probability is 0.65 and 0.62 for Democratic committees; the primaries are similar. The R^2 between the observed and predicted spending for Republican committees is 0.42 and for Democratic committees it is 0.46; the model produces nonzero spending in instances where the committee did not spend in the data. The R^2 for challenger entry is 0.40 and 0.56 for candidate position. For goodness of fit in the voter estimation, I consider the 2SLS version of this GMM: the adjusted R^2 for the second stage is 0.49, with the candidate spending first stage with 0.36, the Super PAC spending with 0.17, Party spending with 0.25, and candidate position with 0.24.⁶⁴ The fit is similar for the Republican primary with an adjusted R^2 of 0.31, but the Democratic primary is weaker with an adjusted R^2 of 0.1.⁶⁵

⁶⁴To gauge instrument strength, I re-run the voter regression GMM as a two-step and evaluate the first-stage F-stats; they are 36, 13, 21, and 18 for the three spending and position coefficients respectively. Results are generally robust to alternative IV specifications; see Table 1.C.16. The GMM Hansen’s over-identification tests fail to reject with $p > 0.1$ across the over-identified cases.

⁶⁵If I run a Democratic primary OLS regression with the same specification, the coefficients are not substantially different but the R^2 jumps to 0.35. The changes are similar for the other primaries, but the general election coefficients are statistically different between the 2SLS and the OLS specifications.

1.5.2 Counterfactuals

I consider the counterfactual scenario of Super PACs never existing. To evaluate the elections in this setting, I first use the parameter estimates to fully solve the model under the observed data of Super PACs, and then solve the model with the same parameter estimates but now I exclude Super PACs.⁶⁶ There are two sources of differences for a given stage: first the change in behavior conditional on the same outcomes from the previous stage, and then the change in behavior given a different outcome from a previous stage. Comparing the full differences in equilibrium outcomes between the observed and counterfactual scenarios incorporates the latter.⁶⁷ Across all of the counterfactual distributions, there will be a large pile-up at zero, which is driven by the fact that Super PACs did not spend anything or very little in many races; in the data, Super PACs spent in 41% of general elections and 15% of primaries (including the non-contested ones) and 29% of contested primaries.

Overall Super PACs increased general election spending, as total spending would decrease by 18% [4.41, 27.43] if Super PACs did not exist. This effect is largely driven by the absence of Super PAC spending; the remaining committees see a total 4% [1.82, 11.43] spending increase in the counterfactual compared to reality. Many races have increased spending as candidates cannot rely on Super PACs to spend on their behalf. However at the same time, the lack of large Super PAC expenditures, not sufficiently compensated for with increased spending elsewhere due to contribution limits and ineffectiveness, depresses total spending.

In Figure 1.C.11, I report the counterfactual distribution of the percent change in general election spending without Super PACs. There is substantial variation in the effects across all four main committee types, namely Republican candidate committees (average change 1.62% [0.32, 13.03]), Republican parties (average change 2.93% [1.84, 9.71]), Democratic candidates (average change 10.29% [1.06, 30.49]), and Democratic parties (average change 2.22% [-7.98, 9.38]). These dis-

⁶⁶I need the fixed point algorithm to find the same equilibrium across districts; sufficient for this is equilibrium uniqueness but that is not necessary; results are not sensitive to starting values. I consider one simulation and private information draw to study actual choices instead of just probability distributions (and due to computational resource constraints); counterfactuals are not largely different either way.

⁶⁷For the distribution graphs, I show the 95% interval across the sample as a few outliers skew the graphs.

tributions have additional heterogeneity across time. Republican candidate and Republican party spending increases without Super PACs in 2010 with decreases in subsequent years. This time-trend follows the pattern of valuations indicating that Super PACs had distinct effects across time. The increase in Republican candidate spending is larger in Republican-leaning states like Texas and the South and more often negative in New England. This is likely due to the fact that Republican candidates are willing to spend more without assistance in states in which their general election chances are greater.

In Figure 1.C.12, I report the counterfactual distribution of the percent change in primary election spending without Super PACs. The large right tail for the candidate distribution is a function of challengers spending significantly more since they cannot rely on Super PAC support. Democratic party spending has a few large decreases in spending, compared to the reality benchmark, perhaps because they do not have to spend to fend off anti-incumbent Super PACs. Overall, primary spending changes by -13% [-29.21, 15.89] in the absence of Super PACs. The noisy result is largely a function of outliers and competing effects. Total candidate spending changes by -8% [-20.48, 11.32] without Super PACs whereas party spending increases 21% [-16.94, 105.02]. Thus Super PACs seem to play heterogeneous roles in the primaries by complementing challenger spending and crowding out party spending. The relatively small number of bins for Democratic parties is a function of the fact that there are many uncontested primaries and Democratic parties are selective in spending.⁶⁸

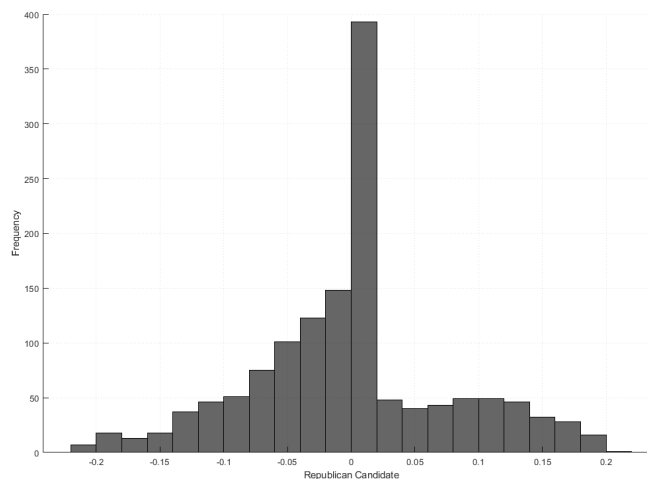
In Figure 1.2 below, I report the percent change in Republican general election vote share (excluding abstention) without Super PACs.⁶⁹ The average Republicans vote share changes by -0.88% [-4.34, 1.70] with substantial variation. Republican incumbent shares increase by less than 0.3 percentage points without Super PACs and Republican challengers see their chances decrease

⁶⁸In Figure 1.C.13, I report the percent change in party committee entry probability into general and primary elections without Super PACs. The average change for Republicans is positive, indicating that Super PACs may crowd out parties. The effect is flipped for Democratic parties (with a lower entry baseline).

⁶⁹In Figure 1.C.14 I show how this result changes across uncertainty normalizations of σ_ξ . Average results are not significantly different across 10%, 25%, and 50% reductions. For a 50% change, the center and tails of the distribution become more prominent, due to the higher degree of certainty and thus higher sensitivity.

by 1.9 points. This is intuitive as Super PACs typically help challengers more than incumbents. The effect is strongest in 2010 with more heterogeneity in subsequent years. Furthermore, the change is slightly larger in Democratically leaning states. Thus Super PACs may provide higher benefits in competitive but difficult environments. It is interesting to note that poorly performing candidates often do worse without Super PACs and many candidates who were already likely to win sometimes receive Super PAC support.⁷⁰ Overall, Republicans may lose 0.8% of House seats without Super PACs; they exist on both sides and thus their absence does not significantly tilt the power balance between parties.

Figure 1.2: Percent Change in Republican General Election Vote Share without SPACs



This plots the histogram of percent changes in Republican general election vote share (excluding abstention) with and without Super PACs. I compare the simulated equilibrium and counterfactual shares if Super PACs cannot enter.

In Figure 1.C.16, I report the percent change in incumbent primary election vote share without Super PACs for contested primaries; incumbents are generally helped as the distribution skews to the right. The effect for Democrats is relatively small, with most of the distribution falling between ± 1 percentage point changes, whereas Republican incumbents see slightly larger increases. Thus

⁷⁰In Figure 1.C.15 I show the percent change in Republican vote share with and without Super PACs across binned original vote share. The downward slope is indicating that Super PACs disappearing may help those who were not doing so well to begin with; those with low win chances would sometimes see increases without Super PACs (largely because the Super PACs were helping their opponents). One way of thinking about this is that Super PACs typically help already strong candidates, and some of that is wasted money. The uncertainty about outcomes rationalizes spending beyond what ex-post seems necessary.

Super PACs mainly help challengers, but the effect is still overall small with a 1.2% [-0.09, 16.83] change in vote share for Republican incumbents without Super PACs. In open races, Republican challengers with Super PAC support have their vote share decrease by 4.2% without Super PACs. This larger effect is intuitive as challengers do not have the war-chest or donor-networks of an incumbent. There is variation over time, with the smallest effects in 2016 and the largest in 2012. This may seem at odds with a learning by doing framework as one may expect Super PACs to become more effective over time. However, the strategic interaction likely counteracts these effects, meaning that candidates, parties, and opposing Super PACs themselves have learned how to counter Super PACs, thus nullifying electoral influence. The cannibalization of spending efforts is displayed in both the data and the model; in many cases, spending by one side is closely matched with spending by the other and lopsided spending is generally not an equilibrium outcome.

In Figure 1.C.17, I report the percent change in challenger entry probability without Super PACs, defined as one minus the probability of $d_c = 0$. There is a concentration near zero for both Republican and Democratic challengers, but with a large left tail for Republicans. The tail indicates that challenger entry decreases without Super PACs; the average change in Republican challenger entry without Super PACs is -11.21% [-19.89, -0.39]; the average change for Democrats is 0.3% [0.04, 1.22]. The effect is also twice as large in states that are dominated by the candidate's same party as opposed to opposition states. The model may slightly over-assign credit to Super PACs in 2010 given the large Tea-Party induced entry with only fledgling Super PAC primary activity. When the Republican incumbent has Super PAC support, the ex-ante challenger entry probability is on average 0.50, which increases to 0.53 without an incumbent Super PAC. Thus Super PACs supporting incumbents do not deter challengers to the extent that Super PACs supporting challengers encourage entry.

In Figure 1.C.18, I report the percent change in challenger extreme position probability without Super PACs (see Figure 1.C.19 for the moderate position). Both Republican and Democratic challengers are more likely to pick an extreme position without Super PACs. Average Republican challenger change in moderate position is -0.79% [-3.91, 0.16] and the average change in extreme

position is 5.62% [0.43, 10.69]. The average extreme change for Democrats is 2.13% [-0.08, 5.57]. Super PACs are more likely to support challengers and increase their chances of winning the primary, and thus challengers now have higher expected probabilities of winning the general, and since general election voters have a preference for moderation, challengers can increase their general election chances. Without Super PACs, challengers have a harder time winning the primary and reduce moderation.⁷¹

In Figure 1.C.20, I report the percent change in challenger extreme position probability without Super PACs, decomposing the effect into the direct effect of Super PAC entry and the indirect threat of their existence. The first histogram shows that when comparing races in which a Super PAC in fact entered, challengers are much more likely to switch to an extreme position when they do not have that Super PAC support. The right histogram indicates that even in races in which the Super PAC did not enter, there is still a change in probability of a position, however the effect is muted with fewer large effects. Thus the mere threat of Super PAC entry can induce candidate behavior changes. This is a natural consequence of having the candidate's choice occur before observing the Super PAC's decision.

Finally, in Figure 1.C.21, I report the percent change in incumbent extreme position probability without Super PACs; the average change is 12.92% [0.76, 51.57] for Democratic incumbents and 0.15% [-0.06, 1.15] for Republicans. Thus Super PACs seem to be a moderating force for Democratic incumbents. One explanation is that since Super PACs helped Republicans in the general, their absence relieves general election pressure on Democrats, and so the incumbent focuses on the primary. This is backed up by the fact that the moderating effect for Democrats is stronger in districts where the Republican candidate fairs well in the general election with Super PAC support.⁷² While some Democratic incumbent supporting Super PAC donors slightly prefer extremism, the incentives to win may override these concerns. How should one reconcile this moderating effect

⁷¹Barber (2016) finds that ideological donors lead to more extreme candidates while PACs are moderating.

⁷²Also, Democratic Super PACs are more likely to support challengers and thus without them, challengers are more vulnerable; an incumbent can deter entry by going more extreme in the primary. This move is less effective when Super PACs support the challenger as they are less deterred. Without Super PACs, Democratic challenger entry decreases a few percentage points (conditional on races with Super PACs).

with the trend towards polarization since 2010 as seen in Figure 1.C.6? Super PACs may not necessarily be part of the cause; in fact their subtle effects are clearly not affecting the overall trend and may only be dampening it.

1.6 Conclusion

In this chapter I tackle the role of unregulated money in national level campaigns. I focus on Super PACs and their effect on House elections, making clear distinctions between the kinds of players in each race. I solve a novel campaign model that incorporates a variety of important factors and estimate the model using joint variation in spending and donor data.

I find that while Super PACs have noisy effects that largely cancel each other out, their presence has changed the campaign finance environment. The overall increase in spending may have unforeseen consequences and the moderate changes on policy platforms may affect eventual Congressional policy. The result in the literature that Republicans are on average helped in the general election by Super PACs is corroborated in this chapter but there is heterogeneity in this result. Super PACs seem to help challengers in primaries with larger effects for Republicans, and the effects on candidate positions are nuanced and varied. Incumbents rarely lose their primary, and Super PACs have only slightly changed that.

There are many variants to the methodology used in this chapter, mentioned throughout, such as different specifications or valence estimation methods. These additional validations are part of an agenda to flesh out the procedure used here. I do not study the effects on policy outcomes, but Super PAC funded Republican state-legislature electoral gains (Klumpp, Mialon, and Williams 2016) have not necessarily resulted into major policy changes at the state level (Grossmann 2019). Furthermore, the literature on the role of campaign contributions in affecting policy has largely found mixed effects, indicating that campaign contributors may primarily target their funds to simply help get their preferred candidates into office (Ansolabehere, De Figueiredo, and Snyder 2003; Fowler, Garro, and Spenkuch 2020a). Those effects are also mixed, which is consistent with the observation that outside spending on campaigns is much lower than lobbying expenditures (De

Figueiredo and Richter 2014a).

Social welfare 501(c)(4) nonprofits, known as “dark money” groups, are absent in this study. They do not report their spending or donors to the FEC as they do not engage in “express advocacy” for a candidate. Their ads can be tracked with raw advertising data, but their influence is also indirect; a growing number of Super PAC donations come from these nonprofits, providing a discreet alternative for Super PAC donors.⁷³ My future research agenda is to incorporate “dark money” into the analysis for a more comprehensive framework.

Finally, future research on Super PACs needs to account for evolving strategies. Super PACs, and campaigns in general, are gradually shifting away from television towards the Internet. For example, the Super PAC “The Lincoln Project” creates “viral” content and produces a podcast. The group “America First Action” operates a news website called “American Herald”, and shares their content on social media. Modeling these strategies and their network effects is a major avenue for studying 21st century campaign finance.

⁷³When a 501(c)(4) donates to Super PAC, the original donor is undisclosed. This is allowed as long as the donor does not instruct the 501(c)(4) to give to the Super PAC; otherwise they risk being a “Straw Donor”.

APPENDICES

APPENDIX A

Additional Details

1.A.1 Background, Data, and Model Addendum

1.A.1.1 Background Addendum

Independent expenditures (IEs) were created by the 1976 *Buckley v. Valeo* case that allowed unlimited spending on political messaging (by individuals or PACs). *SpeechNOW v. FEC* (not a Supreme Court ruling, but a DC court of appeals), ruled that individuals could contribute unlimited funds to committees that make IEs. The SpeechNOW committee wanted to raise funds for IEs without forming a PAC (to avoid limiting itself to receiving at most \$5,000 per person). The court ruled that if the organization is IE only (not a PAC that can make both direct contributions and IEs), then it has no restrictions on fundraising (still no foreign funding however). This allowed individuals to basically pool IEs through Super PACs, making large sums more coordinated. Before *SpeechNow* individuals could either donate to a PAC (subject to contribution limits) or act on their own (not with a PAC).

Prior to *Citizens United v. FEC*, corporations had to form their own PACs. The case allowed corporations and unions to use their general treasury funds to make IEs. This was partially a response to the 2002 “Bipartisan Campaign Reform Act”. Part of this act was the banning of “electioneering communications” (EC) [TV ads mentioning candidates 60 days prior to general or 30 days prior to primary] by non-PACs. It also prohibited corporations and unions from spending on ECs. See Prato and Wolton (2017) for a discussion.

While most committees fall cleanly between independent expenditure-only (Super) or traditional PACs, the district court case *Carey v. FEC* allowed for the formation of the “hybrid PAC” (Carey Committee), which is a single PAC that operates as both a traditional PAC and Super PAC, with the requirement that the funding for each respective activity stems from two separate bank accounts. Thus unlimited donations aimed at independent expenditures originate from one and

none of that money can be used in coordination expenses, and vice-versa. An example of a hybrid PAC is the “American Future Fund”.

Spending on ads that do not support/oppose a candidate (issue advocacy) are less regulated. If the issue ad mentions a candidate and is within 60(30) days of a general (primary) election, then the ad must be disclosed (called an electioneering communication). Furthermore, prior to 2010, corporations/etc. could not make ECs, and *Citizens United* overturned that. The 2007 case *Wisconsin Right to Life v. FEC* loosened the restrictions on what classified ads to be EC, allowing more politically charged non-EC ads.

“Hard money” is money donated with a donation limit. “Soft” money has no cap and has been limited to parties ever since the Federal Election Campaign Act (FECA) of 1971 and were subsequently upheld in the 1976 *Buckley v. Valeo* case and were further limited in the 2002 “Bipartisan Campaign Reform Act”. There is substantial legal scholarship on IEs and soft money. Some consider IEs to be the new form of soft money (Tokaji and Strause 2014). The 2014 *McCutcheon v. FEC* case overruled some of the 2002 “Bipartisan Campaign Reform Act” (The BCRA was upheld in the 2003 case *McConnell v. FEC*), removing “aggregate contribution limits” made to national parties and federal candidate committees (the total amount one can give across all contributions in a cycle). This made it possible for individuals to give to many more candidates.⁷⁴

Social welfare nonprofits (501(c)(4)s), known as “Dark money” organizations, used to be limited in their political activity in that they could not directly engage in IEs. They could still lobby and make non-EC issue ads. *Citizens United* changed that, so that they can also make political expenditures; they still cannot spend the majority (> 50%) of their operating budget on these funds. But they do not need to disclose their donors and they can raise unlimited amounts (see Oklobdzija (2018) for a network analysis). 501(c)(4) spending totaled 257 million in 2012 ($\approx$ 20% of outside spending), but declined to 106 mil. in 2018.⁷⁵

⁷⁴The 2011-2012 limits: \$46,200 for federal candidates + \$70,800 for national parties = \$117,000 limit.

⁷⁵See CRP. This spending is predominantly issue ad based. Any IEs or ECs must be reported to the FEC. Few 501(c)(4)s file reports with the FEC so either these groups stick to non-EC issue ads or do not properly disclose. 501(c)(5) unions and 501(c)(6) trade associations have similar rules but spend much less.

1.A.1.2 Investment PAC extension

The payoff for the incumbent's investment PAC is the product of their personal valuation of winning $V_{ic} \in \mathbb{R}_{++}$ and the probability of their aligned candidate c winning the overall election all minus their funding level: $\pi_{P_I} = V_{P_I} \cdot P(w_c^G = 1|\cdot) - m$. The P_I 's funding level m affects the mapping $h_R^G : \mathbb{R}^k \times d \times m \rightarrow \mathbb{R}$. In the new first stage, the “shadow primary” (pre-primary), the investment PAC funds the incumbent with $m \in \mathbb{R}_+$ (we could also generalize to let there be many investment PACs with the same objective just different valuations). This war-chest building stage prior to the challengers choosing entry has some similar elements as the entry deterrence model from Epstein and Zemsky (1995). The data motivation for the investment PAC is detailed in Appendix 1.A.1.5. Their objective function is given below, where we must sum over the decisions made by the incumbent, which the investment PAC cannot perfectly predict given the private information.

The cost for the investment PAC is simply the money they spend in donations, which one can allow to vary based on the incumbent's policy choice to capture policy preference. Note that if we let $m(d_I) = m$, the investment PAC does not care about the incumbent's position beyond its effects on the chances of the incumbent winning the election.⁷⁶

$$\max_{m \geq 0} V_{P_I} \cdot \sum_{d'_I \in \{0, \dots, \Theta\}} P_I^G(d'_I|m) \cdot p(d'_I) - m(d_I) \quad (1.A.1)$$

Regardless of the parameterization, the investment PAC's single-agent environment guarantees a solution given that their revenue function, a strictly positive valuation V_{P_I} times the bounded expected probability of the incumbent winning P_I^G , is bounded and positive and their costs are unbounded as I assume $m(d_I)$ is strictly increasing in m and weakly convex.⁷⁷

⁷⁶This idea is to separate out the ideological from the investment PACs. The former has donors that have preferences over the position a candidate takes, whereas the investment PACs who already have an established relationship with the incumbent simply want them to win again.

⁷⁷To establish uniqueness we can either prove the first order condition has a single solution with an additional curvature assumption or simply discretize the argument space: $m \in \{0, \dots, M\}$.

1.A.1.3 Wealthy donor details

Donors can give unlimited amounts to Super PACs, so if there is a “mega-donor” who wants to spend a large amount in a given race with ads, they must go through Super PACs. Thus a Super PAC’s incentive to invest in a race is largely influenced by whether there are mega-donors who will contribute to them. Since Super PACs raise significant funds from these mega-donors, they are especially vulnerable to a downward shock in how much that donor gives.

While Super PACs are arguably more sensitive to large swings in donor incomes, donor variation may be weakened by the fact that reported incomes are right censored and the wealthy are less sensitive to local economic shocks; their contributions respond to a variety of factors (Larreguy and Teso 2018; Broockman, Ferenstein, and Malhotra 2019). Other sources of donor variation are how much they give unrelated to a given race, how much their “network”/neighbors give, or lagged giving. Conceptually, it is be difficult to define mega-donor pre-2010 without defining them via multiple candidates (due to contribution limits), and even that is limited before the 2014 case *McCutcheon v. FEC*.

1.A.1.4 Forbes List

I scraped the Forbes list of U.S. citizen billionaires since 2010. Forbes states their wealth that year but does not retain historical records. I used the Internet Archive’s “Wayback Machine” to find archived versions of the page to get time-variation in their stated wealth. I matched this list of names (601 in total) to campaign contributions using a fuzzy-matching algorithm with a Levenshtein-distance cutoff of 99.2%. In total, 24.6% of them gave over \$100,000 to Super PACs, but that only represented 20.6% of \$100,000+ donations to Super PACs. They have a higher degree of repeated giving than non-billionaires (average 9.46 instances of giving compared to non-billionaire population of 5.05), but only 137 Super PACs out of the 309 that received \$100,000+ had a billionaire donor. Family members would not be matched.

1.A.1.5 Investment PACs

The motivation for adding the investment PAC and their role can be seen in the data. A major deterrent to entry is the war-chest of the incumbent and I proxy for that by looking at the PAC contributions to incumbents starting from the very end of the previous election cycle up to the June of the year prior to the current cycle: this extremely early period constitutes the time period where challengers have perhaps not made their entry decisions yet but are observing the state of the future race. This is highly predictive in curbing entry prior to 2010. However after 2010, it is noisy and trivially positive; thus the war-chest may be seen as less of a threat to challengers in the new electoral environment.

1.A.1.6 Ad spending Heterogeneity

I combine attack/support ads in the main text, but there is interesting variation when differentiating between explicit support/attack ads (Chand 2017). Prior to *Citizens United*, supporting ads dominated attack ads, and candidates spending ads themselves dominated PAC or party expenditures. Post *Citizens United*, Super PACs more heavily relied on attack ads (relative to traditional PACs and parties), and spending by everyone increased. There is also more outside spending helping challengers (either attacking the incumbent or supporting the challenger in the advertisement). When looking at Republican vs Democratic spending, there is increased spending across the board with support and attack from both sides. Party spending is significant (especially post *Citizens United*), indicating that parties likely matter in explaining outcomes (also noted by Lax, Phillips, and Zelizer (2019)).

1.A.1.7 Polling Data

Polling data has issues, such as more polling for competitive races, some races only having polling late into the election, and others having early in the election. Polling data variation includes between and within elections; there is variation across time within an election for some races, but

the intervals are not uniform. I do not include polling data recorded throughout the election. One could track the spending effects on each poll up until election day, turning the cross-section into a panel, but this is complicated as the presence of a poll is endogenous. Many Congressional races will only have a couple polls throughout the entire election cycle, and the most competitive races have the most polling done. For example, in 2010 only 8 races had 7 polls on different days (Incerti 2018); with the vast majority having less than 2. Presidential and Senate races have significantly more polling coverage.

1.A.1.8 Media Market Overlap Data

The data on media market overlap is from the Daily Kos election dataset. Districts that contain multiple media markets are costly to advertise in because ads are purchased at the media market level, and advertising outside of the district of interest is wasteful. Thus districts with the highest degree of overlap are least costly, conditional on prices. This provides exogenous variation in how costly it is to spend in that district.

1.A.1.9 Number of Candidates Per Race

Of primaries since 2010 in my sample (House elections ignoring third party), 74% have fewer than three candidates, but this is because 42% are not even contested. 55% of contested primaries have only two candidates. Among contested races with at least three, 66% have only two dominant candidates, defined as where the sum of the non-top two candidates by vote share is less than 25% of the total vote, and in 90% of races three plus, the top two receive 60% of or more of the vote. Furthermore, among primary races with three plus, in 96% of races, 90% or more of the ad-spending by candidate committees is done by the top two candidates and in 99.7% of races, 75% or more of ad-spending is done by the top two. In terms of outside spending (meaning support from non-candidate sources like Super PACs), 98% of races have the top two receiving 75% or more of that spending. This indicates that in most of these elections, the smaller candidates are not in the same strategic environment as the “serious” candidates and can be added to the absenteeism count.

1.A.2 Estimation Addendum

1.A.2.1 Approximations

The first equilibrium object to approximate is the general election probability of the candidate winning conditional on a given entry profile: this approximation simply is a shortcut to solving all combinations of general election spending stages with a single function that takes the entry profile and the minimal set of exogenously given variables at that point to give a prediction of the probability. To make a linear sieve perform well, I approximate the log-odds ratio and transform it (instead of trying to flexibly approximate the fractional).

The estimation method requires solving certain stages for all combinations of decision variables. Given that this is computationally intensive (on the order of evaluating certain functions millions of times - number of observations times number of entry combinations for the general and the primary and any discrete decisions by the candidates), I employ a variety of shortcuts. First, as is common in the literature I semi-parametrically approximate the conditional choice probabilities for all discrete decisions, following Bajari, Hong, Krainer, and Nekipelov (2010). We have two options to estimate the probability function: solving the fixed point or an approximation. Given that the probability function is continuous in all arguments, we can apply the Stone-Weierstrass approximation theorem to guarantee the existence of a polynomial function that approximates it well.

We can approximate the function with a flexible polynomial or lasso.⁷⁸ Our approximation can either be of the data and parameters, or simply the data. The latter approach implicitly is the function with the parameter values at the “true” value. Calculating the polynomial approximation as a function of data and parameters is straightforward.⁷⁹ The probability function for the general election can be shown to be a function of only two terms that are composite terms of data and

⁷⁸We can also form a Taylor approximation after calculating the partial derivatives of the underlying function. While the latter exploits more information from the function, it also requires many terms if the number of inputs is large.

⁷⁹To approximate $P(X, \mathcal{P})$, calculate the fixed point over a sufficiently fine grid of $X \times \mathcal{P}$. Then we calculate the approximation for the inputs $(X, \mathcal{P})$ and the corresponding P . This is computationally prohibitive if the dimension of the inputs is large enough and we want a fine enough grid to be accurate.

parameters; thus a grid is low cost to create. However for the primary, the minimum number is seven; a better approach is to directly approximate the underlying function in terms of data alone. A semi-parametric estimate of the probability function as a function only of data has the benefit of being estimable outside of the estimation routine for parameters (it does not change during iterations) as it represents the equilibrium function at the true parameter values. In this case that means we have only have a few thousand observations with around a dozen variables for the general election. For a flexible enough polynomial we will not have sufficient degrees of freedom.⁸⁰ I approximate:

$$EP_c^G(\mathbf{d}) = \sum_{a_i^P \in \{0,1\}^{4N}} \left[\sum_{a_i^G \in \{0,1\}^{2N}} P_c^G(\mathbf{a}^P, \mathbf{a}^G | \mathbf{d}) \prod_j p_j^*(a_j^G) \right] \prod_j p_j^*(a_j^P).$$

This needs to be evaluated for all combinations of challenger and incumbent entry and policy decisions which is on the order $\dim(\Theta)^{\#C+1}$ where $\#C$ is the number of challengers. The easiest approach is to approximate the P and p functions with data given the observed d_c decisions. To calculate the payoff for a committee for one of the counterfactual entry profiles, we need both the P function and the equilibrium spending function S for that entry profile. There are two ways of calculating that: first we could flexibly approximate the spending function in an analogous manner as we approximated the vote probability and entry probability functions. However we can exploit the structure of the first order condition, which holds with equality for entrants:

$$\omega S^\phi / \phi = P(1 - P) \implies S = \left(\frac{P(1 - P)}{\omega / \phi} \right)^{1/\phi}.$$

Thus for the entry profiles in which a committee enters, the first order condition tells us what their optimal spending (at the true parameter values) is when plugging in P .

To generate the semi-parametric approximation above, one necessarily needs to observe va-

⁸⁰Also, with sufficient smoothness, the derivative of the polynomial approximation approximates the derivative of the original function (see Proposition 1.3 in Schmuland (1992)). Calculating the derivative of the polynomial with automatic differentiation is easier than with the underlying non-closed form function.

lences for all candidates that entered as they are inputs for that function. To exploit as much data as possible and not burden the estimation computation, I back out the valences for different sets of candidates differently. Recall I estimate the valences of candidates for each race in which they received votes. Also recall for candidates that never entered I draw from a distribution informed by observed valences and historical records. When approximating the equilibrium probabilities, one can use two approaches. First is to approximate it as a function of its direct inputs. In the case of the general election, that would be spending, spending effectiveness, and candidate characteristics. The downside of using this approach is that when one wants to consider counterfactual scenarios of committee entry, it is necessary to find the counterfactual spending level for that given entry profile.

An alternative approach is to use entry rather than spending as the input. This approach however then requires one to include additional inputs that enter the probability indirectly through spending (thus they were not required to be inputted before). These include the data from estimating committee parameters. In the case of the primary election, this additionally includes the expected general election probabilities of the counterfactual matchups, which are functions of the unobserved valences for the candidates that did not win their primary.

The general election probability of winning as a function of entry approximation: regression with 13 terms [$\mathbb{1}$, $\theta_R \cdot \delta_\theta$, $\theta_D \cdot \delta_\theta$, $X_R \delta_R + \xi_R$, $X_D \delta_D + \xi_D$, X_{V_R1} , X_{V_D1} , X_{C_R1} , X_{C_R2} , X_{C_D1} , X_{C_D2} , a_{R1} , a_{R2} , a_{D1} , a_{D2}]; 1463 observations; fit of 0.9485. The general election CCPs: 100 terms [levels/interactions of election prob terms, incumbent/challenger dummies, probability of winning and spending per entry combination]; 1463 observations; fit of 0.6166 for R-Spac model, 0.6732 R-party, 0.6026 D-spac, 0.6361 D-party. The poly for general election valence inversion: 11 terms [same as election prob but without entry and with EPG]; 1463 observations; fit of 0.9772.

The primary election prob as a function of entry: 53 terms [same as general prob but with all combinations of EPG matchups and the additional characteristics for primary-losers]; 780 observations for R and 536 for D; fit of 0.6875 for R and 0.8161 for D. The primary election CCPs: 54

terms [same as general ccp but with all combinations of EPG matchups and the additional characteristics for primary-losers, and a dummies for incumbent/challenger]; 1463 observations; fit of 0.5884 for R-Spac, 0.4646 R-party, 0.7069 D-spac, 0.6608 D-party. The challenger CCPs: 46 terms [Xs that enter challenger parameters and all non-collinear (relevant) EPGs for each candidate (for the different entry/position combinations)]; 653 observations for R1 challenger, 1463 for R2, 810 for D1, 1463 for D2; fit of 0.5789 for R1, 0.5302 R2, 0.6653 D1, 0.6199 D2.

Next recall I recover the general election valence for candidates that lost their primary by exploiting the model: I invert the expected general election probability with respect to the unobserved valence and match it to the primary first order condition of a candidate that won their primary. This estimated valence is a function of parameters, and precludes semi-parametric estimation of the expected probabilities outside of the estimation routine. There is a way to approximate ω_P as an alternative to estimating the primary election as done in the main analysis. The issue is that $\psi_{D_2}^{G,CF} = P^{-1}((F - EP^G P^{-P})/(1 - P^{-P}))$ and hence a function of $\omega_{ic}^P = (g_{ic}^P)/(V_{ic}^P \beta_{ic}^P)$. Recall that $V_{ic}^P = V_{ic}^G$ and we already estimated β_{ic}^P . Thus the only unobserved object is the primary cost of spending to the candidate g_{ic}^P . Note that we can relate the general and primary election effective cost terms: $\omega^P = \omega^G \cdot \bar{\omega}_c$, where $\bar{\omega}_c$ is an adjustment that varies at the district-candidate level. We can then relate the first order conditions of the primary and the general through this equation and estimate $\psi_{D_2}^{G,CF}$.⁸¹

⁸¹Write $\omega_{ic}^P = (\phi(S_{ic})^{\phi-1} P_c(1 - P_c)) \cdot \bar{\omega}_c$. Estimate $\bar{\omega}_{dc}$ using variation in elections for which there is a contested primary on one side and an uncontested primary on the other; consider the first order conditions for the candidate that has a contested primary on their own side but the opposing side is uncontested (say only candidate D_1): $(\omega_{ic}^P (S_{ic}^P)^\phi) / (\phi P^P (1 - P^P)) = EP(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1) = EP_c^G(a^P, \theta)$. Note that the right hand side is observed as that general election occurs for the R candidate that won their primary. Then $\bar{\omega}_c = (\phi(S_{ic}^P)^{\phi-1} P_c^P (1 - P_c^P) EP_c^G) / (\phi(S_{ic}^G)^{\phi-1} P_c^G (1 - P_c^G))$. Parameterize $\bar{\omega}_{dc}$ as a function of controls and impute for the missing races. Then estimate ω_c^P and back out $\psi_{D_2}^{G,CF}$. The sufficient identification assumption is that g_{ic}^P/β_{ic}^P and g_{ic}^G/β_{ic}^G for the candidate that wins their primary are proportional by an expression that varies only across district and candidate observables and common parameters.

1.A.2.2 Full Estimation Routine

The “estimate” steps are done using GMM with the interior point algorithm (with real-valued parameters and $1e-8$ step tolerance). All “get” steps are done using the approximations. The “construct” steps are simply using the estimates and approximations to loop over values to create the expected value. “CCP” refers to the conditional choice probability. “EPG” is expected probability of winning the general election. I use the identity weighting matrix for each GMM step; for data with potentially heavy tails, identity has relatively good small sample properties compared to optimal weighting (Altonji and Segal 1996).

```
#1 Estimate General & Primary voters
#2 Estimate General first order conditions
#3 Get General Probability & CCP approximation
#4 Construct General Probability prediction and EPG pre-general
#5 Estimate General entry conditions
#6 Using fully estimated general, get inverse EPG pre-general w.r.t. valence
#7 Estimate Primary FOC first order conditions Using inverse function
#8 Construct all entrant valences and matchup EPG pre-general and EPG pre-primary
#9 Get Primary Probability & CCP approximation
#10 Estimate Non-entrant Valence distribution
#11 Loop over non-entrant Valence draws
    #12 Loop over all incumbent decisions
        #13 Loop over all challenger decisions
            #14 Construct EPG pre-challenger across policy
            #15 Construct challenger CCPs
            #16 Construct incumbent EPG pre-incumbent
        #17 Construct incumbent CCPs
#18 Estimate challenger policy conditions using observed incumbent decision
#19 Estimate incumbent policy conditions
```

Model conditions needed for estimation:

Beyond the conditions listed in the estimation and results section, a more thorough description per step is helpful. It should be noted that a unique equilibrium in pure strategies is sufficient for identification, but not necessary. I describe the specific conditions as follows:

The second step of the estimation, the FOC estimation of the general, requires no additional assumptions as the estimation of the ratio to valuations to costs does not require a unique solution to that system; we are not solving for spending, just using the observed equilibrium spending already.

The third step of the estimation, getting the EPG for entry and the CCP via semi-parametric approximation, does require more. We can just the same identifying assumption as in Bajari et al. (2010), namely that “different values of the primitives generate different choice probabilities” (see their Definition 1). For the EPG, we just need the eventual EPG to be unique for the same entry profile. We can check for uniqueness of the FOC system beforehand after having estimated the FOC parameters. We can then check for uniqueness of the entry stage after estimating it as well.

The fourth and fifth steps of the estimation assumptions are described in the previous paragraph. For entry stage to be unique, we need assumptions on σ , but cannot test that until having estimated V, g ; but we can check ex-post.

For the sixth step, we need the EPG to be a function and be invertible in ψ . That is easily checked beforehand, by simply evaluating the EPG curvature at the estimated parameter values across the full range of estimated $\psi = \hat{\xi}$.

For the seventh step, again we are just using the FOC, not solving it so uniqueness of that stage is not immediately required.

For the eighth step, we need the EPGs from the perspective of pre-primary to be a function. While we can check for uniqueness of the primary entry game just as we did for the general, we just need the EPG to be unique for the same policy-platform profile. For the ninth step, see the discussion for the third step.

For steps eleven through nineteen, see the discussion of step eight. We also need the candidate CCPs to be functions, needing the same assumption from Bajari et al. (2010).

1.A.2.3 Additional Moments

In the main analysis, I used the semi-parametrically estimated conditional choice probabilities as dependent variables. This is useful as one can then directly compare them to model predictions without having structural error terms. However, in the event that these estimated CCPs are heavily biased, one can construct moments based on conditional expectations. For estimating the general

election entry stage, one can use the moment of observed entry minus its conditional expectation:⁸²

$$E\left\{\mathbf{Z}'\left[a_{ic} - \frac{\exp(u_{ic}(e_{ic}^G|\cdot))}{\exp(u_{ic}(e_{ic}^G|\cdot)) + \exp(u_{ic}(0,|\cdot))}\right]\right\} = \mathbf{0}.$$

Given that we must solve for the equilibrium spending for all entry profiles, we can compare the observed spending to the model prediction and minimize the distance between them. To be precise, we solve the maximization below and compare the observed spending to the model prediction for the observed entry profile. $S_{ic}^* = \arg \max\{V_{ic}P(w_c^G = 1|x, m, \mathbf{d}, \mathbf{w}^{\mathbf{P}}(\mathbf{y}^{\mathbf{P}}(\mathbf{e}^{\mathbf{P}}))) - (g_{ic})(S_{ic}) \ \forall ic\}$. Also, the within race variation between different committees: the model predicts spending by either side to be proportional based on race and committee characteristics: $0 = (\omega_{ic}/\frac{dS_{ic}^\phi}{dS_{ic}}) - (\omega_{jc}/\frac{dS_{jc}^\phi}{dS_{jc}}) \ \forall j, \forall c$.

We can generate another moment by rewriting the FOC in terms of the probability of winning: $\omega_{ic}/\frac{dS_{ic}^\phi}{dS_{ic}} = \frac{\prod_{c \in \{D, R\}} \exp(\mathbb{U})}{(\sum_{c \in \{D, R\}} \exp(\mathbb{U}))^2} = P(1 - P)$, where $\mathbb{U} = \sum_{ic \in N_c} \beta_{ic}(S_{ic}^*)^\phi + h_c^G + \xi_c$.

Also, note that entry variation is not necessary to identify primary costs, but would provide additional moments.

⁸²Using the actual entry rather than the approximated CCP is beneficial in that it does not rely on a good approximation, but it may perform poorly if the structural error u in $a = E[a|X] + u$ has high variance.

APPENDIX B

Proofs

Lemma 1. *When voter i 's indirect utility from choosing candidate j is expressed as: $U_{ij} = u_j + \xi_j + \epsilon_{ij}$, where $\epsilon \sim \text{iid Type 1 EV}$ with $\psi = 0, \sigma = 1$, then the share of votes can be written as the following (with utility of abstention $U_{i0} = \epsilon_{ij}$ and number of candidates J):*

$$s_j = \frac{\exp(u_j + \xi_j)}{1 + \sum_{k=1 \dots J} \exp(u_k + \xi_k)}.$$

Proof of Lemma 1.

Consider the voter i with the following preferences over alternatives $j = 1 \dots J$ with an outside option $j = 0$: $U_{ij} = u_j + \xi_j + \epsilon_{ij}$, $\epsilon \sim \text{iid Type 1 EV}$ with $\psi = 0, \sigma = 1$. Then the probability that voter i , drawn at random from the population, votes for candidate j is: $P_{ij} = (u_j + \xi_j + \epsilon_{ij} > u_k + \xi_k + \epsilon_{ik} \forall k \neq j)$. Following Train (2009), given the distribution of the errors, $F(\epsilon_{ij}) = \exp(-\exp(-\epsilon_{ij}))$, and that the ϵ are independent, the cumulative distribution function over all alternatives different from j is the product of each CDF.

$$\begin{aligned} P_{ij} &= \int_{-\infty}^{\infty} \left(\prod_{k \neq j} \exp(-\exp\{-(u_j + \xi_j + \epsilon_{ij} - u_k - \xi_k)\}) \right) \exp(-\epsilon_{ij}) \exp(-\exp(-\epsilon_{ij})) d\epsilon_{ij} \\ &= \int_{-\infty}^{\infty} \exp \left(-(\exp(-\epsilon_{ij})) \sum_j \exp\{-(u_j + \xi_j - u_k - \xi_k)\} \right) \exp(-\epsilon_{ij}) d\epsilon_{ij} \end{aligned}$$

Then define $x = \exp(-\epsilon_{ij})$, which with the transformation of variables:

$$\begin{aligned} P_{ij} &= \int_0^1 \exp \left(-(x) \sum_j \exp\{-(u_j + \xi_j - u_k - \xi_k)\} \right) (-1) dx \\ &= \frac{\exp \left(-(x) \sum_j \exp\{-(u_j + \xi_j - u_k - \xi_k)\} \right)}{-\sum_j \exp\{-(u_j + \xi_j - u_k - \xi_k)\}} \Big|_0^1 \\ &= \frac{1}{\sum_j \exp\{-(u_j + \xi_j - u_k - \xi_k)\}}. \end{aligned}$$

Finally, we can rewrite out the choice probability: $P_{ij} = \frac{\exp(u_j + \xi_j)}{\sum_{k=0 \dots J} \exp(u_k + \xi_k)}$. Note that this term is the same $\forall i$, meaning $P_{ij} = P_j$. Since choice probabilities are not observed, we can construct the share of votes for a given candidate based on an average of choices from a sample of the voters: $s_j = \frac{\sum \mathbb{1}[\text{choice}=j]}{n}$. For the market share to be consistent for the probability, we need would need $s_j \rightarrow_p P_j$ as the number of votes $n \rightarrow \infty$.⁸³ I assume we have sufficient number of votes to utilize the equivalence between shares and aggregate probability. If we normalize the utility for the outside option $j = 0$ to be $U_{i0} = \epsilon_{i0}$, then we can write the following vote share for a given candidate:

$$s_j = \frac{\exp(u_j + \xi_j)}{1 + \sum_{k=1 \dots J} \exp(u_k + \xi_k)}.$$

□

Lemma 2. *The program in equation (1.3.8) has a strictly (finite) positive solution for strictly positive $V_{ic} \forall ic \forall c$, strictly positive $\beta_{ic} \forall ic \forall c$, $\phi \in (0, 1)$, and strictly positive $\sum_{j \in J} \gamma_{jic} \forall ic \forall c$.*

Proof of Lemma 2.

Rewrite the effort game as the spending game with the following grouping of variables: the cost of spending $g_{ic} = \left(\sum_{j \in J} \gamma_{jic} \right)^{-1}$, heterogeneous spending: $\tilde{\beta}_{ic} = \beta_{ic}(1 + X_c^{G1} \delta_1)$, and candidate characteristics $\Delta_c = h_c^G + \psi_c$.

$$\max_{S_{ic}^G \in \mathbb{R}_+} V_{ic} \left(\frac{\exp \left(\sum_{j \in N_c} \tilde{\beta}_{jc} (S_{jc})^\phi + \Delta_c \right)}{\sum_{c \in \{D, R\}} \exp \left(\sum_{j \in N_c} \tilde{\beta}_{jc} (S_{jc})^\phi + \Delta_c \right)} \right) - g_{ic} S_{ic}^G$$

First we must check whether a solution exists at all.⁸⁴ It is clear that the payoff is continuous

⁸³As Gandhi et al. (2019) point out, this is not sufficient for the parameters in u_j to be identified given the nonlinearity in $\log(\cdot)$ and is not well defined for a candidate that receives 0 votes.

⁸⁴Note that we cannot rely on the conditions from the Debreu, Glicksberg, and Fan Theorem (Debreu 1952): in an infinite strategic form game, if the strategy space is compact and convex, if the payoffs are continuous in other players' strategies, and if the payoff is continuous and concave in own strategies, then there exists a pure strategy Nash equilibrium. I cannot use this as the payoff is not globally concave. While a quasi-concave version of this theorem exists, I just directly show an equilibrium exists.

in all arguments. The unrestricted strategy space is non-compact but without loss of generality we can consider a top-bounded space, despite the payoff not being globally concave. Intuitively this is clear as the payoff is a positive constant times a probability (bounded between 0 and 1) plus a linear strictly decreasing cost function. Thus at some point, the costs will overpower the benefits and any solution will be finite.

The first order condition for player i_c of this program is:

$$V_{i_c} \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} \left(\frac{\prod_{c \in \{D, R\}} \exp \left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c} (S_{j_c})^\phi + \Delta_c \right)}{\left(\sum_{c \in \{D, R\}} \exp \left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c} (S_{j_c})^\phi + \Delta_c \right) \right)^2} \right) - g_{i_c} = 0.$$

Note that the derivative of the probability of winning function $P_c = P(w_c^G = 1 | w_c^P = 1, \mathbf{w}_{-c}^P) = \left(\frac{\exp \left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c} (S_{j_c})^\phi + \Delta_c \right)}{\sum_{c \in \{D, R\}} \exp \left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c} (S_{j_c})^\phi + \Delta_c \right)} \right)$ is strictly positive and is increasing in $S_{i_c}^G$. Also note that we can write this first order condition more compactly:

$$V_{i_c} \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} P_c (1 - P_c) - g_{i_c} = 0.$$

The second order condition is the following, letting the probability be written as P_c :

$$V_{i_c} \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} \left((\phi - 1)(S_{i_c})^{-1} P_c \cdot (1 - P_c) + \frac{\partial P_c}{\partial S_{i_c}} \cdot (1 - P_c) + P_c \cdot \left(-\frac{\partial P_c}{\partial S_{i_c}} \right) \right).$$

To determine the sign of this expression, the following version is easier to work with, using the fact that $\frac{\partial P_c}{\partial S_{i_c}} = \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} P_c \cdot (1 - P_c)$ and combining terms:

$$V_{i_c} \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} [P_c \cdot (1 - P_c)] \left((\phi - 1)(S_{i_c})^{-1} + [\tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1} \cdot (1 - 2P_c)] \right).$$

The expression called $V_{i_c} \tilde{\beta}_{i_c} \phi(S_{i_c})^{\phi-1}$ is strictly positive, and thus the sign is determined by the sum in the parentheses. Since we assumed $\phi \in (0, 1)$, the first term $(\phi - 1)(S_{i_c})^{-1}$ is strictly negative for any $S_{i_c} > 0$. Note that if $P_c > 1/2$ then the entire expression will be negative and thus the objective function will be concave. However, if $P_c < 1/2$, then it is unclear. The following

expression determines the sign of the second order condition $\frac{\partial \pi_{i_c}^2}{\partial S_{i_c}^2}$:

$$\text{sign} \left[\frac{\partial \pi_{i_c}^2}{\partial S_{i_c}^2} \right] = \text{sign}[(1 - 2P_c)\tilde{\beta}_{i_c}\sqrt{S_{i_c}} - 1].$$

Since P_c is strictly increasing in S_{i_c} , as S_{i_c} increases, the term $(1 - 2P_c)\tilde{\beta}_{i_c}\sqrt{S_{i_c}}$ will become larger and eventually negative. Thus the convexity of π_{i_c} , if any, is confined to some interval $[0, B]$ for $B > 0$. Whether or not any optimal $S_{i_c}^G$ is strictly positive can easily be seen by comparing the payoff from positive spending and zero spending, denoting the sum of others' spending on the same side, $\sum_{j_c \in N_c \setminus \{i_c\}} \tilde{\beta}_{j_c}(S_{j_c})^\phi$, with $\mathcal{S}_{-i_c}$. Note that the other side does not have an excluded player.

$$V_{i_c} \left(\frac{\exp(\tilde{\beta}_{i_c}(S_{i_c})^\phi + \mathcal{S}_{-i_c} + \Delta_c)}{\sum_{c \in \{D, R\}} \exp(\tilde{\beta}_{i_c}(S_{i_c})^\phi + \mathcal{S}_{-i_c} + \Delta_c)} \right) - g_{i_c} S_{i_c}^G - V_{i_c} \left(\frac{\exp(\mathcal{S}_{-i_c} + \Delta_c)}{\sum_{c \in \{D, R\}} \exp(\mathcal{S}_{-i_c} + \Delta_c)} \right)$$

At $S_{i_c} = 0$, this term is zero. Thus a positive solution will always dominate a zero if this expression is ever positive for all values of the other variables. To see whether this term is strictly positive for any $S_{i_c} > 0$, we can check its derivative at zero:

$$V_{i_c} \tilde{\beta}_{i_c} \phi (S_{i_c})^{\phi-1} \left(\frac{\prod_{c \in \{D, R\}} \exp(\sum_{j_c \in N_c} \tilde{\beta}_{j_c}(S_{j_c})^\phi + \Delta_c)}{\left(\sum_{c \in \{D, R\}} \exp(\sum_{j_c \in N_c} \tilde{\beta}_{j_c}(S_{j_c})^\phi + \Delta_c) \right)^2} \right) - g_{i_c}.$$

Since $\phi \in (0, 1)$ and the expression in parentheses is strictly positive, the limit from the right is positive infinity. Thus this function initially increases, starting from zero, and hence is somewhere positive.

Now we need to check for the existence of a positive solution. First take the first order condition and rearrange it: $P_c(1 - P_c) = \frac{g_{i_c}}{V_{i_c} \tilde{\beta}_{i_c} \phi (S_{i_c})^{\phi-1}}$. Since the right hand side is the same for all players

in the game, the best responses are linear functions, letting $\omega_{i_c} = g_{i_c}/(V_{i_c}\tilde{\beta}_{i_c})$:

$$S_{i_c} = S_{j_c} \left(\frac{\omega_{j_c}}{\omega_{i_c}} \right)^{1/\phi} \quad \forall j_c \forall c.$$

Thus we can rewrite the first order condition in terms of one player, say player 1_R :

$$V_{1_R} \tilde{\beta}_{1_R}^\phi (S_{1_R})^{\phi-1} \left(\frac{\prod_{c \in \{D, R\}} \exp \left((S_{1_R})^\phi \sum_{j_c \in N_c} \tilde{\beta}_{j_c} \left(\frac{\omega_{1_R}}{\omega_{j_c}} \right) + \Delta_c \right)}{\left(\sum_{c \in \{D, R\}} \exp \left((S_{1_R})^\phi \sum_{j_c \in N_c} \tilde{\beta}_{j_c} \left(\frac{\omega_{1_R}}{\omega_{j_c}} \right) + \Delta_c \right) \right)^2} \right) - g_{i_c} = 0.$$

We can show that this has a real and unique solution. From the preceding discussion, we know that any solution is nonzero and finite, so since the payoff function starts off positive, increases, and eventually becomes negative, we know a positive solution exists. $\square$

Lemma 3. *The equations that define whether there is a unique solution for the program (1.3.8) can be expressed as a single equation with two parameters and one variable. Sufficient for a unique solution are magnitude restrictions on the relative sizes of the two parameters.*

Proof of Lemma 3.

Continuing from the proof of Lemma 2, the question now is multiplicity. It will be useful to denote terms with simpler notation: $A_c = \sum_{j_c \in N_c} \tilde{\beta}_{j_c} / (\omega_{j_c})$, and express the solution in terms of $X = \omega_{1_R} (S_{1_R})^\phi$, with shorthand $e_c = \exp(X A_c + \Delta_c)$. Then we can rewrite:

$$(1/\phi)X = \frac{e_R e_D}{(e_R + e_D)^2}.$$

The goal is to show that these two functions intersect once. First note that the term on the left is strictly increasing linear function starting at 0. The term on the right starts above zero and eventually decreases (which can be seen because the denominator is strictly larger than the numerator and increases at a faster rate). As shown below, this function may initially increase

or decrease, but a single intersection with the left hand size function is guaranteed. Consider the derivative of the second term after some combining of terms:

$$\frac{e_R e_D (e_D - e_R)(A_R - A_D)}{(e_R + e_D)^3}.$$

The equation that determines the sign: $\text{sign}[(\exp(X A_D + \Delta_D) - \exp(X A_R + \Delta_R))(A_R - A_D)]$. If $(A_R - A_D)$, then eventually this will be negative. However for low values of X , if $\Delta_D > \Delta_R$, this can be positive. Thus it either starts off positive then goes strictly negative, or is negative throughout. Since the left hand side function starts below the right hand side function, the only possibility of more than one intersection is when the right hand side function increases at a slow enough rate to cross the left hand side and subsequently cross two more times: the bell shape curve can lead to either 1 crossing or three. This can occur when there are extreme differences on opposite ends: if the effective influence of one side $\sum_{i_c \in N_c} \beta_{ic}^2 V_{ic}/g_{ic}$ is much higher than the other side while simultaneously the other side has an extreme effective valence $h_d + \psi_d$ relative to the initial side (however if too extreme then again a single crossing), then 3 equilibria arise. The only possibility of 2 equilibria are when the increasing part of the bell curve function intersects the left hand side straight line with a tangent before coming back down with another intersection.

Note that we can fully characterize the right hand side in terms of just two parameters (fixing ϕ), where we define $\varpi = A_R - A_D$ and $\varrho = \Delta_R - \Delta_D$:

$$\frac{e_R e_D}{(e_R + e_D)^2} = (\exp(\varpi X + \varrho) + \exp(-(\varpi X + \varrho)) + 2)^{-1}.$$

Then uniqueness can be characterized from the relative magnitude of those two parameters, namely $(\sum_{i_c \in N_c} \beta_{ic}^2 V_{ic}/g_{ic} - \sum_{i_d \in N_d} \beta_{id}^2 V_{id}/g_{id})$ and $(h_d + \xi_d - h_c - \xi_c)$ for candidates c and d . The derivative of this expression is as follows:

$$\frac{\varpi(\exp(-(\varpi X + \varrho)) - \exp(\varpi X + \varrho))}{(\exp(\varpi X + \varrho) + \exp(-(\varpi X + \varrho)) + 2)^2}.$$

Thus the function increases when $\varpi(\exp(-(\varpi X + \varrho)) - \exp(\varpi X + \varrho)) > 0$, but if that increasing rate is small enough, it will cross $(1/\phi)X$ while it is increasing: meaning when $\varpi(\exp(-(\varpi X + \varrho)) - \exp(\varpi X + \varrho)) < (1/\phi)$. By solving for the equality, we can find when the slopes are equal:

$$\log \left(\frac{-(1/\phi)(1/\varpi) \pm \sqrt{((1/\phi)(1/\varpi))^2 - 4}}{2} \right) / \varpi - \varrho/\varpi = x.$$

□

Lemma 4. *The program in equation (1.3.9) has a pure strategy solution for strictly positive $V_{ic} \forall ic \forall c$, strictly positive $\beta_{ic} \forall ic \forall c$, $\phi \in (0, 1)$, and strictly positive $\sum_{j \in J} \gamma_{jic} \forall ic \forall c$, and this solution is unique for sufficiently large σ .*

Proof of Lemma 4.

This proof follows the approach from Chapter 3. Denote any second stage Nash equilibrium vector of spending decisions given an entry profile $(a_1, \dots, a_N)$ as $(S_1^*, \dots, S_N^*)$, which given Lemma 2 is unique. The committee's interim expected payoff for a given entry decision conditional on their private information is denoted with U_i and given in equation (1.B.2). The summation is across all 2^{N-1} combinations of opponent decisions a_{-i} ; the term $p_j(a_{-i})$ is the belief by player i in the probability of player j choosing a_j from the decision profile a_{-i} . The term $p_{i,j}(e_{-i})$ is the belief by player i of the probability of player j choosing the a_j from the decision profile a_{-i} ; the term p_{-i} is the vector of opponent probabilities of $a = 1$; the term ε_i is private information:

$$U_i(S_1^*, \dots, S_N^*, a_1, \dots, a_N, p_{-i}) = \sum_{a_{-i} \in \{0,1\}^{2N-1}} \pi_i^*(S_1^*, \dots, S_N^* | a_1, \dots, a_N) \prod_{j \neq i} p_j(a_{-i}) + \varepsilon_i \cdot a_i. \quad (1.B.2)$$

First I show that there exists a pure strategy (Perfect Bayesian equilibrium for this stage) in cutoff strategies. Let the first part of the payoff be denoted with u_i so that $U_i = u_i + \varepsilon_i$. Given the iid distribution of ε , the beliefs are symmetric, meaning player i 's belief about player j equals

player k 's belief about player j : $p_{i,j} = p_{k,j} = p_j$. Thus one can write out any player's belief about player i choosing $a_i = 1$ as $p_i(a_i = 1) = \text{Prob}[u_i(1, p_{-i}) + \varepsilon_i > u_i(0, p_{-i})]$. Which given the scaled Logistic distribution of ε yields the functional form below:

$$p_i = \frac{\exp(u_i(1, p_{-i})/\sigma)}{\exp(u_i(1, p_{-i})/\sigma) + \exp(u_i(0, p_{-i})/\sigma)} = f(p_{-i}).$$

This is a continuous system of choice probabilities $\mathbf{p}$ that defines an equilibrium if one exists: $\mathbf{p} = f(\mathbf{p})$. Note that $\mathbf{p} \in [0, 1]^N$ and $f(\mathbf{p}) : [0, 1]^N \rightarrow [0, 1]^N$. Thus f is a continuous function over a compact convex set. As noted in Bajari et. al (2010), applying Brouwer's fixed point theorem to this system yields a pure strategy equilibrium for finite values of π .

The proof of uniqueness stems from the sufficient conditions detailed in Seim (2006). The system $\Phi(\mathbf{p}) = \mathbf{p} - f(\mathbf{p}) = 0$ will have one zero if the matrix of partial derivatives of Φ with respect to p is a positive dominant diagonal matrix, meaning:

$$|\frac{\partial \Phi_i}{\partial p_i}| > 0 \quad \forall i \quad \& \quad |\frac{\partial \Phi_i}{\partial p_i}| \geq \sum_{j \neq i} |\frac{\partial \Phi_i}{\partial p_j}| \quad \forall i.$$

Given the functional form, the first is satisfied with value of unity. The second can be satisfied for a sufficiently large σ . To see this, first write out the expression for a given i :

$$\sum_{j \neq i} |\frac{\partial \Phi_i}{\partial p_j}| = \frac{\exp(u_i(1)/\sigma - u_i(0)/\sigma)}{(1 + \exp(u_i(1)/\sigma - u_i(0)/\sigma))^2} \sum_{j \neq i} |\frac{\partial u_i(1)}{\partial p_j} - \frac{\partial u_i(0)}{\partial p_j}| \frac{1}{\sigma}.$$

$$\frac{\partial u_i(1)}{\partial p_j} = \sum_{a_{-\{i,j\}}} [\pi_i(a_i = 1, a_j = 1, a_{-\{i,j\}}) - \pi_i(a_i = 1, a_j = 0, a_{-\{i,j\}})] \prod_{k \neq \{i,j\}} p_k(a_{-\{i,j\}})$$

with a complementary expression for $\frac{\partial u_i(0)}{\partial p_j}$. Note that $\frac{\partial u_i(1)}{\partial p_j}$ is less than the maximum difference in payoffs for entering M , with an analogous bounding for $\frac{\partial u_i(0)}{\partial p_j}$, equal to m . Both M and

m are well-defined given the interior solution to the second stage game.

$$\frac{\partial u_i(1)}{\partial p_j} \leq \max_{a_{-\{i,j\}}} [\pi_i(a_i = 1, a_j = 1, a_{-\{i,j\}}) - \pi_i(a_i = 1, a_j = 0, a_{-\{i,j\}})] = M_{ij}$$

$$\frac{\partial u_i(0)}{\partial p_j} \geq \min_{a_{-\{i,j\}}} [\pi_i(a_i = 0, a_j = 1, a_{-\{i,j\}}) - \pi_i(a_i = 0, a_j = 0, a_{-\{i,j\}})] = m_{ij}$$

The expression $\frac{\exp(u_i(1)/\sigma - u_i(0)/\sigma)}{(1 + \exp(u_i(1)/\sigma - u_i(0)/\sigma))^2}$ can also be bounded above by noting that the function $\frac{\exp(x/\sigma)}{(1 + \exp(x/\sigma))^2}$ achieves its maximum at $x = 0$ for any positive σ with a function value of $1/4$ at that point. Thus one can bound the sum of the absolute cross-partials:

$$\sum_{j \neq i} \left| \frac{\partial \Phi_i}{\partial p_j} \right| \leq \frac{1}{4\sigma} \sum_{j \neq i} \left| \frac{\partial u_i(1)}{\partial p_j} - \frac{\partial u_i(0)}{\partial p_j} \right| \leq \frac{1}{4\sigma} \sum_{j \neq i} |M_{ij} - m_{ij}|.$$

Thus sufficient for uniqueness is the left-most expression being weakly bounded by $1 \forall i$, and sufficient for that is $\sigma \geq \max_{i \in \mathcal{I}} \{\sum_{j \neq i} |M_{ij} - m_{ij}|/4\}$. $\square$

Lemma 5. *The program in equation (1.3.10) has a strictly (finite) positive solution for strictly positive $V_{ic} \forall ic \forall c$, strictly positive $\beta_{ic} \forall ic \forall c$, $\phi \in (0, 1)$, and strictly positive $\sum_{j \in J} \gamma_{jic} \forall ic \forall c$.*

Proof of Lemma 5.

$$\max_{e_{ic}^P \in \mathbb{R}_+} V_{ic} P(w_c^P = 1) P(w_c^G = 1 | w_c^P = 1 \cap w_{D_2}^P = 1) \cdot P(w_{D_2}^P = 1) +$$

$$V_{ic} P(w_c^P = 1) P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1) \cdot P(w_{D_1}^P = 1) - e_{ic}^P$$

Which can be rewritten as below, where $\Omega_c = P(w_c^G = 1 | w_c^P = 1 \cap w_{D_2}^P = 1) \cdot P(w_{D_2}^P = 1) + P(w_c^G = 1 | w_c^P = 1 \cap w_{D_1}^P = 1) \cdot P(w_{D_1}^P = 1)$.

$$\max_{e_{ic}^P \in \mathbb{R}_+} V_{ic} P(w_c^P = 1) (\Omega_c) - e_{ic}^P$$

The arguments for the existence of a solution follow from the proof for the general election contest, as the payoffs have the same shape in own arguments, but are just scaled by the probabilities from the other primary election.

□

Conjecture 1. *The program in equation (1.3.10) is unique under parameter restrictions.*

Evidence for Conjecture 1.

Continuing from the proof of Lemma 5.

$$\Omega_c V_{i_c} \tilde{\beta}_{i_c} \phi (S_{i_c})^{\phi-1} \left(\frac{\prod_{d \in \{R_1, R_2\}} \exp \left(\sum_{j_d \in N_d} \tilde{\beta}_{j_d} (S_{j_d})^\phi + \Delta_d \right)}{\left(\sum_{d \in \{R_1, R_2\}} \exp \left(\sum_{j_d \in N_d} \tilde{\beta}_{j_d} (S_{j_d})^\phi + \Delta_d \right) \right)^2} \right) - g_{i_c} = 0$$

Define the term $\omega_{i_c}^P = g_{i_c} / (V_{i_c} \tilde{\beta}_{i_c})$. Note that the best response functions are linear with respect to the other players from your direct primary (not with respect to players from the other primary, whose actions are contained in Ω_c).

$$S_{i_c} = S_{j_d} \left(\frac{\omega_{j_d}}{\omega_{i_c}} \cdot \frac{\Omega_c}{\Omega_d} \right)^{1/\phi} \quad \forall j_d \forall c \in \{R_1, R_2\}$$

We have two sets of these for both sides of the primary. This mirrors the general election just now with two sets with the exception of the Ω terms which capture the forward-looking nature of committees during the primary. Thus we can write out the primary election first order condition for the Republican side as just a function of spending of a single Republican committee (from either side) and the spending from the Democratic primary (with the analogous case for the Democratic spending).

Thus the solution is characterized by two sets of equations:

$$\begin{aligned}
(1/\phi)\omega_{1R}S_{1R_1}^\phi &= \Omega_{R_1} \cdot P_{R_1}([\Omega_{R_2}/\Omega_{R_1}]\omega_{1R}S_{1R_1}^\phi) \cdot (1 - P_{R_1}(\cdot)) \\
(1/\phi)\omega_{1D}S_{1D_1}^\phi &= \Omega_{D_1} \cdot P_{D_1}([\Omega_{D_2}/\Omega_{D_1}]\omega_{1D}S_{1D_1}^\phi) \cdot (1 - P_{D_1}(\cdot)).
\end{aligned}$$

Recall from the proof for the general election, that each equation can have a unique solution (assumed here) so that we can write out the best responses as functions (not correspondences): $S_{1R_1} = BR_R(S_{1D_1})$, and $S_{1D_1} = BR_D(S_{1R_1})$. We can write out the two equations with simpler notation, letting $X = \omega_{1R}S_{1R_1}^\phi$ and $Y = \omega_{1D}S_{1D_1}^\phi$. Let G_{11}^R be the equilibrium expected general election probability of candidate R_1 beating candidate D_1 , with similar notation for the other terms. Note that $G_{11}^D = 1 - G_{11}^R$, $G_{12}^R = 1 - G_{21}^D$, etc.

$$\begin{aligned}
(1/\phi)X &= [G_{11}^R P_{D_1}(Y) + G_{12}^R(1 - P_{D_1}(Y))] \cdot \\
&\quad P_{R_1} \left(X \cdot \left[\frac{G_{21}^R P_{D_1}(Y) + G_{22}^R(1 - P_{D_1}(Y))}{G_{11}^R P_{D_1}(Y) + G_{12}^R(1 - P_{D_1}(Y))} \right] \right) \cdot (1 - P_{R_1}(\cdot))
\end{aligned}$$

$$\begin{aligned}
(1/\phi)Y &= [G_{11}^D P_{R_1}(X) + G_{12}^D(1 - P_{R_1}(X))] \cdot \\
&\quad P_{D_1} \left(Y \cdot \left[\frac{G_{21}^D P_{R_1}(X) + G_{22}^D(1 - P_{R_1}(X))}{G_{11}^D P_{R_1}(X) + G_{12}^D(1 - P_{R_1}(X))} \right] \right) \cdot (1 - P_{D_1}(\cdot))
\end{aligned}$$

We must establish the curvature of the best responses. First take the derivative of the best response for X in terms of Y by differentiating the first equation, which is an implicit function of the best response function, by Y and re-arranging, where it will be useful to define the a new term which is derived from to the derivative of the ratio $\Omega_{R_2}/\Omega_{R_1}$ with respect to Y : $\Omega_\delta^R = \frac{(G_{21}^R - G_{22}^R)\Omega_{R_1} - (G_{11}^R - G_{12}^R)\Omega_{R_2}}{(\Omega_{R_1})^2}$.

$$\frac{\partial BR_X(Y)}{Y} = \frac{\frac{\partial P_{D_1}}{\partial Y} \left(G_{11}^R - G_{12}^R \right) P_{R_1}(1 - P_{R_1}) + \Omega_{R_1} \frac{\partial P_{R_1}}{\partial X \cdot [\Omega_{R_2}/\Omega_{R_1}]} BR_X(Y) \frac{\partial P_{D_1}}{\partial Y} \Omega_\delta^R (1 - 2P_{R_1})}{1/\phi - [\Omega_{R_1}] \frac{\partial P_{R_1}}{\partial X \cdot [\Omega_{R_2}/\Omega_{R_1}]} \left[\Omega_{R_2}/\Omega_{R_1} \right] (1 - 2P_{R_1})}$$

If we assume $\Omega_{R_2} = \Omega_{R_1}$, then it is straightforward to establish curvature [see below]. Anal-

ysis of the case of $\Omega_{R_2} \neq \Omega_{R_1}$ is still ongoing.

To determine the curvature of the best responses, consider the G terms. If $G_{11}^R = G_{12}^R$, then the best response curve is flat because player 1_{R1} is indifferent to which Democratic candidate wins. In this case the solution from the general election contest suffices to show a unique solution. Similarly, if either of the probabilities for the opposing side are equal to 1, meaning the other candidate did not enter, then we again reach the degenerate best response. To consider the other cases, we must establish the curvature of the best responses. First take the derivative of the best response for X in terms of Y by differentiating the first equation, which is an implicit function of the best response function, by Y and re-arranging:

$$\frac{\partial BR(Y)}{Y} = \frac{\frac{\partial P_{D1}}{\partial Y} (G_{11}^R - G_{12}^R) P_{R1} (1 - P_{R1})}{1/\phi - [G_{11}^R P_{D1} + G_{12}^R (1 - P_{D1})] \frac{\partial P_{R1}}{\partial X} (1 - 2P_{R1})}.$$

The sign of the numerator is based on the following, where $A_{Dc} = \sum_{j_{Dc} \in N_{Dc}} \tilde{\beta}_{j_{Dc}} / (\omega_{j_{Dc}})$.

$$\text{sign} \left[\frac{\partial P_{D1}}{\partial Y} (G_{11}^R - G_{12}^R) \right] = \text{sign} \left[(A_{D1} - A_{D2}) (G_{11}^R - G_{12}^R) \right]$$

The A terms are the aggregate effective spending influence of the democratic committees for the Democratic primary. The G terms are the equilibrium expected probability of the Republican candidate winning against either Democratic candidate. Thus the sign is positive if Democrat 1 candidates are more effective at spending and the Republican 1 has a better chance against Democrat 1 than Democrat 2 in the general. The sign of the denominator is determined by the following condition, where for shorthand $\theta = G_{11}^R P_{D1} + G_{12}^R (1 - P_{D1})$, and $\exp_{1_{Rc}} = \exp(A_{1_{Rc}} X + \Delta_{Rc})$:

$$\text{sign}[denom] = \text{sign} \left[1/\phi - \theta \cdot \frac{(\exp_{R1} \exp_{R2})(A_{R1} - A_{R2})(\exp_{R2} - \exp_{R1})}{(\exp_{R1} + \exp_{R2})^3} \right].$$

Note that $1/\phi$ is strictly greater than one and Ξ is strictly between zero and one. Also note

that if the sign of this term ever changed, then it necessarily crosses 0 (as it is continuous) and the derivative would be undefined at that point. If $A_{R_1} - A_{R_2}$ is sufficiently large and $\Delta_{R_2} - \Delta_{R_1}$ is sufficiently large, then the sign can be positive for small X' ; thus the question remains of whether there exists a Y' such that $X' = BR(Y')$.

The best response is a Sigmoid function (with the convex-concave turning point being based on the difference in candidate characteristics for the opposite primary), either increasing if the product $(A_{D_1} - A_{D_2}) \cdot (G_{11}^R - G_{12}^R)$ is positive, decreasing if strictly negative, or flat if zero. Thus there are four combinations of shapes for the best responses: both increasing Sigmoids, both decreasing Sigmoids, or the two alternating Sigmoids. Simulations indicate that given the parameter condition “ $|(A_{c_1} - A_{c_2})(\Delta_{c_1} - \Delta_{c_2})|$ is not too large which is satisfied if these terms are not multiple orders of magnitude different”, these Sigmoid function can have at most one intersection. Note that this can be empirically validated in the voter preferences estimation before needing to solve the model. □

Lemma 6. *The program in equation (1.3.11) has a pure strategy solution for strictly positive $V_c, V_c^0 \forall c$ and nonnegative $\kappa_c \forall c$. Furthermore, the solution to program in equation (1.3.11) is unique for sufficiently large σ_C .*

Proof of Lemma 6.

Using the same logic as from the Proof of Lemma 4, Brouwer’s fixed point theorem for the multinomial logit case guarantees existence for finite payoff values. The sufficient conditions for uniqueness in the Proof of Lemma 4 have multinomial Logit analogs. The proof of uniqueness stems from the sufficient conditions detailed in Seim (2006). However now there are additional equations, namely three per player (one for each decision). Thus player i has probability p_{i_d} : specifically p_{i_0}, p_{i_1} , and p_{i_2} such that $p_{i_0} + p_{i_1} + p_{i_2} = 1$; for example i_0 refers to the $d_c = 0$ decision for candidate i .

$$p_{i_d} = \frac{\exp(u_{i_d}(d, p_{j_d} \forall j \forall d) / \sigma_C)}{\sum_{f=\{0,1,2\}} \exp(u_{i_f}(f, p_{j_d} \forall j \forall d) / \sigma_C)} = f(p_{-i_d}).$$

The system $\Phi(\mathbf{p}) = \mathbf{p} - f(\mathbf{p}) = 0$ will have one zero if the matrix of partial derivatives of Φ with respect to $\mathbf{p}$ is a positive dominant diagonal matrix, meaning:

$$\left| \frac{\partial \Phi_{i_d}}{\partial p_{i_d}} \right| > 0 \quad \forall i \quad \forall d \quad \& \quad \left| \frac{\partial \Phi_{i_d}}{\partial p_{i_d}} \right| \geq \sum_{(j_d \forall j \forall d) \setminus (i_d)} \left| \frac{\partial \Phi_{i_d}}{\partial p_{j_d}} \right| \quad \forall i_d.$$

The summation in the second inequality, namely $(j_d \forall j \forall d) \setminus (i_d)$, includes all of i 's probabilities other than their choice for d and each other player j 's full set of choice probabilities.

The own-derivative condition is satisfied with value of one. The second is satisfied with own cross-choice probability with a value of zero. The second for cross-player derivatives can be satisfied for a sufficiently large σ_C . To see this, first write out the expression for i_0 :

$$\sum_{j_d \forall j \neq i \forall d} \left| \frac{\partial \Phi_{i_0}}{\partial p_{j_d}} \right| = \sum_{e=\{1,2\}} \left(\frac{\exp((u_{i_e} - u_{i_0}) / \sigma_C)}{(1 + \sum_{f=\{1,2\}} \exp([(u_{i_f} - u_{i_0}) / \sigma_C])^2)} \sum_{j_d \forall j \neq i \forall d} \left| \frac{\partial u_{i_e}}{\partial p_{j_d}} - \frac{\partial u_{i_0}}{\partial p_{j_d}} \right| \frac{1}{\sigma_C} \right).$$

Following the logic from the Proof of Lemma 4, each cross partial of u_{i_d} with respect to p_{j_d} can be bounded; let that maximum be denoted with M_{i_d, j_d} . Then similarly, we can rewrite that first term on the right hand side:

$$\frac{\exp((u_{i_e} - u_{i_0}) / \sigma_C)}{(1 + \sum_{f=\{1,2\}} \exp([(u_{i_f} - u_{i_0}) / \sigma_C])^2)} = p_{i_1} p_{i_0}.$$

This product is strictly bounded between 0 and 1. Thus one can bound the sum of the absolute cross-partials for i_0 and by extension every other choice and player:

$$\sum_{j_d \forall j \neq i \forall d} \left| \frac{\partial \Phi_{i_0}}{\partial p_{j_d}} \right| < \frac{1}{\sigma_C} \sum_{e=\{1,2\}} \left(1 \cdot \sum_{j_d \forall j \neq i \forall d} |M_{i_e, j_d} - M_{i_0, j_d}| \right)$$

Thus sufficient for uniqueness is the left-most expression being weakly bounded by 1 $\forall i_d$, and

sufficient for that is $\sigma_C \geq \max_{i_D \forall i} \{ \sum_{e=\{1,2\}} \sum_{j_d \forall j \neq i \forall d} |M_{i_e, j_d} - M_{i_D, j_d}| \}$.

□

Proposition 1. *There exists a pure strategy Bayesian Nash equilibrium in which all agents condition on payoff relevant actions.*

Proof of Proposition 1.

The proof is by backward induction. All of the Lemmas are based on conditioning on payoff relevant only actions. By Lemma 2, the general election spending stage has a pure strategy Nash equilibrium. By Lemma 4, the general election entry stage has a pure strategy Bayesian Nash equilibrium. By Lemma 5, the primary spending stage has a pure strategy Nash equilibrium. By re-applying Lemma 4 to the primary stage, the primary entry stage has a pure strategy Bayesian Nash equilibrium. Then by Lemma 6, the challenger entry stage has a unique pure strategy Bayesian Nash equilibrium. The incumbent's discrete choice single-agent environment will have a unique pure decision rule given the discrete set of actions.⁸⁵ Thus the entire game has a Bayesian Nash equilibrium in pure strategies.

□

Conjecture 2. *The function $P(w_c^G = 1 | w_c^P)$ is invertible in ψ_c given parameter restrictions.*

Evidence for Conjecture 2.

Start with:

$$E[P_c^G] = \sum_{\mathbf{a}^G \in \{0,1\}^{2N}} P_c^G(\mathbf{a}^G) \prod_j p_j^*(a_j^G).$$

⁸⁵For the extension with the investment PAC, the investment decision is a continuous choice single-agent environment with a bounded revenue function, which guarantees at least one finite solution.

The derivative of this in the two player case is as follows (for exposition):

$$\begin{aligned} \frac{dE[P_c^G]}{d\psi_c} = & \sum_{\mathbf{a} \in \{0,1\}^{2N}} \left[\frac{dP_c^G(a_1, a_2)}{d\psi_c} p_1(a_1) p_2(a_2) \right. \\ & \left. + P_c^G(a_1, a_2) p_2(a_2) \frac{dp_1(a_1)}{d\psi_c} + P_c^G(a_1, a_2) p_1(a_1) \frac{dp_2(a_2)}{d\psi_c} \right]. \end{aligned}$$

The p functions are defined as the fixed point from the following equation:

$$p_i = \frac{\exp(u_i(1, p_{-i})/\sigma)}{\exp(u_i(1, p_{-i})/\sigma) + \exp(u_i(0, p_{-i})/\sigma)}.$$

The u_i are the expected payoffs for a decision $\sum_{a_{-i} \in \{0,1\}^{2N-1}} \pi_i^G(a_1, \dots, a_N) \prod_{j \neq i} p_j(a_{-i})$, where $\pi_{i_c}^G = V_{i_c} \cdot P(w_c^G = 1|\cdot) - e_{i_c}^G$ at the Nash equilibrium values for that respective spending game (conditional on entry). Recall the definition of P , where the spending arguments are the equilibrium values and thus functions of ψ_c , and derive $\frac{dP_c^G}{d\psi_c}$:

$$P_c^G = \frac{\exp\left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c}(S_{j_c}^*(\psi_c))^\phi + h_c + \psi_c\right)}{\sum_{c \in \{D, R\}} \exp\left(\sum_{j_c \in N_c} \tilde{\beta}_{j_c}(S_{j_c}^*(\psi_c))^\phi + h_c + \psi_c\right)}$$

$$\frac{dP_c^G}{d\psi_c} = \left(\sum_{j_c \in N_c \forall c \in \{D, R\}} \frac{\partial P_c^G}{\partial S_{j_c}} \cdot \frac{\partial S_{j_c}}{\partial \psi_c} \right) + \frac{\partial P_c^G}{\partial \psi_c}.$$

Recall that we can write out all of the actions by the other players as a function of one player's actions very easily: $S_{i_c} = S_{j_c} \left(\frac{\omega_{j_c}}{\omega_{i_c}} \right)^{1/\phi}$. Using this we can rewrite the derivative:

$$\frac{dP_c^G}{d\psi_c} = P(1 - P) \phi \omega_1^{\frac{\phi-1}{2\phi}} S_1^{\phi-1} \frac{\partial S_1}{\partial \psi_c} \left(\sum_{j_c \in N_c \forall c \in \{D, R\}} \beta_i(1/\omega_j)^{\frac{\phi-1}{2\phi}} \right) + P(1 - P).$$

We can rewrite this, where $\kappa = \phi \sum_{j_c \in N_c \forall c \in \{D, R\}} \beta_i(\omega_1/\omega_j)^{\frac{\phi-1}{2\phi}}$, note that $\kappa > 0$:

$$P(1 - P) \left(\kappa S_1^{\phi-1} \frac{\partial S_1}{\partial \psi_c} + 1 \right).$$

The comparative static $\frac{\partial S_1}{\partial \psi_c}$ can be written as follows:

$$\frac{\partial S_1}{\partial \psi_c} = \frac{\frac{\partial P_c^G}{\partial \psi_c}}{\phi \omega_1 S_1^{\phi-1} - \frac{\partial P_c^G}{\partial S_1} (1 - 2P)} = \frac{1}{\phi \omega_1 S_1^{\phi-1} \frac{1+P^2-3P}{P(1-P)(1-2P)}}.$$

Thus it is clear that S_1 is non-monotonic, with increasing and decreasing ranges based on the magnitude of P . Thus to sign $\frac{dP_c^G}{d\psi_c}$ we necessarily need to consider ranges or make sufficient restrictions. Thus a sufficient condition to check is that:

$$\kappa S_1^{\phi-1} > -\frac{\partial S_1}{\partial \psi_c}.$$

Note this can be verified for any given draw of parameters during estimation. Thus once we ensure that $\frac{dP_c^G}{d\psi_c}$ is positive, we can consider $\frac{dp_1(a_1)}{d\psi_c}$, which is difficult to sign.

$$\frac{dp_1(a_1)}{d\psi_c} = (1/\sigma) \frac{\exp(u_i(1, p_{-i})/\sigma) \exp(u_i(0, p_{-i})/\sigma) \left(\frac{du_i(1, p_{-i})}{d\psi_c} - \frac{du_i(0, p_{-i})}{d\psi_c} \right)}{(\exp(u_i(1, p_{-i})/\sigma) + \exp(u_i(0, p_{-i})/\sigma))^2}$$

Next, we would need to solve the $N \times N$ system of fixed point equation derivatives to solve for each $\frac{dp_j(a_j)}{d\psi_c}$; it is clear that this sign will be ambiguous; the term $\left(\frac{du_i(1, p_{-i})}{d\psi_c} - \frac{du_i(0, p_{-i})}{d\psi_c} \right)$ is the difference in the marginal increase in the expected payoff from entering versus not entering with respect to a change in expected valence. Since spending is non-monotonic in valence, this difference's sign will depend on S .

□

APPENDIX C

Tables

1.C.3 Campaign Finance Laws

Table 1.C.1: Contribution and Spending Regulations

Can Make IEs	Pre-2010	Post-2010
Individuals	yes	yes
Corporations & Unions	no	yes
Traditional PACs & Parties	yes	yes
Super PACs	n/a	yes
Can Contribute to Any Committee	Pre-2010	Post-2010
Individuals	yes	yes
Corporations & Unions	no	no
Traditional PACs & Parties	yes	yes
Super PACs	n/a	no
Can Contribute to Super PACs	Pre-2010	Post-2010
Individuals	n/a	yes
Corporations & Unions	n/a	yes
Traditional PACs & Parties	n/a	yes
Super PACs	n/a	no
Fundraising Limits for IEs	Pre-2010	Post-2010
Individuals	n/a	n/a
Corporations & Unions	n/a	n/a
Traditional PACs & Parties	yes	yes
Super PACs	n/a	no

This table gives the different rules prior to and after the major 2010 campaign finance law changes for independent expenditures and contributions by the main entities spending in elections. Independent expenditures (IEs) are communications not coordinated with the candidate or party. Those who can contribute can also make Coordinated expenditures, which are communications that can be coordinated with the candidate. “Can Make IEs” refers to whether or not those entities are allowed to spend their own money on an IE. “Can Contribute to Any Committee” refers to whether or not those entities can give money directly to a candidate’s election committee. “Can Contribute to Super PACs” refers to whether or not those entities can give money directly to a Super PAC. “Fundraising Limits for IEs” refers to whether or not those entities who can make IEs have limits on fundraising (for entities that legally engage in fundraising).

Table 1.C.2: Campaign Contribution Limits

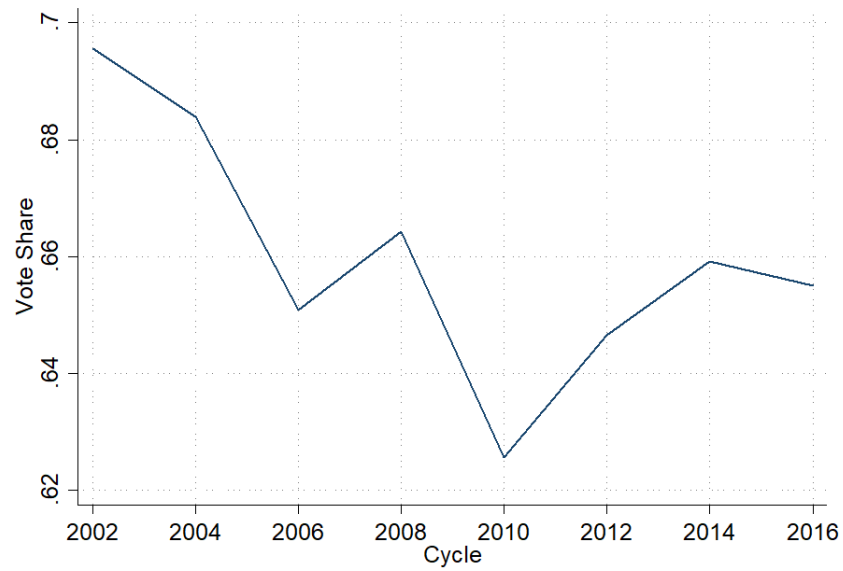
Contribution limits for 2017–2018 federal elections

		Recipient				
		Candidate committee	PAC† (SSF and nonconnected)	Party committee: state/district /local	Party committee: national	Additional national party committee accounts‡
Donor	Individual	\$2,700* per election	\$5,000 per year	\$10,000 per year (combined)	\$33,900* per year	\$101,700* per account, per year
	Candidate committee	\$2,000 per election	\$5,000 per year	Unlimited transfers	Unlimited transfers	
	PAC: multicandidate	\$5,000 per election	\$5,000 per year	\$5,000 per year (combined)	\$15,000 per year	\$45,000 per account, per year
	PAC: nonmulticandidate	\$2,700* per election	\$5,000 per year	\$10,000 per year (combined)	\$33,900* per year	\$101,700* per account, per year
	Party committee: state/district/local	\$5,000 per election	\$5,000 per year	Unlimited transfers	Unlimited transfers	
	Party committee: national	\$5,000 per election**	\$5,000 per year	Unlimited transfers	Unlimited transfers	

Source: Federal Election Commission <https://transition.fec.gov/info/contriblimitschart1718.pdf>. This table describes the various campaign contribution limits by the different combinations of donor and recipient. The footnotes are defined as follows: *: “Indexed for inflation in odd-numbered years”. **: “Additionally, a national party committee and its Senatorial campaign committee may contribute up to \$47,400 combined per campaign to each Senate candidate”. †: “‘PAC’ here refers to a committee that makes contributions to other federal political committees. Independent-expenditure-only political committees (sometimes called ‘super PACs’) may accept unlimited contributions, including from corporations and labor organizations”. ‡: “The limits in this column apply to a national party committee’s accounts for: (i) the presidential nominating convention; (ii) election recounts and contests and other legal proceedings; and (iii) national party headquarters buildings. A party’s national committee, Senate campaign committee and House campaign committee are each considered separate national party committees with separate limits. Only a national party committee, not the parties’ national congressional campaign committees, may have an account for the presidential nominating convention”.

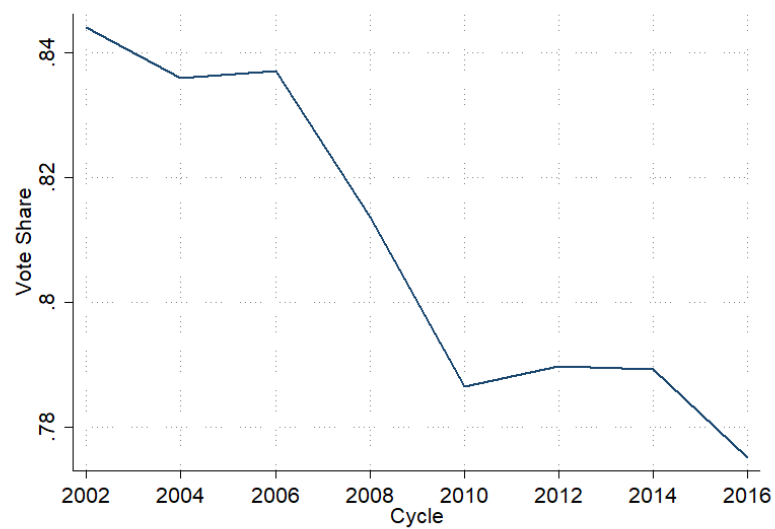
1.C.4 Descriptive Statistics

Figure 1.C.3: Incumbent Vote Share in General Elections



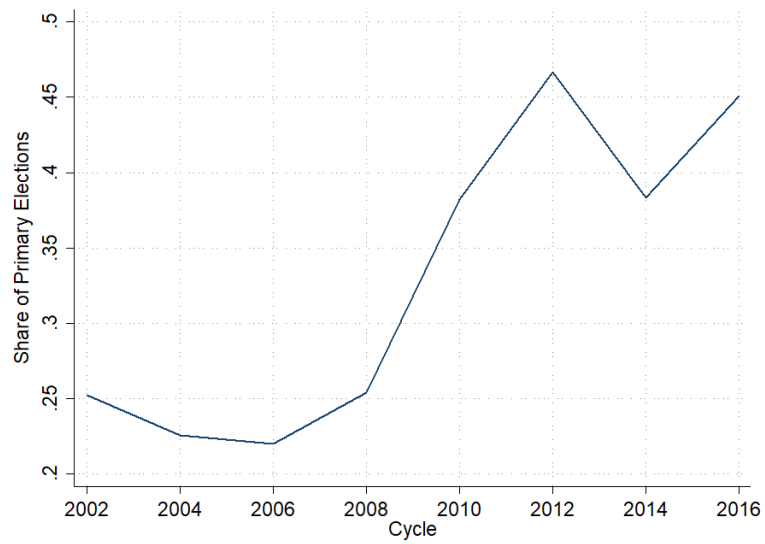
This shows the incumbent vote share in general elections from 2002-2016, where only the Republican and Democratic candidates are included and absenteeism is not.

Figure 1.C.4: Incumbent Vote Share in Primary Elections



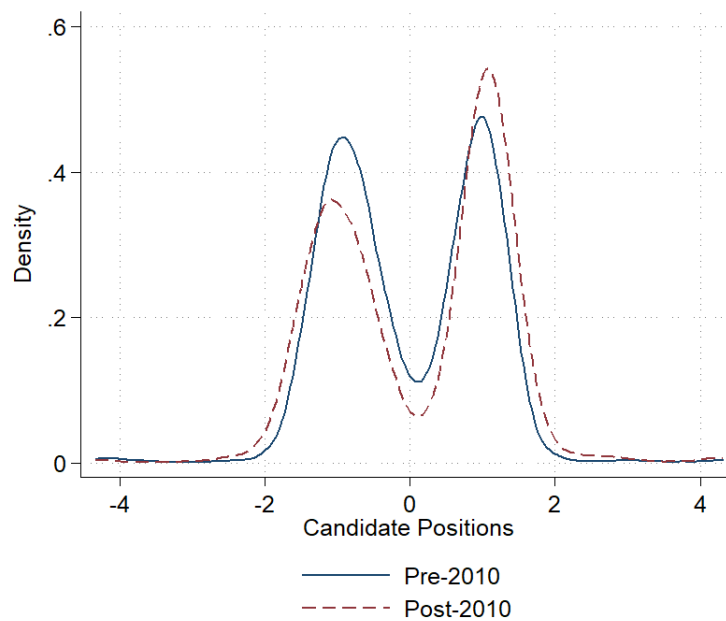
This shows the incumbent vote share in primary elections from 2002-2016, including non-contested elections.

Figure 1.C.5: Primary Entry



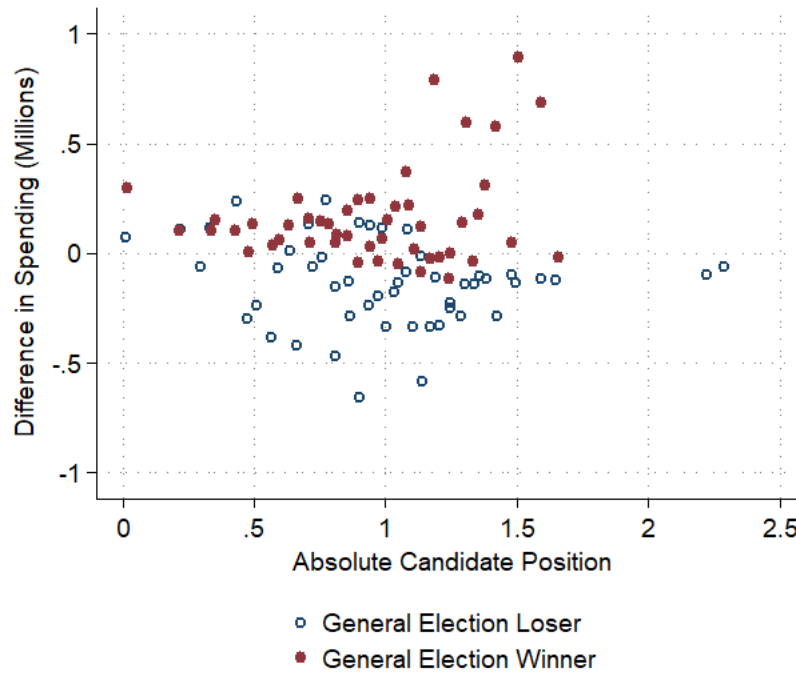
This shows the share of contested elections from 2002-2016: at least one primary opponent in a primary election divided by all of the races in that election cycle.

Figure 1.C.6: Distribution of Candidate Positions



This shows the distribution of candidate positions for elections prior to 2010 and post (including) 2010, based on Bonica's score. -4 is most "left-wing" (liberal) and 4 is most "right-wing" (conservative).

Figure 1.C.7: Candidate Positions, Spending, and Election Outcome



This shows the relationship between absolute position of a candidate and the difference in spending by both sides in the general election, with indicators for whether that candidate won the election.

Table 1.C.3: Total General (Ad) Spending (in Millions)

	Democrat		Republican		
	Challenger	Incumbent	Challenger	Incumbent	Total
	Pre, Post	Pre, Post	Pre, Post	Pre, Post	Pre, Post
Candidate	237.0, 207.8	145.3, 270.1	148.3, 206.5	278.2, 239.0	808.8, 923.4
Party	132.6, 140.5	25.5, 133.8	80.4, 179.8	99.2, 78.0	337.7, 532.1
PAC	23.7, 16.2	5.8, 23.2	5.4, 13.5	13.8, 14.3	48.7, 67.1
Super PAC	0.0, 96.4	0.0, 51.6	0.0, 76.7	0.0, 52.5	0.0, 277.2
Total	393.4, 460.9	176.6, 478.7	234.1, 476.5	391.1, 383.8	

This table shows pre and post (including) 2010 total general election ad spending by candidate election committees and general election independent expenditures by parties, and PACs, separated by whether the committee is aligned with a Democrat or Republican candidate and whether the candidate is an incumbent or challenger.

Table 1.C.4: Total Non-Open Race Primary (Ad) Spending (in Millions)

	Democrat		Republican		Total
	Challenger	Incumbent	Challenger	Incumbent	
	Pre, Post	Pre, Post	Pre, Post	Pre, Post	
Candidate	8.7, 12.0	45.2, 71.7	5.4, 18.9	51.5, 83.9	110.7, 186.5
Party	0.4, 2.1	7.4, 3.3	0.5, 0.8	3.6, 1.0	12.0, 7.2
PAC	1.7, 0.7	1.5, 4.6	1.5, 1.3	0.7, 2.8	5.4, 9.4
Super PAC	0.0, 1.6	0.0, 4.5	0.0, 9.4	0.0, 6.5	0.0, 22.0
Total	10.9, 16.4	54.0, 84.1	7.4, 30.4	55.8, 94.2	

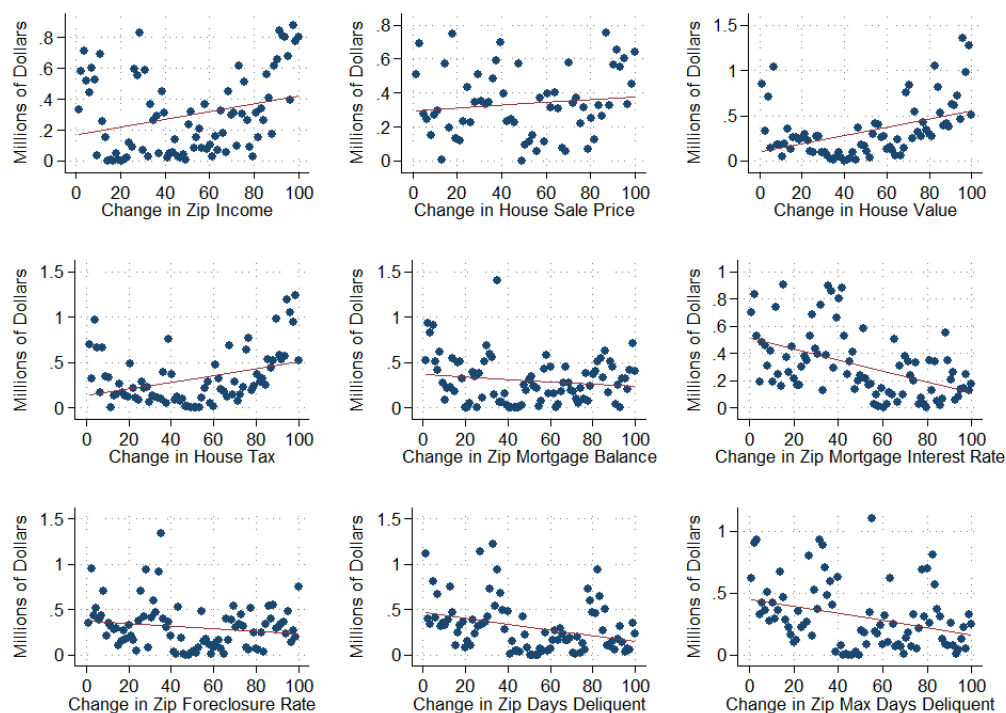
This table show pre and post (including) 2010 total primary election ad spending by candidate election committees and primary election independent expenditures by parties, and PACs, separated by whether the committee is aligned with a Democrat or Republican candidate and whether the candidate is an incumbent or challenger.

Table 1.C.5: Total Open Race Primary (Ad) Spending (in Millions)

	Democrat	Republican	Total
	Pre, Post	Pre, Post	Pre, Post
Candidate	76.4, 66.2	86.5, 108.4	162.9, 174.6
Party	11.6, 1.4	10.1, 1.9	21.7, 3.4
PAC	2.8, 1.5	5.5, 3.1	8.3, 4.6
Super PAC	0.0, 7.2	0.0, 24.4	0.0, 31.6
Total	90.8, 76.3	102.1, 137.9	

This table show pre and post (including) 2010 total primary election ad spending by candidate election committees and primary election independent expenditures by parties, and PACs, separated by whether the committee is aligned with a Democrat or Republican candidate and whether the candidate is an incumbent or challenger. The terminology “Open Race Primary” is used to not confuse races without incumbents to “Open Primaries”, a term commonly used for primaries in which party affiliation is not required.

Figure 1.C.8: Super PAC Spending (Millions) Across Donor Financial Measure Bins



These graphs show the distribution of average Super PAC spending (at the committee level) across 100 bins of various donor financial well-being measures. “Zip” refers to whether the variable is measured at the zip code level; “House” variables are measured at the address level. I condition on nonzero spending and exclude districts not used in the main analysis. I include a linear fit.

Table 1.C.6: Variation Between Zip Code Income and Committee Finances

Unit of Analysis Dependent Var.	Donor-Level Contributions	Committee-Donor Contributions	Com.-year Budget	Com.-election Spending
Lagged Contributions	0.774*** (0.0010)	0.130*** (0.0003)	0.131*** (0.0027)	0.537* (0.0211)
Lagged Income	0.269*** (0.0127)	0.145*** (0.0015)	1.155*** (0.0261)	-0.244*** (0.0050)
Income Shock	1.063*** (0.0699)	1.064*** (0.0089)	0.760*** (0.2030)	
Out-of-State Income Shock				0.872*** (0.0860)
Observations	319,574	4,177,411	43,693	227,945

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. This shows a regression of various committee budget dependent variables on the zip code level income variation of the committee's donors. "Donor-level contributions" refers to how much that zip code level donor [sum of donors in that zip code] gave in that election cycle. "Committee-Donor contributions" refers to how much that committee raise from that zip code level donor. "Com.-year budget" refers to how much that committee raise in that election cycle and hence is referred to as their budget. "Com.-election spending" refers to how much the committee spend in a given district.

Table 1.C.7: General Election Voter Regression: OLS

Candidate Spending	0.0060*	District high-school rate	-0.0046
	(0.0027)		(0.0030)
Super PAC Spending	-0.0045	District median age	0.0563***
	(0.0042)		(0.0047)
Party Spending	0.0110***	District election day precipitation	-0.0219
	(0.0030)		(0.0862)
Candidate Positions	0.0061	R x District high-school rate	0.0054
	(0.0219)		(0.0037)
Within-state candidate donor zip income variation	-0.0189	R x District median age	0.0036
	(0.0359)		(0.0066)
Within-state party donor zip income variation	-0.3120***	R x Lagged Republican Presidential Votes	2.8398***
	(0.0722)		(0.2157)
Within-state Super PAC donor zip income variation	-0.0371	Incumbent x district unemployed number	0.0122**
	(0.0229)		(0.0037)
District unemployed rate	0.0173*	Incumbent x district unemployed rate	0.0042
	(0.0087)		(0.0095)
District income	0.1167***	Incumbent x lagged incumbent votes	0.1853*
	(0.0124)		(0.0816)
District unemployed number	-0.0393***	Incumbent x district income	-0.0340*
	(0.0027)		(0.0164)
Lagged Republican Presidential Votes	-1.5472***	Inc=0 x Party=D x Cook's competitiveness	-0.0069
	(0.1535)		(0.0167)
Incumbent	0.2661	Inc=0 x Party=R x Cook's competitiveness	0.0788***
	(0.1675)		(0.0129)
Party==Republican	-1.5953***	Inc=1 x Party=D x Cook's competitiveness	0.0375
	(0.2505)		(0.0252)
Lagged Incumbent Votes	-0.2621***	Inc=1 x Party=R x Cook's competitiveness	0.0075
	(0.0573)		(0.0271)
Number of Senate Candidates	-0.0078***	Constant	-2.7911***
	(0.0013)		(0.2290)
Contested Primary	-0.0143	Cycle== 2012	0.5569***
	(0.0442)		(0.0331)
Governor same party	-0.0425*	Cycle== 2014	-0.4356***
	(0.0213)	Cycle== 2016	0.3539***
			(0.0477)
Observations	2795		
R ²	0.611		
F	127.3582		

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. This shows a regression of the different in general election log vote share from absenteeism share on election spending, candidate position, and various controls. Both columns are from the same regression.

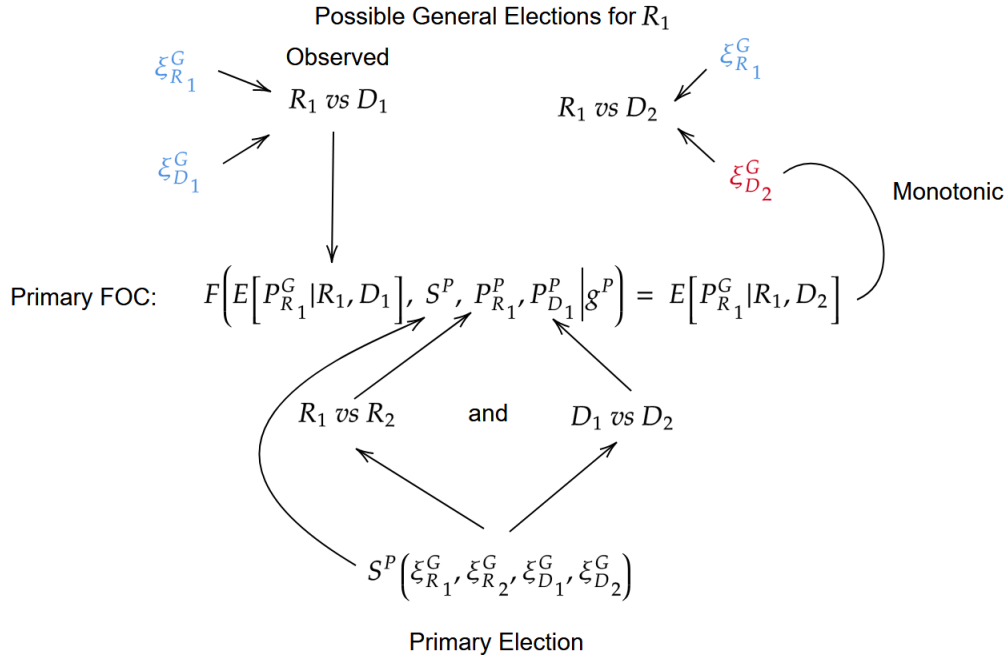
1.C.5 Model Estimation

Table 1.C.8: Voter Parameter Estimates

General election	Estimate	95% CI
Candidate Spending	0.0366	[0.0000, 0.0657]
Super PAC Spending	0.0413	[0.0000, 0.0866]
Party Spending	0.0106	[0.0000, 0.0680]
Candidate Position	-0.3585	[-0.8612, 0.2256]
Observations	2795	
Republican Primary election	Estimate	95% CI
Candidate Spending	0.1711	[0.0680, 0.2580]
Outside Spending	0.0722	[0.0000, 0.2168]
Candidate Position	0.4651	[-0.4932, 1.4378]
Observations	1925	
Democratic Primary election	Estimate	95% CI
Spending	0.1296	[0.0000, 0.2428]
Candidate Position	1.4220	[0.2790, 2.3704]
Observations	1608	

Suppressed: controls [see Table 1.C.18]. The 95% confidence intervals are percentile bootstrap. The zeros are positive at the 5th decimal point.

Figure 1.C.9: Diagram of Primary FOC Estimation



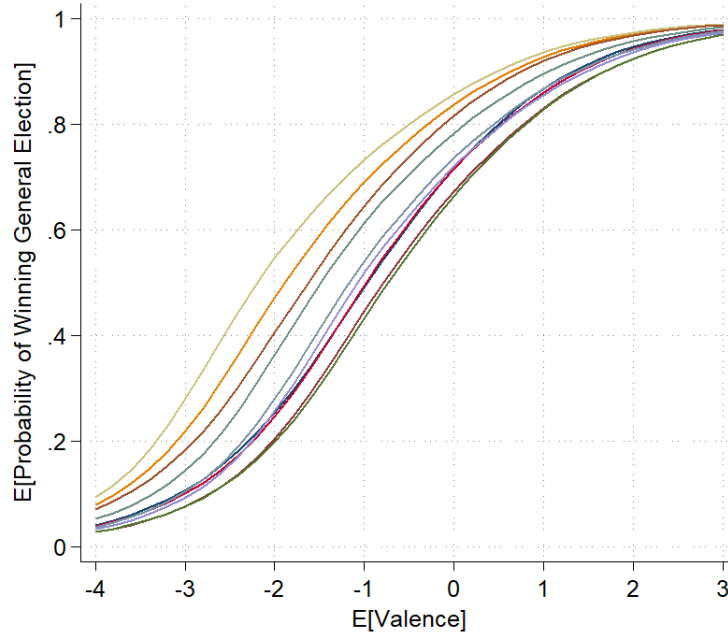
This diagram shows the intuition behind the estimation using the primary FOC: the main inputs and the source of their identification alongside the backed-out valence (blue) and the unobserved valence (red) that forms the basis of the moment. I omit the additional arguments present in the primary spending function for notational ease.

Table 1.C.9: Illustrating Variation in Primary Moments

model dependent	Omitting EPGs primary spending	With observed EPG primary spending	With both primary spending
Cost	-88.05 (51.8611)	-99.63 (51.0124)	-335.9*** (57.5907)
Observed EPG		329.3*** (64.7049)	294.8*** (62.2606)
Counterfactual EPG			349.0*** (44.7931)
Constant	153.1*** (11.9833)	-18.31 (35.6783)	-144.1*** (37.8585)
Observations	701	701	701
R^2	0.004	0.040	0.117
F	2.883	14.44	30.69

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. These regressions show the effect of including various variables on the prediction of primary spending. “Omitting EPGs” refers to not including the expected probability of winning the general election in the estimation of primary spending. “With observed EPG” refers to only including the general election expected probability of winning for the general election matchup that was observed in the data. “With both” refers to including both EPGs for the hypothetical matchup in addition to the observed matchup.

Figure 1.C.10: Invertibility of Expected Probability in Valence



This graphs the expected probability of winning the general election (EPG) estimated parameters across the full range of estimated expected valences, for 10 different observations.

Table 1.C.10: Illustrating Variation in Challenger Moments

model dependent	Omitting EPG entry probability	Including EPG entry probability
Valuation	0.0331* (0.0135)	0.0152 (0.0114)
EPG		2.1885*** (0.0878)
Constant	0.4844*** (0.0213)	0.2280*** (0.0206)
Observations	1463	1463
R^2	0.004	0.301
F	6.0024	314.8426

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. These regressions show the effect of including the expected probability of winning the general election (EPG) from the pre-primary perspective on predicting the probability of candidate entry.

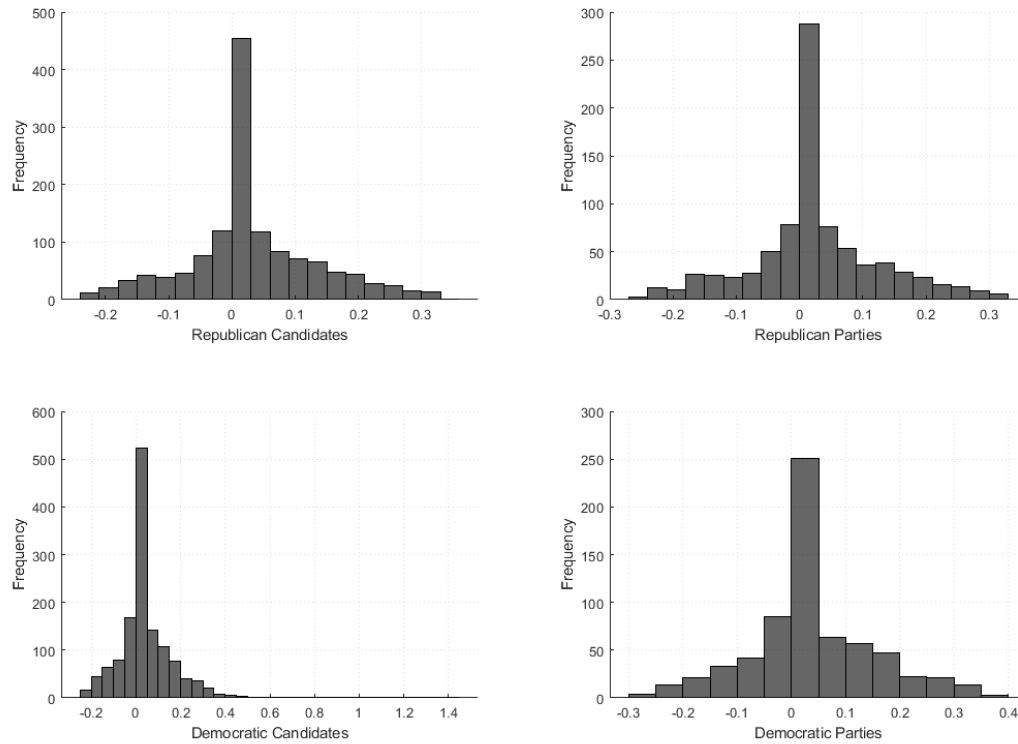
Table 1.C.11: Committee and Candidate Valuation and Cost Estimates

V R1 candidate	220.2300	[80.4330, 933.2640]	C Pri D1 candidate	0.0748	[0.0353, 2.0474]
V R1 Super PAC	18.3285	[12.9057, 29.8113]	C Pri D1 Super PAC	0.6023	[0.1901, 14.8849]
V R1 Party	45.1860	[27.5836, 105.6579]	C Pri D1 Party	1.1359	[0.2771, 31.5116]
V R2 candidate	144.3795	[20.1524, 610.7674]	C Pri D2 candidate	0.5888	[0.0562, 20.4472]
V R2 Super PAC	19.5713	[13.2993, 31.9504]	C Pri D2 Super PAC	4.7431	[0.2374, 149.4814]
V R2 Party	62.4883	[37.1229, 145.6592]	C Pri D2 Party	8.9456	[0.5083, 324.3463]
V D1 candidate	172.1490	[19.9848, 546.7790]	C Gen R1 candidate	0.2042	[0.2100, 0.5719]
V D1 Super PAC	25.0625	[18.7937, 47.2116]	C Gen R1 Super PAC	0.0247	[0.0151, 0.0369]
V D1 Party	67.2524	[47.5172, 150.0607]	C Gen R1 Party	0.0076	[0.0036, 0.0149]
V D2 candidate	85.6845	[59.5525, 255.1216]	C Gen R2 candidate	0.2344	[0.2432, 0.6545]
V D2 Super PAC	27.2200	[20.7123, 49.7528]	C Gen R2 Super PAC	0.0200	[0.0121, 0.0299]
V D2 Party	68.2171	[48.3337, 152.5594]	C Gen R2 Party	0.0067	[0.0032, 0.0131]
C Pri R1 candidate	0.1188	[0.0020, 0.6577]	C Gen D1 candidate	0.2035	[0.1560, 0.4235]
C Pri R1 Super PAC	0.0314	[0.0188, 0.0657]	C Gen D1 Super PAC	0.0220	[0.0137, 0.0358]
C Pri R1 Party	0.5780	[0.3002, 2.1688]	C Gen D1 Party	0.0169	[0.0110, 0.0284]
C Pri R2 candidate	0.0745	[0.0013, 0.4326]	C Gen D2 candidate	0.3036	[0.2455, 0.6238]
C Pri R2 Super PAC	0.0197	[0.0123, 0.0413]	C Gen D2 Super PAC	0.0257	[0.0154, 0.0415]
C Pri R2 Party	0.3626	[0.1968, 1.3889]	C Gen D2 Party	0.0203	[0.0133, 0.0327]
V_e RC	6.5344	[3.9304, 12.7183]	V_{ne} RC	1.7874	[1.1128, 2.4797]
V_e DC	4.0705	[2.6441, 6.0389]	V_{ne} DC	1.8802	[1.1242, 2.6304]
V_e RI	3.5124	[0.3214, 7.9149]	V_{ne} RI	0.3322	[0.3178, 0.3481]
V_e DI	3.3463	[0.2647, 6.6271]	V_{ne} DI	0.2679	[0.2550, 0.2813]

The 95% confidence intervals are percentile bootstrap. This table shows the full list of valuations and costs for committees and candidates. V refers to valuations, C refers to costs. The ne subscript is for not-entering, meaning outside option and e refers to entry. The number 1, 2 indexing party R, D refer to the candidate among the top two. The incumbent is always number 1 and for open races, 1 is for the more politically-senior candidate.

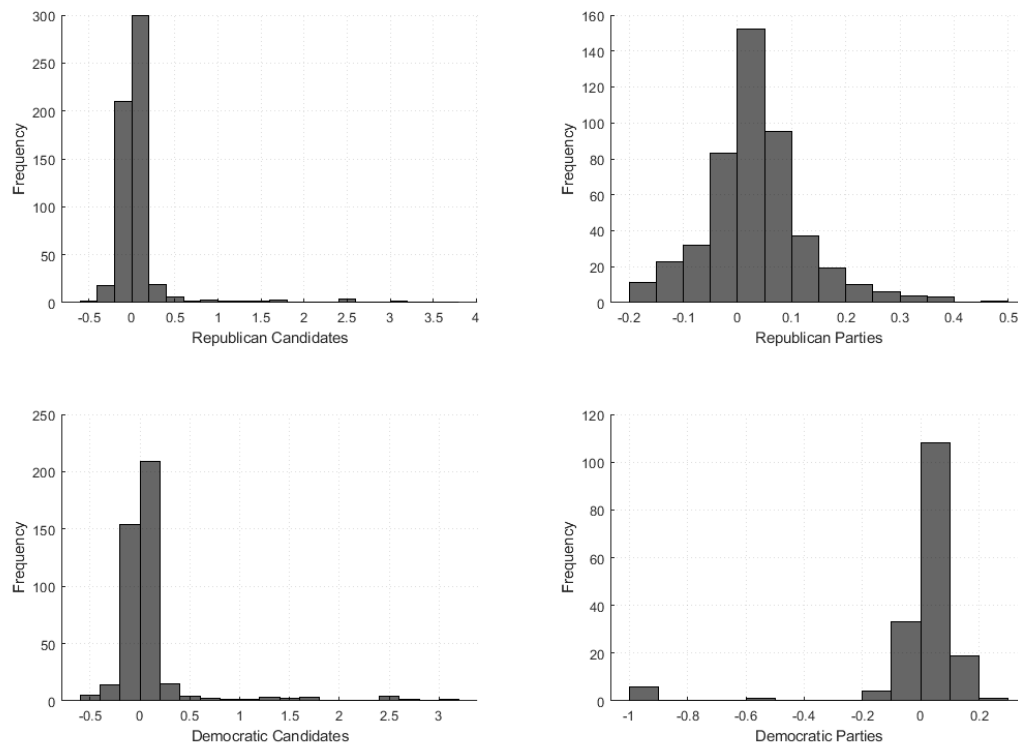
1.C.6 Counterfactual Estimation

Figure 1.C.11: Percent Change in General Election Spending Without Super PACs



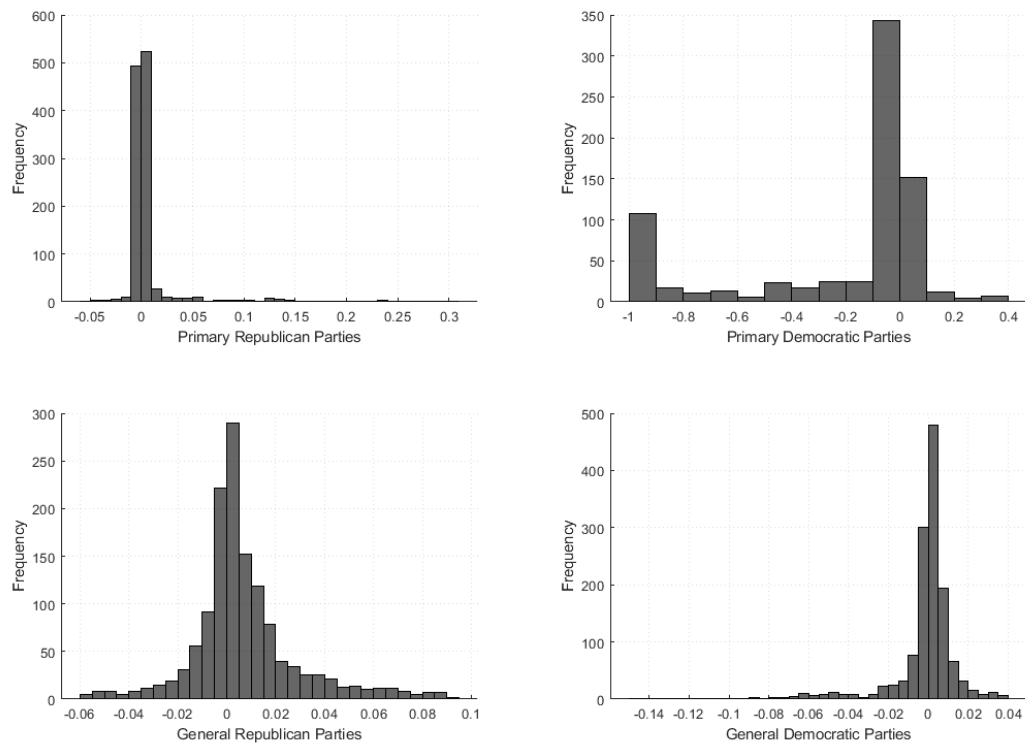
This plots the histogram of percent changes in general election spending with and without Super PACs. I compare the simulated equilibrium spending and counterfactual spending if Super PACs cannot enter for candidates and political party committees for both Republicans and Democrats.

Figure 1.C.12: Percent Change in Primary Election Spending Without Super PACs



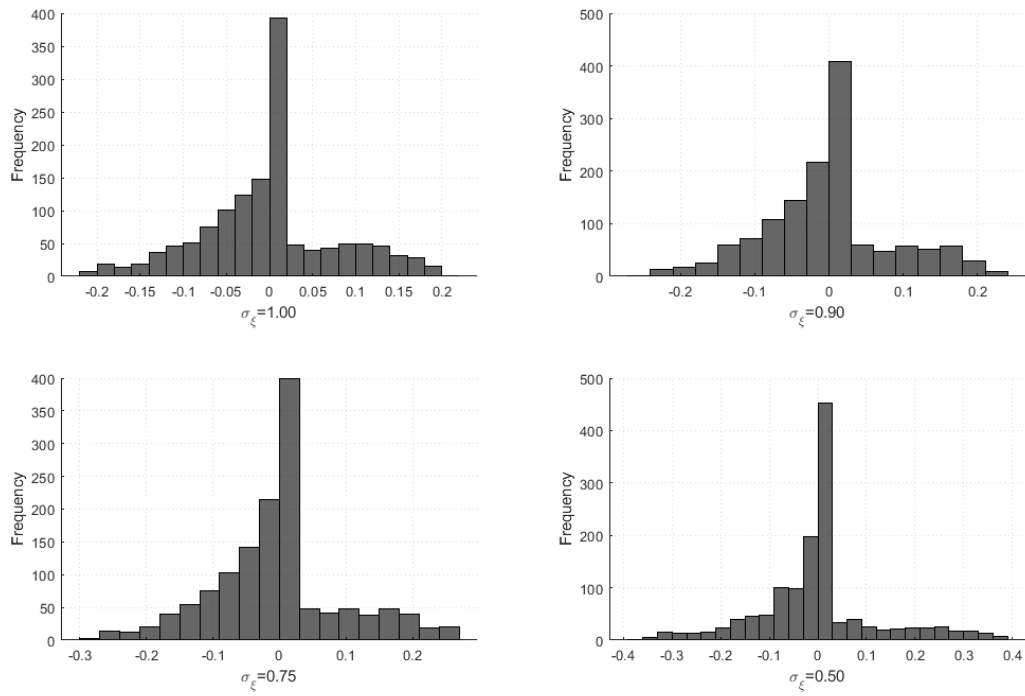
This plots the histogram of percent changes in primary election spending with and without Super PACs. I compare the simulated equilibrium spending and counterfactual spending if Super PACs cannot enter for candidates and political party committees for both Republicans and Democrats.

Figure 1.C.13: Percent Change in Committee Entry Without Super PACs



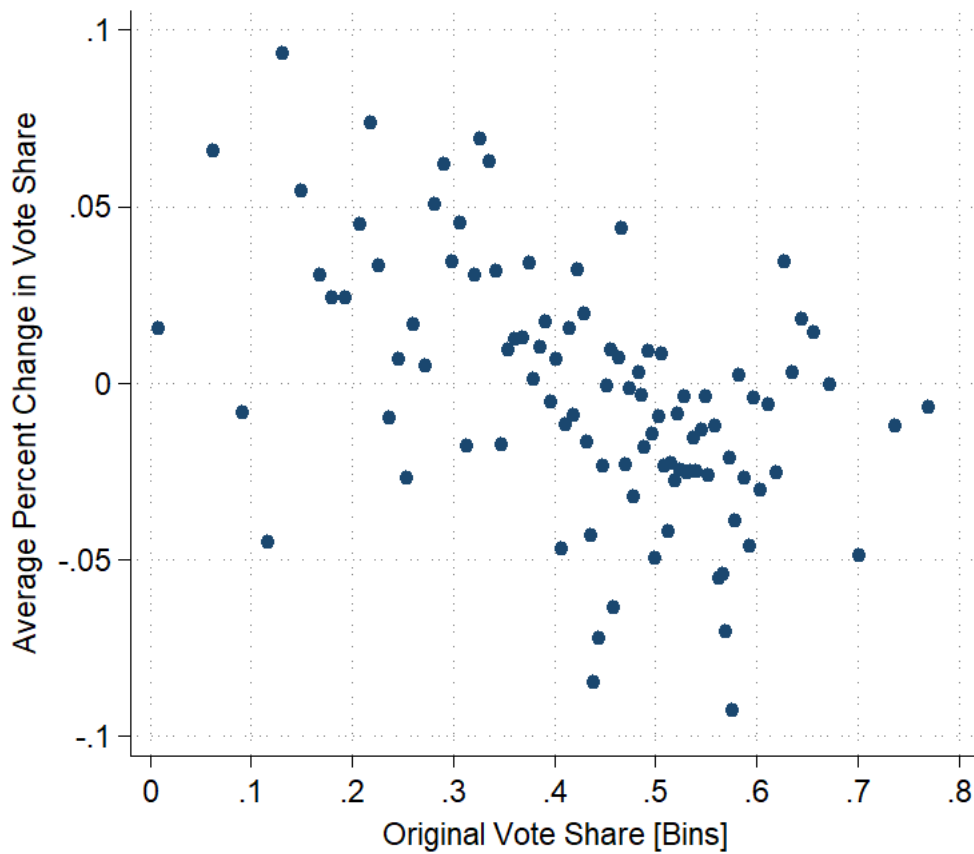
This plots the histogram of percent changes in primary and general election committee entry with and without Super PACs. I compare the simulated equilibrium and counterfactual committee entry probabilities if Super PACs cannot enter for candidates and political party committees for both Republicans and Democrats.

Figure 1.C.14: Percent Change in Republican General Election Vote Share Without Super PACs Across Degrees of Committee Uncertainty



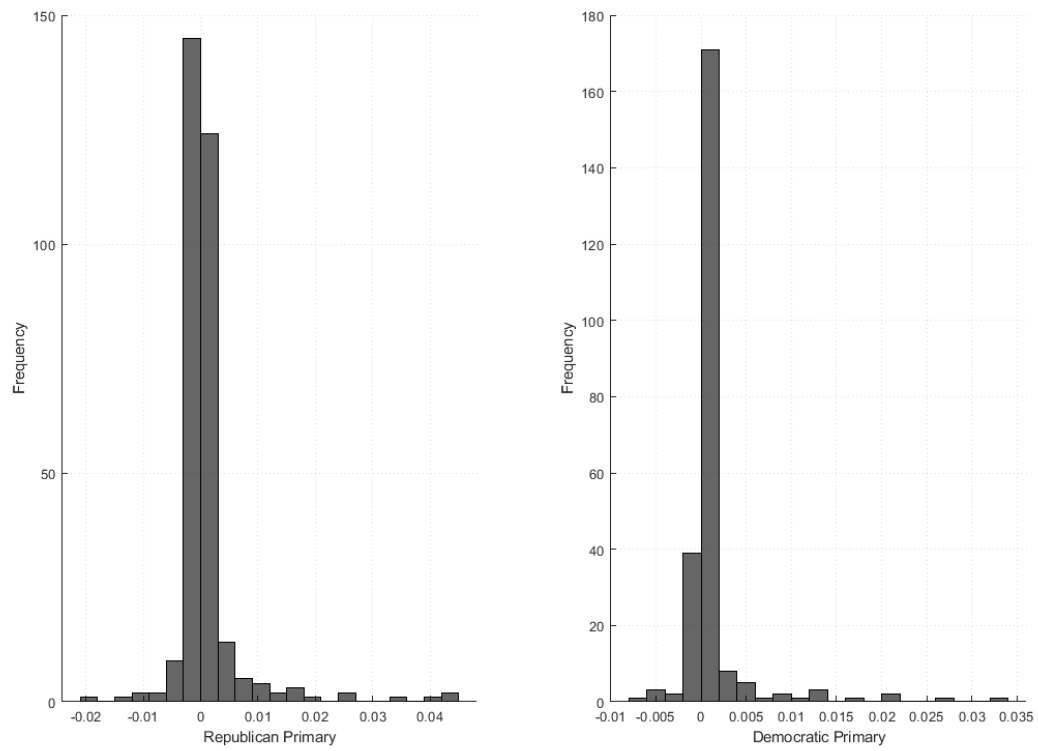
This plots the histogram of percent changes in Republican general election vote share (excluding abstention) with and without Super PACs for four different degrees of normalized uncertainty: I consider “high” uncertainty $\sigma_\xi = 1$ (used in the main text) with 10%, 25%, and 50% reductions.

Figure 1.C.15: Percent Change in Republican General Vote Share Without Super PACs by Original Vote Share



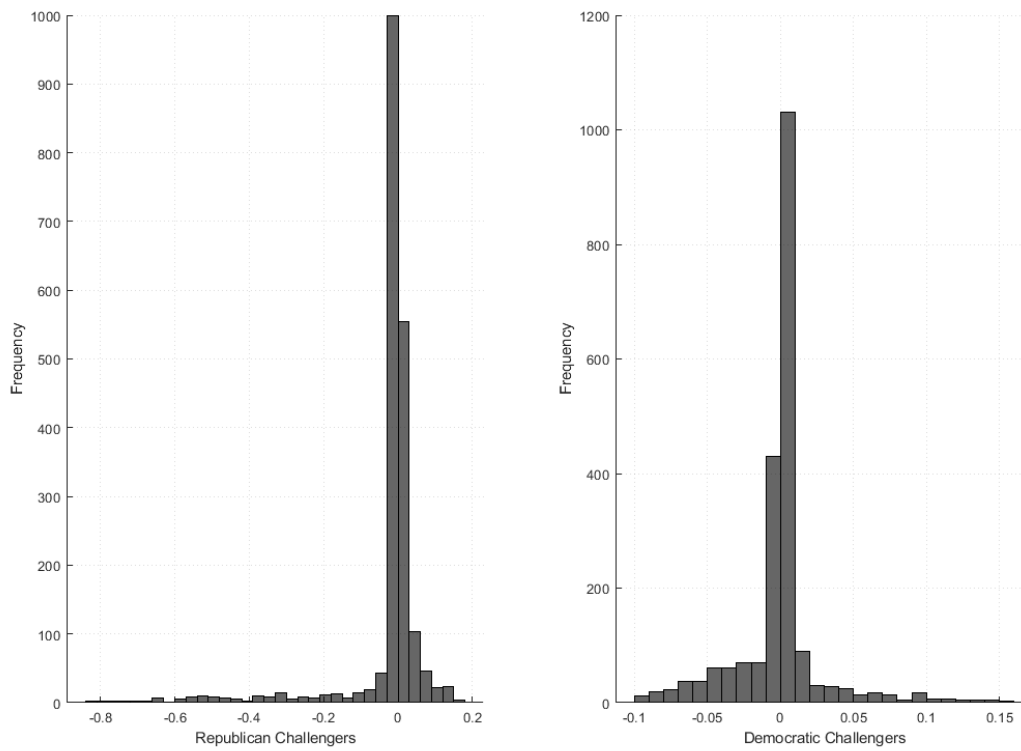
This graph shows the percent change in Republican vote share (excluding abstention) with and without Super PACs across binned original vote share.

Figure 1.C.16: Percent Change in Incumbent Primary Vote Share Without Super PACs



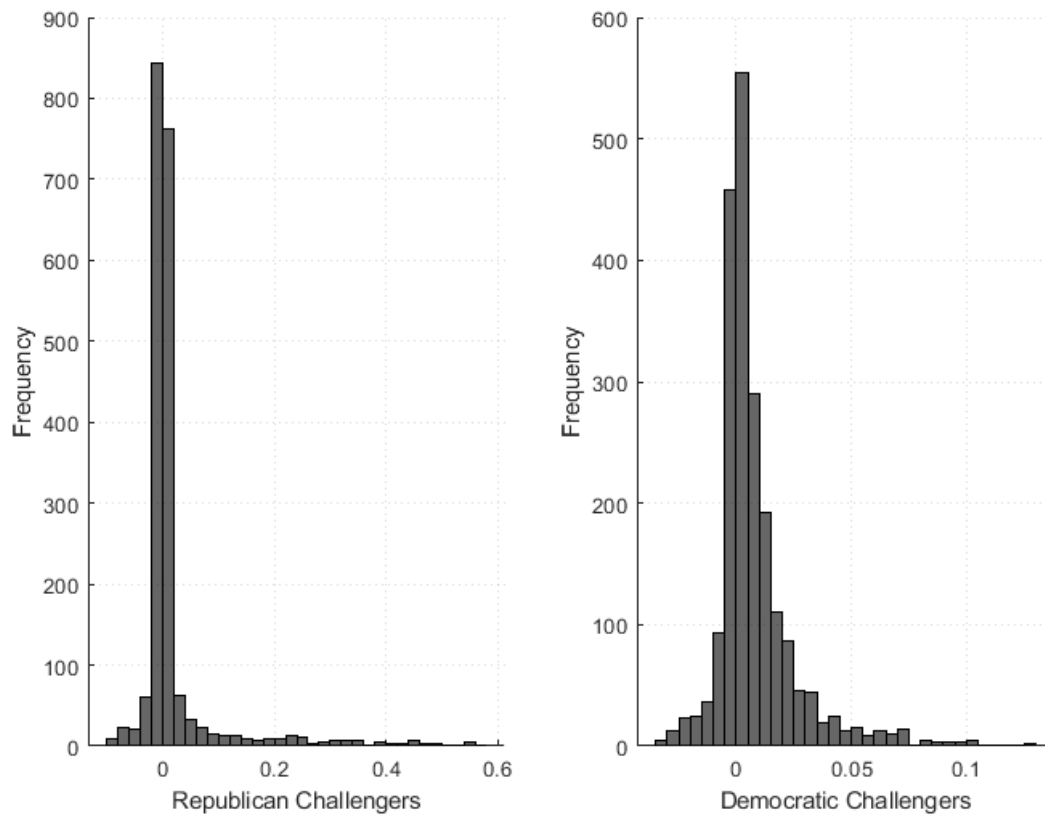
This plots the histogram of percent changes in incumbent primary election vote share (excluding abstention) with and without Super PACs. I compare the simulated equilibrium and counterfactual shares if Super PACs cannot enter.

Figure 1.C.17: Percent Change in Challenger Entry Without Super PACs



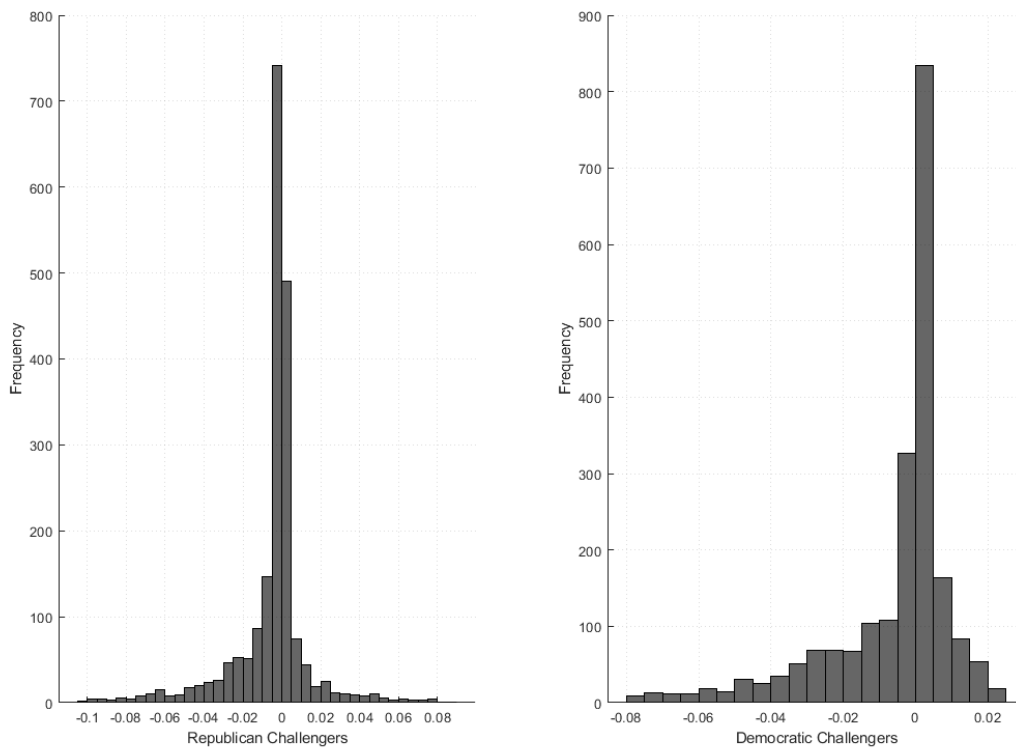
This plots the histogram of percent changes in challenger entry with and without Super PACs. I compare the simulated equilibrium and counterfactual challenger entry probabilities if Super PACs cannot enter, for both Republican and Democratic candidates.

Figure 1.C.18: Percent Change in Challenger Extreme Position Without Super PACs



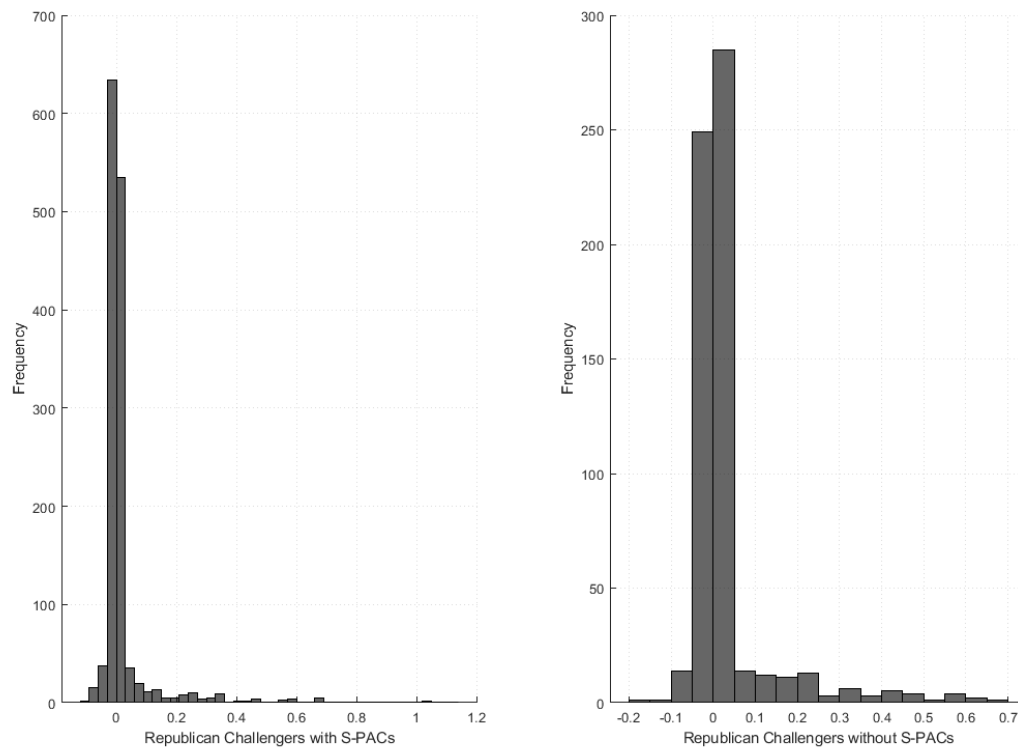
This plots the histogram of percent changes in challenger extreme position with and without Super PACs. I compare the simulated equilibrium and counterfactual challenger extreme position probabilities if Super PACs cannot enter, for both Republican and Democratic candidates.

Figure 1.C.19: Percent Change in Challenger Moderate Position Without Super PACs



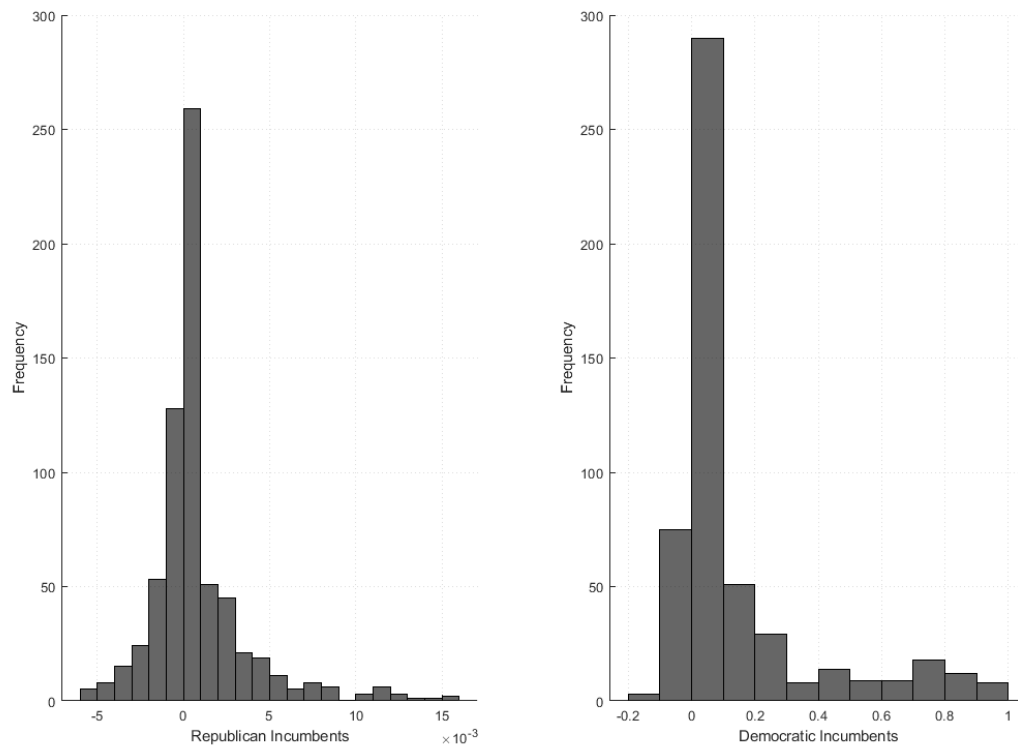
This plots the histogram of percent changes in challenger moderate position with and without Super PACs. I compare the simulated equilibrium and counterfactual challenger moderate position probabilities if Super PACs cannot enter, for both Republican and Democratic candidates.

Figure 1.C.20: Percent Change in Challenger Extreme Position Without Super PACs: Direct & Indirect Effects



This plots the histogram of percent changes in Republican challenger extreme position with and without Super PACs, but separating elections in which the Super PACs actually entered compared to those where they did not.

Figure 1.C.21: Percent Change in Incumbent Extreme Position Without Super PACs



This plots the histogram of percent changes in incumbents extreme position with and without Super PACs. I compare the simulated equilibrium and counterfactual incumbent extreme position probabilities if Super PACs cannot enter, for both Republican and Democratic candidates.

1.C.7 Additional Tables

Table 1.C.12: General Election Voter Controls Estimates

Constant	-2.350	[-3.402, -1.3827]
Within-state candidate donor zip income variation	0.106	[-0.0864, 0.3020]
Within-state party donor zip income variation	-0.7093	[-1.019, -0.3148]
Within-state Super PAC donor zip income variation	-0.0375	[-0.0648, 0.0015]
District unemployed rate	0.022	[0.0040, 0.0574]
District income	0.1230	[0.0970, 0.1376]
District unemployed number	-0.0380	[-0.0454, -0.0316]
Lagged Republican Presidential Votes	-1.666	[-2.072, -1.2128]
Incumbent	0.0012	[-0.5143, 0.4152]
Party==Republican	-1.187	[-1.975, -0.4543]
Lagged Incumbent Votes	-0.1209	[-0.2111, 0.0177]
Number of Senate Candidates	-0.0068	[-0.0097, -0.0031]
Contested Primary	0.0599	[-0.0159, 0.1387]
Governor same party	-0.0005	[-0.0953, 0.0412]
Cycle== 2012	0.5415	[0.4323, 0.6379]
Cycle== 2014	-0.4166	[-0.6066, -0.2587]
Cycle== 2016	0.3027	[0.0444, 0.5566]
District high-school rate	-0.0143	[-0.0345, -0.0077]
District median age	0.0602	[0.0398, 0.0924]
District election day precipitation	0.0162	[-0.3255, 0.1463]
R x District high-school rate	0.0103	[0.004, 0.0217]
R x District median age	-0.0169	[-0.0478, 0.0091]
R x Lagged Republican Presidential Votes	3.382	[2.287, 4.8361]
Incumbent x district unemployed number	0.0111	[0.0047, 0.0192]
Incumbent x district unemployed rate	-0.0095	[-0.0395, 0.0198]
Incumbent x lagged incumbent votes	0.058	[-0.1750, 0.2040]
Incumbent x district income	-0.0394	[-0.069, -0.0124]
Inc=0 x Party=D x Cook's competitiveness	0.0456	[-0.0170, 0.1157]
Inc=0 x Party=R x Cook's competitiveness	0.0407	[0.0140, 0.0687]
Inc=1 x Party=D x Cook's competitiveness	-0.0814	[-0.135, -0.001]
Inc=1 x Party=R x Cook's competitiveness	0.1546	[0.0827, 0.2196]

This table shows the parameter estimates for the controls used in the estimation of general election voter preferences.

Table 1.C.13: Primary Election Voter Controls Estimates

	Democratic		Republican	
Constant	-7.0019	[-7.0870,-6.9168]	-6.8080	[-7.5293,-6.0771]
Within-state cand. income IV	0.0939	[0.0605, 0.1274]	0.0889	[0.0036, 0.1718]
Within-state S-PAC income IV	0.0665	[0.0326, 0.1005]	-0.0009	[-0.1563, 0.1195]
District unemployed rate	0.1263	[0.1157, 0.1369]	0.1162	[0.0797, 0.1503]
District unemployed number	-0.0169	[-0.0221,-0.0116]	-0.0199	[-0.0325,-0.0111]
Incumbent	1.2209	[1.0571, 1.3848]	1.1776	[0.9766, 1.4204]
Lagged Incumbent Votes	0.2084	[0.1175, 0.2994]	0.2504	[0.0081, 0.4386]
Cycle== 2012	-0.1604	[-0.2122,-0.1086]	-0.0510	[-0.1386, 0.0494]
Cycle== 2014	-0.0471	[-0.1203, 0.0259]	0.0145	[-0.0942, 0.1088]
Cycle== 2016	0.5609	[0.5575, 0.5643]	0.5117	[0.3775, 0.6513]
District high-school rate	0.0268	[0.0237, 0.0298]	0.0222	[0.0105, 0.0336]
District median age	-0.0078	[-0.0164, 0.0008]	-0.0041	[-0.0247, 0.0153]
District election day rain	0.0000	[0.0000, 0.0001]	0.0003	[0.0000, 0.0006]
Inc. x district unemployed	0.0175	[0.0155, 0.0194]	0.0133	[0.0050, 0.0266]
Inc. x district unemployed rate	-0.0717	[-0.0741,-0.0693]	-0.0443	[-0.0975,-0.0043]
Inc. x lagged incumbent votes	0.6010	[0.5729, 0.6290]	0.4596	[0.1920, 0.6933]

This table shows the parameter estimates for the controls used in the estimation of general election voter preferences.

Table 1.C.14: Parameterization Controls Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.
Number of Senate Candidates in State/10	0.813	0.758	0	2.7
Voting Age Population/1e6	0.511	0.094	0.23	0.804
Incumbent's Tenure/10	0.54	0.453	0	3
(District income/1e4) ^{0.5}	2.524	0.45	1.666	4.86
Time Trend	1.444	1.13	0	3
Dem Incumbency Dummy	0.42	0.494	0	1
Rep Incumbency Dummy	0.48	0.5	0	1
N	1463 wide (12104 long)			

This table shows the summary statistics for the variables used in the estimation of copmmitee and candidate preferences (beyond the fixed effects discussed in the main text).

Table 1.C.15: Full Committee/Candidate Parameter Estimates

V_0 R candidate	5.2819	[5.0759, 6.6969]	C_0^G R Super PAC	-3.7524	[-4.3176, -3.3415]
V_0 R Super PAC	3.7490	[3.3518, 4.3125]	C_0^G R Party	-4.0698	[-4.9522, -3.5167]
V_0 R Party	4.0698	[3.5248, 4.9590]	C_0^G D Super PAC	-3.0153	[-3.5407, -2.7603]
V_0 D candidate	4.6970	[4.3125, 5.7847]	C_0^G D Party	-3.6502	[-4.2922, -3.3338]
V_0 D Super PAC	3.0147	[2.7570, 3.5383]	C_0^P R candidate	-2.8665	[-5.7329, -0.6226]
V_0 D Party	3.6488	[3.3382, 4.2908]	C_0^P R Super PAC	-4.1952	[-6.1189, -2.3514]
V_1 R candidate	0.7586	[0.5951, 0.9386]	C_0^P R Party	-1.2841	[-2.5681, -0.0000]
V_1 R Super PAC	-0.1619	[-0.3099, -0.0126]	C_0^P D candidate	3.1422	[0.0000, 6.2843]
V_1 R Party	-0.8521	[-1.2463, -0.4829]	C_0^P D Super PAC	5.2286	[0.4306, 9.4942]
V_2 R candidate	-0.2392	[-0.3080, -0.1536]	C_0^P D Party	5.8630	[2.0884, 9.3437]
V_2 R Super PAC	-0.7816	[-0.9721, -0.6403]	C_1^P R	-1.6519	[-3.3037, -0.0000]
V_2 R Party	0.0443	[0.0063, 0.0848]	C_2^P R	-2.8760	[-5.7520, -0.0018]
V_1 D candidate	1.2022	[1.0365, 1.4750]	C_1^P D	-1.0128	[-2.0256, 0.0000]
V_1 D Super PAC	-0.2165	[-0.4143, -0.0275]	C_2^P D	-5.9353	[-11.8706, 0.0000]
V_1 D Party	-0.0362	[-0.0619, -0.0116]	$C^P\theta$ R	1.7603	[0.3945, 3.1978]
V_2 D candidate	-0.1856	[-0.2577, -0.1063]	$C^P\theta$ D	-3.2158	[-6.4309, -0.0238]
V_2 D Super PAC	0.1851	[0.0411, 0.3482]	V_1^e chal	0.4698	[-0.4060, 0.7779]
V_2 D Party	0.3452	[0.2097, 0.5262]	V_2^e chal	-0.7502	[-1.3589, 0.5281]
C_θ^G R candidate	-0.2268	[-0.3351, -0.1040]	V_2^{ne} chal	0.3236	[0.0739, 0.5300]
C_θ^G R Super PAC	0.4087	[0.1338, 0.7186]	V_0^e R1 chal	4.1033	[0.8046, 6.0300]
C_θ^G R Party	0.2289	[0.0320, 0.4378]	V_0^e R2 chal	1.9561	[-0.4903, 4.2509]
C_θ^G D candidate	-0.4734	[-0.6824, -0.3334]	V_0^e D1 chal	3.7875	[0.5641, 5.1323]
C_θ^G D Super PAC	-0.1841	[-0.3472, -0.0168]	V_0^e D2 chal	-1.2345	[-3.7034, 1.2344]
C_θ^G D Party	-0.2213	[-0.4157, -0.0211]	V_0^e inc	0.2469	[0.1949, 0.3537]
C_1^G R candidate	0.1868	[0.0817, 0.2729]	V_1^e inc	4.1965	[4.1059, 4.8320]
C_1^G R Super PAC	-0.1308	[-0.2544, -0.0111]	V_2^e inc	0.6041	[0.3846, 0.9321]
C_1^G R Party	0.0600	[0.0051, 0.1160]	V_1^{ne} inc	0.1937	[0.1858, 0.2108]
C_2^G R candidate	-2.8885	[-2.7585, -0.8143]	V_2^{ne} inc	-0.5560	[-0.5618, -0.5250]
C_2^G R Super PAC	-0.8763	[-1.2746, -0.5530]	$Ideal_1$ R	1.1544	[0.7649, 1.4991]
C_2^G R Party	-2.3706	[-4.5185, -0.1484]	$Ideal_2$ R	3.1878	[3.1870, 3.1895]
C_1^G D candidate	0.1219	[0.0335, 0.1957]	$Ideal_3$ R	1.6177	[1.1458, 2.0127]
C_1^G D Super PAC	0.0698	[0.0051, 0.1346]	$Ideal_4$ R	1.7438	[1.3094, 2.0409]
C_1^G D Party	0.3102	[0.0838, 0.5394]	$Ideal_1$ D	1.1528	[0.5684, 1.2981]
C_2^G D candidate	-2.2116	[-2.5925, -0.7325]	$Ideal_2$ D	1.0645	[0.8148, 1.1030]
C_2^G D Super PAC	-1.2290	[-1.9164, -0.1638]	$Ideal_3$ D	1.3344	[0.8456, 1.4839]
C_2^G D Party	-0.8341	[-0.6677, -0.1048]	$Ideal_4$ D	1.3472	[0.8908, 1.4860]

The 95% confidence intervals are percentile bootstrap. Each parameter is the coefficient for a variable for that candidate-party grouping. V_0, C_0, V_0^e , etc. terms are constants (fixed effects). V_1 is incumbency status. V_2 is a time trend. C_θ is candidate position. C_1 is Number of Senate Candidates in State/10. C_2 is Voting Age Population / 1e6. V_1^e is Incumbent's Tenure / 10. V_2^e is (District income / 1e4)^{0.5}. V_1^{ne} is party. V_2^{ne} is a time trend. $Ideal_1 - Ideal_4$ are cycle dummies.

Table 1.C.16: General Election Voter Estimation: Alternative Specifications

Candidate Spending Coefficient	0.0393	0.0365	0.0449	0.0396	0.0357
Super PAC spending Coefficient	0.0467	0.0412	0.0270	0.0294	0.0462
Party Spending Coefficient	0.0188	0.0105	0.0124	0.0129	0.0037
Candidate Positions Coefficient	-0.3485	-0.3584	-0.3460	-0.4147	-0.0195
Candidate Spending F-stat	40	36	44	59	36
Super PAC spending F-stat	14	13	16	22	13
Party Spending F-stat	23	21	26	36	21
Candidate Positions F-stat	21	18	23	23	
model R^2	0.4471	0.4897	0.4892	0.4774	0.5297
change in zip income	X	X			X
change in house sale price	X	X			X
change in house tax		X			X
change in zip mortgage balance		X			X
linear-combination			X		
linear combo and restricted controls				X	
no instrument for position					X

This table shows various general election spending coefficients for different instrumental variables specification. Linear combination is: combination of IVs predicted by committee budgets. Restricted controls excludes controls with t-statistics less than 0.5.

Table 1.C.17: General Election Voter Estimation: Heterogeneous Super PAC Effects

Super PAC spending x Incumbent	0.0245			
Super PAC spending x Challenger	0.0895			
Super PAC spending x 2010-2012		0.0031		
Super PAC spending x 2014-2016		0.0608		
Super PAC spending x Dem-State			0.0195	
Super PAC spending x Rep-State			0.0473	
Super PAC spending x Rep. x R-St.				0.0106
Super PAC spending x Rep. x D-St.				0.0247
Super PAC spending x Dem. x R-St.				0.0883
Super PAC spending x Dem. x D-St.				0.0105
Candidate Spending Coefficient	0.0351	0.0207	0.0332	0.0377
Party Spending Coefficient	0.0006	0.0242	.0206215	0.0031
Candidate Positions Coefficient	-0.3927	-0.6336	-0.4100	-0.2966

This table shows various spending coefficients for heterogeneous general election voter preference regression specifications. The dependent variable is log vote share minus log abstention. Controls and instruments are suppressed, but the specifications are similar to the general election GMM specification from main text. I define Republican (rep) state as states above the median in average win probability for Republicans across all years (Democrat (Dem) is below median).

Table 1.C.18: General Election Regression All Variables Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Log Difference in Vote Share	-0.765	0.814	-5.365	1.099	2822
Within-state candidate general donor zip income variation	0.303	0.383	-1.781	2.721	2822
Within-state party general donor zip income variation	0.177	0.206	-0.375	1.322	2822
Within-state Super PAC general donor zip income variation	0.276	0.55	-3.268	5.442	2822
District unemployed rate	7.07	2.333	2.6	16.869	2814
District income	7.99	1.415	5.267	15.369	2822
District unemployed number	9.539	6.857	1.382	29.548	2822
Lagged Republican Presidential Votes	0.477	0.147	0.03	0.813	2822
Incumbency Status	0.471	0.499	0	1	2822
Party==Republican	0.505	0.5	0	1	2822
Lagged Incumbent Votes	0.577	0.249	0	1	2822
Number of Senate Candidates	8.138	7.565	0	27	2822
Contested Primary	0.901	0.298	0	1	2822
Governor same party	0.504	0.5	0	1	2822
Cycle== 2012	0.243	0.429	0	1	2822
Cycle== 2014	0.232	0.422	0	1	2822
Cycle== 2016	0.239	0.427	0	1	2822
District high-school-only rate	29.097	6.172	11.2	46.757	2822
District median age	40.232	3.479	29.306	51.269	2803
District election day precipitation	0.053	0.115	0	1.052	2822
Lagged Senate candidate positions	0.512	0.236	0	2.198	2822
Outside-state candidate general donor zip income variation	0.503	0.576	-1.313	5.704	2822
Outside-state Super PAC general donor zip income variation	0.29	0.466	-1.362	3.892	2822
Outside-state party general donor zip income variation	0.231	0.252	-0.686	2.091	2822
Outside-state candidate general donor house price variation	-0.369	10.973	-19.802	18.876	2822
Outside-state Super PAC general donor house price variation	-1.365	9.991	-17.339	17.872	2822
Outside-state party general donor house price variation	4.957	9.185	-16.564	17.881	2822
Outside-state candidate general donor zip mortgage payment variation	-0.746	8.409	-14.837	15.189	2822
Outside-state Super PAC general donor zip mortgage payment variation	-0.956	6.947	-12.166	12.578	2822
Outside-state party general donor zip mortgage payment variation	0.603	7.733	-13.163	12.336	2822
Outside-state candidate general donor house tax variation	2.898	5.897	-12.135	12.493	2822
Outside-state Super PAC general donor house tax variation	2.385	4.304	-10.192	11.883	2822
Outside-state party general donor house tax variation	1.786	5.478	-10.939	13.266	2822
Cook's competitiveness ratings	0.387	2.79	-3	3	2822
Candidate ad spending	4.142	5.55	0	43.541	2822
Super PAC ad spending	1.074	3.285	0	32.056	2822
Party ad spending	1.787	4.963	0	36.874	2822
Candidate positions (entrants)	1.444	0.497	1	2	2822

This table shows the summary statistics for the variables used in the estimation of general election voter preferences. Spending by each committee, district income, district unemployment number, and precipitation is scaled as followed: $(X/1e3)^{0.5}$.

CHAPTER 2

DARK MONEY IN CONGRESSIONAL ELECTIONS

2.1 Introduction

Political advertising may be influential in United States elections. To accurately characterize the effects of advertising, one needs to approximate the total amount spent in a given election. This may be difficult if a non-trivial amount of political advertising is undisclosed. 40% of political advertisements aired during the 2012 presidential election came from groups that are not required to disclose this activity (Wesleyan Media Project 2016). In this chapter I overcome this disclosure loophole by using the Wesleyan Media Project's (WMP) raw advertising data and analyze the magnitude and effects of "dark money" in United States Congressional House elections.

If an individual wants to donate money to support (or oppose) a candidate in an election but does not want their identity known, there are limited options in the United States. Donations to candidates, parties, and political action committees must be disclosed. Donations to 501(c)(3) nonprofit charities are not required to be disclosed, but nonprofit charities cannot spend any of that money on political advertising.¹ Certain nonprofit organizations, known as 501(c)(4) nonprofit "social welfare organizations", are allowed to spend as long as less than 50% of their expenditures constitute political spending.² The secretive donor may then give to a 501(c)(4) nonprofit that is active in political advertising spending, but there is another possibility of their identity being revealed. First, if the advertisement expressly advocates for the victory/defeat of a candidate, or what is known as "express advocacy" (EA), and second, if the advertisement mentions a candidate and is aired within 30 days of the primary or within 60 days of the general election, known as an "electioneering communication" (EC).³ See Figure 2.B.1 for a visual breakdown of the disclosure

¹501(c)(3) charities may use alternative routes to influence political outcomes, such as through the contributions by their executives (Cox 2020).

²These are distinct from Super PACs in which donors must be disclosed, but Super PACs can spend all of their money on political expenditures.

³In principle, any advertisement that satisfies the two criteria must be disclosed alongside the donor money ear-

windows.

Any advertisement that does not satisfy the express advocacy criteria but is still overtly political is known as “issue advocacy” (IA) and the funds for these advertisements are known as “dark money” as neither the expenditures nor the donors need to be reported. Thus a 501(c)(4) nonprofit can, in principle, spend unlimited amounts without disclosing its donors on IAs if they do not fall within the EC window (and the 501(c)(4) nonprofit spends at least 50% of its budget on other “non-political” purposes).⁴

Many 501(c)(4) nonprofits run issue advocacy advertisements that are political-adjacent, such as Greenpeace and People for the Ethical Treatment of Animals; their advertisements may target politicians but more often are trying to convince the public to change their opinion on policy issues. However some 501(c)(4) nonprofits are simply the “dark money” cousin of an existing Super PAC with ads that are clearly election oriented. For example, the 501(c)(4) nonprofit called Crossroads Grassroots Policy Strategies had a 2012 anti-Obama advertisement, as shown in Figure 2.B.3, that was classified as issue advocacy because it did not instruct viewers to vote against President Obama, just simply to “call him” to advocate better policy. For a comparison, the Super PAC American Crossroads had a clear anti-Obama express advocacy advertisement, shown in Figure 2.B.4, because it told the audience to vote against President Obama; the funding for this ad was disclosed to the FEC while the one in Figure 2.B.3 was not.

These are the clear demarcations that allow 501(c)(4) nonprofits to easily have an advertisement attacking a politician without needing to disclose their donors. Furthermore, the linkages between those who must disclose, like Super PACs, and the dark money are unrestricted. Steven J. Law is the president of both American Crossroads and Crossroads Grassroots Policy Strategies. Since 501(c)(4) nonprofits are also allowed to give money to Super PACs without the original donors being disclosed, they provide dual roles of running politically charged issue advertisements and

marked for this purpose, however this rarely is done as earmarking is by discretion. If the group doesn’t earmark anything and spends on EC out of general treasury it can avoid this disclosure of donor identity for ECs; this is not possible for independent expenditures (described in data section).

⁴In this case, the nonprofit must only report its typical IRS 990 forms that only require one to report expenditures without breaking them down nor reporting any of their donors.

anonymous money for Super PACs who can run unlimited express advertisements.

These limitations can be binding as various groups have been fined and penalized for pushing advertisements that had clear intent supporting a candidate. For example, the Michigan Bureau of Elections determined that the 527 organization “Build a Better Michigan” violated the rules with a supportive Gretchen Whitmer advertisement for her 2018 gubernatorial election.⁵ While the advertisement did not explicitly advocate for the election of Gretchen, it lauded her accomplishments and displayed the statement “Gretchen Whitmer Candidate for Governor” in the advertisement (Oosting 2018).⁶ Build a Better Michigan spent \$3.3 million in her 2018 campaign and was only fined \$37,500 (Eggert 2019).

One source to uncover the extent of “dark money” spending in elections is the Wesleyan Media Project using Kantar media/CMAG data (Wesleyan Media Project 2016). This dataset contains a large subset of major media market television advertisements during election years and codes them based on the content and the identity of the group who bought the air-time. They also report the approximate cost for the advertisement. I pair this information with Federal Election Commission (FEC) data, and various datasets used in Chapter 1, to estimate the magnitude of Dark money expenditures in House elections.

This chapter speaks to the new role of outside spending and the lack of significant spending in traditional channels (Ansolabehere, De Figueiredo, and Snyder 2003). The role of advertising spending in elections is well studied (Stratmann 2009; Gordon and Hartmann 2016; Klumpp, Milon, and Williams 2016; Ellickson, Lovett, and Shachar 2019; Jimeno and Yildirim 2017) but dark money is relatively understudied due to its recent surge and difficulty to measure. The literature on 501(c)(4) nonprofits is limited and largely descriptive in nature. Oklobdzija (2019) focuses on a special dataset where a dark-money group had its donors revealed, and Oklobdzija (2018) studies the networks between these dark money groups. Dark money is non-trivial and has grown over

⁵ A 527 is a distinct kind of group that can make express advocacy but must disclose its donors. The problem in this case was that it was not disclosing donors and was claiming to only be running issue advertisements (not necessitating disclosure under Michigan law).

⁶ It is interesting to note that the director of Build a Better Michigan later went on to be a part of Whitmer’s transition team after her successful run.

the years (Wesleyan Media Project 2018); see Figure 2.B.2 for a list of the number of dark money advertisements. I find that the nonprofit spending is not particularly effective and the magnitude of spending is lower than the disclosed and conventional methods.

2.2 Data

To investigate the effects of dark money on elections we need first information on election outcomes and I use the share of votes a given candidate receives. I consider general elections, with the data coming from the FEC.⁷ The main groups that spend in elections are candidates, various types of Political Action Committees (PACs), and non-PAC spenders (predominately 501(c)(4) nonprofits but also 501(c)(5) unions, 501(c)(6) trade associations, and rarely corporations and individuals). PACs are formal entities regulated under the FEC that can raise and spend money in elections and the main types are political party PACs, interest group PACs, and “independent expenditure only” PACs (known as Super PACs). These committees can support candidates through a variety of ways but spend the bulk either giving money to the candidate’s campaign or spending on advertisements supporting them (or attacking their opponent). Directly giving to candidates has limitations and only other candidates, traditional PACs, and political parties can coordinate with candidates in that manner; Super PACs and the non-PAC spenders cannot (see Chapter 1 for a lengthy discussion on Super PACs).

The FEC requires any spending by candidates, all types of PACs, and any “independent expenditures” by any entity be reported.⁸ As previously mentioned, there are two kinds of advertisements, namely “direct/express advocacy” and “issue advocacy”. Only political committees can engage in the former whereas the latter is available to all groups post *Citizens United v. FEC*.⁹

⁷ Special elections are added from the CQ Press election database.

⁸ An independent expenditure (IE) is expenditure for a communication “expressly advocating the election or defeat of a clearly identified candidate that is not made in cooperation, consultation, or concert with, or at the request or suggestion of, a candidate, a candidate’s authorized committee, or their agents, or a political party or its agents” [11 CFR 100.16(a)].

⁹ An earlier case in 2007, namely *Wisconsin Right to Life v. FEC*, loosened restrictions on how politically charged advertisements could be and not be labeled/disclosed as such. *Citizens United* allowed any entity to make independent expenditures, including 501(c)(4) nonprofits but they have not utilized this to a large extent because it requires disclosure.

Issue advocacy advertisements do not need to be reported and thus one needs raw advertising data (reported by the station buying the advertisement slot) and matching the buyer list to the known list of existing groups to approximate their spending.

The advertising data comes from the Wesleyan Media Project (WMP) based on Kantar Media data. WMP's data is at the level of the individual political ad, with characteristics of the ad, such as the sponsor, date and time, frequency, channel, location, alongside characteristics of the actual advertisement such as tone. The WMP dataset indicates the name of the group sponsoring the advertisement and broad category of the sponsor including whether the sponsor is a candidate, party, coordination between a candidate and party, or "interest group/other". This is incomplete for my purposes as all interest-group PACs and dark money groups fall into the final category.

I match the sponsor list to the Center for Responsive Politics' (CRP) database of nonprofits with known political spending; I also have select tax information (from 990 forms) for the nonprofits. This combined list gives me the universe of political advertisements by all candidate election committees, political action committees, 501(c)(4) nonprofits, 510(c)(5) unions, and 501(c)(6) trade associations. Figure 2.B.5 from the CRP reports total spending by all these groups across election cycles and 501(c)(4) nonprofits clearly dominate.

I report summary statistics for the main spending variables in Table 2.B.1, including spending as reported from the FEC for groups requiring disclosure and WMP for all main groups. There are differences in average spending across comparable variables (WMP vs FEC for the same committee type); this may be due to my coding of the "advertising spending" also including Internet and other non-TV advertisements whereas WMP data only contains broadcast television.¹⁰ Out of the 721 races (Congressional district and election cycle combination) in the analysis (those that have any non-trivial spending), only 92 have non-trivial dark money spending in them by 28 groups such as the American Action Network, the Club for Growth, and the Sierra Club; dark money groups, such as these 501(c)(4) nonprofits, are similar to Super PACs in that they spend significant amounts in a relatively few number of races compared to candidates and political party committees.

¹⁰In addition, there may be imprecision in WMP's cost estimate as they do not have the actual price paid; see Moshary (2019) for Federal Communications Commission data that has actuals prices paid

I report statistics for the control variables in Table 2.B.2 . I consider the Congressional district level unemployment rate and level, average income, average age, high school graduation rate, vote share for the Republican candidate in the last Presidential election, incumbency status of the candidate, party, votes for the incumbent in the previous election, number of senate candidate running, whether the primary election was contested, if the governor is the same party as the candidate, Cook’s Political report competitiveness ratings, and the election day city precipitation (rainfall inches); for more details on these controls see Chapter 1.¹¹

I do not allow for heterogeneous effects of advertisements supporting a candidate and attacking the opponent for simplicity of the instrumental variables estimation, but some have shown there is heterogeneity in their usage across group types (Chand 2017). I combine advertisements supporting a candidate and attacking the opponent as simply advertisements that help a candidate. The Wesleyan Media Project labels each advertisement by its contents, including the issue, tone, and target candidate. Some advertisements are classified as “contrast” and to determine whether that is pro Republican or pro Democrat I consider the affiliation of the underlying group.

2.3 Estimation

The estimation framework considers general election voters and how spending by the different groups affect vote share and turnout (stemming from Chapter 1). A general election voter v chooses candidate R , D , or not to vote. Their utility from voting for candidate c , U_{vc} , is given in equation (2.3.1) and inspired by Gordon and Hartmann (2016). It is a function of campaign spending, exogenous observables, and private information. The spending $S_{ic}^G \geq 0$ is by committees $i_c \in N_c$ supporting the candidate c , with N_c denoting the set of committees supporting candidate c , and has corresponding effectiveness parameters $\beta_{ic} \geq 0$ and $\phi = 1/2$ (normalized for simplicity). The term X_c is composed of k observed exogenous district-candidate characteristics and parameters $\delta \in \mathbb{R}^k$.¹² Unobserved candidate and district characteristics are denoted with $\xi_c \in \mathbb{R}$. Idiosyncratic

¹¹Weather has been shown to affect turnout and Liao and Junco (2020) show that news-worthy weather and climate events affect voting behavior.

¹²The variables in X_c include the controls mentioned in the data section (some interacted with party and incumbency status) alongside within-state donor finances variation (see Chapter 1 for details).

variation in voter utility is denoted with $\varepsilon_{vc} \stackrel{iid}{\sim} \text{Type 1 Extreme Value}(0, 1)$. Since voter turnout is an issue, I allow for not voting with a normalized utility level $U_{v0} = \varepsilon_{v0}$.

$$U_{vc} = \overbrace{\sum_{i_c \in N_c} \beta_{i_c} (S_{i_c})^\phi}^{u_c} + X_c \delta + \xi_c + \varepsilon_{vc} \quad (2.3.1)$$

The voter's optimal sincere voting decision is defined as a probability of voting for a certain candidate (due to the private information from the researcher's perspective): $P_{vc} = \Pr(U_{vc} > U_{vd} \forall d \in \{0, \dots, C\} \setminus \{c\})$. This can be converted, based on the distribution, into the share of votes a given candidate receives from the voting population: $s_c = \frac{\exp(u_c + \xi_c)}{1 + \sum_{c=1}^C \exp(u_c + \xi_c)}$. While this can be directly estimated, a more straightforward regression is the following transformation, where s_0 is the share of absenteeism. I estimate this differences in vote share equation for 2012-2016 House elections.

$$\ln(s_c) - \ln(s_0) = \sum_{i_c \in N_c} \beta_{i_c} (S_{i_c})^\phi + X_c \delta + \xi_c \quad (2.3.2)$$

With suitable instruments to control for endogenous spending, this regression equation can be estimated with 2SLS. Given that one does not observe donors for 501(c)(4) groups, I utilize two common instrumental variables for campaign spending, namely lagged advertising prices (Gordon and Hartmann 2016; Chung and Zhang 2020) and media market overlap (Spenkuch and Toniatti 2018); since I need an instrument for all spending coefficients and cannot use lagged prices for each (as individual contracts are not observed, only market level averages), I use the instruments based on variation in donor proxy income for committees from Chapter 1. The overlap between the district and the media market affects how many voters in the district one can reach from an advertisement being played in a given media market, and the demarcation lines are arguably exogenous; the main threat to this assumption is strategic partisan Congressional district mapping that may be affected by media markets and could create distortions in the geographic overlap.

The data on media market overlap is from the Daily Kos election dataset. Districts that contain

multiple media markets are costly to advertise in because advertisements are purchased at the media market level, and advertising outside of the district of interest is potentially wasteful (ignoring spillover benefits in adjacent races). Thus, conditional on prices, districts with the highest degree of overlap are least costly to reach the intended voters.

2.4 Results

In Table 2.B.3, I consider linear regressions of general election outcomes on various general election spending variables (suppressing the controls which are reported in Table 2.B.4). In column 1, I consider the FEC reported spending by candidates and then a composite term combining party and Super PAC spending. The results here mirror Chapter 1 with a strong and significant candidate effect and weaker non-candidate spending (driven by weak party effects). In column 2, I add WMP reported 501(c)(4) nonprofit spending and it is noisy and weak and does not change the effects for the other spending coefficients. In column 3 I also add in PAC spending and results do not significantly change. Finally, in column 4, I use WMP reported spending by candidates and non-candidate groups as a comparison and results change; all results are now noisy and 501(c)(4) nonprofit spending effects increase in magnitude with slight changes to the other coefficients. This may be attributed to the mismatch between what is contained in the FEC and WMP spending variables I constructed.

Since there may be selection into spending, I also consider an instrumental variables approach to deal with the potential endogeneity of ξ_c . In Table 2.B.5, I report the first stage instrument estimates and second stage endogenous estimates for the column 2 OLS specification but now instrument for the spending variables.¹³ In column 4, I report the 2nd stage results; the 501(c)(4) nonprofit spending coefficient is now larger than the other spending coefficients but this result is not reliable due to the weak instrument; the first stage F-statistics for the 501(c)(4) nonprofit spending variable, reported in column 3, is only 3.3. Results for candidate spending does not significantly

¹³In Table 2.B.7 I report the regressions used to generate the composite IVs; in the case of multiple potential IVs but some that may be perhaps weak, an optimal convex combination, generated with a regression, may produce a stronger instrument.

change if we omit 501(c)(4) nonprofit spending as an endogenous covariate, which may indicate that candidates do not strategically respond to 501(c)(4) nonprofit behavior. I report the remaining controls for the 2SLS specifications in Table 2.B.6.

The primary issue is the lack of strong instruments for “dark money” spending. Neither lagged advertising prices nor media market and district overlap are strong; it is interesting to note that the latter is significantly more important than the former. Part of the difficulty is that the instruments available to study candidates and Super PACs that vary at the individual committee level via donors (as used in Chapter 1) cannot be observed for 501(c)(4) nonprofits and thus only instruments that vary at a more aggregate level (like media market specific) or observed financial characteristics of the nonprofit (via 990 forms) are available; the former are weak and the latter are unlikely to be exogenous.

In addition the way that issue advertisements influence voters could be distinct from express advocacy. Since issue advertisements are not as candidate focused, they may have larger effects on broad turnout by party and affect more than just one election in that media market; for example an express advocacy advertisement for a candidate may not affect voting behavior for the Senate or Presidential races that overlap in that district but issue advertisements may have muted effects per race but nontrivial effects across multiple races (see appendix for a discussion). An empirical approach to better accommodate this framework would be to consider the election results by party in a given geographic region (precinct, city, county) for all races present there to see whether the aggregate partisan vote share (or turnout) is affected by issue advertisements.

2.5 Conclusion

Dark money spending has received significant press, but its effects are uncertain. The overabundance of spending by various groups likely leads to a cannibalization of efforts that reduces the effectiveness of any single group. However the lack of disclosure is concerning as voters would likely want to know who is funding their candidates.

In this chapter I begin exploring the role of dark money and how it may interact with the other

groups spending significant amounts in U.S. elections. I do not find evidence for strong dark money effects, but there are clear limitations with being able to identify such influence. Further study is needed to get a clear sense of how dark money may differentially affect voters in comparison with Super PACs in particular.

As previously alluded to, dark money influence may go beyond their issue advocacy advertisements. If express advocacy advertisements are substantially more influential than issue advertisements, then 501(c)(4) nonprofits may be most effective at influencing elections by funneling money to Super PACs. Since Super PACs must disclose donors, that limits their fundraising abilities if many potential donors prefer anonymity. 501(c)(4) nonprofits provide this anonymous avenue and a growing number of Super PAC donations originate from such groups, where the disclosed donor is the name of the nonprofit, not the original donor who gave the money to the nonprofit.¹⁴ Studying these dual roles of 501(c)(4) nonprofits is an avenue for future empirical research and a potential theoretical framework is outlined in the appendix of this chapter.

Finally, the shifting party dynamics of dark money needs to be further investigated. While Democrats largely oppose *Citizens United* and support campaign finance reform, they now outspend Republicans in dark money over ten to one in Presidential elections (Crabtree 2021) and contributed to the Congressional “Blue Wave” in 2018 (Fowler, Franz, and Ridout 2020b). Since Republicans are mostly aligned with dark money (from the 2012 election’s large number of anti-Obama dark money advertisements), the large shift in the donor class may have effects on party attitudes or even policy in the future.

¹⁴As mentioned in Chapter 1, the donations from dark money to Super PACs are allowed as long as the donors do not instruct the 501(c)(4) nonprofit to give to the Super PAC; otherwise they risk being a “Straw Donor”. See Herrnson, Heerwig, and Spencer (2018) for a discussion of Super PAC financing heterogeneity.

APPENDICES

APPENDIX A

Model Extensions

Most dark money spending occurs in advance of Super PAC spending as the FEC rules gives 501(c)(4) nonprofits the incentive to spend before the disclosure window. Thus a more likely sensible model is to take the dark-money spending as given prior to spending decisions of the candidates, parties, and Super PACs (similar to a Stackelberg scenario). While the framework considered in the estimation section could have this dynamic structure alongside the effect on voters staying the same (meaning 501(c)(4) nonprofit spending affects the voter at the same time the other spending does). However this is likely unrealistic if 501(c)(4) nonprofit spending occurs before spending by the others. Thus a more accurate model would be for the nonprofit spending to affect voters on its own, then candidate, party, and Super PAC spending affects the updated voters. The variation needed to estimate this model for House races is problematic as there is insufficient polling data.¹⁵

Consider the decision of a committee (not the nonprofit) to spend to affect the probability of their preferred candidate winning (with an associated valuation V_{ic} of winning and a marginal cost of spending g_{ic}):

$$P(w_R^G = 1 | \mathbf{w}^P) = \frac{\exp((u_R^G + \psi_R^G)/\sigma_\xi)}{\sum_{c \in \{D, R\}} \exp((u_c^G + \psi_c^G)/\sigma_\xi)}. \quad (2.A.1)$$

$$\max_{S_{ic}^G \in \mathbb{R}_+} V_{ic} \cdot P(w_c^G = 1 | w_c^P = 1, \mathbf{w}_{-c}^P) - g_{ic} \cdot S_{ic}^G \quad (2.A.2)$$

Abstracting away from the committee entry, primaries, and entry (see Chapter 1 for a full model treatment of this issue), we can now consider the decision of the nonprofit to spend to affect the probability before any of the FEC regulated committees spend. To augment the probability

¹⁵Polling data has issues, such as more polling for competitive races (endogenous polling), some races only having polling late into the election, and others having early in the election. Polling data variation includes between and within elections; there is variation across time within an election for some races, but the intervals are not uniform. Most having less than 2 per race and only 8 races had 7 polls on different days in the 2010 election (Incerti 2018). This is not a problem for Presidential or Senate elections (but fewer of those races).

above to allow for nonprofit spending to affect it, consider the following extension, with nonprofit spending affect the baseline probability α_R for the Republican candidate (and corresponding α_D for the Democratic candidate, where $\alpha_R + \alpha_D = 1$).

$$P(w_R^G = 1 | \mathbf{w}^P) = \frac{\alpha_R + \exp((u_R^G + \psi_R^G)/\sigma_\xi)}{1 + \sum_{c \in \{D, R\}} \exp((u_c^G + \psi_c^G)/\sigma_\xi)}. \quad (2.A.3)$$

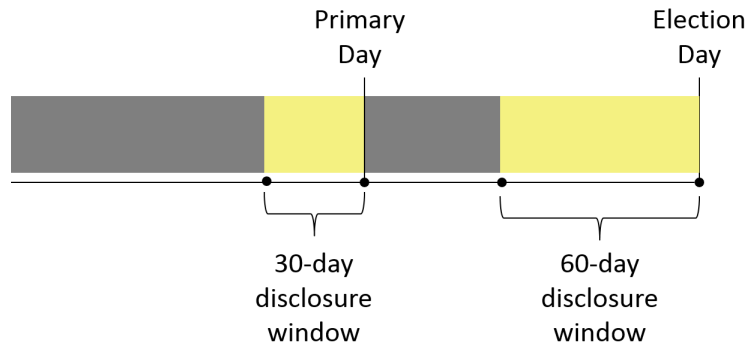
Then the nonprofit chooses their spending level to affect $\alpha_R(S_R^{NP})$ with the same objective function as above. The functional form of $\alpha_R(S_R^{NP})$ could itself be a logit share but just among the nonprofit groups spending or any valid conditional density function. An alternative approach to model the probability updating is with a simple convex combination of probabilities from the two spending sources: $P'_R = \lambda \alpha_R + (1 - \lambda) P_R$ (see chapter 3).

As mentioned in the main text, 501(c)(4) nonprofits have two distinct roles: funding issue advertisements and funding Super PACs who engage in express advocacy independent expenditures. The model framework considered so far only tackles the former strategy. To extend this to two choice variables, we need to incorporate the fundraising production function and budget constraints for the Super PAC (as in Chapter 1 Appendix A.2.1). The most straightforward way to augment that framework with dark money funding is simply to make one of the Super PAC's donors a dark money group and bifurcate the fundraising parameters into dark money specific and non-dark money. Then the nonprofit choose their funding level for the Super PAC which affects the capacity of the Super PAC to spend. The Investment PAC extension considered in Chapter 1 Appendix A.2.3 is a good starting point to model the 501(c)(4) nonprofits and their potential influence on the election.

APPENDIX B

Tables

Figure 2.B.1: Reporting Window For Political Advertisements (Source: WMP)



Disclosure window to report any political advertisement (including issue advocacy) to the FEC. Primary (General) Day refers to the day of the Primary (General) election for that race. Figure created by the Wesleyan Media Project.

Figure 2.B.2: Dark Money Statistics (Source: WMP)

TABLE 1: DARK MONEY IN HOUSE AND SENATE, 2012-2018

	US House	US Senate	Total Dark	% Dark
2012	50,717	151,475	202,192	14.9%
2014	37,432	161,335	198,767	14.2%
2016	6,752	76,774	83,526	7.1%
2018	74,328	169,324	243,652	11.2%

Figures are from January 1 in the first year of the cycle through October 25 in the second year of the cycle. Numbers include broadcast television. Disclosure categorization from the Center for Responsive Politics. CITE SOURCE OF DATA AS: Kantar Media/CMAG with analysis by the Wesleyan Media Project.

The number of dark money group funded TV advertisements (and the percentage of all ads they represent) for House and Senate races between 2012 and 2018. Table created by the Wesleyan Media Project.

Figure 2.B.3: Negative President Obama Issue Advocacy Advertisement



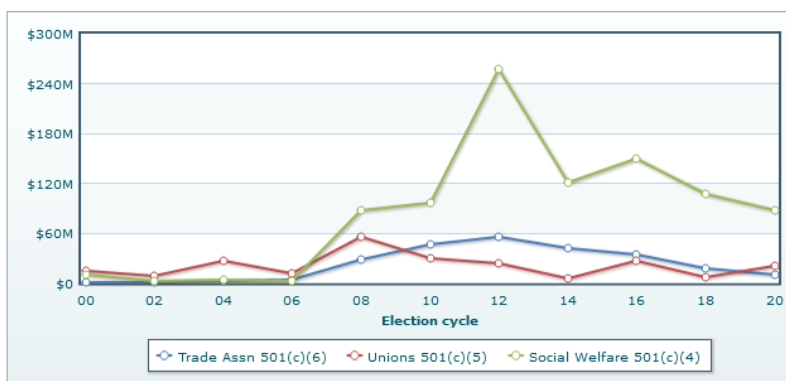
Screen capture from a television issue advocacy ad critical of President Obama from a dark money group; from 2012 and captured from Google Images.

Figure 2.B.4: Negative President Obama Express Advocacy Advertisement



Screen capture from a television express advocacy ad critical of President Obama from a Super PAC group; from 2012 and captured from Google Images.

Figure 2.B.5: Dark Money Spending By Group (Source: CRP)



Graph over time of spending by three different dark money group types, namely trade associations, unions, and social welfare organizations. Graph created by the Center for Responsive Politics.

Table 2.B.1: Spending Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Candidate Spending (WMP)	513859.485	681863.162	0	5604874.812	767
Coordinated Spending (WMP)	62380.771	287328.4	0	3764577.17	767
501(c)(4) Nonprofit Spending (WMP)	68118.152	265608.875	0	2421715.477	767
“Outside” Committee Spending (WMP)	259103.714	687556.835	0	7200214.239	767
Party Spending (WMP)	268469.291	602392.176	0	3889867.406	767
Candidate Spending (FEC)	657678.857	781170.527	0	5529945.633	721
Super PAC Spending (FEC)	320366.536	704657.283	0	5718540	721
Party Spending (FEC)	534343.48	1054308.803	0	5980660.5	721
PAC Spending (FEC)	48180.896	170333.132	0	2221264.75	721

WMP refers to the Wesleyan Media Project source constructed variables from their TV ad database. FEC refers to the Federal Election Commission source constructed variables from their itemized disbursement and independent expenditure databases.

Table 2.B.2: Controls Summary Statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
District Unemployed Rate	6.498	2.019	2.775	15.385	720
District Income	64618.043	21821.162	39015.986	190077.653	721
District Unemployed Number	80712.118	128123.371	2343.042	868037.583	721
Lagged Republican Presidential Votes	0.498	0.092	0.186	0.791	721
Incumbent	0.347	0.476	0	1	721
Party=Republican	0.484	0.5	0	1	767
Lagged Incumbent Votes	0.493	0.225	0	1	721
Number Of Senate Candidates In State	8.404	8.664	0	35	721
Governor Same Party	0.463	0.499	0	1	721
Contested Primary	0.829	0.376	0	1	721
District High-School Rate	29.32	6.163	14.5	46.757	721
District Median Age	40.754	3.487	29.306	51.269	721
District Election Day Precipitation	10.552	33.152	0	349.25	721
Cook's Competitiveness Rating	0.864	2.563	-3	3	721

This table shows the summary statistics for the variables used in the estimation. District income, district unemployment number, and precipitation is scaled as followed: $(X/1e3)^{0.5}$.

Table 2.B.3: OLS Regressions

DV:Log Difference in Vote Share	(1)	(2)	(3)	(4)
Candidate Spending (FEC)	0.0054*** (0.0016)	0.0054*** (0.0016)	0.0051** (0.0016)	
Party + Super PAC Spending (FEC)	0.0016 (0.0009)	0.0016 (0.0009)		
Nonprofit Spending (WMP)		0.0002 (0.0023)	0.0001 (0.0023)	0.0019 (0.0025)
PAC + Party + Super PAC Spending (FEC)			0.0018 (0.0009)	
Candidate Spending (WMP)				0.0029 (0.0015)
Party + “Outside” Spending (WMP)				0.0009 (0.0010)
<i>N</i>	712	712	712	712
<i>R</i> ²	0.592	0.592	0.592	0.580
F	69.5033	66.7829	66.9170	61.2745

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Suppressed: controls [see Table 2.B.4]. Dependent variable is the difference in the log of the vote share for the candidate and the share of absenteeism. WMP refers to the Wesleyan Media Project sourced variables. FEC refers to the Federal Election Commission sourced variables.

Table 2.B.4: OLS Regressions Controls

DV:Log Difference in Vote Share	(1)	(2)	(3)	(4)
District Unemployed Rate	-0.0517*** (0.0127)	-0.0517*** (0.0127)	-0.0516*** (0.0127)	-0.0553*** (0.0130)
District Income	0.0698** (0.0218)	0.0699** (0.0218)	0.0702** (0.0218)	0.0759*** (0.0219)
District Unemployed Number	-0.0245*** (0.0050)	-0.0245*** (0.0050)	-0.0246*** (0.0050)	-0.0226*** (0.0051)
Within-State Candidate Donor Finances Variation	-0.1455 (0.0899)	-0.1454 (0.0900)	-0.1446 (0.0899)	-0.1752 (0.0928)
Within-State Party Donor Finances Variation	-0.3081* (0.1288)	-0.3096* (0.1312)	-0.3149* (0.1314)	-0.2103 (0.1291)
Within-State Super PAC Donor Finances Variation	-0.0203 (0.0374)	-0.0203 (0.0374)	-0.0206 (0.0374)	-0.0172 (0.0391)
Lagged Republican Presidential Votes	0.1434 (0.2903)	0.1425 (0.2918)	0.1415 (0.2916)	0.0624 (0.3011)
Incumbent	0.0221 (0.0902)	0.0208 (0.0928)	0.0199 (0.0929)	0.1320 (0.0874)
Party=Republican	0.0543 (0.0548)	0.0548 (0.0551)	0.0542 (0.0551)	0.0354 (0.0571)
Lagged Incumbent Votes	-0.0860 (0.0752)	-0.0856 (0.0754)	-0.0864 (0.0753)	-0.0951 (0.0776)
Number Of Senate Candidates In State	-0.0051* (0.0021)	-0.0051* (0.0021)	-0.0051* (0.0021)	-0.0048* (0.0021)
Contested Primary	-0.0101 (0.0574)	-0.0101 (0.0575)	-0.0118 (0.0575)	-0.0315 (0.0591)
Governor Same Party	-0.0320 (0.0385)	-0.0321 (0.0385)	-0.0317 (0.0385)	-0.0274 (0.0390)
2014 Dummy	-1.1217*** (0.0520)	-1.1216*** (0.0521)	-1.1208*** (0.0520)	-1.1267*** (0.0534)
2016 Dummy	-0.4641*** (0.0904)	-0.4642*** (0.0905)	-0.4658*** (0.0903)	-0.4413*** (0.0916)
District High-School Rate	-0.0076 (0.0050)	-0.0076 (0.0050)	-0.0075 (0.0050)	-0.0072 (0.0050)
District Median Age	0.0612*** (0.0051)	0.0613*** (0.0051)	0.0612*** (0.0051)	0.0631*** (0.0053)
District Election Day Precipitation	0.2971 (0.1903)	0.2969 (0.1904)	0.2963 (0.1905)	0.2395 (0.1923)
Inc=0 X Party=D X Cooks Competitiveness	-0.0204 (0.0194)	-0.0204 (0.0195)	-0.0200 (0.0195)	-0.0317 (0.0204)
Inc=0 X Party=R X Cooks Competitiveness	0.0554** (0.0178)	0.0554** (0.0178)	0.0552** (0.0178)	0.0657*** (0.0183)
Inc=1 X Party=D X Cooks Competitiveness	-0.0584 (0.0350)	-0.0587 (0.0358)	-0.0596 (0.0359)	-0.0255 (0.0339)
Inc=1 X Party=R X Cooks Competitiveness	0.0572 (0.0376)	0.0577 (0.0387)	0.0586 (0.0387)	0.0373 (0.0367)
Constant	-2.5167*** (0.4128)	-2.5178*** (0.4132)	-2.5155*** (0.4128)	-2.5220*** (0.4238)
N	712	712	712	712
R ²	0.592	0.592	0.592	0.580
F	69.5033	66.7829	66.9170	61.2745

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the difference in the log of the vote share for the candidate and the share of absenteeism. This table shows the parameter estimates for the controls used in Table 2.B.3.

Table 2.B.5: IV Regressions

1st stage DV: Spending by Committee Type	Candidate	Super PAC + Party	Nonprofit	Log Diff. in Vote Share
Nonprofit Composite IV	-0.3737 (0.4266)	-0.1205 (0.6814)	0.6335** (0.2330)	
Candidate Composite IV	1.1206*** (0.1948)	0.9206** (0.3112)	0.0376 (0.0896)	
Party/Super PAC Composite IV	0.2493** (0.0844)	0.6839*** (0.1348)	-0.0657 (0.0461)	
Candidate Spending (FEC)				0.0126 (0.0125)
Party + Super PAC Spending (FEC)				0.0020 (0.0075)
Nonprofit Spending (WMP)				0.0230 (0.0248)
<i>N</i>	720	720	720	712
<i>R</i> ²	0.347	0.289	0.222	0.508
F	14.7212	11.2603	3.3087	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Suppressed: controls [see Table 2.B.6]. Dependent variable is the difference in the log of the vote share for the candidate and the share of absenteeism. WMP refers to the Wesleyan Media Project sourced variables. FEC refers to the Federal Election Commission sourced variables. Instruments are donor financial well-being variation for the different kinds of disclosing committees, lagged ad prices, media market-district overlap. “Composite IV” refers to the linear combination approach used to construct the single IV as a function of multiple IVs.

Table 2.B.6: IV Regression Controls

1st stage DV: Spending by Committee Type	Candidate	Super PAC + Party	Nonprofit	Log Diff. in Vote Share
District Unemployed Rate	-0.7224* (0.3581)	-0.9349 (0.5725)	-0.0096 (0.2012)	-0.0445** (0.0146)
District Income	1.2859* (0.6146)	0.2982 (0.9826)	-0.2920 (0.3453)	0.0671* (0.0291)
District Unemployed Number	0.1581 (0.1298)	0.3359 (0.2076)	-0.0013 (0.0730)	-0.0262*** (0.0052)
Within-State Candidate Donor Zip Income Variation	-6.1423** (2.0874)	-10.1192** (3.3371)	-1.4048 (1.1728)	-0.0804 (0.0946)
Within-State Party Donor Zip Income Variation	21.7002*** (3.4025)	42.1489*** (5.4393)	12.7718*** (1.9116)	-0.7725 (0.4264)
Within-State Super PAC Donor Zip Income Variation	-0.1243 (0.8854)	-1.8124 (1.4154)	0.0338 (0.4974)	-0.0206 (0.0348)
Lagged Republican Presidential Votes	-11.8792 (7.1050)	-2.1348 (11.3583)	5.6784 (3.9917)	0.1682 (0.3356)
Incumbent	22.3053*** (3.2878)	29.3136*** (5.2559)	10.5375*** (1.8471)	-0.3539 (0.3342)
Party=Republican	-2.3548 (1.7761)	1.7501 (2.8393)	-2.6698** (0.9978)	0.1275 (0.1057)
Lagged Incumbent Votes	-2.5891 (2.1792)	-3.2692 (3.4837)	-2.2642 (1.2243)	-0.0104 (0.1087)
Number Of Senate Candidates In State	-0.0329 (0.0612)	0.1415 (0.0979)	0.0260 (0.0344)	-0.0051 (0.0028)
Contested Primary	-1.7092 (1.6813)	1.0116 (2.6877)	0.3784 (0.9446)	0.0022 (0.0740)
Governor Same Party	0.8247 (0.9994)	-0.5022 (1.5977)	0.5854 (0.5615)	-0.0492 (0.0431)
2014 Dummy	-1.8570 (1.5137)	-2.5816 (2.4199)	0.2148 (0.8504)	-1.0945*** (0.0578)
2016 Dummy	4.6348 (2.4604)	12.5717** (3.9334)	3.7753** (1.3823)	-0.5335*** (0.1114)
District High-School Rate	0.0092 (0.1147)	-0.0159 (0.1834)	0.0924 (0.0644)	-0.0092 (0.0051)
District Median Age	0.0202 (0.1583)	0.2668 (0.2531)	-0.1744 (0.0890)	0.0633*** (0.0078)
District Election Day Precipitation	-10.7292 (5.5010)	-6.1260 (8.7941)	0.9684 (3.0906)	0.3923 (0.2370)
Inc=0 X Party=D X Cooks Competitiveness	-1.8646** (0.6012)	-2.1081* (0.9611)	-0.5420 (0.3378)	0.0059 (0.0293)
Inc=0 X Party=R X Cooks Competitiveness	1.9200*** (0.5399)	2.1013* (0.8631)	-0.2783 (0.3033)	0.0425 (0.0266)
Inc=1 X Party=D X Cooks Competitiveness	7.4233*** (1.2162)	11.1084*** (1.9443)	3.4736*** (0.6833)	-0.1841 (0.1120)
Inc=1 X Party=R X Cooks Competitiveness	-5.1400*** (1.2202)	-11.1720*** (1.9507)	-3.9201*** (0.6856)	0.1738 (0.1243)
N	720	720	720	712
R ²	0.348	0.289	0.223	0.529
F	14.8376	11.3047	7.9494	

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Dependent variable is the difference in the log of the vote share for the candidate and the share of absenteeism. This table shows the parameter estimates for the controls used in Table 2.B.5.

Table 2.B.7: Composite IV Regressions

DV: Spending by Committee Type	Candidate	Party+Super PAC	Nonprofit
Outside-State Candidate General	5.1154***		-0.0205
Donor Zip Income Variation	(1.1427)		(0.7144)
Outside-State Candidate General	0.0934		0.0062
Donor House Price Variation	(0.0491)		(0.0256)
Outside-State Candidate General	0.1233		-0.0564
Donor Zip Mortgage Payment Variation	(0.0806)		(0.0430)
Outside-State Candidate General	0.1862		0.0922
Donor House Tax Variation	(0.1049)		(0.0548)
Outside-State Party General		9.1539**	2.9017*
Donor Zip Income Variation		(3.5288)	(1.2534)
Outside-State Super PAC General		8.1900***	1.3697*
Donor Zip Income Variation		(1.8825)	(0.6615)
Outside-State Super PAC General		-0.1036	0.0335
Donor House Price Variation		(0.0828)	(0.0289)
Outside-State Party General		0.1790*	-0.0242
Donor House Price Variation		(0.0818)	(0.0286)
Outside-State Super PAC General		0.3989**	0.0332
Donor Zip Mortgage Payment Variation		(0.1389)	(0.0484)
Outside-State Party General		0.6216***	0.0490
Donor Zip Mortgage Payment Variation		(0.1611)	(0.0604)
Outside-State Super PAC General		0.5393**	0.0765
Donor House Tax Variation		(0.1963)	(0.0686)
Outside-State Party General		0.4984**	0.1116
Donor House Tax Variation		(0.1848)	(0.0655)
DMA-District Coverage Overlap			-0.0206*
			(0.0093)
Lagged Average Advertising Price			-0.0000
			(0.0004)
Constant	17.3955***	10.2722***	1.9392*
	(0.7948)	(1.4123)	(0.7888)
<i>N</i>	721	721	721
<i>R</i> ²	0.047	0.105	0.067
F	8.8861	10.4486	3.5937

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. This table shows the composite IV construction from a large set of potential IVs; used to instrument for spending in Table 2.B.5.

CHAPTER 3

LOBBYING FOR GOVERNMENT APPROPRIATIONS

3.1 Introduction

Lobbying in the United States is the process by which corporations solicit government officials to change policy. Appropriation bills, which determine funding for most government operations including federal contracts, are prime targets of lobbying. Amazon spent over \$10 million in lobbying in 2018, aiming for a \$10 billion Pentagon contract (Fortune 2018), and Oracle is suing the federal government over recent changes to the contract language that favors Amazon (Silicon Valley Business Journal 2018). Boeing's lobbying push in 2008-2009, aimed at increasing funding for its two-stage ground-based air defense technology (Space News 2008), may help explain Senate Amdt.2616 to H.R.3326 - 111th Congress (2009-2010): "[An additional] \$151,000,000 shall be available for research, development, test, and evaluation of the two-stage ground-based interceptor missile." In another case, a canceled Pentagon contract worth over \$100 billion was refunded after significant lobbying by interested contractors (Ağca and Igan 2015).

Between 2000 and 2015, federal contract awards totaled \$384 billion per year. Contractors that lobbied on appropriations received on average 30 times more in contract awards than non-lobbying contractors. Contract sectors (industries) with firms lobbying on relevant appropriation bills saw significantly higher funding growth rates relative to the non-lobbying sectors. Lobbying and spending have also closely mirrored each other, with the number of firms lobbying on defense appropriations bills explaining 80% of the yearly variation in defense contract spending.

As these examples illustrate, lobbying might affect the distribution of contracts between firms and change the pool of funds available for contracts. In this chapter, I consider both pathways of influence, and in doing so, take a new approach to modeling the relationship between lobbying and contracts. I develop and solve a game-theoretic model, building upon recent theoretical and empirical chapters. I then estimate the model and determine the extent to which lobbying affects

contracts in the U.S. with a panel of federal contractors between 2001 and 2015.

This chapter is primarily related to the literature on lobbying and government procurement (de Figueiredo and Silverman 2006; Ağca and Igan 2015; Choi, Penciakova, and Saffie 2017), with connections to the literature on Congressional bill lobbying (Tovar 2011; Kerr, Lincoln, and Mishra 2014; Kang 2016; You 2017) and chapters on political connections and government contracts (Goldman, Rocholl, and So 2013; Wang 2014; Brogaard, Denes, and Duchin 2016; Baltrunaite 2018; Schoenherr 2018). See de Figueiredo and Richter (2014b) for a survey on the empirical lobbying literature. Two of the most relevant articles are de Figueiredo and Silverman (2006) and Kang (2016). De Figueiredo and Silverman consider firms lobbying to increase earmark spending, and given this setup, they do not model competitive lobbying. Kang studies coalitions lobbying over the enactment probability of a given policy, and assumes that the value of a policy to a given firm is unaffected by lobbying.

I incorporate the endogeneity of lobbying by modeling it as a choice variable. I allow for selection into lobbying through a two-stage game with private information on the profitability of entering. These elements borrow from Seim (2006) and Kang (2016).¹ The competitive nature of lobbying is modeled with a rent-seeking contest between firms and lobbying is allowed to affect how much the government allocates to a given sector for contracts. With the addition of this latter component, called an “endogenous prize,” I go beyond the current empirical literature in considering two strategic aspects to lobbying: the pure rent-seeking of fighting over a slice of the contract pie and the positive externality of increasing the overall size of the pie. Omission of such a positive externality will ignore the potential influence of aggregate lobbying and the strategic changes therein; relative to the exogenous prize case, a firm has incentives to over-lobby due to a self-generated prize value and under-lobby due to the free-riding opportunity. The models without competition or the externality are special cases of my framework; I test the importance of both components to see which, if either, help explain observed lobbying behavior and contract

¹The second stage of the model here is an extension of Hirai and Szidarovszky (2013). Lobbying models typically follow Grossman and Helpman (1994) or Tullock (1967) (Gregor 2017). For empirical articles based on the former framework, see Gawande, Krishna, and Olarreaga (2012) and Huneeus and Kim (2018).

outcomes. A key contribution of this study is to quantify the upward pressure from lobbying on government contract spending.

I find that the government spends an average of \$8.837 billion [5.777, 17.276] more per year on contracts than it would otherwise due to the pressure from lobbying; this represents a 3.22% increase in contract spending toward those firms.² Lobbying also alters the between-firm contract allocations; I find an average absolute change in contract profits per firm per year of 5.18%, but the effect on the distribution of contracts within a sector is noisy. Also, firms that in the data enter gain an average of 12.37% in contract revenues for lobbying participation. Finally, I find that decreasing market concentration generally leads to less lobbying. A combination of the positive externality and the noisy share effects help explain this result.

The chapter proceeds as follows: Section 2 describes the institutional details and data, Section 3 presents the model, Section 4 discusses identification and describes the estimation method, Section 5 presents the empirical results, and Section 6 concludes.

3.2 Contract and Lobbying Data

Every year the U.S. Congress passes a series of appropriations bills that determine funding for government services including federal contracts.³ At the same time, firms engage Members of Congress and other government officials on bill contents, agency funding, and other policies; this regulated solicitation defines “lobbying.” Firms use professional lobbying agencies or create in-house teams and hire lobbyists to represent the firm’s interests. The individual lobbyists meet with congresspersons and federal agencies, often providing policy-relevant information.⁴

Politicians can be influenced by this lobbying through a variety of mechanisms (Austen-Smith and Wright 1992; Richter, Samphantharak, and Timmons 2009; LaPira and Thomas 2017). For ex-

²Baltrunaite (2018) finds that banning political donations in Lithuania would save taxpayers almost 1% of GDP from lower procurement spending.

³Agencies submit their budget requests to the OMB early in the 4th quarter of the previous year. The president submits a budget to Congress the following 1st quarter. Both houses make versions and vote on a budget around the 3rd quarter. Regular appropriations are implemented starting with the fiscal year in October (Ağca and Igan 2015).

⁴As budget requests are made the previous year during early 4th quarter, lobbying should match to specific contracts through a lag. The lobbying reports are written according to fiscal year from January to December. The main appropriations process is during January and October, but supplemental appropriations are added afterward.

ample, through information transfer, lobbyists can persuade the politician to implement the firm's preferred policy by providing information on constituent preferences for the policy. Lobbyists can also directly benefit the politicians by writing laws and running electoral campaigns. Finally, lobbyists offer former Congress members jobs as lobbyists, often paying over \$1 million a year (Republic Report 2012). Firms, however, are constrained by laws from certain lobbying activities.⁵ Lobbyists cannot give money directly to politicians and thus lobbying does not constitute monetary transfers. Some laws prohibit the use of specific contract dollars to lobby (18 U.S.C. 1913).

After the appropriations are set, the contract decisions are made, with guidelines detailed by the Federal Acquisition Regulation. The specific service being requested comes from a federal agency; after the budget is approved, the agency receives the funds allocated for these specific services and creates contracts for them.⁶ Federal agencies have substantial leeway in determining who wins a contract; they award competitive contracts to the "best value" bidder and award many no-bid or specialized contracts for which only certain firms are even eligible (The Center for Public Integrity 2004; Kang and Miller 2017; Palguta and Pertold 2017).

Given the nature of lobbying and the available data, it is difficult to identify the exact link between lobbying and contracts. A firm could lobby a Member of Congress to add more funds to a bill on contracts in its industry, which could affect the pool of contracts available to many firms. A given firm could also lobby to make a bill's language specific enough to help that firm end up with most of the funding intended for an entire sector. Finally, a firm could spend that money persuading the agency to give it the contract. The available variation in the lobbying data cannot easily differentiate among these pathways, so in this chapter I allow for the same lobbying dollar to potentially influence both the overall pool of contracts and the amount going to the given firm.

The main variables for analysis include lobbying expenditures on appropriations bills, contract

⁵The first (modern) major legislation aimed at reining in lobbying was the Lobbying Disclosure Act of 1995, which required reports on lobbying activity. The Honest Leadership and Open Government Act of 2007 expanded upon the 1995 law and forced former Members of Congress to wait 1 year before they could be employed by a lobbyist firm.

⁶The agency assigns a contracting officer to each contract. For competitive contracts, officers list the contracts on the FBO board and firms apply. For non-competitive bids, the officer contacts select firms. After the bidders submit their bids and the agency decides the winner, the agency sets the terms of the contract in motion alongside payment.

winnings, predictors of lobbying effectiveness, predictors of contract awards, and characteristics of each contract sector that predict the distribution and size of contracts in that sector.⁷

Lobbying

The lobbying data originate from federal lobbying disclosure reports, which I acquire from the Center for Responsive Politics. The dataset spans 1998-2016, and I observe the total lobbying expenditures by a firm per half or quarter of a year, which is aggregated to year. I also observe a frequency list of issues and bills on which they lobby. The lobbying expenditures represent the costs to the firm of either payments to the hired lobbying firm or the in-house costs. Smaller and inactive firms are more likely to hire outside, and 90% in the final sample use inside lobbyists.⁸ The dataset also contains lobbying by groups like trade associations. There are very few trade associations that lobby on appropriations, and only a handful have ever received a contract.

To approximate the dollar amount of lobbying devoted to a general issue, appropriations in this case, I follow Kerr et al. (2014) and Kang (2016) by multiplying total expenditures by the fraction of bills lobbied on devoted to that issue. Specifically, I create a list of every appropriations bill between the 106th and 113th congresses and determine whether a firm reported lobbying on such a bill in a given report. I then tabulate the frequency of the reports that list an appropriations bill and divide by the number of all bills lobbied on in a given year to generate the share of lobbying dedicated to appropriations.⁹ One does not observe the specific sector within each bill on which the firm lobbied on so, following Kang (2016), if a firm lobbies on a given bill I assign participation to all relevant sectors covered in that bill (relevant is defined in the contracts section).

⁷ All dollars are denominated in 2015 dollars. For variable selection I follow the literature (Bombardini and Trebbi 2012; Antia, Kim, and Pantzalis 2013; Unsal, Hassan and Zirek 2016). I do not consider campaign contributions; lobbying dwarfs contributions (de Figueiredo and Richter (2014b)), but Lake (2015) finds them to be correlated.

⁸ Some articles differentiate between outside vs in-house (Vidal, Draca, and Fons-Rosen 2012; Bertrand, Bombardini, and Trebbi 2014; You and Kang 2018; Ellis and Groll 2018).

⁹ This measure has challenges: each bill does not in general receive equal monetary attention; some bills will see larger expenditures and this measure would not capture this. There is no clear sign on the bias induced by this measure as appropriations bills could either be under or over estimated. For a discussion of authorization bills, see the appendix.

Some firms may be more effective at turning their lobbying expenditures into contract dollars. I control for whether or not a firm employs a former Member of Congress as a lobbyist as a source of this heterogeneity. Although isolating the causal effect of their influence is difficult, as their presence on a firm’s lobbying team could be correlated with other firm unobservables, including them as a control is important and often ignored.¹⁰ I observe the identity of every lobbyist who actively lobbied on behalf of a given firm although I do not observe the issue on which they specifically lobbied; I also observe whether this lobbyist was formerly a Member of Congress. I create a dummy variable of whether a firm had a former congressperson lobby for them over that year (*FC*); on average 26% of firms in the sample have at least one in a given year.¹¹

A former Member of Congress is likely an effective lobbyist due to their experience and connections, but there are even further benefits; for example, “Former Members of Congress retain access to the members-only dining facilities, gymnasiums, cloakrooms and the chamber floors—areas not accessible to others” (The Center for Public Integrity 2014). It is an active market as 51% of congresspersons that left Congress during the 2013-2015 sessions became lobbyists by 2018 (Open Secrets 2017). Firms employing a former congressperson in a given year spend on average five times more than those without, which may hint at higher marginal returns to lobbying with one, but as already noted, such firms could differ in unobserved ways.

Contracts

The contract data are gathered from the federal government database USAspending and span 2000-2016. I extract the payment a firm receives from the government for fulfilling a contract, which minus costs is the profit from the contract. Other variables include firm characteristics, the type of service procured in the contract, and the bidding process on each contract. I combine the lobbying and contract datasets with parent organization name through a string matching algorithm.

¹⁰De Figueiredo and Silverman (2006) interact lobbying influence with political representation at the district level, which measures how a given representative may respond to their constituents, but this is not directly linked to the firm. Some articles model the decision of a Member of Congress to become a lobbyist (Diermeier, Keane, and Merlo 2005).

¹¹I use the binary measure instead of the discrete number of former congresspersons for simplicity and to use the latter one would have to additionally match names to ensure non-double counting between reports.

The analysis in this chapter is at the level of a set/bundle of contracts called sector. This approach is useful because it allows one to model the firms in a given sector lobbying over the amount allocated to that sector and lobbying among themselves for the contracts within it. I define the sector in which firms receive contracts and lobby to be a combination of the federal agency distributing the contract and the type of service being procured by that agency. The agencies are mostly top-level departments such as the Department of Defense. The “types” are categorized with the “Product and Service Codes” which “describe products, services, and research and development purchased by the federal government; these codes indicate “what” was bought for each contract action reported in the Federal Procurement Data System” (Federal Acquisition Service PSC manual). Example categories are ammunition, R&D Space Flight, IT services, and building construction.¹² As the contract data are at the individual contract level, I aggregate up to the sector level.

One drawback of the contract dataset is that one observes only the winner of each contract, so the likely potential competitors need to be backed out. I allow firms to be present in the sample for a given year even if they did not win a contract in that sector that year as I want to avoid the sample selection issue of observing only those who win contracts. To do this I first create a balanced panel for firms and the sectors in which they have ever received a contract. For example, if a firm earned a contract in “10mm ammunition production” from the Department of Defense in 2006 but not 2005, I want to include them in the 2005 analysis as they could have just unsuccessfully attempted to win a contract in 2005. It is not feasible to include every firm that ever won a contract of any size as that would result in thousands of firms per sector and the estimation involves solving many fixed points. I employ a single trimming criterion to include firms that are the likely firms to be interested in lobbying a non-trivial amount over contracts; I include a firm as a potential participant in a given sector-year if they made at least \$100 million in contract revenues in that sector over the 5 year window around that year. I run sensitivity tests around this cutoff in the appendix.

¹²The most common types: “IT Support-Professional: Other” and “Medical and Surgical Instruments, Equipment, and Supplies”. The largest contracts are “Operation of Government-Owned Contractor-Operated R&D Facilities” and “Amphibious Assault Ships”. See https://www.acquisition.gov/PSC_Manual for a full list.

Summary Statistics

The sample for estimation covers 2001-2013 and I reserve 2014-2015 for out of sample prediction. The unbalanced panel consists of 1,109 firms that have been awarded contracts between 2001 and 2013 (and thus the 2000 and 2012 lobbying cycles) with a total of 15,766 firm-sector-year observations. Of these firms, 301 have lobbied at some point and 808 have never lobbied. There are also a total of 805 contract sectors over this 13 year period; I drop sectors with less than \$1 million in total contracts. The average number of firms present per year is 546 and the average number of sectors per year is 411. Average contract revenues are \$227 million per firm per sector in a given year and firms operate in about 15 sectors per year. 73% of contracts in the sample are funded by the Department of Defense and the rest are scattered across 33 other agencies. I keep non-defense sectors as we need to observe all major areas in which a given firm is seeking contracts as that is the level at which lobbying dollars are observed.

The average number of firms per sector is 8.9 and the average number of firms per sector that have ever lobbied is 4.3. See Figure 3.A.1 for a distribution of firms across sectors, Figure 3.A.2 for a distribution of potential entrants across sectors, and Figure 3.A.3 for a distribution of entrants across sectors. These distributions all have positive skew and indicate that there is substantial heterogeneity in activity. The skewness is even more stark for lobbying expenditures; Figure 3.A.4 shows the distribution of nonzero lobbying across firms.

I represent the dollar value of contracts a firm earns in a given sector as two distinct objects: the total dollar value of contracts (the pool) allocated to that sector and the share of that pool that the firm earns. This decomposition is useful as one can then analyze both the overall size of the pool and the between-firm distribution given a pool. Table 3.A.1 shows a basic relationship at the firm-sector level of whether or not the firm lobbied on a given sector and the share of contracts that firm earned in that sector. Participation in lobbying is correlated with higher contract shares, but the shares are also determined by other factors such as competitiveness. Figure 3.A.5 shows the positive correlation between the number of potential entrants and the total contracts in a sector.

Contracts can be allocated using a competitive bidding process or through a non-competitive

assignment. As these decisions are made at the discretion of the agency, I consider the share of contracts within a sector that are competitive as one measure of how likely a sector may be influenced by lobbying (*CM*). In Table 3.A.2, I report total lobbying across sectors for firms by the average degree of competitiveness (in the previous year) across sectors in which each firm operates. The difference in lobbying by sector competitiveness may indicate that firms are more likely to lobby if they are in sectors that have been less competitive.

Table 3.A.3 shows contract revenues totaled across all sectors for firms differentiated by lobbying participation. Note that there is a monotonic increase in average revenues based on the degree of political connectedness; although not causal, these statistics are suggestive and motivate the model. Table 3.A.4 shows total contract spending by the government across sectors differentiated by the average lobbying (across all sectors) of firms in the sector. The statistically significant difference indicates that sectors with firms who lobby may see higher funding. In Table 3.A.5, I show the distribution of these effects with contract revenues quantiles by lobbying participation.

Table 3.A.6 presents summary statistics, grouped by the level of variation. The firm-sector-year level variables include the share of contracts a firm receives in a given sector-year, whether or not the firm lobbied on that sector, and the number of sectors in which that firm operates. The 15,766 observations include the sectors without any potential entrants for lobbying. If we condition on the set of firm-sector-years with at least one potential entrant, we have 14,096 observations and the lobbying participation variable has a mean of 0.308 with a standard deviation of 0.462.

The sector-year level variables include the total pool of contract funds in that sector-year, the degree of competition, whether or not the sector is related to defense, and the number of firms in the sector. There are two types of firms for that last variable: those that at some point lobby and those that have never lobbied. The firm-year level variables include the lobbying (on appropriations) expenditures, presence of a former congressperson on a firm's lobbying team, and whether the firm (or a major contract-seeking subsidiary) is based in the metropolitan D.C. area.

Finally, in Table 3.A.7, I show basic reduced form regressions. In the first column, I regress total contracts at the sector-year level on the number of firms, number of potential entrants, and

the number of actual entrants, finding a positive relationship on all three. In column 2, I show the same regression but condition on sectors with at least one entrant. In column 3, I regress shares at the firm-sector-year level on the same measures but also include the number of other firms that entered. The own entry measure is now just a dummy of whether that given firm entered. Shares decrease as there are more firms, and the effect is stronger in sectors with other lobbying firms.

In column 4, I regress entry on the other sector number and entry variables; firms appear to enter more often in smaller sectors and respond to entry by others. In column 5, I regress total lobbying expenditures at the firm-year level on average sector level variables, where entry is then the average for that firm across sectors. We see similar results to the previous regression except lobbying is now negatively correlated with average entry by others. In the final column, I regress total contracts at the firm-year level on average entry, average entry by other firms, and total lobbying expenditures. The positive correlation between contracts and others' entry may hint at the positive externality. Also, the coefficient on lobbying expenditures is positive but noisy, alluding to the result that entry matters more than the level of spending.

As already discussed, one observes only the (approximate) lobbying expenditures on all appropriations, but not how much per sector in which the firm participates. Thus there is a disconnect in the level of observation for the outcome of lobbying expenditures, namely contract awards, and the lobbying itself. To conduct empirical analysis at the contract sector level, we need to model sector level lobbying.

3.3 A Model of Appropriations Lobbying

Firms lobby Congress and federal agencies on the appropriations budget to increase how much they earn in federal contracts in a given sector. I model this interaction for a single sector as a static two-stage incomplete information game among firms in which they decide how much to lobby on appropriations.¹³ I omit sector notation for simplicity of the model exposition.

¹³Congress and the agencies are not modeled as agents, as the contest function defines the relationship between firms and the government. Also, the mechanisms through which the government allows themselves to be influenced is not explicitly defined here, but the information transfer framework of Austen-Smith and Wright (1992) works well.

There are a finite set of firms (the players) $\mathcal{I} = \{1, \dots, N\}$, each of whom chooses two actions sequentially. In the first stage, firms simultaneously determine whether they will participate in the lobbying game by choosing $e_i = \{0, 1\}$, such that $e_i = 1$ indicates participation in the contest and $e_i = 0$ indicates non-participation. Firms then pay the participation fee $F \cdot e_i$, where $F \in \mathbb{R}$. Firms make this decision with a private information shock ε_i that they incur upon entering and privately observe beforehand. These shock are independently and identically distributed Logistic(0, σ). This includes idiosyncratic variation in participation costs and benefits to entering the appropriations lobbying market unrelated to contracts. In the second stage, the firms simultaneously decide how much to lobby if they participate; I denote the lobbying expenditures by each firm with $\ell_i \in \mathbb{R}_+$, and $e_i = 0$ implies $\ell_i = 0$. The set of participants is known prior to making the second decision. Each firm's period payoff can then be expressed as a mean π_i with private noise ε_i .

The mean payoff is a function of the entry profile by all players, and subsequent lobbying decisions by entrants, denoted as $\pi_i : (\ell_1, \dots, \ell_N | e_1, \dots, e_N) \rightarrow \mathbb{R}$. The term π_i is equal to their expected contract profits net their lobbying expenditures. I represent firm i 's contract profits as two parts: the pool of contract profits Γ , and the share s_i going to firm i . Thus profits from contracts for firm i are $\Gamma \cdot s_i$. I specify a functional form for s_i , given in equation (3.3.1), letting it be a convex combination of a "base share", denoted by s_i^0 , and the effect from lobbying, with coefficient $\lambda \in [0, 1]$. The lobbying component is modeled as a contest, in which relative lobbying efforts determine the additional shares a firm earns.¹⁴ Lobbying expenditures map into non-negative effective influence over the share with a lobbying effectiveness parameter β_i and a returns to scale parameter α , where $\beta_h > 0 \forall h \in \mathcal{I}$ and $\alpha \in (0, 1]$; they are exogenously given and common knowledge

$$s_i = \begin{cases} \lambda s_i^0 + \left(1 - \lambda\right) \frac{\beta_i(\ell_i)^\alpha}{\sum_{h \in \mathcal{I}} \beta_h(\ell_h)^\alpha} & \text{if } \exists h \in \mathcal{I} \text{ s.t. } \ell_h > 0 \\ s_i^0 & \text{if } \ell_h = 0 \forall h \in \mathcal{I} \end{cases} \quad (3.3.1)$$

¹⁴In the standard Tullock contest, players win or fail to win an object. In my case, players earn a share of an object; this is a proportional prize contest (Sheremeta 2018), also known as a continuous outcome contest (Hirschleifer 1989).

The base share can be interpreted as the share of contract awards a firm earns for reasons other than lobbying.¹⁵ This base share cannot be perfectly predicted as the contracting process is stochastic. I assume it is independent of the other parameters and its distribution is common knowledge. Note that if $\lambda = 1$, lobbying has no influence over the contract shares and if $\lambda = 0$, firms' relative lobbying efforts explain the entire share distribution. I assume $E[s_h^0] \geq 0 \forall h \in \mathcal{I}$.

I allow the total pool of contract profits (Γ), that the firms compete over, to be a function of lobbying as in equation (3.3.2). The base total level of appropriations is denoted with Γ^0 and γ is an influence scaling parameter; note that if $\gamma = 0$ then there is no endogenous prize aspect to the model. Both Γ^0 and γ are exogenously given and common knowledge, with $\Gamma^0 \in \mathbb{R}_+$ and $\gamma \in \mathbb{R}_+$.

$$\Gamma = \Gamma^0 + \gamma \sum_{h \in \mathcal{I}} \beta_h(\ell_h)^\alpha \quad (3.3.2)$$

Given this setup, lobbying can indirectly help other firms. If firms lobby to increase Γ , the non-lobbying firms in that sector could see an increase in their own contracts as the lobbying firm may not be able to guarantee each new contract dollar generated by lobbying goes directly to them. Note that when a firm decides not to lobby, they still receive their expected base share and the influence on the total pool from others' lobbying efforts. Firm i 's expected contract profits net lobbying costs is given below in equation (3.3.3); this expression is constructed by multiplying equation (3.3.1) by (3.3.2), taking an expectation, and subtracting off the lobbying expenses:

$$\pi_i = \begin{cases} (\Gamma^0 + \gamma \sum_{h \in \mathcal{I}} \beta_h(\ell_h)^\alpha) \left(\lambda E[s_i^0] + \left(1 - \lambda\right) \frac{\beta_i(\ell_i)^\alpha}{\sum_{h \in \mathcal{I}} \beta_h(\ell_h)^\alpha} \right) - \ell_i - Fe_i & \text{if } \exists h \in \mathcal{I} \text{ s.t. } \ell_h > 0 \\ \Gamma^0 E[s_i^0] - Fe_i & \text{if } \ell_h = 0 \forall h \in \mathcal{I} \end{cases} \quad (3.3.3)$$

The firm's interim expected payoff for a given entry decision conditional on their private in-

¹⁵This non-zero payoff from non-entry is similar to the share-rule collective contest from Nitzan (1991) and Balart, Chowdhury, and Troumpounis (2017). Alternative ways of incorporating share rules are considered in Amegashie (2006), Nitzan and Ueda (2014), and Kang (2016).

formation is denoted with U_i and given in equation (3.3.4). The summation is across all 2^{N-1} combinations of opponent decisions e_{-i} ; the term $p_j(e_{-i})$ is the belief by player i in the probability of player j choosing e_j from the decision profile e_{-i} .

$$U_i(\ell_1, \dots, \ell_N, e_1, \dots, e_N, p_{-i}) = \sum_{e_{-i} \in \{0,1\}^{2N-1}} \pi_i(\ell_1, \dots, \ell_N | e_1, \dots, e_N) \prod_{j \neq i} p_j(e_{-i}) + \varepsilon_i \cdot e_i \quad (3.3.4)$$

Define Ω as the set of states of nature and let $p_{i,j}$ be the belief of player i about the probability that player j will choose $e_j = 1$. Then define the game $G = (\mathcal{I}, \Omega, (e_i, \ell_i)_{\forall i \in \mathcal{I}}, (\varepsilon_i)_{\forall i \in \mathcal{I}}, (\pi_i)_{\forall i \in \mathcal{I}}, (p_{i,j})_{\forall i,j \in \mathcal{I}})$. The proposition below is provided given the set of commonly known objects $\{\Gamma^0, \gamma, \beta, \alpha, E[s_0], \lambda, F\}$ and distribution for the private information $\varepsilon_i \sim \text{Logistic}(0, \sigma) \forall i$.

Proposition 2. *There exists a pure strategy Perfect Bayesian Nash equilibrium in cutoff strategies for game G , and, if σ is sufficiently large, the equilibrium is unique.*

See proof in Appendix A. As shown in the proof, regardless of σ , for a given participation profile vector $(e_1, \dots, e_N)$, the 2nd stage continuation game at any given information set has a unique pure strategy Nash equilibrium.

3.4 Identification and Estimation

In an ideal experiment, one would randomly assign lobbying entry and expenditures to firms across sectors and years. However even in this scenario, estimating the average treatment effect of lobbying on contracts is confounded by the spillover effects from both the rent-seeking contest and the positive externality of the endogenous prize. To remedy this, I utilize the model to map out this strategic interaction. Thus random assignment of treatment aids only in dealing with unobserved heterogeneity that creates nonrandom selection into lobbying. In the absence of the experimental setup, as is the case with this observed lobbying dataset, I solve the model to construct the conditional expectation functions of equilibrium endogenous variables and utilize a rich covariate set to soak up confounding unobserved heterogeneity.

There are two important ways in which I leverage the model. As described in de Figueiredo and Silverman (2006), one aspect of the endogeneity of lobbying in the context of contracts is that firms may lobby more when they expect to receive contracts. This is incorporated in the model by allowing the lobbying decision to be a function of these unknowns, such as the base share and base contracts pool without lobbying, s_i^0 and Γ^0 respectively. In other words, I explicitly allow lobbying to be correlated with these parameterized unknowns by estimating the lobbying decision as a dependent variable. The key assumption is that the parametrizations used for these objects are sufficient to explain the relevant lobbying decision.

Also, previous articles on lobbying do not focus on decomposing the two effects illustrated in the model here. As already noted, a firm's profit can be decomposed into two parts: the pool of contracts available Γ and the share of that pool the firm wins s_i . Their product minus costs gives you the observed profit for the firm π_i . Key to identification is this separability between shares, which are bounded between 0 and 1 and firm sector specific, and the pie size, which is just a total per sector. This separability allows one to utilize the two sets of variation. A univariate regression using just contract dollars per firm per sector, meaning $\Gamma \cdot s_i$, is insufficient.

To further illustrate this point, consider a simplified model without an endogenous prize, meaning the effect of lobbying on the contracts pool $\gamma = 0$. Then the main object to estimate would be the share contest parameters. As Kang (2016) showed, if one can predict the valuation with exogenously given observables, then knowing the exact valuation is unnecessary and the “exogenous-prize” contest can be estimated with just moments based on the contest and lobbying. However, once I estimate the endogenous prize, the exact valuation is a function of two unobserved components. The first is the base level prize Γ^0 and the second is the lobbying effect with $\gamma \geq 0$. Knowing the exact value of the combined object, meaning total contracts Γ , is necessary for the additional identifying variation. Key to separate identification of γ is that we restrict Γ^0 to be some function of a common set of parameters and allow for year-sector variation through observables and exogenous unobserved heterogeneity.

Without parameterization, it is also clearly necessary that γ is constant across all sector-years; it

represents a homogeneous treatment effect, with heterogeneity being generated by heterogeneous firm lobbying ℓ_i and lobbying effectiveness β_i . Now in addition to variation in contracts Γ , we have another equation relating observed lobbying ℓ_i to the prediction from the model ℓ_i^* . Thus we can identify the ℓ_i^* function off lobbying variation then plug it into the contract equation to identify the intercept and slope terms, Γ^0 and γ respectively. The cross-equation restriction of the parameters being in both sets of equations necessitates estimating these jointly.

The data structure also informs the identification as the number of potential entrants affects which parameters can be identified. In sectors without any potential entrants, we have only firms that never lobby. In the data these firms still receive contracts, meaning their sectors get appropriations, and are thus helpful in providing more variation to identify Γ^0 and s_i^0 . A non-trivial number of sectors have only one potential entrant in them; this is a function of highly specialized sectors with entrenched incumbents. Those firms still lobby for the endogenous prize as they attempt to increase the size of their sector. This variation is useful to identify γ as the linkage between lobbying and the contract pie is clear. 2,321 of the 5,346 sectors have a single potential entrant and as Figure 3.A.6 indicates, they are similar in characteristics to larger sectors.

However we still must assume that in sectors with at least 2 potential entrants, the same lobbying dollar affects both the pie and the share (meaning the same ℓ_i affects s_i and Γ). If untrue, meaning lobbying dollars are differentially allocated towards the share or the pie, this assumption likely causes downward bias in the estimated effect of lobbying on contracts as it over-estimates how much lobbying goes into each channel. The parameters γ and β_i can be identified only in sectors with at least 1 potential entrant.¹⁶ Between sector variation in how much s_i^0 predicts shares identifies λ (the extent to which lobbying affects shares), and requires at least 2 potential entrants.

It is also useful to discuss how different parameter values show up in the data. First, consider the lobbying effectiveness over the size of the pie parameter γ . If $\gamma = 0$, then aggregate lobbying of firms in that sector has no effect on the size of the pie. If we assume that the same lobbying

¹⁶Note that if we allowed for β_i to be different in the endogenous prize and rent-seeking parts of the payoff function, then the β_i associated with the latter part could be identified only in sectors with at least 2 potential entrants; this functional form restriction thus reduces the data requirements.

dollar goes for the share and the pie, then the variation to identify γ is straightforward: extract the variation in the contract pie size due to exogenous variation in aggregate lobbying. Higher total lobbying conditional on Γ^0 leads to higher γ if the sector pie increases.

Next consider the base share of contracts s_i^0 and the convex combination parameter λ that determines the extent to which lobbying affects shares. If $s_i^0 = 0$, then for that firm, they receive nothing if they do not lobby. This is separate from $\lambda = 1$ because that affects all the firms in the sector. Now if $s_i^0 = 1$, then that firm gets the entirety of the λ share of contracts; those who did not lobby get nothing and those who did lobby still fight over the $1 - \lambda$ share. So if a firm with zero lobbying receives a high share then that would imply high s_i^0 or λ . But those two are separated by looking at firms within one sector (two non-lobbying firms with differential shares) and then across sectors (since λ affects everyone in that sector).

If $\lambda = 0$, then all the weight goes to lobbying; in this case those with zero lobbying expenditures would see zero shares. If $\lambda = 1$, then all weight goes towards base share and lobbying has no effect. This affects all firms within a given sector the same. Note however, if lobbying was correlated with the base share, then even if $\lambda = 1$, we would observe those who entered getting larger shares. Recall that I explicitly allow lobbying to be a function of the base share through the model because lobbying is a dependent variable. This additional equation aids in identification beyond what a basic reduced form equation of shares on lobbying is able to identify.

Finally, suppose the lobbying effectiveness over share parameter $\beta_i = 0$. The parameter β_i affects how much of the $1 - \lambda$ share firm i 's lobbying affects. If firm i has $\beta_i = 0$ and the others have $\beta_j > 0$, then firm i 's lobbying would have no effect while the others' would. Higher individual lobbying conditional on s_i^0 leads to higher β_i if shares go up and this varies at the firm level. To separate β_i from λ we simply need firm variation in β_i . If everyone has $\beta_i = 0$, then their lobbying has no effect on the $1 - \lambda$ share and we would expect infinitesimal levels of lobbying. In the data we would see that among entrants, differential levels of lobbying intensity have no effect over the share. However they still receive the $1 - \lambda$ share, and it simply is distributed evenly across those who entered; thus we would see higher shares for the entrants relative to non-entrants.

However any nonzero lobbying is inconsistent with $\beta_i = 0$.

Parameterization

The model described in the model section is played once in every sector $k = 1, \dots, K$ and in each year $t = 1, \dots, T$, however not every firm is present in each sector and not every sector is present in each year; I let $\mathcal{I}_{kt}$ be the set of firms in sector k and year t and $\mathcal{K}_{it}$ be the set of sectors in year t in which firm i operates. Let $N_{kt} \equiv \dim\{\mathcal{I}_{kt}\}$ and let 1_{kt} refer to the first indexed firm from $\mathcal{I}_{kt}$. The exogenously given model parameters for each sector-year combination present in the data are: $\{\Gamma^0, \gamma, \beta, \alpha, E[s_0], \lambda, F, \sigma\}_{k,t}$. Given the large number of parameters, I must reduce the dimensionality of the parameter space for estimation. I do this by approximating F from the data, normalizing σ , making α and γ homogeneous across firms-sector-years, and making each parameter vector in $\{\Gamma^0, \beta, E[s_0], \lambda\}_{k,t}$ a function of data and coefficients.

As noted in Kang (2016), one can identify the upper bound of a homogeneous entry fee by looking at the expenditures of a firm that enters one sector.¹⁷ I decompose the entry cost into an observed and unobserved part: $F_{kt} = \tilde{F}_t + \check{F}_{kt}$. I let the common aspect of the entry fee $\tilde{F}_t$ be the minimum observed lobbying expenditure across all firms per year. The minimum $\tilde{F}_t$ is about \$5,000 and the average is about \$11,000. I follow Seim (2006) in adding unobserved sector level heterogeneity $\check{F}_{kt}$. Thus the overall cost affecting entry is $F_{kt} + \varepsilon_{ikt}$. The observed data combine their optimal spending plus the observed part of the entry fee $\tilde{F}_t$. The latter term ε_{ikt} includes unobserved heterogeneous privately known costs and benefits.

The approach I use to model $\check{F}_{kt}$ is motivated by Seim (2006): she has an unobserved sector level variable and fixes it to equate the observed number of entrants and the model equilibrium number of entrants. Her framework allows for a closed form expression for it, whereas mine does not, and numerically solving it would require an additional layer of fixed points. I let $\check{F}_{kt} \equiv [(\Xi/N_{kt}) \sum (e_{ikt}^*(F_{kt} = \tilde{F}_t) - e_{ikt}^{obs})]$, where $e_{ikt}^*(F_{kt} = \tilde{F}_t)$ is equilibrium entry when

¹⁷The intuition is that if a firm spent zero beyond the entry fee, then their observed lobbying would be the entry fee. Since firms likely spend beyond the entry fee, the smallest observed expenditure is an upper bound for the entry fee.

the unobserved cost is set to zero, e_{ikt}^{obs} is observed entry, and $\Xi \geq 0$. This approach is a middle ground, in terms of fitting the data, between picking an arbitrary number and exactly solving for it.

The parameter α , which defines the returns to scale of lobbying, is assumed to be in the range $(0, 1]$. This concavity assumption is needed for a unique equilibrium and the homogeneity assumption is not stringent given the heterogeneity I allow in β . The presence of the endogenous prize parameter, γ , is assumed to be nonnegative, which again is needed for uniqueness. While γ is homogeneous for the sake of simplicity, I allow for sector-year level variation in Γ^0 . I also let $\sigma = 1$ and scale the units into millions of dollars. The lower bound on σ sufficient for uniqueness can be calculated and on average is 0.05; this lower bound can be checked during each iteration of the estimation routine to ensure uniqueness is not violated. I restrict the firm's lobbying effectiveness coefficient β to vary at the firm-year level as a function of variables $\mathbf{Z}_{it}$. Let $\mathbf{Z}_{it} = [FC_{it}, \ln(1+LL_{it}), CC_t \forall t]$, where FC_{it} is whether the firm employs a former congressperson as a lobbyist that year, $LL_{it} \equiv \sum_{j=1}^3 \ell_{i,t-j}$ is the amount the firm lobbied in the previous 3 years, and $CC_t \forall t$ are Congressional session fixed effects. Then we have $\beta_{it} = \exp(\mathbf{Z}_{it}\boldsymbol{\zeta})$.¹⁸

I let the unobservable base share of appropriations s_{ikt}^0 be a ratio of firm characteristics $\mathbf{X}_{ikt}$, time and sector invariant firm heterogeneity c_i , and a stochastic unobservable scalar element $\xi_{ikt} \sim \mathcal{N}(0, \sigma_\xi^2)$. Estimating many individual firm dummies is too computationally demanding (see appendix for details); as an alternative, I follow Wooldridge (2010) in utilizing the Mundlak (1978) (correlated random effects) approach to partially specify the distribution of the firm-specific time-invariant heterogeneity as a function of the time averaged covariates: $c_i = \bar{\mathbf{X}}_i \boldsymbol{\delta}_2$.¹⁹

I let $\mathbf{X}_{ikt} = [s_{ik,t-1}, DC_{it}]$, such that $s_{ik,t-1}$ is the firm's share of contract winnings from the

¹⁸I omit a constant in $\mathbf{Z}_{it}$ because it drops out in the share contest and is not meaningfully different (separately identified) from γ in the endogenous prize equation. Attributing differences in outcomes to FC is difficult because of unobservables. Due to this, I cannot credibly run a counterfactual on the revolving door effect by testing whether a ban on FC from lobbying would have an effect on contracts. Also note that the costs associated with FC are incorporated into the parameter as it can be thought of as the net added effectiveness.

¹⁹In linear models, the parameters on the time-varying covariates are equivalent between FE and CRE via Chamberlain or Mundlak (the variation soaked up by the individual intercepts is the same as that soaked up by the firm varying time-averages of each variable). However there is no general equivalence result for nonlinear models. In nonlinear models, estimating the individual fixed effects is not only computationally burdensome, but may also suffer from the incidental parameters problem. The correlated random effects model with Mundlak does not suffer from this problem.

previous year in that sector and DC is whether the firm has major production or headquarters in the D.C. metropolitan area. The latter's inclusion is motivated by Taylor's (2018) observation that there is a trend towards D.C. based contractors due to proximity benefits.

$$s_{ikt}^0 = \frac{\exp(\mathbf{X}_{ikt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_i\boldsymbol{\delta}_2 + \xi_{ikt})}{\sum_{h \in \mathcal{I}_{kt}} \exp(\mathbf{X}_{hkt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_h\boldsymbol{\delta}_2 + \xi_{hkt})} \quad (3.4.1)$$

I parametrize the sector level convex combination parameter λ_{kt} , that determines the extent to which a given sector is sensitive to lobbying influence, to be a function of sector level characteristics: $\lambda_{kt} = \Phi(\mathbf{Y}_{kt}\boldsymbol{\eta}_1 + \bar{\mathbf{Y}}_k\boldsymbol{\eta}_2)$, in which Φ is the cumulative density function for the univariate standard normal distribution. I let $\mathbf{Y}_{kt} = [1, CM_{kt}, \ln(N_{kt})]$, such that CM_{kt} is the lagged competitiveness measure and N_{kt} is the number of potential entrants for that sector. I control for sector heterogeneity using the Mundlak approach by adding in the sector-level averages for the covariates. Substituting equation (3.4.1) into the overall share function yields equation (3.4.2) below, which pins down shares as a function of controls and lobbying.

$$s_{ikt} = \begin{cases} \Phi(\mathbf{Y}_{kt}\boldsymbol{\eta}_1 + \bar{\mathbf{Y}}_k\boldsymbol{\eta}_2) \frac{\exp(\mathbf{X}_{ikt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_i\boldsymbol{\delta}_2 + \xi_{ikt})}{\sum_{h \in \mathcal{I}_{kt}} \exp(\mathbf{X}_{hkt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_h\boldsymbol{\delta}_2 + \xi_{hkt})} + \\ (1 - \Phi(\mathbf{Y}_{kt}\boldsymbol{\eta}_1 + \bar{\mathbf{Y}}_k\boldsymbol{\eta}_2)) \frac{\exp(\mathbf{Z}_{it}\boldsymbol{\zeta})(\ell_{ikt})^\alpha}{\sum_{h \in \mathcal{I}_{kt}} \exp(\mathbf{Z}_{ht}\boldsymbol{\zeta})(\ell_{hkt})^\alpha} \text{ if } \sum_{h \in \mathcal{I}_{kt}} \ell_{hkt} > 0 \\ \frac{\exp(\mathbf{X}_{ikt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_i\boldsymbol{\delta}_2 + \xi_{ikt})}{\sum_{h \in \mathcal{I}_{kt}} \exp(\mathbf{X}_{hkt}\boldsymbol{\delta}_1 + \bar{\mathbf{X}}_h\boldsymbol{\delta}_2 + \xi_{hkt})} \text{ if } \sum_{h \in \mathcal{I}_{kt}} \ell_{hkt} = 0 \end{cases} \quad (3.4.2)$$

Finally, I let the base pool of contracts $\Gamma_{kt}^0 = \max(\mathbf{G}_{kt}\boldsymbol{\mu}_1 + \bar{\mathbf{G}}_t\boldsymbol{\mu}_2 + g_{kt}, 0)$, where $g_{kt} \sim N(0, \sigma_g^2)$ is unobserved heterogeneity and $\mathbf{G}_{kt} = [1, \Gamma_{k,t-1}, DD_{kt}]$. The term $\Gamma_{k,t-1}$ is the total pool of contracts in sector k in the previous year and DD_{kt} is a dummy of whether the contracts are solicited by the Department of Defense. The inclusion of $\bar{\mathbf{G}}_t$ is to control for year level variation across all sectors. Then one can write out the total contract pool size for a given sector, as in

(3.4.3), which pins down the pool of contracts as a function of controls and lobbying.

$$\Gamma_{kt} = \max(\mathbf{G}_{kt}\boldsymbol{\mu}_1 + \bar{\mathbf{G}}_t\boldsymbol{\mu}_2 + g_{kt}, 0) + \gamma \sum_{h \in \mathcal{I}_{kt}} \exp(\mathbf{Z}_{ht}\boldsymbol{\zeta})(\ell_{hkt})^\alpha \quad (3.4.3)$$

To close, recall that I assume all firms are maximizing static (per period) profits when making their entry and lobbying decisions. This approach is not uncommon in the empirical lobbying literature (de Figueiredo and Silverman 2006, Kang 2016, Huneeus and Kim 2018).²⁰ Note however, that I also use lagged outcome variables as controls. The assumption of non-forward looking firms is also not uncommon in static models that utilize variables in estimation that are functions of lagged choice variables, like market presence (Toivanen and Waterson 2005; Ciliberto and Tamer 2009; Berry and Jia 2010). Relaxing this assumption, especially given the aggregate nature of the lobbying data, would complicate the setup and distract from this paper's focus.

Estimating Equations

I estimate the scale parameters γ and α , the coefficient parameters $\boldsymbol{\zeta}$, $\boldsymbol{\delta} = [\delta_1; \delta_2]$, $\boldsymbol{\eta} = [\eta_1; \eta_2]$, and $\boldsymbol{\mu} = [\mu_1; \mu_2]$, the distribution parameters σ_ξ and σ_g , and the adjustment parameter Ξ . The observed variables for a given firm i in sector k and year t include Γ_{kt} , $\mathbf{G}_{kt}$, s_{ikt} , $\mathbf{Z}_{it}$, $\mathbf{X}_{ikt}$, $\mathbf{Y}_{kt}$, $\ell_{it} \equiv \sum_{\mathcal{K}_{it}} (\ell_{ikt} + \tilde{F}_t \cdot \sum_{\mathcal{K}_{it}} e_{ikt})$, e_{ikt} , and F_{kt} . The observed contracts are revenues and the model is in terms of profits. Individual profit margins are not available, so I assume a constant profit margin for the firms in the sample of 10%, which I base on a survey of contractors (Grant Thornton 2015) and the maximum allowable profit margins [on certain types of contracts] (FAR 15.404-4 2005).²¹ In the absence of lobbying, the equations for s_{ikt} and Γ_{kt} above would be sufficient to identify the base-level parameters, but due to lobbying expenditures being present in those equations and being unobserved at the sector level, one needs to solve the model for

²⁰The dynamic lobbying model of Kerr et al. (2014) abstracts away from strategic interaction and thus following their approach is not appropriate in my setting.

²¹Arnold et al. (2008) found little variation in profit margins across contract types (fixed price, incentive based, etc). Whereas I do not differentiate between the types, some articles have (Kang and Miller 2017; Flammer 2018).

equilibrium lobbying.

I generate the reduced form estimating equations by solving the game for each sector through backward induction and then integrating out unobservables. Now consider an arbitrary entry profile $\mathbf{e}_{kt} = (e_{1_{kt},kt}, \dots, e_{N_{kt},kt})$ in which player i enters. Then player i 's program for optimal lobbying given that entry profile is given in equation (3.4.4) leading to the first order condition (3.4.5) and the implied optimal function (3.4.6) (which is well-defined given the unique second stage):

$$\max_{\ell_i} \pi_{ikt}(\ell_{1_{kt},kt}, \dots, \ell_{N_{kt},kt} | \mathbf{e}_{kt}) \quad (3.4.4)$$

$$\frac{\partial \pi_{ikt}}{\partial \ell_{ikt}}(\ell_{1_{kt},kt}^*, \dots, \ell_{N_{kt},kt}^* | \mathbf{e}_{kt}) = 0 \quad \forall i \in \mathcal{I}_{kt} \quad (3.4.5)$$

$$\ell_{ikt}^* = \ell_{ikt}^*(g_{kt}, \mathbf{G}_{kt}, \mathbf{Y}_{kt}, (\mathbf{Z}_{it})_{\forall i \in \mathcal{I}_{kt}}, (\mathbf{X}_{ikt})_{\forall i \in \mathcal{I}_{kt}}; \gamma, \alpha, \boldsymbol{\mu}, \boldsymbol{\zeta}, \boldsymbol{\delta}, \boldsymbol{\eta}, \sigma_\xi | \mathbf{e}_{kt}) \quad (3.4.6)$$

I solve the program above $2^{N_{kt}}$ times for a given sector-year, then substitute the optimal π_{ikt}^* into the expected utility function (3.4.7), which, given utility maximization with uncertainty over opponents' ε_{kt} , leads to the system of conditional choice probabilities that defines equilibrium beliefs (3.4.8), where $u_{ikt}(e_{ikt}, p_{-i,kt}) \equiv U_{ikt} - \varepsilon_{ikt} \cdot e_{ikt}$.

$$U_{ikt}(e_{ikt}, p_{-i,kt}) = \sum_{e_{-i,kt} \in \{0,1\}^{2N_{kt}-1}} \pi_{ikt}^*(\mathbf{e}_{kt}) \prod_{j \neq i} p_{jkt}^*(e_{-i,kt}) + \varepsilon_{ikt} \cdot e_{ikt} \quad (3.4.7)$$

$$p_{ikt}^* = \frac{1}{1 + \exp((u_{ikt}(0, p_{-i,kt}) - u_{ikt}(1, p_{-i,kt}))/\sigma)} \equiv f_{ikt}(p_{-i,kt}) \quad \forall i \in \mathcal{I}_{kt} \quad (3.4.8)$$

I then solve this system for the equilibrium beliefs (3.4.9) with σ , the scale parameter for the

distribution of ε_{ikt} , known.

$$\mathbf{p}_{kt}^* = \mathbf{p}_{kt}^*(g_{kt}, \mathbf{G}_{kt}, \mathbf{Y}_{kt}, (\mathbf{Z}_{it})_{\forall i \in \mathcal{I}_{kt}}, (\mathbf{X}_{ikt})_{\forall i \in \mathcal{I}_{kt}}, F_{kt}; \gamma, \alpha, \boldsymbol{\mu}, \boldsymbol{\zeta}, \boldsymbol{\delta}, \boldsymbol{\eta}, \sigma_\xi) \quad (3.4.9)$$

Using these equilibrium probabilities, one can find the expected equilibrium lobbying expenditures (3.4.10) conditional on the econometric unobservable g_{kt} and all controls $\mathbf{D}_{kt} \equiv \{\mathbf{G}_{kt}, \mathbf{Y}_{kt}, (\mathbf{Z}_{it})_{\forall i \in \mathcal{I}_{kt}}, (\mathbf{X}_{ikt})_{\forall i \in \mathcal{I}_{kt}}, F_{kt}\}$:

$$\begin{aligned} E[\ell_{ikt}^* | g_{kt}, \mathbf{D}_{kt}] = & \sum_{e_{-i,kt} \in \{0,1\}^{2N_{kt}-1}} \ell_{ikt}^*(\cdot | e_{ikt} = 1, e_{-i,kt}) \prod_{j \neq i} p_{jkt}^*(e_{-i,kt}) \cdot p_{ikt}^* + \\ & \sum_{e_{-i,kt} \in \{0,1\}^{2N_{kt}-1}} \ell_{ikt}^*(\cdot | e_{ikt} = 0, e_{-i,kt}) \prod_{j \neq i} p_{jkt}^*(e_{-i,kt}) \cdot (1 - p_{ikt}^*) \end{aligned} \quad (3.4.10)$$

Then finally integrate out g_{kt} to generate the expected lobbying expenditures (3.4.11). Similar expressions can be generated for entry, shares, and the total pool of contracts.

$$E[\ell_{ikt}^* | \mathbf{D}_{kt}] = l_{ikt}(\mathbf{D}_{kt}; \gamma, \alpha, \boldsymbol{\mu}, \boldsymbol{\zeta}, \boldsymbol{\delta}, \boldsymbol{\eta}, \sigma_\xi, \sigma_g) \quad (3.4.11)$$

To generate estimating equations I decompose the conditional expectations to write $s_{ikt} = E[s_{ikt} | \mathbf{D}_{kt}] + \nu_{ikt}$, where ν_{ikt} is a reduced form error term with the property $E[\nu_{ikt} | \mathbf{D}_{kt}] = 0$. One can similarly construct these for total spending in a given sector. These two sets of equations define how the contract outcome data are used in estimation, given in equations (3.4.12) and (3.4.13).

$$s_{ikt} = E[s_{ikt}^* | \mathbf{D}_{kt}] + \nu_{ikt} \quad (3.4.12)$$

$$\Gamma_{kt} = E[\Gamma_{kt}^* | \mathbf{D}_{kt}] + v_{kt} \quad (3.4.13)$$

I utilize the total lobbying expenditures across sectors (as in Kang (2016)), and construct the

estimating equation by summing equilibrium lobbying up to the firm-year level as in equation (3.4.14). Finally I use the observed lobbying entry decisions and compare them to the equilibrium entry probabilities: by calculating equation (3.4.10) for entry, one can see that the expected entry $E[e_{ikt}^*|g_{kt}, \mathbf{D}_{kt}] = p_{ikt}^*$.

$$\ell_{it} = \sum_{\mathcal{K}_{it}} \left(E \left[\ell_{ikt}^* + \tilde{F}_t \cdot e_{ikt}^* | \mathbf{D}_{kt} \right] \right) + w_{it} \quad (3.4.14)$$

$$e_{ikt} = E[p_{ikt}^* | \mathbf{D}_{kt}] + \omega_{ikt} \quad (3.4.15)$$

These are valid reduced form equations as the model generates a single prediction conditional on $\mathbf{D}$ and firms take $\mathbf{D}$ as given when making the lobbying decision. Key assumptions are that the observed data are in equilibrium, that ξ and g are independent of $\mathbf{D}$ and each other, and that both are i.i.d with known distributions (up to scale). The unobserved noise ξ captures the unpredictable aspects of the contract environment that are unrelated to the firm's characteristics. The unobserved heterogeneity g is the unexplained part of the base level of appropriations that is uncorrelated with the observables used to predict the base level.

The unique equilibrium is important as, if multiple existed, the equilibrium predictions would be correspondences and the estimating equations would not be valid. Methods robust to multiple equilibria (Bajari, Hong, Krainer, and Nekipelov 2010; Pakes, Porter, Ho, and Ishii 2015; Gordon and Hartmann 2016) are not readily usable here as, among other reasons, they require one to plug in observed choices into the model and I do not observe the lobbying expenditure per sector.

Estimation Method

The estimation is based on solving the equilibrium to construct the objective function (Bresnahan and Reiss 1991B; Laffont, Ossard, and Vuong 1995; Smith 2004; Seim 2006; Kang 2016).²² Let $\Theta \equiv \{\gamma, \alpha, \mu, \zeta, \delta, \eta, \sigma_\xi, \sigma_g, \Xi\}$. A candidate estimator is a simulated multivariate nonlinear least

²²See Strömberg (2008), Gordon and Hartmann (2016), and He and Huang (2017) for different approaches to estimating political contests.

squares estimator (Berry 1992; Taylor, Peel, and Sarno 2001; Wooldridge 2010), with the scalar objective function Q_K given in equation (3.4.16). Let $\hat{E}[s_{ikt}^*|\mathbf{D}_{kt}]$ be an unbiased simulator of $E[s_{ikt}^*|\mathbf{D}_{kt}]$ with similar notation for the others. The sectors are denoted with $k = \{1, \dots, K\}$. The fixed number of firms and years are denoted with $i = \{1, \dots, N\}$ and $t = \{1, \dots, T\}$ respectively.

I average the squared difference between the dependent variables $\mathbf{y}_{ikt} \equiv [s_{ikt}, \Gamma_{kt}, \ell_{it}, e_{ikt}, \bar{\ell}]'$ and their simulated conditional expectation counterparts $\mathbf{m}_{ikt}(\mathbf{D}_{kt}; \Theta) \equiv [\hat{E}[s_{ikt}^*|\mathbf{D}_{kt}], \hat{E}[\Gamma_{kt}^*|\mathbf{D}_{kt}], \sum_{k=1}^K \hat{E}[\ell_{ikt}^* + \tilde{F}_t \cdot e_{ikt}^*|\mathbf{D}_{kt}], \hat{E}[p_{ikt}^*|\mathbf{D}_{kt}], \hat{E}[\bar{\ell}^*|\mathbf{D}_{kt}]]'$, and subtract off a correction term; for any fixed number of simulation draws R , simulated nonlinear least squares is biased and must be adjusted with a simulation variance term (Laffont et al. 1995; Gourieroux & Monfort 1996). Let $\mathbf{y}_{iktr}^* = [s_{iktr}^*, \Gamma_{ktr}^*, \sum_{k=1}^K \ell_{iktr}^*, p_{iktr}^*, \bar{\ell}^*]$ be the vector of model predicted outcomes for a given simulation draw r .²³ The correction term is very small in magnitude in this case. The addition of the squared difference in mean lobbying is similar to adding a constant for fit.

$$Q_K = \frac{1}{NKT} \sum_{t=1}^T \sum_{k=1}^K \sum_{i=1}^N [\mathbf{y}_{ikt} - \mathbf{m}_{ikt}(\mathbf{D}; \Theta)]' [\mathbf{y}_{ikt} - \mathbf{m}_{ikt}(\mathbf{D}; \Theta)] - \frac{1}{NKTR(R-1)} \sum_{t=1}^T \sum_{k=1}^K \sum_{i=1}^N \sum_{r=1}^R [\mathbf{y}_{iktr}^* - \mathbf{m}_{ikt}(\mathbf{D}; \Theta)]' [\mathbf{y}_{iktr}^* - \mathbf{m}_{ikt}(\mathbf{D}; \Theta)] \quad (3.4.16)$$

As $K \rightarrow \infty$, each sector level difference is minimized at the true parameter value and the aggregate lobbying term goes to zero. Then under standard NLS regularity conditions (Wooldridge 2010), this proposed estimator is consistent for Θ_0 , and with similar conditions from proposition 2 in Laffont et al. (1995), this estimator should be asymptotically normal. The identifying moments are $E[\nabla_{\Theta} \mathbf{m}_{ikt}(\mathbf{D}; \Theta)(\mathbf{y}_{ikt} - \mathbf{m}_{ikt}(\mathbf{D}; \Theta))]$, which are sufficient for consistent estimation.

²³I numerically solve for the Nash equilibrium and simulate all integrals using a Monte Carlo. See Appendix 3.6 for a discussion of the computational methods. I scale each set of residuals by the variance of the observed variable so their magnitudes are similar in estimation.

3.5 Parameter Estimates and Model Counterfactuals

Parameter Estimates

Table 3.A.8 shows the main parameter estimates with the corresponding 95% confidence intervals (see the additional results appendix for the Mundlak and fixed effects estimates).²⁴ Recall the endogenous prize parameter γ ; this is the “slope” in the expression $\Gamma = \Gamma^0 + \gamma \sum_{h \in \mathcal{I}} \beta_h (\ell_h)^\alpha$. This parameter explains how aggregate lobbying in a sector affects the amount of contract spending Γ in that sector. The estimated endogenous prize parameter γ is 2.885 million [2.8360, 3.303]. It is precisely positive, indicating that the aggregate lobbying in a given sector has some positive effect on total contract spending; I discuss the magnitude of this effect in the counterfactual section.²⁵ To allow for heterogeneity in the “intercept” term Γ_0 from the equation above, I let it be a function of observables and parameters. This parameter vector μ includes the coefficients on the constant, lagged sector pool sizes, and the defense sector dummy; the lagged sector allocation is most predictive of the base level pool of contracts Γ_0 .

The returns to scale for lobbying parameter is α and indicates how nonlinear the benefits are for increasing lobbying expenditures. The estimate on α demonstrates significant downward scaling of lobbying expenditures with a coefficient of 0.106 [0.053, 0.121]; this indicates that the relative differences in magnitudes of lobbying do not drive the contest distribution, but rather the existence of any lobbying. In particular, perhaps simply “being at the table” in terms of lobbying is more important than making sure one spends the most. The recipients of the lobbying influence, namely the politicians, may have difficulty measuring granular differences in lobbying effort and respond more strongly to the presence of any lobbying. This may help explain the lack of significant expenditures in lobbying; going beyond a certain amount does not net one larger returns.

²⁴All confidence intervals use percentile-bootstrapping with 100 samples (and thus technically the CIs are 96%), 100 simulation draw for ξ , and 25 draws for g ; the computational burden limited the numbers. As a robustness check I use quadrature integration over g on manageable subsets of the data (2010-2012) and the results are similar.

²⁵Recall I have a constraint of $\gamma \geq 0$. Testing $\gamma = 0$ is not straightforward because regular hypothesis testing is not valid when the null value is on the boundary (see Andrews (2001) for a discussion). However a trivially small positive γ is sufficient as a null hypothesis for whether the endogenous prize is “economically” significant.

Many articles simply use variation in the binary variable (whether or not the firm lobbied on a bill) to measure lobbying exposure. These papers often find significant effects on policy outcomes. Since this ignores lobbying intensity per firm and considers only the aggregate effect of how many firms lobbied, I believe the evidence in this chapter supports the notion that after a certain point, the marginal dollar is ineffective, and merely participating has the largest effect.²⁶ The puzzle on why many firms do not participate is still present and high entry costs may help explain the phenomena.

Next, recall the parameter β , which allows for heterogeneity in lobbying effectiveness. The parameter vector ζ includes the coefficients on lagged lobbying and FC alongside the Congressional session fixed effects; these translate into an average β_{it} of 2.315 [1.691, 6.154] with significant variation across firms. The parameter vector δ includes the coefficient on lagged shares and DC . The lagged share coefficient soaks up heterogeneity and is not surprising as past performance likely can affect contract outcomes (Decoralis, Pacini, and Spagnolo 2016).

Finally, recall the share of contracts when at least one entrant: $s_i = \lambda s_i^0 + (1-\lambda) \frac{\beta_i(\ell_i)^\alpha}{\sum_{h \in \mathcal{I}} \beta_h(\ell_h)^\alpha}$. The parameter vector η allows for heterogeneity in λ , and this helps explain the extent to which a sector is affected by lobbying. The parameter vector η includes the coefficient on the constant, CM , and the number of potential entrants. The latter two are noisy, which is likely due to the inclusion of their time-averages as covariates. The mean λ_{kt} is 0.969 [0.881, 0.989], indicating that on average, 3.1% of the contract distribution is explained by lobbying. In the whole sample, 73% of the sectors have $\lambda_{kt} < 0.99$, meaning that lobbying has some explaining power for the majority of sectors in the data. The sectors with many firms have significantly higher λ indicating that competition may reduce the benefits to lobbying beyond the rent-seeking contest part. See the counterfactual section for estimation on the magnitude of the rent-seeking lobbying effect.

²⁶This result is in alignment with my model as it has a discontinuity: if a firm does not lobby at all, they receive only their discounted base share $\lambda \cdot s_0$, whereas if they lobby some nonzero amount, they get the additional $1 - \lambda$ share of their relative lobbying efforts. For nonlinear effort effects, this discontinuity is stark.

Model Fit

To measure how well the model fits the data, I compare the main observed variables to their model counterparts, including firm sector shares, firm yearly lobbying, sector level total contract spending, and sector level lobbying participation. I also run out-of-sample prediction by analyzing the fit of the model for 2014 and 2015, which were omitted during estimation for this purpose.

In Table 3.A.9, I compare the lobbying expenditures between the data and the model for a variety of statistics. The average value of lobbying in the data is \$0.341 million and the average value for the model predicted (expected) lobbying is \$0.296 million with a 95% confidence interval of [0.255, 0.381]. The observed median is zero whereas the model median is 0.017 [0.011, 0.029]; this is due to the large left-tail of zeros in the data distribution; the probability distribution over participation in the model will always lead to non-zero expected lobbying.

I also consider the mean and median for the cases in which the observed lobbying expenditures are strictly positive. The positive mean in the data is \$0.748 million and \$0.619 million in the model. The positive median has an observed value of \$0.125 million and model prediction of \$0.051 million. The standard deviations for the data and model are close with values of \$1.193 million and \$1.339 million [1.124, 1.598]. The maxima for the data and model are \$14.600 million and \$17.664 [12.904, 22.653] million respectively. Finally, the correlation between observed and model lobbying expenditures is 0.689 [0.607, 0.739].

Table 3.A.10 shows the comparisons for contract shares. Mean shares are by construction going to be equal as the number of players is the same in the data and model. The medians fit very well, with 0.157 in the data and 0.187 [0.172, 0.194] for the model. The remaining statistics closely as well. Finally, the correlation between real and model predicted shares is 0.896 [0.891, 0.903]. In Table 3.A.11, I compare the sector level lobbying participation decisions and the model prediction. The mean probability of a firm entering a given sector in the data is 0.322 and 0.328 [0.268, 0.393] in the model. This close fit is partially a function of the adjustment parameter Ξ . The standard deviation in the data of 0.467 is higher than for the model with 0.387 [0.357, 0.409], indicating that there is more variation in the data. The correlation coefficient for entry is 0.885 [0.833, 0.902].

In Table 3.A.12, I compare the observed sector pool sizes (total dollar value of all contracts in that sector) and the model predicted values at the sector level. The means fit quite well with an observed average sector size of \$0.669 billion and a model prediction of \$0.667 billion per sector [0.621, 0.701]. At the yearly level, the average pool is \$258.260 billion and \$257.580 billion in the data and model respectively. The other statistics also fit quite well, including the correlation coefficient at 0.943 [0.932, 0.954]. Thus the contract level predictions, namely shares and sector pool sizes, fit the data more closely than the lobbying data based predictions. This could be related to the fact that participation is observed at the bill level and specific sector level participation is extrapolated.

Finally, I calculate the out of sample prediction for 2014-2015 using the estimated parameters. The observed mean lobbying expenditure for 2014-2015 is \$0.577 million and \$0.666 million for the model. The observed and model sector size averages are \$0.648 billion and \$0.736 billion respectively indicating a close fit. The correlations between the model and data for lobbying, shares, and sector pools are 0.645, 0.896, and 0.957 respectively.

Counterfactual Analysis

I estimate four counterfactuals: the difference in total sector contract pools with and without lobbying, the difference in contract distributions with and without lobbying, the returns to lobbying, and the effect of market concentration on lobbying. First, in Table 3.A.13, I show statistics for the effect that lobbying has on the overall sector size. I calculate this as the difference between the equilibrium total spending on contracts and the estimated base level of spending not affected by lobbying at the sector-year level (divided by the profit margin): $\Gamma_{kt} - \Gamma_{kt}^0 = \gamma \sum_{h \in \mathcal{I}_{kt}} \beta_{ht} (\ell_{hkt})^\alpha$. The average gap per sector is \$27.451 million [18.219, 54.222]. The total average difference per year, $(1/T) \sum_t \sum_k (\Gamma_{kt} - \Gamma_{kt}^0)$, is \$8.837 billion [5.777, 17.276], which is 3.22% of the total contract pool (8% [5.6%, 18.4%] at the sector-year level). This indicates that lobbying puts non-trivial upwards pressure on the appropriations budget, at least among the 1,109 firms in the sample.

There is significant heterogeneity in the endogenous pool; see Figure 3.A.7 for the distribution.

There is also variation across sectors; first, the endogenous pool is larger for defense sectors than non-defense. Second, there is also a negative correlation between the endogenous pool percentage and the degree of competitiveness. Finally, there is a natural positive correlation between the number of potential entrants and endogenous pool size, but a strong negative correlation between potential entrants and endogenous pool as a percent of the total (see Figure 3.A.8). This indicates that firms in more concentrated sectors may be more able to extract contract rents from lobbying.

To find the contract allocations in the absence of lobbying, we need to calculate $\Gamma_{ktr}^0 \cdot s_{iktr}^0$ and average over the number of simulation draws R . The average absolute change in contract profits per firm per year is \$2.170 million [1.915, 3.774] which is 5.18% of a firm's contract profits. This equates to an aggregate yearly distortion of \$1.012 billion [0.813, 1.778]. Thus lobbying has a nontrivial influence over the allocation between firms. Note however that this could still be somewhat driven by the endogenous prize. To test the influence of the pure rent-seeking contest lobbying effect, one needs to look at shares; the average absolute difference between shares with and without lobbying is 1.642% [0.345, 6.230]. This small change is a function of the small and noisily estimated λ , which determines the extent to which the base share explains the overall share.

As previously mentioned, I explicitly include firms that never lobby in the analysis. Although their contract shares are threatened by lobbying firms, the endogenous prize pool could increase their overall funding. The positive externality and competitive contest effects make the welfare implications of lobbying on non-lobbying firms ambiguous. To determine which factor dominates I compare the equilibrium contract profits for firms that never lobby when lobbying is allowed and compare it to a counterfactual scenario without any lobbying. Mean profits for the non-lobbying firms are 2.30% larger when lobbying is prohibited and median profits increase by 0.251%. These effects are small but indicate that the positive externality, meaning the benefit the firm receives from others lobbying on the size of the contract pie, dominates the rent-seeking contest for the slice. The variation in the lobbying data could also simply better explain the influence over the appropriations bill spending rather than over the between-firm distribution of contracts. This is intuitive as the link between the sector level spending and lobbying expenditures is more direct.

To estimate the returns of lobbying, I compare a firm's equilibrium profits to the counterfactual scenario of the firm committing to not entering that sector. I omit that firm from participating and re-solve for equilibrium entry probabilities for the others and run this exercise on the sectors for which I do not approximate the equilibrium functions. The results are in Table 3.A.14, and the average profit differential for entry, for those that in the data entered, is \$2.128 million [1.982, 2.862]. This is a 12.37% mean increase in profits and a 14.50 times return on the equilibrium investment. For firms that do not enter in the data, the return from changing their model equilibrium behavior to entering is on average -\$0.080 million.

There is nontrivial heterogeneity in the returns. Figure 3.A.9 shows the distribution of percent returns by entrants and Figure 3.A.10 shows the substantial variation in the returns across years. The average percent return for entrants in defense related sectors is lower than in non-defense. This could be a function of the fact that on average, firms in defense lobby much more often and thus the returns are cannibalized. Finally, percentage returns decrease as the number of potential entrants increases, which may indicate that competition reduces the returns to lobbying.

Kang (2016) estimates an average return of 130% on lobbying by cooperative groups of firms on the value to those groups of energy bills. De Figueiredo and Silverman (2006) estimate returns from null to upwards of 1000% on universities lobbying over academic earmarks. My return is distinct in that it is the private returns to individual firms on lobbying over contracts, accounting for both positive externalities (which Kang does not consider) and rent-seeking (from which De Figueiredo and Silverman abstract away). The lobbying expenditures are quite small relative to the contract awards at stake, but a marginal increase in lobbying will, given α , gain the firm very little. The lumpy participation decision is the primary driver of the return.

I also calculate the effect of market concentration on lobbying behavior. I take an existing sector and simulate how expected lobbying changes if one firm exits from the set of potential entrants at random, and repeat this process until the sector becomes a monopoly.²⁷ As the estimated param-

²⁷The main issue with this approach is that since firms are heterogeneous, the identity of the exiting firms may have an effect. This is not easily resolved by averaging across all combinations of removals as the permutations are quite large. For a sector size of N (and no symmetric firms), there are $\sum_{n=1}^{N-1} \binom{N}{n}$ number of different combinations

eters already allude to, we should expect that decreased competition leads to increased lobbying because firms do not internalize the positive externality, and lobbying over the share is largely ineffective. I find this result with heterogeneity: there is significant variation across sectors with non-monotonic effects. First consider a sector with 5 potential entrants. I find that when the sector size decreases by 1, meaning there are now 4 potential entrants, lobbying in that sector increases by an average of \$6.935 thousand [1.322, 21.652] per firm-sector-year (a 12.67% increase).

If we continue decreasing the sector size, going from 4 to 3 increases the average by \$13.445 thousand [2.302, 55.660] and going from 3 to 2 increases the average by \$16.304 thousand [3.988, 120.070]. However when we go from 2 to 1, the average decreases by \$58.776 thousand [-3.527, 55.132] and per firm lobbying is maximized at 2 players. Figure 3.A.11 shows a graph of these changes with a similar relationship regardless of the original sector size. The last decrease is because in a monopoly, only the endogenous prize matters but the returns to scale incentivizes the monopolist to spend less compared to when they also have to fight over the share. These small share effects still noticeably affect the magnitude of lobbying expenditures.

These noisy estimates may point to the substantial heterogeneity in the data. The distribution of log differences is given in Figure 3.A.12 and shows the effects are non-monotonic; regardless of the initial number of potential entrants, there are firms who increase lobbying and firms who decrease when one of their competitors exits. This is likely driven by the flexible heterogeneity in the model as a homogeneous firm-sector model would not produce this variability. There is less heterogeneity across observable characteristics: the average increase from decreasing players from 5 to 4 in defense is larger in dollars than for non-defense, but the same in percentage terms.

In terms of bias, there are potential sources of downward and upward bias. The downward bias could be a consequence of over-allocating lobbying expenditures to lobbying over contracts; I assume that lobbying for appropriations bills is directed towards contracts. If that assumption fails, meaning only some fraction of appropriations lobbying is used to lobby over contracts, then I am

of sector orientations (removal of 1 to $N - 1$ firms). For 5 firms this would be 30 and for 10 firms this would be 1022. Since we would have to solve for the equilibrium across all simulation draws on top of this, I avoid this general approach. Therefore I do not average across all permutations: I just drop firms randomly and rely on averaging across sectors to smooth out the estimate instead of across permutations within sectors.

understating the return. The main source of potential upward bias is omitted variables. The lobbying expenditures could be occurring at the same time as some other time-varying firm political strategy, or simply contract-maximizing behavior, and the two positively correlate. Thus I could be attributing to lobbying what some other variable is actually capturing. Technically this could cause upward or downward bias, but it is likely a source of upward bias as the most competent firms, with the highest marginal benefits, may be more likely to lobby.

In terms of model induced bias, the model may omit possible costs that reduce the return, but the functional forms are agnostic to the size of the return. The model does equate the marginal benefit from lobbying to the marginal cost, which is implicitly assumed to be 1 dollar. This may be restrictive as I do not allow for heterogeneous costs. Identifying such costs is difficult given the variation available in the data.

3.6 Concluding Remarks

This chapter uses a novel approach to analyze the effects of lobbying on federal contracting. Previous articles often capture only composite effects. This is the first paper to empirically evaluate an endogenous prize contest model and helps isolate the drivers behind the lobbying effects observed in the literature. I find substantial lobbying pressure on government spending, and a model that assumes an exogenously given pool of contracts would completely miss out on, and potentially misattribute, this source of lobbying influence. I also find that lobbying slightly alters between-firm allocations with significant between-sector heterogeneity. These two findings indicate that in the absence of lobbying, the observed allocation of government contract appropriations would be statistically different, with the endogenous prize explaining most of the variation. I also find that market concentration in general increases lobbying expenditures. Finally, I find that lobbying has a high return on investment but yields only a modest increase in profits. Given the data limitations on measuring cost and performance, this chapter does not provide a welfare analysis.²⁸

The large difference between the prize being lobbied over and lobbying expenditures has been

²⁸Thus this chapter does not take a stance on whether lobbying could be welfare improving or not (Cotton 2009; Cotton and Dellis 2016).

noted by others (Kang 2016; Gregor 2017) and this chapter can help explain some of that variation. First, the endogenous prize effect clearly dominates the rent-seeking effect; this means there is less incentive for certain firms to participate and instead simply free-ride. Second, there are substantial decreasing returns to scale, reducing the gains from increasing expenditures. However, there may still be other unobserved frictions not incorporated here; modeling the government's problem may shed light on this unexplained aspect. Finally, firms may also use other forms of political influence, such as nonmarket strategies (Bertrand, Bombardini, Fisman, and Trebbi 2018; Holburn and Raiha 2018; Raiha 2018), that the lobbying data do not capture.

APPENDICES

APPENDIX A

Tables

Table 3.A.1: Share of Contracts in a Sector by Lobbying Participation

Contract Shares Per Sector			
	Mean	Standard Deviation	Count
Lobbied in sector	0.402	0.381	4348
Did not lobby	0.315	0.374	11418

Contract shares are the share of contracts a firm earns within a sector. Lobbying participation is whether the firm lobbied on the appropriations bill that funded the department that gave out the contract in that sector.

Table 3.A.2: Lobbying Expenditures by Average Sector Competitiveness

Lobbying (Millions)			
	Mean	Standard Deviation	Count
Below mean competitiveness	0.644	1.696	1044
Above mean competitiveness	0.129	0.551	1502

Lobbying is at the firm-year level; I take an average over sectors for that firm to get a measure of the average degree of competitiveness. Degree of competitiveness is lagged average share of contracts allocated on a competitive basis in a given sector.

Table 3.A.3: Contract Revenues by Lobbying Participation

Contracts (Billions)			
	Mean	Standard Deviation	Count
Never lobbying	0.203	0.442	4560
No lobbying that year	0.313	0.744	1387
Lobbying without former congressperson	0.888	1.575	638
Lobbying with former congressperson	3.166	6.703	521

Contracts is firm contract revenues in that year. “Never lobbying” is for firms that have never lobbied. “No lobbying that year” is for firms that did not lobby in that year but have lobbied at some point. Former congressperson (*FC*) refers to whether the firm is employing an *FC* on their lobbying team and that individual actively lobbied on behalf of that firm during that given year.

Table 3.A.4: Contract Sector Size in Dollars by Mean Lobbying

Contracts (Billions)			
	Mean	Standard Deviation	Count
Low lobbying	0.409	1.024	3659
High lobbying	1.231	2.628	1687

Contracts is the sum of government disbursements (revenues for firms) in a sector. Low and high lobbying are defined as below and above average of the total year-level lobbying for firms in that sector.

Table 3.A.5: Contract Revenues Quantiles by Lobbying Participation

Contracts (Billions)					
	10%	25%	50%	75%	90%
Never lobbying	0.000	0.004	0.091	0.191	0.474
No lobbying that year	0.000	0.044	0.118	0.252	0.620
Lobbying without <i>FC</i>	0.033	0.111	0.289	1.024	2.413
Lobbying with <i>FC</i>	0.053	0.134	0.556	2.164	9.373

Contracts is firm contract revenues in that year. “Never lobbying” is for firms that have never lobbied. “No lobbying that year” is for firms that did not lobby in that year but have lobbied at some point. Former congressperson (*FC*) refers to whether the firm is employing an *FC* on their lobbying team and that individual actively lobbied on behalf of that firm during that given year.

Table 3.A.6: Summary Statistics

Firm-Sector-Year					
	Mean	Sta. Dev.	Min	Max	Count
Contract revenues (billions)	0.227	0.564	0	15.191	15766
Share of contract revenues	0.339	0.378	0	1	15766
Lobbying participation	0.276	0.447	0	1	15766
Number of sectors per firm	15.136	22.080	1	89	15766
Sector-Year					
	Mean	Sta. Dev.	Min	Max	Count
Sector pool size (billions)	0.669	1.744	0.001	29.500	5346
Degree of competition	0.730	0.348	0	1	5346
Defense contract type	0.632	0.482	0	1	5346
Number of firms per sector	2.949	4.189	1	58	5346
Number of “ever-lobbied” per sector	1.715	2.196	0	21	5346
Firm-Year					
	Mean	Sta. Dev.	Min	Max	Count
Ever lobbied:					
Lobbying (millions)	0.341	1.193	0	14.6	2546
Former congressperson	0.259	0.438	0	1	2546
HQ in D.C. area	0.487	0.500	0	1	2546
Never lobbied:					
HQ in D.C. area	0.225	0.417	0	1	4560

Contract pool in a given sector is the total sum of contract revenues across all participants in that sector. Former congresspersons (*FC*) refers to whether the firm is employing an *FC* on their lobbying team and that individual actively lobbied on behalf of that firm during that given year. Degree of competition is lagged average number of contracts allocated on a competitive basis in a given sector. Ever-lobbied is whether the firm is ever present in the lobbying data throughout the entire dataset.

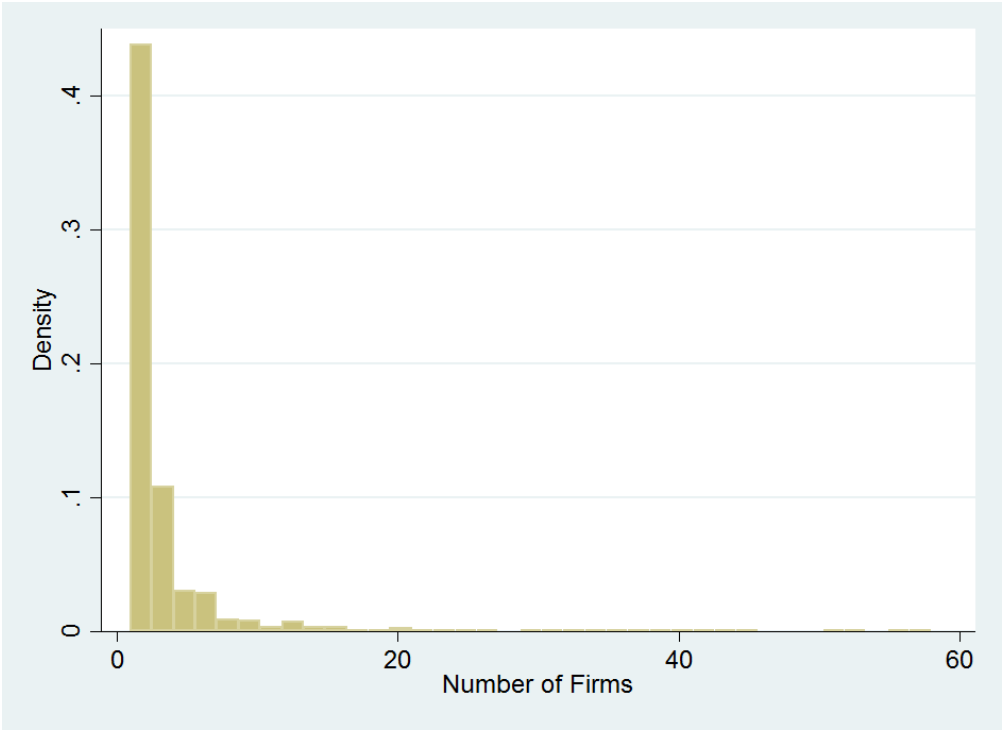
Table 3.A.7: Reduced Form Regressions

	(1) Total Contracts	(2) Total Contracts	(3) Share	(4) Entry	(5) Lobbying	(6) Contracts
# of firms	0.143*** (0.018)	0.181*** (0.035)	-0.006*** (0.000)	-0.014*** (0.000)	-0.004*** (0.001)	
# of Potential Entrants	0.240*** (0.046)	0.128 (0.082)	-0.023*** (0.001)	0.019*** (0.001)	0.013*** (0.002)	
Entry	0.038 (0.050)	0.136 (0.079)	0.090*** (0.006)		0.103*** (0.009)	281.793*** (30.248)
# Entry by others			-0.016*** (0.001)	0.029*** (0.002)	-0.009** (0.003)	35.487*** (7.750)
Lobbying						153.729 (105.144)
<i>N</i>	5346	2334	15766	15766	7106	7106
<i>R</i> ²	0.411	0.380	0.284	0.080	0.522	0.690

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

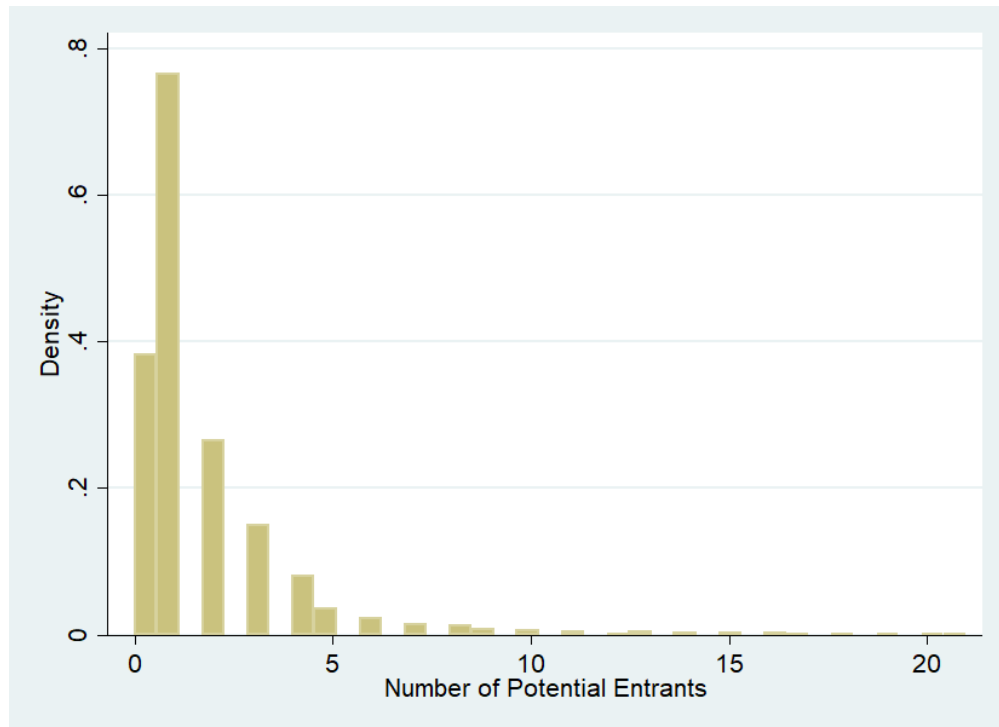
Column 1: total contracts at the sector-year level on three different firm measures: number of firms, number of potential entrants, and number of actual entrants. Column 2: same as 1 but condition on sectors with at least one entrant. Column 3: shares at the firm-sector-year level on the same number of firm measures but also include the number of other firms that enter. Column 4: entry on the other sector number and entry variables. Column 5: total lobbying expenditures at the firm-year level and average sector level variables the firm faced. Column 6: total contracts at the firm-year level on average entry, average entry by other firms, and total lobbying expenditures.

Figure 3.A.1: Distribution of Number of Firms Across Sectors



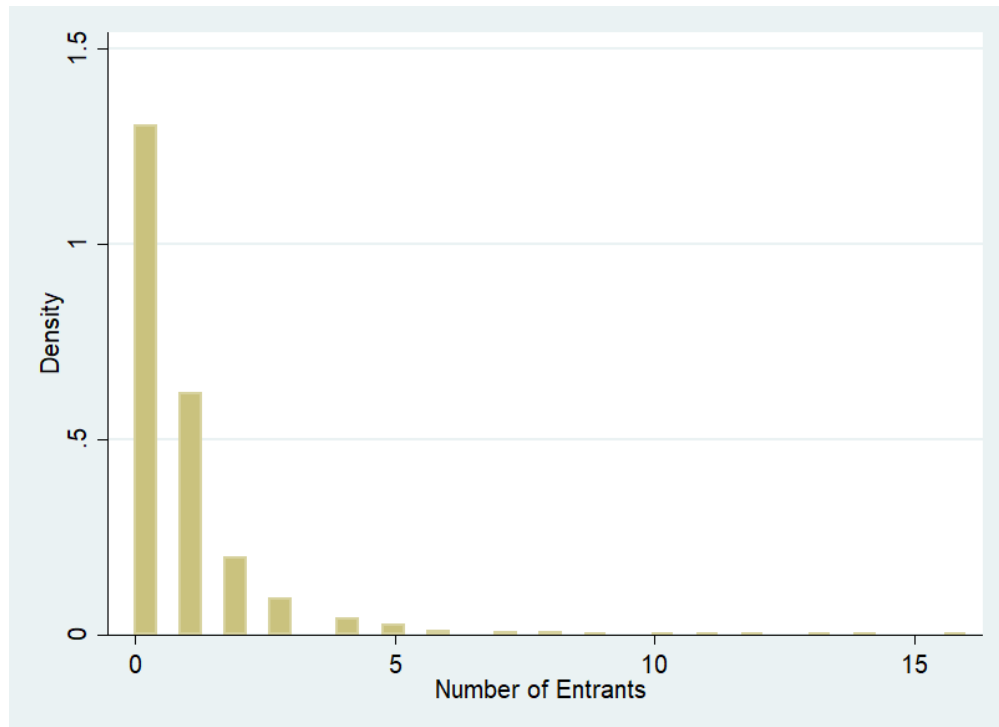
Distribution of the number of firms across contract sectors.

Figure 3.A.2: Distribution of Number of Potential Entrants Across Sectors



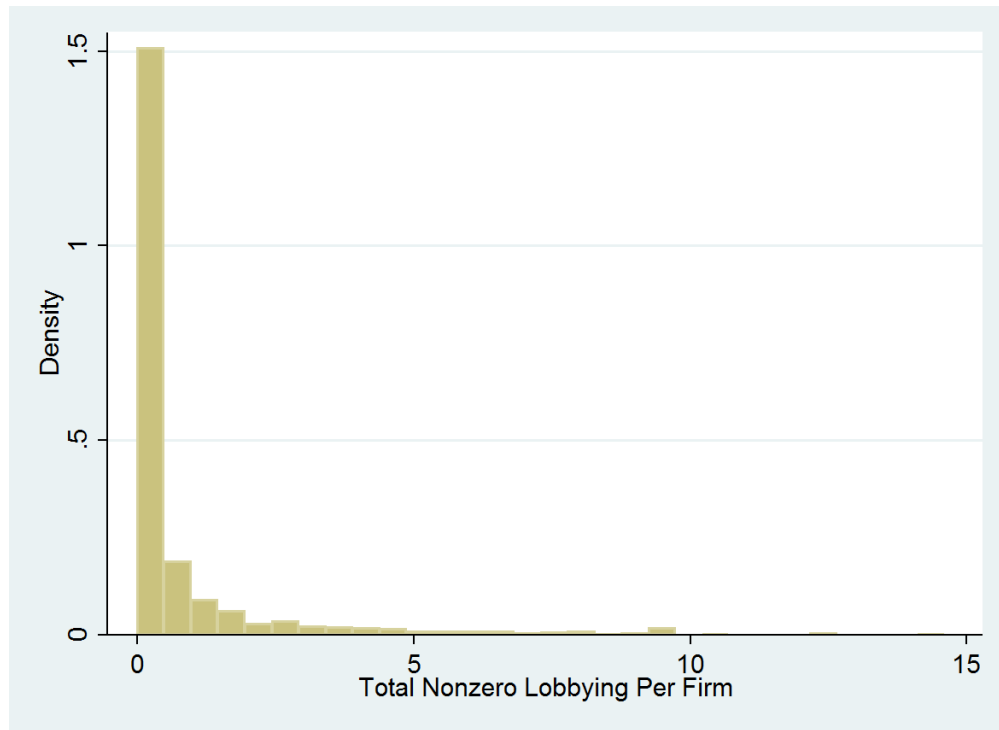
Distribution of the number of potential entrants across sectors (excluding firms not classified as potential entrants).

Figure 3.A.3: Distribution of Number of Total Entrants Across Sectors



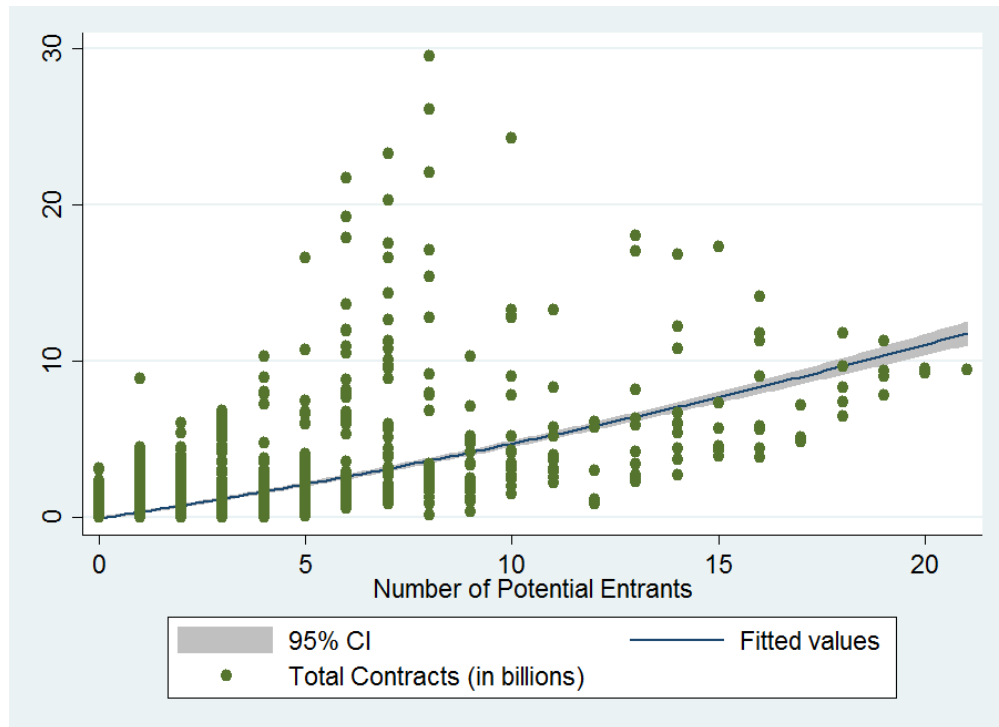
Distribution of the actual lobbying entrants across sectors.

Figure 3.A.4: Distribution of Nonzero Lobbying Across Firms (Millions)



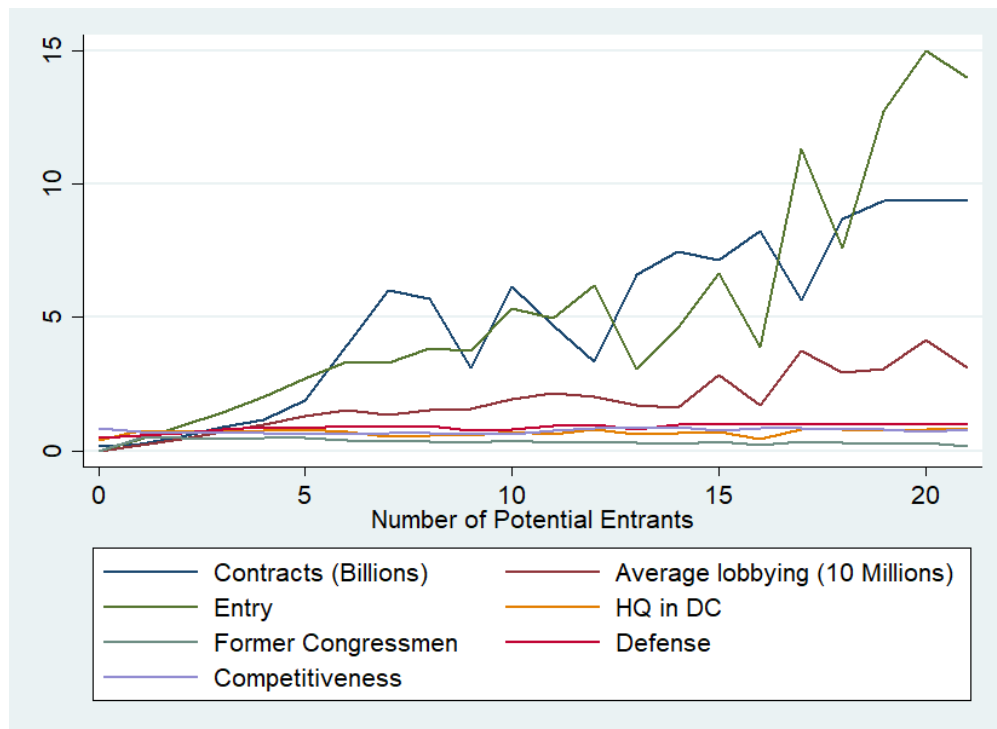
Distribution of strictly positive lobbying across firms (firm-year level).

Figure 3.A.5: Total Contracts [Sector Level (Billions)] by Potential Entrants



Scatter plot and kernel fit of total contracts and number of potential entrants (sector-year level).

Figure 3.A.6: Average Characteristics by Number of Potential Entrants



Lineplot of different observables (firm and market characteristics) across sectors by number of potential entrants.

Table 3.A.8: Main Parameter Estimates

Parameter	Estimate	CI
α	0.106	[0.053, 0.121]
$\gamma/1e6$	2.885	[2.836, 3.303]
δ_1	1.178	[1.037, 1.330]
δ_2	0.069	[-0.169, 0.335]
ζ_1	0.455	[0.057, 0.629]
ζ_2	0.344	[0.111, 0.936]
η_1	1.036	[0.632, 1.909]
η_2	0.592	[0.008, 0.959]
η_3	0.224	[-0.061, 0.503]
$\mu_1/1e8$	0.530	[0.254, 0.975]
$\mu_2/1e8$	0.257	[-0.116, 0.441]
μ_3	0.959	[0.891, 1.025]
σ_ξ	0.049	[0.027, 0.076]
σ_g	0.049	[0.036, 0.059]
$\Xi/1e6$	5.506	[5.027, 5.684]

95% confidence intervals with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ, ζ, η, μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept. δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_ξ and σ_g are the standard deviations of ξ and g respectively; Ξ is the adjustment parameter for the unobserved entry cost.

Table 3.A.9: Statistics for Observed and Model Firm Lobbying Expenditures per Year

Statistic	Observed	Model	Confidence Interval
Mean	0.341	0.296	[0.255, 0.381]
Median	0.000	0.017	[0.011, 0.029]
Sta. Dev.	1.193	1.339	[1.124, 1.598]
Minimum	0.000	0.001	[0.000, 0.001]
Maximum	14.600	17.664	[12.904, 22.653]

In millions. The confidence intervals are at the 95% level. The lobbying expenditures are at the firm year level.

Table 3.A.10: Statistics for Observed and Model Firm Share of Contracts per Sector

Statistic	Observed	Model	Confidence Interval
Mean	0.339	0.339	[0.318, 0.348]
Median	0.157	0.187	[0.172, 0.194]
Sta. Dev.	0.378	0.340	[0.336, 0.343]
Minimum	0.000	0.009	[0.000, 0.012]
Maximum	1.000	1.000	[1.000, 1.000]

The confidence intervals are at the 95% level. The contract shares are at the firm sector year level.

Table 3.A.11: Statistics for Observed and Model Firm Lobbying Entry per Sector

Statistic	Observed	Model	Confidence Interval
Mean	0.322	0.328	[0.268, 0.393]
Median	0.000	0.065	[0.056, 0.174]
Sta. Dev.	0.467	0.387	[0.357, 0.409]
Minimum	0.000	0.000	[0.000, 0.000]
Maximum	1.000	1.000	[0.998, 1.000]

The confidence intervals are at the 95% level. The lobbying entry decisions are at the firm sector year level.

Table 3.A.12: Statistics for Observed and Model Total Contracts per Sector

Statistic	Observed	Model	Confidence Interval
Mean	0.669	0.667	[0.621, 0.701]
Median	0.198	0.224	[0.171, 0.250]
Sta. Dev.	1.744	1.645	[1.547, 1.718]
Minimum	0.001	0.010	[0.000, 0.036]
Maximum	29.500	25.252	[21.815, 26.736]

In billions. The confidence intervals are at the 95% level. The sector pool is the dollar value of all contracts in that sector.

Table 3.A.13: Statistics for Total Contract Spending Induced by Aggregate Lobbying (Endogenous Pool) per Sector

Statistic	Model	Confidence Interval	Total Pool
Mean	27.451	[18.219, 54.222]	667
Median	15.674	[5.385, 35.587]	224
Sta. Dev.	35.820	[25.108, 69.136]	1,645
Minimum	0.287	[0.081, 0.388]	10
Maximum	273.322	[189.653, 825.292]	25,252

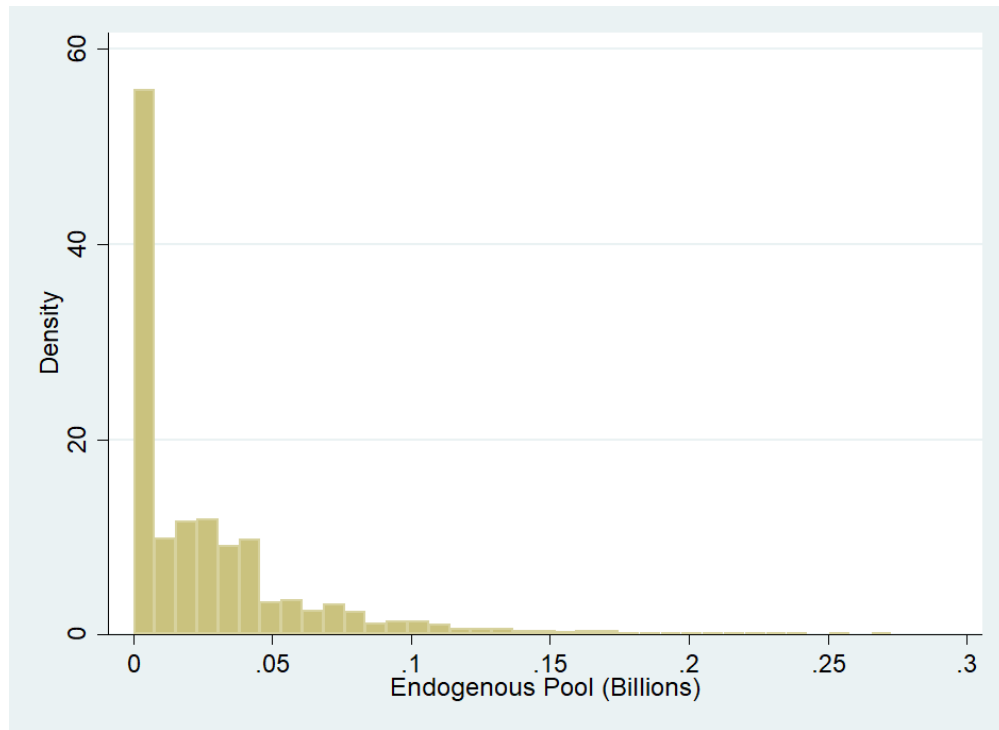
In millions. These are the sector-year total amount of contracts spending attributable to lobbying. The confidence intervals are 95% level. The total pool is the total amount of contracts in the sector.

Table 3.A.14: Return to Lobbying per Sector

Statistic	Model	Confidence Interval
Entrants		
Mean	2.128	[1.982, 2.862]
Median	2.284	[2.203, 2.481]
Sta. Dev.	1.502	[1.211, 2.425]
Minimum	-0.292	[-0.323, -0.282]
Maximum	12.279	[6.314, 29.645]
Non-Entrants		
Mean	-0.080	[-0.132, 0.132]
Median	-0.177	[-0.189, -0.144]
Sta. Dev.	0.677	[0.227, 1.772]
Minimum	-0.988	[-3.949, -0.308]
Maximum	12.302	[3.299, 33.689]

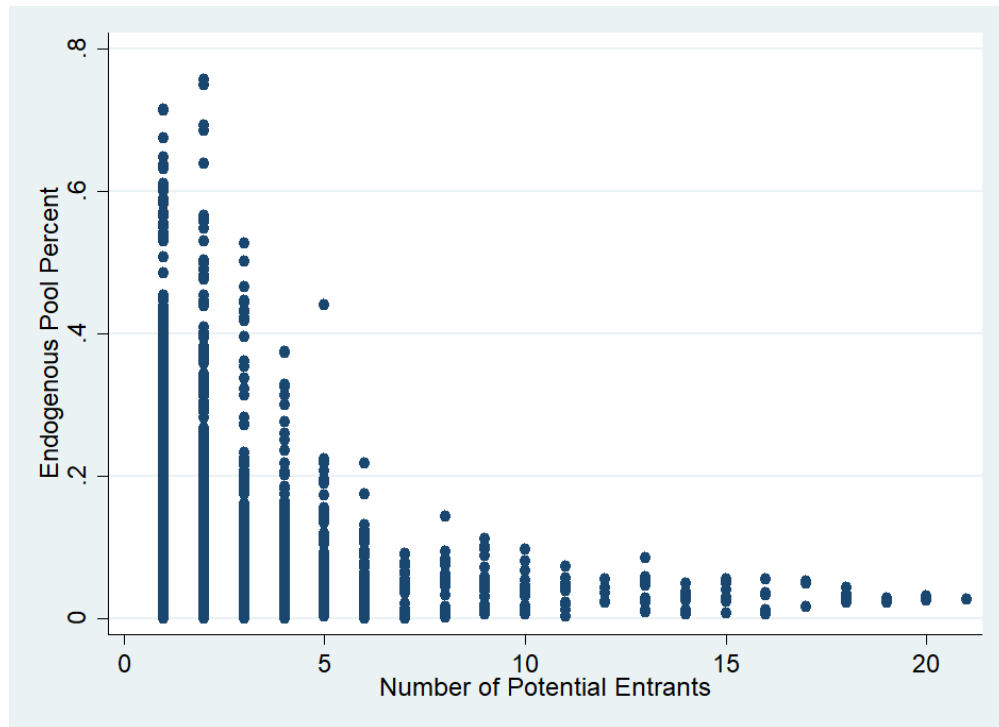
In millions. The confidence intervals are at the 95% level. The returns are calculated as the difference in profits between the equilibrium and non-entry case at the sector level for each entrant and the reverse for non-entrants.

Figure 3.A.7: Distribution of Endogenous Pool (Billions)



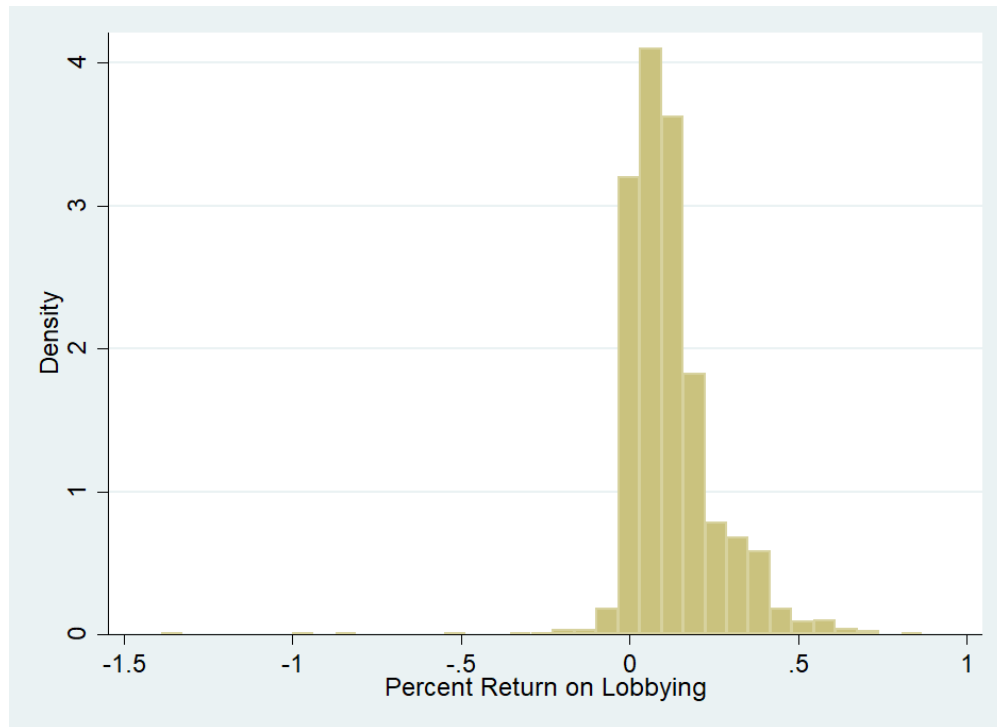
Distribution of estimated endogenous pools (sector level total amount of contracts spending attributable to lobbying) across sectors.

Figure 3.A.8: Endogenous Pool Percent by Potential Entrants



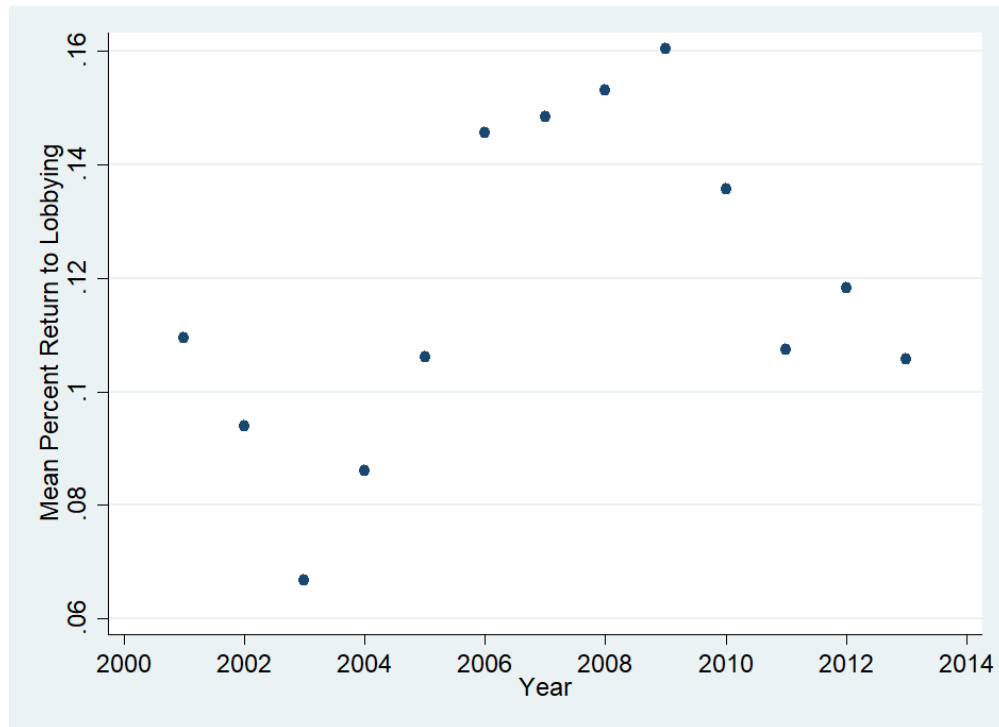
Scatterplot of estimated endogenous pools (percent of total pool) by number of potential entrants in each sector.

Figure 3.A.9: Percent Return on Lobbying by Entrants



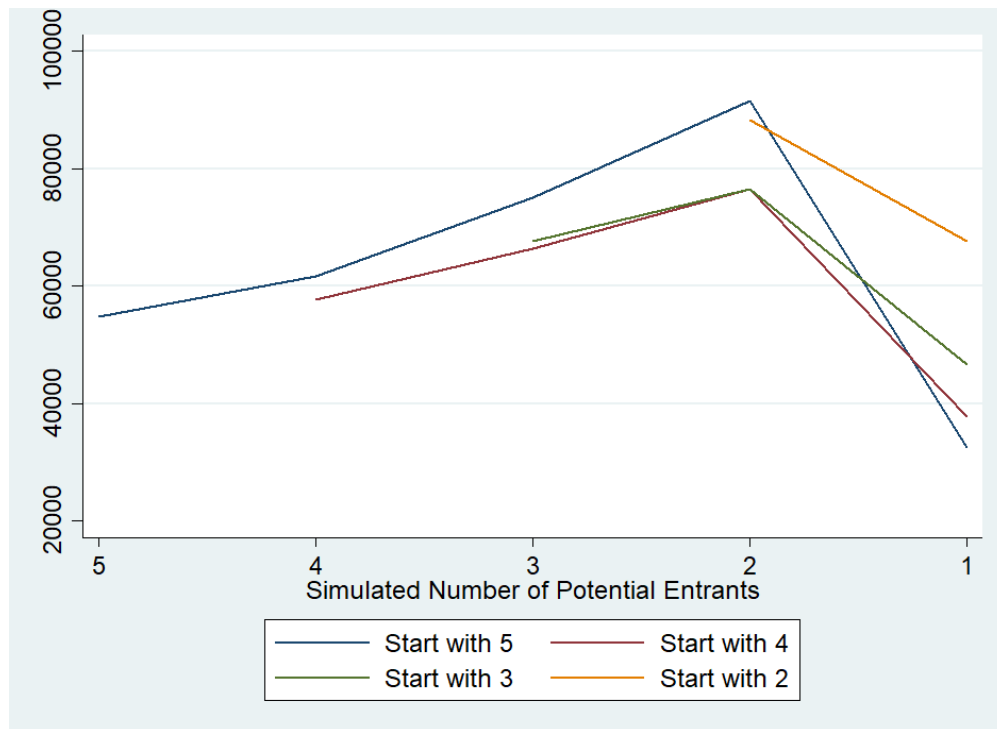
Distribution of lobbying returns (as a percent of firm yearly profits) for those in the data that entered across firms (firm-year level).

Figure 3.A.10: Mean Percent Return on Lobbying by Year



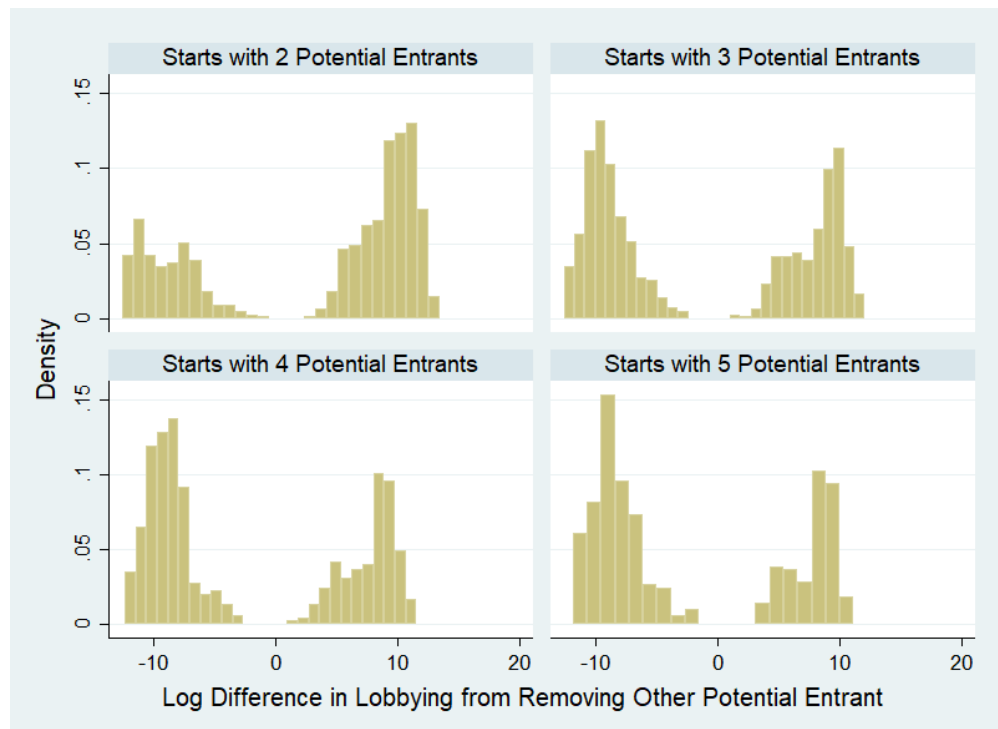
Scatter plot of average yearly lobbying returns (as a percent of total profits) by year (for those that entered).

Figure 3.A.11: Lobbying by Market Concentration



Line plot showing effect of decreasing number of entrants on average lobbying in that sector; showing 4 sets of lines based on the initial number of potential entrants. Note the horizontal axis starts with 5 potential entrants on the left and decreases to 1 on the right.

Figure 3.A.12: Distributions of Log Difference in Lobbying From Removing Other Potential Entrants



Distribution of changes in lobbying expenditures across sectors from reducing sector size (number of potential entrants) by 1. It shows 4 sets based on the initial number of potential entrants.

APPENDIX B

Proofs

This section discusses the proof of Proposition 2. First two lemmas concerning the equilibrium of the 2nd stage continuation game are proven and then the main proof of the proposition is given. The notation and setup for the 2nd stage continuation game is given below.

The second stage has a subset of players from the first stage based on the entry profile $\mathbf{e}$, denoted $\mathcal{I}^e \subseteq \mathcal{I} = \{1, \dots, N\}$ so $|\mathcal{I}^e|$ is the number of players actively lobbying. Each player $i \in \mathcal{I}^e$ chooses $\ell_i \in \mathbb{R}_+$. Given an entry profile $\mathbf{e}$, the second stage payoff is $\pi_i : \mathbb{R}_+^{|\mathcal{I}^e|} \rightarrow \mathbb{R}_+$ and written below for player i :

$$\pi_i = \left(\Gamma^0 + \gamma \sum_{j \in \mathcal{I}^e} \beta_j (\ell_j)^\alpha \right) \cdot \left(\lambda E[s_i^0] + (1 - \lambda) \cdot \frac{\beta_i (\ell_i)^\alpha + E[s_i^0] \mathbb{1}[\sum_{j \in \mathcal{I}^e} \ell_j = 0]}{\sum_{j \in \mathcal{I}^e} \beta_j (\ell_j)^\alpha + \mathbb{1}[\sum_{j \in \mathcal{I}^e} \ell_j = 0]} \right) - \ell_i \quad (3.B.1)$$

First use the transformation $x_i \equiv \beta_i (\ell_i)^\alpha$. The strategy sets remain the same for nonnegative β_i . The cost function is well defined and strictly convex given the regularity conditions $\beta_i > 0 \forall i$ & $\alpha \in (0, 1)$. I let $\Gamma^0 > 0, \gamma > 0$, & $\lambda \in [0, 1)$ as the proofs for the corner cases are straightforward.²⁹

Lemma 7. $\ell_i = 0 \forall i$ is not an equilibrium outcome in any 2nd stage continuation game.

Proof of Lemma 7.

I show the proof for x_i with π and the result equivalently holds for ℓ_i or using $\tilde{\pi}$. Let $X_{-i} = 0$ and check whether $x_i = 0$ is optimal for player i , writing the payoff equation in aggregative form, meaning $\pi_i = \pi_i(x_i, x_i + X_{-i})$:

$$\begin{aligned} \pi_i(0, 0 + 0) &= \Gamma^0 \cdot \left(\lambda E[s_i^0] + (1 - \lambda) \frac{E[s_i^0]}{1} \right) = \Gamma^0 E[s_i^0] \\ \pi(\epsilon, \epsilon + 0) &= (\Gamma^0 + \gamma \epsilon) \cdot \left(\lambda E[s_i^0] + (1 - \lambda) \cdot \frac{\epsilon}{\epsilon} \right) - (\epsilon / \beta_i)^{1/\alpha} \end{aligned}$$

²⁹In the case of $\gamma = 0$, there is no endogenous prize and the proof of Szidarovsky & Okuguchi (1997) can be applied for existence and uniqueness of the second stage continuation game. In the case of $\Gamma^0 = 0$ or $\lambda = 1$, the contest success function drops out and a unique solution is easily found.

Positive lobbying is weakly optimal for player i when the inequality below holds; for some $\epsilon > 0$ it will as the leftmost-term is fixed and nonnegative, the middle term is linear in ϵ and positive, and the rightmost term is convex and negative.

$$\Gamma^0(1 - \lambda)(1 - E[s_i^0]) + \gamma\epsilon(\lambda E[s_i^0] + 1 - \lambda) - (\epsilon/\beta_i)^{1/\alpha} \geq 0$$

Thus $x_i + X_{-i} > 0$ in equilibrium. □

Lemma 8. *For a given participation profile vector $(e_1, \dots, e_N)$, the 2nd stage continuation game at any given information set has a pure strategy Nash equilibrium and it is unique.*

Proof of Lemma 8.

I now omit the indicator functions in light of lemma 7. I define the scaled payoff function $\tilde{\pi}_i$, with extra terms: $X_{-i} \equiv \sum_{j \in \mathcal{I}^e \setminus \{i\}} x_j$, $X \equiv \sum_{i \in \mathcal{I}^e} x_i$,

$$\begin{aligned} \pi_i &= (\Gamma^0 + \gamma(x_i + X_{-i})) \cdot \left(\lambda E[s_i^0] + (1 - \lambda) \cdot \frac{x_i}{x_i + X_{-i}} \right) - (x_i/\beta_i)^{1/\alpha} \\ &\propto \tilde{\pi}_i \equiv (\Gamma^0 + \gamma(x_i + X_{-i}))\phi_i + (\Gamma^0 + \gamma(x_i + X_{-i})) \cdot \frac{x_i}{x_i + X_{-i}} - g(x_i) \quad (3.B.2) \\ \text{s.t. } \phi_i &\equiv \frac{\lambda E[s_i^0]}{(1 - \lambda)}, \quad g(x_i) \equiv \frac{(x_i/\beta_i)^{1/\alpha}}{(1 - \lambda)} \end{aligned}$$

Existence of a pure strategy Nash equilibrium for any 2nd stage continuation game follows from the Debreu, Glicksberg, and Fan Theorem (Debreu 1952; Glicksberg 1952; Fan 1952). Define $B \in \mathbb{R}_{++}$ to be large and restrict the player's strategy space to be $x_i \in [0, B]$. This B is without loss of generality as the concavity of π guarantees a finite solution to the unconstrained program. The strategy space is now compact and convex. Below I give the first order condition $\mathcal{F}_i$ for the program $\max_{x_i \in [0, B]} \tilde{\pi}_i$ assuming B is not binding, alongside the (satisfied) interior second order condition in the case that $X_{-i} > 0$. In case that $X_{-i} = 0$, the first order condition for player i

yields a unique positive and finite solution.

$$\mathcal{F}_i \equiv \frac{\partial \tilde{\pi}_i}{\partial x_i} = \gamma \phi_i + \gamma \frac{x_i}{x_i + X_{-i}} + (\Gamma^0 + \gamma(x_i + X_{-i})) \frac{X_{-i}}{(x_i + X_{-i})^2} - g'_i(x_i)$$

$$\text{s.t. } \mathcal{F}_i \leq 0 \ \& \ x_i[\mathcal{F}_i] = 0$$

$$\frac{\partial^2 \tilde{\pi}_i}{\partial x_i^2} = -\gamma \frac{2X_{-i}}{(x_i + X_{-i})^3} - g''_i(x_i) < 0$$

Thus the payoff is strictly concave in x_i and given Lemma 7 is continuous in all arguments. Thus the DGF theorem holds and a pure strategy Nash equilibrium exists.

The method of uniqueness stems from Hirai and Szidarovsky (2013): show that X can be mapped to the strategy profile x via some function: $x = f(X)$. Then finding a unique X is sufficient to identifying a unique x . They consider the $\phi_i = 0$ case but the proof follows in practically the same manner when $\phi_i \geq 0$. Rewrite $\mathcal{F}_i$ in terms of x_i & X and simplify:

$$\mathcal{F}_i = \gamma(1 + \phi_i) + (\Gamma^0/X)(1 - x_i/X) - g'_i(x_i)$$

Because $X = 0$ is not a solution (by Lemma 7), one can apply the implicit function theorem on $\mathcal{F}_i$ and yield the function $h_i(X)$, where

$$h_i(X) = \begin{cases} 0 & \text{s.t. } \mathcal{F}_i(0) < 0 \\ x_i^* = \text{argsolv}_{x_i \geq 0} \{ \mathcal{F}_i = 0 \} \end{cases}$$

Then define the function $\mathcal{G}$ where $\varsigma_i = x_i/X$:

$$\mathcal{G}_i(\varsigma_i, X) \equiv \gamma(1 + \phi_i) + (\Gamma^0/X)(1 - \varsigma_i) - g'_i(\varsigma_i X)$$

Then $\mathcal{G}_i$ is strictly decreasing in both arguments as $\varsigma_i \leq 1$:

$$\frac{\partial \mathcal{G}_i}{\partial X} = -(1 - \varsigma_i)\Gamma^0/X^2 - \varsigma_i g_i''(\varsigma_i X) < 0 \quad \& \quad \frac{\partial \mathcal{G}_i}{\partial \varsigma_i} = -\Gamma^0/X - X g_i''(\varsigma_i X) < 0$$

Then define the “share function” $S_i(X) = h_i(X)/X$, such that:

$$S_i(X) = \begin{cases} 0 & \text{s.t. } \mathcal{G}_i(0, X) \leq 0 \\ 1 & \text{s.t. } \mathcal{G}_i(1, X) \geq 0 \\ \varsigma_i^* = \text{argsolv}_{\varsigma_i \in (0,1)} \{\mathcal{G}_i = 0\} & \end{cases}$$

Note that given the monotonicity of $\mathcal{G}_i$, only one of the three cases above can hold at once. Then for any $X > 0$ in the third case, $\mathcal{G}_i(0, X) > 0$, $\mathcal{G}_i(1, X) < 0$, and $\frac{\partial \mathcal{G}_i}{\partial \varsigma_i} < 0$, implying that there is a unique ς_i^* satisfying $\mathcal{G}_i = 0$. Then by the implicit function theorem, ς_i^* is differentiable. Then $S_i(X)$ is differentiable and strictly decreasing in the third case. The latter can be shown by differentiating $\mathcal{G}_i(S_i(X), X) = 0$ and re-arranging:

$$\frac{dS_i(X)}{dX} = \frac{\Gamma^0 X^{-2}(1 - S_i) + g_i'' S_i}{-(\Gamma^0 X^{-1} + g_i'' X)} < 0$$

Then $S_i(X)$ is continuous, strictly decreasing in the third case, and flat in the other two cases. Now sum $S_i(X) \forall i \in \mathcal{I}^e$ and note that the following equality must hold in equilibrium:

$$\sum_{j \in \mathcal{I}^e} S_j(X) - 1 = 0$$

Then the left hand side is non-increasing and one can show there is a unique solution: Consider X, X' such that $X < X'$. Then $X' > 0$ and $\exists i$ s.t. $S_i(X') > 0$. If i is the only player with $x_i > 0$, then $S_i(X) = S_i(X') = 1$. Thus player i has two optimal x_i with $X_{-i} = 0$ which is not possible given $\partial^2 \tilde{\pi}_i / \partial x_i^2 < 0$. Thus $X = X'$ in this case.

If there are others with $x_j > 0$, then by S_i decreasing, $S_i(X) > S_i(X')$ and for all other

players $j \neq i$, $S_j(X) \geq S_j(X')$. But then one of X, X' do not jointly satisfy the above equality:

$$\sum_{j \in \mathcal{I}^e} S_j(X) > \sum_{j \in \mathcal{I}^e} S_j(X')$$

Thus $X = X'$ in either case. Thus the equilibrium X^* is unique. Then X^* can be mapped to the equilibrium value of x_i^* via the function: $x_i^* = X^* \cdot S_i(X^*)$. Thus the pure strategy equilibrium profile $\{x_i^*\}_{\forall i \in \mathcal{I}^e}$ is unique. □

With Lemma 8 in hand, Proposition 2 can be proven. First recall the proposition:

Proposition 1. *There exists a pure strategy Perfect Bayesian Nash equilibrium in cutoff strategies for game G [defined in section 3], and if σ is sufficiently large the equilibrium is unique.*

Proof of Proposition 2.

Denote any second stage Nash equilibrium vector of lobbying decisions given an entry profile $(e_1, \dots, e_N)$ as $(\ell_1^*, \dots, \ell_N^*)$, which given Lemma 8 is unique. The firm's interim expected payoff for a given entry decision conditional on their private information is denoted with U_i and given in equation (3.B.3). The summation is across all 2^{N-1} combinations of opponent decisions e_{-i} ; the term $p_j(e_{-i})$ is the belief by player i in the probability of player j choosing e_j from the decision profile e_{-i} . The term $p_{i,j}(e_{-i})$ is the belief by player i of the probability of player j choosing the e_j from the decision profile e_{-i} ; the term p_{-i} is the vector of opponent probabilities of $e = 1$; the term ε_i is private information:

$$U_i(\ell_1^*, \dots, \ell_N^*, e_1, \dots, e_N, p_{-i}) = \sum_{e_{-i} \in \{0,1\}^{2N-1}} \pi_i^*(\ell_1^*, \dots, \ell_N^* | e_1, \dots, e_N) \prod_{j \neq i} p_j(e_{-i}) + \varepsilon_i \cdot e_i \quad (3.B.3)$$

First I show that there exists a pure strategy Perfect Bayesian equilibrium of game G in cutoff strategies. Let the first part of the payoff be denoted with u_i so that $U_i = u_i + \varepsilon_i$. Given the iid

distribution of ε , the beliefs are symmetric, meaning player i 's belief about player j equals player k 's belief about player j : $p_{i,j} = p_{k,j} \equiv p_j$. Thus one can write out any player's belief about player i choosing $e_i = 1$ as below:

$$p_i(e_i = 1) = \text{Prob}[u_i(1, p_{-i}) + \varepsilon_i > u_i(0, p_{-i})]$$

Which given the scaled Logistic distribution of ε yields the functional form below:

$$p_i = \frac{\exp(u_i(1, p_{-i})/\sigma)}{\exp(u_i(1, p_{-i})/\sigma) + \exp(u_i(0, p_{-i})/\sigma)} \equiv f(p_{-i})$$

This is a continuous system of choice probabilities $\mathbf{p}$ that defines an equilibrium (constitute a fixed point) if one exists:

$$\mathbf{p} = f(\mathbf{p})$$

Note that $\mathbf{p} \in [0, 1]^N$ and $f(\mathbf{p}) : [0, 1]^N \rightarrow [0, 1]^N$. Thus f is a continuous function over a compact convex set. As noted in Bajari et. al (2010) and McKelvey and Palfrey (1995), an application of Brouwer's fixed point theorem to this system guarantees an equilibrium for finite values of π .

The proof of uniqueness stems from the sufficient conditions detailed in Seim (2006) (see end of proof for more general conditions under which the equilibrium system is a contraction mapping). The system $\Phi(\mathbf{p}) \equiv \mathbf{p} - f(\mathbf{p}) = 0$ will have one zero if the matrix of partial derivatives of Φ with respect to p is a positive dominant diagonal matrix, meaning:

$$\left| \frac{\partial \Phi_i}{\partial p_i} \right| > 0 \quad \forall i \quad \& \quad \left| \frac{\partial \Phi_i}{\partial p_i} \right| \geq \sum_{j \neq i} \left| \frac{\partial \Phi_i}{\partial p_j} \right| \quad \forall i$$

Given the functional form, the first is satisfied with value of unity. The second can be satisfied for a sufficiently large σ . To see this, first write out the expression for a given i :

$$\sum_{j \neq i} \left| \frac{\partial \Phi_i}{\partial p_j} \right| = \frac{\exp(u_i(1)/\sigma - u_i(0)/\sigma)}{(1 + \exp(u_i(1)/\sigma - u_i(0)/\sigma))^2} \sum_{j \neq i} \left| \frac{\partial u_i(1)}{\partial p_j} - \frac{\partial u_i(0)}{\partial p_j} \right| \frac{1}{\sigma}$$

$$\frac{\partial u_i(1)}{\partial p_j} = \sum_{e_{-\{i,j\}}} [\pi_i(e_i = 1, e_j = 1, e_{-\{i,j\}}) - \pi_i(e_i = 1, e_j = 0, e_{-\{i,j\}})] \prod_{k \neq \{i,j\}} p_k(e_{-\{i,j\}})$$

With a complementary expression for $\frac{\partial u_i(0)}{\partial p_j}$. Note that $\frac{\partial u_i(1)}{\partial p_j}$ is less than the maximum difference in payoffs for entering M , with an analogous bounding for $\frac{\partial u_i(0)}{\partial p_j}$, equal to m . Both M and m are well-defined given the interior solution to the second stage game.

$$\frac{\partial u_i(1)}{\partial p_j} \leq \max_{e_{-\{i,j\}}} [\pi_i(e_i = 1, e_j = 1, e_{-\{i,j\}}) - \pi_i(e_i = 1, e_j = 0, e_{-\{i,j\}})] = M_{ij}$$

$$\frac{\partial u_i(0)}{\partial p_j} \geq \min_{e_{-\{i,j\}}} [\pi_i(e_i = 0, e_j = 1, e_{-\{i,j\}}) - \pi_i(e_i = 0, e_j = 0, e_{-\{i,j\}})] = m_{ij}$$

The expression $\frac{\exp(u_i(1)/\sigma - u_i(0)/\sigma)}{(1 + \exp(u_i(1)/\sigma - u_i(0)/\sigma))^2}$ can also be bounded above by noting that the function $\frac{\exp(x/\sigma)}{(1 + \exp(x/\sigma))^2}$ achieves its maximum at $x = 0$ for any positive σ with a function value of $1/4$ at that point. Thus one can bound the sum of the absolute cross-partials:

$$\sum_{j \neq i} \left| \frac{\partial \Phi_i}{\partial p_j} \right| \leq \frac{1}{4\sigma} \sum_{j \neq i} \left| \frac{\partial u_i(1)}{\partial p_j} - \frac{\partial u_i(0)}{\partial p_j} \right| \leq \frac{1}{4\sigma} \sum_{j \neq i} |M_{ij} - m_{ij}|$$

Thus sufficient for uniqueness is the left-most expression being weakly bounded by $1 \forall i$, and sufficient for that is $\sigma \geq \max_{i \in \mathcal{I}} \{\sum_{j \neq i} |M_{ij} - m_{ij}|/4\}$. This completes the proof. $\square$

For more general conditions under which the equilibrium system is a contraction mapping: Sufficient for a contraction is $\|J_f(\tilde{\mathbf{x}})\| < 1 \forall x, x'$ for the Jacobian matrix J_f for function f (Li, Wang, Wipf, and Tu 2013), where $\tilde{\mathbf{x}}$ is a convex combination of vectors $\mathbf{x}, \mathbf{x}'$, and $\|\cdot\|$ is a matrix

norm induced by some vector norm. The diagonals of J are all zero and the off diagonals are simply the negative of the off-diagonal partials of Φ . Using the L_1 norm yields the following inequality, which is equivalent to the condition from the proof of uniqueness in proposition 1 with strict inequality: $\max_i \sum_{j \neq i} \left| \frac{\partial f_i}{\partial p_j} \right| < 1$. Thus for $\sigma > \max_{i \in \mathcal{I}} \{ \sum_{j \neq i} |M_{ij} - m_{ij}|/4 \}$, f is a contraction mapping.

APPENDIX C

Computational Discussion

The second stage outcomes ℓ^* are not tractably solved for in closed form so I use Newton's method. Modeling the players in a given sector requires solving the second stage continuation game for all $2^{N_{kt}}$ possible entry combinations. For more than a dozen or so players this becomes computationally prohibitive given the nonlinear setup and computing resources available. However including the firms that never lobby in the analysis is clearly important as those firms are potentially affected by the lobbying firms. Firms that in the entire dataset have never registered with or as a lobbyist are assumed to never lobby and this is common knowledge. The revealed preference by these firms to never lobby may be caused by their private information on profitability of entering.

The maximum number of players is 21, and there are 5,346 sector-years. Solving a highly nonlinear system for all sectors per simulation draw and algorithm iteration is burdensome. For “medium” sectors of size greater than 5 but less than 8, I use an approximation: for the smaller sectors I solve the system for all $2^{N_{kt}}$ combinations, which generates pairs of inputs $\mathcal{D}_{kt} \equiv \{N, e, \Gamma_0, \beta, E[s_0], \lambda\}_{k,t}$ and the corresponding output ℓ_{kt} . This relationship can be approximated using a flexible regression,: I regress ℓ on the inputs using a third degree polynomial sieve to get a vector of coefficients $\hat{B}$. I generate the predicted outputs $\hat{\ell}_{kt} = \mathcal{D}_{kt}\hat{B}$. I still must calculate the predicted ℓ_{kt} vector $2^{N_{kt}}$ times for these medium sectors, however the simple multiplication is much faster than solving the system of first order equations. The fit between the full solution and the linear projection are very close. I run robustness checks on this approximation in the additional results appendix.

I then construct the interim expected payoff for the firm. Given logistic distribution for the private information vector, I construct the system of probabilities that define the equilibrium beliefs. One benefit of satisfying the criteria for a contraction mapping is evident from the Banach fixed point theorem; the unique fixed point of a contraction mapping is guaranteed to be found through the limit of fixed point iteration. I start with a random starting value of beliefs, then solve for the system, then repeat until a tolerance level is reached. For “large” sectors greater than size 8, I use

a second approximation: for small and medium sectors I solve the equilibrium, which generates pairs of inputs $\mathcal{D}_{kt}^* \equiv \{N, \Gamma_0, \beta, E[s_0], \lambda, F\}_{k,t}$ and the corresponding output $E[\ell_{kt}^* | D_{kt}]$. I then use a flexible regression similar to the first approximation method. This way I avoid calculating the 2nd stage ℓ_{kt} vector $2^{N_{kt}}$ times. Thus the first method approximates the second stage Nash function and the second method approximates the first stage Nash function. The monotonicity and smoothness of these function at the sector size cutoffs make these approximations work well.

Given a unique prediction, I then repeat the entire process above for another draw of $\mathbf{g}_r$. I simulate the expectations with Monte Carlo integration. I solve the minimization problem defined in the estimation section using a constrained interior-point algorithm. I bootstrap the errors, by drawing samples with replacement over sectors. I repeat the estimation exercise above for each bootstrap sample; I then take the top and bottom estimates to construct confidence intervals.

APPENDIX D

Additional Results

I run a series of robustness checks. First, in Table 15, I consider the 100 million cutoff for inclusion in the sample (described in the data section and data details appendix). I consider plus or minus 10 million around the cutoff and find similar results. Second, in Table 16, I consider the “5 year” activity window cutoff for inclusion in the sample (described in the data section and data details appendix). I test 3 and 7 year windows and find similar results. Across these specifications, note that any sign changes on coefficients are for those that are statistically indistinguishable from zero. Third, in Table 17, I re-estimate the model changing the cutoff number of firms I use for the flexible approximation for the Nash function (see computational appendix). I consider 3 different specifications and find similar results. While the coefficients on γ and the Congressional FE terms increase on the 7&10 cutoff, the lower estimates on the already noisy ζ_1 and ζ_2 result in similar predictions on the equilibrium lobbying and contract outcomes.

I also run joint tests for significance of parameters for both the Mundlak terms and Congressional session fixed effects. I re-run with a restricted model (without calculating their confidence intervals) and compare to the main results; see Table 18 for the coefficient estimates for these restricted models. The F-statistic for a test of joint significance for the Mundlak coefficients is 72.9036, where $F = [(SSR_r - SSR_u)/6] * (15766 - 28 - 1)/SSR_u$ with $SSR_u = 0.3094$ and $SSR_r = 0.3180$. The F-statistic for a test of joint significance for the Congressional session fixed effect coefficients is 1.4532. This result may be due to the fact that their relative magnitude is the main influencing effect on equilibrium spending and none of them are statistically different from each other.

Finally, in Table 19, I show a bias corrected confidence interval; methods exist to help make percentile based bootstrap confidence intervals second-order accurate (Efron and Tibshirani 1994). I do not use the bias-corrected and accelerated (BCa) bootstrap percentile confidence intervals as the jackknife approach to estimate the acceleration term would require estimating the model 15,766 times (the length of the unbalanced panel: $N * T * K$ minus gaps). The bias corrected CIs

are largely similar with variation for the noisy estimates.

Table 3.D.15: Robustness Checks 1: Around The Monetary Cutoff

Parameter	Main Estimate	CI	90m cutoff	110m cutoff
α	0.106	[0.053, 0.121]	0.102	0.109
$\gamma/1e6$	2.885	[2.836, 3.303]	2.917	2.898
δ_1	1.178	[1.037, 1.330]	1.188	1.181
δ_2	0.069	[-0.169, 0.335]	0.236	-0.009
δ_1	1.501	[1.270, 1.704]	1.578	1.575
δ_2	0.050	[-0.251, 0.269]	-0.102	0.128
ζ_1	0.455	[0.057, 0.629]	0.394	0.429
ζ_2	0.344	[0.111, 0.936]	0.354	0.339
η_1	1.036	[0.632, 1.909]	1.023	1.052
η_2	0.592	[0.008, 0.959]	0.504	0.582
η_3	0.224	[-0.061, 0.503]	0.233	0.258
η_2	0.532	[-0.081, 0.790]	0.405	0.517
η_3	0.320	[-0.360, 0.495]	0.334	0.336
$\mu_1/1e8$	0.530	[0.254, 0.975]	0.562	0.556
$\mu_2/1e8$	0.257	[-0.116, 0.441]	0.199	0.248
μ_3	0.959	[0.891, 1.025]	0.960	0.958
$\mu_2/1e8$	0.684	[0.502, 0.990]	0.719	0.703
$\mu_3/1e8$	-0.113	[-0.187,-0.064]	-0.126	-0.109
σ_ξ	0.049	[0.027, 0.076]	0.058	0.053
σ_g	0.049	[0.036, 0.059]	0.049	0.056
ζ_{T_1}	-0.779	[-0.971,-0.243]	-0.796	-0.769
ζ_{T_2}	-0.751	[-1.264,-0.242]	-0.799	-0.783
ζ_{T_3}	-0.737	[-1.188,-0.261]	-0.772	-0.731
ζ_{T_4}	-0.953	[-1.329,-0.374]	-0.813	-0.909
ζ_{T_5}	-1.063	[-1.602,-0.583]	-0.998	-1.018
ζ_{T_6}	-1.250	[-1.639,-0.829]	-1.236	-1.246
ζ_{T_7}	-1.107	[-2.037,-0.978]	-1.204	-1.164
$\Xi/1e6$	5.506	[5.027, 5.684]	5.464	5.492

The intervals are 95% confidence generated with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ, ζ, η, μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept. δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_ξ and σ_g are the standard deviations of ξ and g respectively; $\zeta_{T_1} - \zeta_{T_7}$ are Congressional session dummies from 2000-2013; Ξ is the adjustment parameter for the unobserved entry cost. The subscripts with a bar on top are for the averages of those variables.

Table 3.D.16: Robustness Checks 2: Around The Year Cutoff

Parameter	Main Estimate	CI	3 year window	7 year window
α	0.106	[0.053, 0.121]	0.117	0.098
$\gamma/1e6$	2.885	[2.836, 3.303]	2.909	2.926
δ_1	1.178	[1.037, 1.330]	0.665	1.457
δ_2	0.069	[-0.169, 0.335]	0.236	0.271
$\delta_{\bar{1}}$	1.501	[1.270, 1.704]	1.466	1.736
$\delta_{\bar{2}}$	0.050	[-0.251, 0.269]	-0.147	-0.191
ζ_1	0.455	[0.057, 0.629]	0.292	0.497
ζ_2	0.344	[0.111, 0.936]	0.204	0.362
η_1	1.036	[0.632, 1.909]	0.827	1.070
η_2	0.592	[0.008, 0.959]	0.453	0.493
η_3	0.224	[-0.061, 0.503]	0.373	0.235
$\eta_{\bar{2}}$	0.532	[-0.081, 0.790]	0.402	0.439
$\eta_{\bar{3}}$	0.320	[-0.360, 0.495]	0.299	0.285
$\mu_1/1e8$	0.530	[0.254, 0.975]	0.653	0.466
$\mu_2/1e8$	0.257	[-0.116, 0.441]	0.303	0.294
μ_3	0.959	[0.891, 1.025]	0.959	0.959
$\mu_{\bar{2}}/1e8$	0.684	[0.502, 0.990]	0.780	0.640
$\mu_{\bar{3}}/1e8$	-0.113	[-0.187,-0.064]	-0.117	-0.112
σ_{ξ}	0.049	[0.027, 0.076]	0.048	0.049
σ_g	0.049	[0.036, 0.059]	0.050	0.044
ζ_{T_1}	-0.779	[-0.971,-0.243]	-0.719	-0.757
ζ_{T_2}	-0.751	[-1.264,-0.242]	-0.803	-0.714
ζ_{T_3}	-0.737	[-1.188,-0.261]	-0.726	-0.644
ζ_{T_4}	-0.953	[-1.329,-0.374]	-0.999	-0.975
ζ_{T_5}	-1.063	[-1.602,-0.583]	-0.928	-1.076
ζ_{T_6}	-1.250	[-1.639,-0.829]	-1.327	-1.220
ζ_{T_7}	-1.107	[-2.037,-0.978]	-1.178	-1.279
$\Xi/1e6$	5.506	[5.027, 5.684]	5.442	5.465

The intervals are 95% confidence generated with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ, ζ, η, μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept. δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_{ξ} and σ_g are the standard deviations of ξ and g respectively; $\zeta_{T_1} - \zeta_{T_7}$ are Congressional session dummies from 2000-2013; Ξ is the adjustment parameter for the unobserved entry cost. The subscripts with a bar on top are for the averages of those variables.

Table 3.D.17: Robustness Checks 3: Around The Approximation Window

Parameter	Main Estimate	CI	7&10	6&9	4&7
α	0.106	[0.053, 0.121]	0.069	0.125	0.098
$\gamma/1e6$	2.885	[2.836, 3.303]	4.584	3.300	3.173
δ_1	1.178	[1.037, 1.330]	1.196	1.176	1.177
δ_2	0.069	[-0.169, 0.335]	0.109	0.064	0.073
δ_1	1.501	[1.270, 1.704]	1.486	1.500	1.482
δ_2	0.050	[-0.251, 0.269]	-0.020	0.066	0.051
ζ_1	0.455	[0.057, 0.629]	0.039	0.040	0.173
ζ_2	0.344	[0.111, 0.936]	0.039	0.062	0.487
η_1	1.036	[0.632, 1.909]	1.347	1.406	1.407
η_2	0.592	[0.008, 0.959]	0.087	0.624	0.629
η_3	0.224	[-0.061, 0.503]	0.617	0.075	0.283
η_2	0.532	[-0.081, 0.790]	-0.157	0.022	0.126
η_3	0.320	[-0.360, 0.495]	0.008	0.386	0.161
$\mu_1/1e8$	0.530	[0.254, 0.975]	0.685	0.839	0.901
$\mu_2/1e8$	0.257	[-0.116, 0.441]	0.014	0.083	0.026
μ_3	0.959	[0.891, 1.025]	0.956	0.962	0.957
$\mu_2/1e8$	0.684	[0.502, 0.990]	1.007	0.961	0.959
$\mu_3/1e8$	-0.113	[-0.187,-0.064]	-0.162	-0.171	-0.178
σ_ξ	0.049	[0.027, 0.076]	0.059	0.056	0.057
σ_g	0.049	[0.036, 0.059]	0.053	0.051	0.051
ζ_{T_1}	-0.779	[-0.971,-0.243]	0.166	-0.612	-0.583
ζ_{T_2}	-0.751	[-1.264,-0.242]	0.398	-0.129	-0.457
ζ_{T_3}	-0.737	[-1.188,-0.261]	0.410	-0.292	-0.647
ζ_{T_4}	-0.953	[-1.329,-0.374]	0.641	-0.410	-0.731
ζ_{T_5}	-1.063	[-1.602,-0.583]	-1.062	-1.122	-1.009
ζ_{T_6}	-1.250	[-1.639,-0.829]	-0.409	-1.323	-1.253
ζ_{T_7}	-1.107	[-2.037,-0.978]	-2.486	-1.817	-1.380
$\Xi/1e6$	5.506	[5.027, 5.684]	3.563	4.618	5.319

The intervals are 95% confidence generated with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ, ζ, η, μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept. δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_ξ and σ_g are the standard deviations of ξ and g respectively; $\zeta_{T_1} - \zeta_{T_7}$ are Congressional session dummies from 2000-2013; Ξ is the adjustment parameter for the unobserved entry cost. The subscripts with a bar on top are for the averages of those variables.

Table 3.D.18: Significance Check Around Fixed Effects

Parameter	Main Estimate	CI	restrict Mundlak	restrict Cong-FE
α	0.106	[0.053, 0.121]	0.081	0.082
$\gamma/1e6$	2.885	[2.836, 3.303]	2.890	2.708
δ_1	1.178	[1.037, 1.330]	1.366	1.178
δ_2	0.069	[-0.169, 0.335]	0.203	0.062
$\delta_{\bar{1}}$	1.501	[1.270, 1.704]	0	1.483
$\delta_{\bar{2}}$	0.050	[-0.251, 0.269]	0	0.068
ζ_1	0.455	[0.057, 0.629]	0.473	0.470
ζ_2	0.344	[0.111, 0.936]	0.394	0.139
η_1	1.036	[0.632, 1.909]	1.070	1.043
η_2	0.592	[0.008, 0.959]	0.547	0.587
η_3	0.224	[-0.061, 0.503]	0.369	0.221
$\eta_{\bar{2}}$	0.532	[-0.081, 0.790]	0	0.433
$\eta_{\bar{3}}$	0.320	[-0.360, 0.495]	0	0.318
$\mu_1/1e8$	0.530	[0.254, 0.975]	0.426	0.655
$\mu_2/1e8$	0.257	[-0.116, 0.441]	0.239	0.160
μ_3	0.959	[0.891, 1.025]	0.953	0.956
$\mu_{\bar{2}}/1e8$	0.684	[0.502, 0.990]	0	0.758
$\mu_{\bar{3}}/1e8$	-0.113	[-0.187,-0.064]	0	-0.134
σ_{ξ}	0.049	[0.027, 0.076]	0.058	0.051
σ_g	0.049	[0.036, 0.059]	0.049	0.049
ζ_{T_1}	-0.779	[-0.971,-0.243]	-0.753	0
ζ_{T_2}	-0.751	[-1.264,-0.242]	-0.764	0
ζ_{T_3}	-0.737	[-1.188,-0.261]	-0.708	0
ζ_{T_4}	-0.953	[-1.329,-0.374]	-0.986	0
ζ_{T_5}	-1.063	[-1.602,-0.583]	-1.087	0
ζ_{T_6}	-1.250	[-1.639,-0.829]	-1.214	0
ζ_{T_7}	-1.107	[-2.037,-0.978]	-1.140	0
$\Xi/1e6$	5.506	[5.027, 5.684]	5.503	5.412

The intervals are 95% confidence generated with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ , ζ , η , μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept; δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_{ξ} and σ_g are the standard deviations of ξ and g respectively; $\zeta_{T_1} - \zeta_{T_7}$ are Congressional session dummies from 2000-2013; Ξ is the adjustment parameter for the unobserved entry cost. The subscripts with a bar on top are for the averages of those variables.

Table 3.D.19: Bias Corrected Confidence Interval

Parameter	Main Estimate	CI	BC CI
α	0.106	[0.053, 0.121]	[0.087, 0.123]
$\gamma/1e6$	2.885	[2.836, 3.303]	[2.709, 2.903]
δ_1	1.178	[1.037, 1.330]	[1.037, 1.326]
δ_2	0.069	[-0.169, 0.335]	[-0.159, 0.301]
$\delta_{\bar{1}}$	1.501	[1.270, 1.704]	[1.291, 1.703]
$\delta_{\bar{2}}$	0.050	[-0.251, 0.269]	[-0.240, 0.267]
ζ_1	0.455	[0.057, 0.629]	[0.290, 0.679]
ζ_2	0.344	[0.111, 0.936]	[0.076, 0.526]
η_1	1.036	[0.632, 1.909]	[0.566, 1.465]
η_2	0.592	[0.008, 0.959]	[0.204, 1.033]
η_3	0.224	[-0.061, 0.503]	[-0.062, 0.431]
$\eta_{\bar{2}}$	0.532	[-0.081, 0.790]	[0.329, 0.866]
$\eta_{\bar{3}}$	0.320	[-0.360, 0.495]	[0.128, 0.579]
$\mu_1/1e8$	0.530	[0.254, 0.975]	[0.102, 0.817]
$\mu_2/1e8$	0.257	[-0.116, 0.441]	[0.037, 0.461]
μ_3	0.959	[0.891, 1.025]	[0.891, 1.018]
$\mu_{\bar{2}}/1e8$	0.684	[0.502, 0.990]	[0.361, 0.873]
$\mu_{\bar{3}}/1e8$	-0.113	[-0.187,-0.064]	[-0.158, -0.063]
σ_{ξ}	0.049	[0.027, 0.076]	[0.025, 0.061]
σ_g	0.049	[0.036, 0.059]	[0.031, 0.050]
ζ_{T_1}	-0.779	[-0.971,-0.243]	[-1.166, -0.578]
ζ_{T_2}	-0.751	[-1.264,-0.242]	[-1.460, -0.463]
ζ_{T_3}	-0.737	[-1.188,-0.261]	[-1.113, -0.260]
ζ_{T_4}	-0.953	[-1.329,-0.374]	[-1.443, -0.785]
ζ_{T_5}	-1.063	[-1.602,-0.583]	[-1.601, -0.656]
ζ_{T_6}	-1.250	[-1.639,-0.829]	[-2.024, -1.001]
ζ_{T_7}	-1.107	[-2.037,-0.978]	[-1.211, -0.924]
$\Xi/1e6$	5.506	[5.027, 5.684]	[5.396, 5.772]

The intervals are 95% confidence generated with a percentile bootstrap. α is the returns to scale on lobbying expenditures. γ is the endogenous prize parameter, the slope parameter on how much aggregate lobbying affects total contract spending. The δ, ζ, η, μ parameters are the coefficients on the corresponding data; η_1, μ_1 constant/intercept. δ_1 : lagged firm shares; δ_2 : hq in D.C area; ζ_1 : former Congressmen on the lobbying team; ζ_2 : lagged lobbying; η_2 : degree of competition in sector; η_3 : number of firms per sector; μ_2 : DoD contract sector; μ_3 : lagged sector size; σ_{ξ} and σ_g are the standard deviations of ξ and g respectively; $\zeta_{T_1} - \zeta_{T_7}$ are Congressional session dummies from 2000-2013; Ξ is the adjustment parameter for the unobserved entry cost. The subscripts with a bar on top are for the averages of those variables.

APPENDIX E

Data Details

The raw datasets used:

- Full list of federal government contracts. Source: https://www.usaspending.gov/#/download_center/award_data_archive
- Open Secrets Open Data lobbying disclosure. Source: <https://www.opensecrets.org/open-data>
- Appropriations list with bill numbers. Source: <https://www.congress.gov/resources/display/content/Appropriations+for+Fiscal+Year+2019>

The yearly contract datasets each contain 225 columns with some years have millions of rows; I extract “vendor”, “mod-parent”, “productorservicecode”, “maj-fund-agency-cat”, “fund-ag”, “agencyid”, “piid”, “state”, “extentcompeted”, “annualrevenue”.³⁰ I then collapse the data to the firm-agency-contract type-year level. “Agency” in this case is the major agency (like DoD) authorizing (or funding if the authorization cell is missing) the contract. “Contract type” means the first four digits (out of 5; choosing 5 led to too many small sectors) of the product-or-service code [as defined in the data section]. The combination of agency and product code form the “sector”. The full firm-sector-year dataset has 6,463,148 observations after dropping those without names.³¹

The “Product and Service Codes” describes “products, services, and research and development purchased by the federal government; these codes indicate “what” was bought for each contract action reported in the Federal Procurement Data System” (Federal Acquisition Service PSC manual). Example categories are ammunition, R&D Space Flight, IT services, and building construction. The most common types are “IT Support-Professional: Other” and “Medical

³⁰Since these are too large to combine on a computer with less than about 100GB of ram, I use Powershell’s “select” function to choose columns (alternative methods include using Matlab’s “tall arrays”).

³¹For the few dozen or so cases where the contract was negative (by owing the agency from a previous contract), I add the negative to the previous year’s contract for that firm in that sector and replace the current year with zero. The idea is that the cost to the firm of a delinquency is internalized within the year that the contract was earned.

and Surgical Instruments, Equipment, and Supplies”. The largest contracts are “Operation of Government-Owned Contractor-Operated R&D Facilities” and “Amphibious Assault Ships”. See https://www.acquisition.gov/PSC_Manual for a full list.

The yearly lobbying disclosure database from Open Secrets contains the processed raw lobbying disclosure reports from the House and Senate (<https://lobbyingdisclosure.house.gov/>, https://www.senate.gov/pagelayout/legislative/g_three_sections_with_teasers/lobbyingdisc.htm). The data is dispersed across multiple files due to the unique structure of lobbying; quarterly/semi-annually total lobbying expenditures reported by each firm (alongside firm information and the lobbying company they may have hired) are in one file, whereas the list of individual lobbyists representing the firm is in another, and then the list of bills and issues the firm specifically lobbied on is in yet another. I use the “Ultorg” as the parent company name to match names across the lobbying and contracts data. To match with the contract data, I create a fully balanced panel as I do not want to miss some firms by matching only firm-year based on the years in which they have positive lobbying. Thus the “filled-in” dataset has many zeros and 683,072 observations.

While I focus on appropriations bills, authorization bills deserve discussion. Authorization bills largely determine which programs can be funded whereas appropriation bills determine the funding levels for authorized programs. Thus differentiating between lobbying over appropriation and authorization bills may be informative. Of the firms that lobbied over a defense authorization in a given year, 58% lobbied over defense appropriations in that same year (among the set of firms that have ever lobbied on both at some point). Similarly, of the firms that lobbied over a defense appropriation bill, 37% also lobbied over the defense authorization bill. Thus many firms lobbied only over appropriations. This may be due to the fact that many programs may be authorized in a boiler-plate fashion year to year and the main lobbying action goes on over funding levels and the distribution of that funding on the individual contracts by agencies.

The federal government used the “Data Universal Numbering System” (DUNS) identification system as the single unique identifier for each contractor (it is now shifting away). Open Secrets does not use an common firm identifier. At the time of creating this dataset, there was no cross-walk

between DUNS and any other identifier linkable to lobbying firms.³² Thus my only option was to match on names with a string-matching algorithm; luckily the major differences between the names between the two databases were only instances of abbreviation for terms like “Limited Liability Company” with “LLC”. There were 559,566 distinct parent company names [2000-2015] in the contract database and 42,692 distinct parent company names in the lobbying dataset. I standardized the names and eliminated variation in common terminology. I compared my full-string matching to the “matchit” fuzzy string matching program by analyzing the Jaccard similarity scores. Less than a dozen names (which I then added manually) had similarity scores above 95% and below 100% (and were actually the same firm). A few firms used acronyms for their name in the contract database and those had to be manually added as they did not match.

The 6,463,148 observation firm-sector-year dataset for contracts translates into a 2,181,220 observation firm-year dataset. Out of the 2,181,220 observations, 79,820 (943,198 out of 6,463,148 at the firm-sector-year level), or 3.66%, matched in a one-to-one merge with the firm-year list of lobbying firms dataset (683,072 observations). This represents 11.69% of the firm-years in the lobbying dataset; thus 11.69% of firm that lobbied at some point have received at least one contract. The small number of firms that receive contracts that also lobby (3.66%) is not too surprising as this merge included all firms that received contracts and for the most part only large firms lobby.

Next I drop those that that lobby but have never received a contract in the entire 15 year panel. Modeling these firms as contract-seekers is likely inaccurate (see data description for more discussion); furthermore, determining over which contracts they may lobby would be impossible as they have never received one. Recall I do not drop those that never lobby but receive contracts; they affect the share for which the lobbying firms are lobbying.

As described in the main text, I allow firms to be present in the sample for a given year even if they did not win a contract in that sector that year as I want to avoid the sample selection issue of observing only those who win contracts. To do this I first create a balanced panel for

³²And to my current knowledge there is no systematic cross-walk that I have access to. This is further complicated as many IDs are for public corporations, but many large private contractors are privately owned. LobbyView, a recently created lobbying database provides Ticker, GVKey, and BvD ID. The latter is for private companies but is proprietary; it’s new database “Orbis” may provide a crosswalk but the accessibility or scalability is unknown to me.

firms and the sectors in which they have ever received a contract. For example, if a firm earned a contract in 10mm ammo production from the Defense Department in 2006 but not 2005, I may want to include them in the 2005 analysis as they could have just unsuccessfully attempted to win a contract in 2005. Thus I “fill-in” missing instances of the unbalanced panel. This procedure increases the number of observations to 16,919,968 from the 6,463,148 firm-sector-year dataset. It is not feasible to include every firm that ever won a contract of any size as that would result in thousands of firms per sector and the estimation involves numerically solving many fixed points.

The single trimming condition of significance requiring sensitivity analysis is the cutoff for contract size at the firm level. I include a firm as a potential participant in a given sector-year if they made at least \$100 million in contract revenues in that sector over the 5 year window around that year. A cutoff significantly lower than this leads to sectors with hundreds of firms (and computationally infeasible to run a nested fixed point algorithm). Out of the 16,919,968 fully balanced firm-sector-year panel, 19,608 satisfy this criterion. Recall however that the majority of the 16,919,968 were all added to balance the panel (just filling in missing spaces). Not all of those will be dropped however because the cutoff is for a 5 year window; if a firm reached the criterion in one year and had nothing the following year inside the window, both years would be included.

The sensitivity around that cutoff is not large. When adding or subtracting \$1 million to the \$100 million cutoff, about 200 observations, or 1.05%, are added/subtracted. If we enlarge this to plus or minus \$10 million, we increase/decrease the number of observations by about 10%. The symmetry for these smaller cutoff ranges is indicative of the fact that there is no sharp discontinuity near the chosen point. If we substantially change the cutoff to plus or minus \$50 million, then we double the number of observations with a \$50 million cutoff and lose 34% of observations with a cutoff of \$150 million.

An alternative sensitivity to analyze is one around the 5 year window time-frame. To be precise the window considers the current year plus 2 years and minus 2 years. If we consider a 1 year window (meaning they must reach that amount in the current year), we lose 9,993, or 51%, of the 19,608 observations. If we consider a 3 year window (meaning plus or minus only 1), we lose

4,473, or 23%, of the observations. If we expand the window to a 7 window (meaning plus or minus 3), we gain only 3,993, or 20.36%, of the observations. If we increase this to a 9 year window, we gain 38% more observations; in other words, in a 9 year window, 72.3% of the observations would satisfy the 5 year window.

If we choose too large of a window, then the majority of the additionally included firms are of the type that they won a large contract in the past (or in the future) but either left/merged (or are newly formed) or change the sector in which they operate. This is evident as of the 27.73% of the 9-year window observations that do not fall under the 5-year window, 52% have zero contracts. There are not too many firms that received near that cutoff point but fell off with consistently smaller amounts for the duration of the panel. The final dataset for analysis has 15,766 firm-sector-year observations which drops the year 2000 (due to no pre-2000 data for controls) and 2014-2015 (for out of sample post-estimation comparison).

The dataset is at the firm-sector-year level. The contracts data is observed at this level. The lobbying expenditures are at the firm-year level. The lobbying entry data is approximately at the firm-sector-year level as we do observe the exact appropriations bill on which the firm lobbied; we can then match the bill to the specific agencies appropriating the funds to the different contract sectors. This is the finest level of granularity feasible for defining lobbying entry; thus (as in Kang) we must assume the entry is in all sectors covered in that agency; however doing this for firms that never receive contracts in some of those sectors is likely inaccurate. Thus I assign the entry to all sectors relevant to the firm (as defined by whether they have been active in that sector using the cutoff above) and assign entry to those. The possible bias this induces is by over-estimating entry into multiple sectors; this is more likely to depress (than inflate) estimated lobbying effects as the model is attempting to find lobbying influence in a sector in which the firm never lobbied.

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BIBLIOGRAPHY

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