Valuing Ideological Customer Capital: Measurement through Procurement

Winston Wei Dou   Yan Ji   David Reibstein   Di Tian*

January 14, 2026

Abstract

A firm's ideological customer capital, which captures the value derived from attracting customers with similar ideological beliefs, directly impacts the firm's ability to generate cash flows from customers. We examine the value of a firm's ideological customer capital in the context of federal government procurement, because the U.S. government is a major customer and it has the discretion to consider ideological factors in procurement. With detailed contract-level data, we directly observe the government's procurement decisions and outcomes. By developing and structurally estimating a procurement auction model, we show that a firm's political ideology, sustainability, gender composition, and exposure to China play significant roles in determining its cash flows from government procurement, though the effects exhibit substantial heterogeneity across industries.

Keywords: Ideological customer capital, Government procurement, Mechanism design, Structural estimation

*Dou: University of Pennsylvania (wdou@wharton.upenn.edu) and NBER; Ji: Hong Kong University of Science and Technology (jiy@ust.hk); Reibstein: University of Pennsylvania (reibstein@wharton.upenn.edu); Tian: Hong Kong University of Science and Technology (ditian@ust.hk).

1 Introduction

A firm's customer capital, which captures the loyalty of its customer base, is vital to the firm's profitability and performance, as firms derive their cash flows primarily from customers. An important component of customer capital is ideological customer capital—the value derived from attracting customers with similar ideological beliefs. In today's world with heightened social and political awareness, customers' ideological beliefs have a significant impact on their perception and valuation of a firm's products and services. Consequently, a firm's ideological customer capital helps increase customer loyalty and advocacy and stabilize demand flows against negative market trends, thereby directly affecting the firm's competitiveness, profitability, and cash flows. Despite its essential role, few have systematically examined the value of ideological customer capital.

The literature has examined the value of a firm's customer capital via investment-based approaches (e.g., Belo et al., 2022) or brand survey data (e.g., Dou et al., 2021*b*). However, traditional approaches tend to conflate distinct components of customer capital and fail to capture the nuanced ways in which a firm's ideologies impact its cash flows. Thus, we focus specifically on U.S. federal government procurement and examine the value of ideological customer capital in this context. Federal government procurement provides an ideal setting for our analysis. First, the U.S. government is one of the largest customers in the world. Federal government procurement accounts for approximately 3% of the gross domestic product in the U.S. Second, a large number of procurement contracts are awarded to firms through full and open competition, and the government has the discretion to consider ideological factors when selecting contractors. In fact, the Federal Acquisition Regulation (FAR) stipulates that contracting under full and open competition allows the government to consider non-price criteria before awarding contracts to prospective contractors. Furthermore, the Federal Procurement Data System (FPDS) provides detailed contract-level data on the government's procurement decisions and outcomes. We match the FPDS data with data on firm characteristics related to ideological customer capital. This allows us to structurally evaluate the role of a firm's ideological customer capital in government procurement.

We focus on four salient dimensions of a firm's ideological customer capital that are highly relevant to the U.S. government: the firm's political alignment with the procuring subagency, the firm's sustainability as captured by its carbon emission, the firm's gender composition as captured by its female leadership ratio, and the firm's connection to China. These ideological characteristics directly speak to the core ideological beliefs and socio-political goals of the U.S. government, and can play a significant role in determining a firm's cash flows from government procurement. To examine how these ideological characteristics determine procurement outcomes, we develop and structurally estimate a procurement model, in which the government and multiple competing firms with hidden types and multi-dimensional characteristics play an auction game. The government designs an optimal mechanism for the auction game and invites firms to bid. Among the competing firms, the government selects the winner based on the firms' reported hidden efficiency types, which influence the project's pecuniary cost, and observable characteristics that determine the non-pecuniary benefits for the government. Our estimated model indicates that firms' ideological characteristics significantly influence the government's awarding decisions, though their relative importance varies across industries. For instance, our estimates suggest that, in the IT industry, firms with lower carbon emission and firms with a lower female leadership ratio are favored by the government and have a significant advantage in procurement competition. In the office management industry, firms that are politically aligned with the procuring subagency and firms with a lower female leadership ratio are more likely to win the contracts. In contrast, in the transportation and logistics industry, firms that are politically aligned are less likely to win the contracts, while firms with lower carbon emission and firms with no connection to China are more likely to win.

A typical U.S. federal procurement procedure starts with the procuring agency identifying its needs and issuing a solicitation notice. During solicitation, federal regulations require full and open competition as the default process, but allow the procuring agency to not solicit competitive bids under certain circumstances. For procurement under full and open competition, the procuring agency has a broad range of discretion to determine the competitive range of firms and specific contract terms, such as payment, schedule, and type of contract. After soliciting and receiving the bids from interested firms, the agency awards the procurement project to a winner based on several evaluation factors to achieve the best value for the government. Unlike pecuniary factors, the criteria for considering non-pecuniary factors in selecting winners may not be disclosed to the public. The contract-level data provided by FPDS only includes information on contract terms and procurement outcomes. Finally, the winning contractor executes the project, and adjustments in payment or schedule may occur before project completion.

To capture these unique institutional features of U.S. federal government procurement, we model the procurement process as a non-cooperative auction game between the government and firms with multi-dimensional heterogeneity. The government seeks to minimize the expected total cost of a procurement project by optimally designing the mechanism of the auction game. Firms differ from each other in both efficiency types and multi-dimensional characteristics. The efficiency types are firms' private information and directly influence the project's execution costs. Firm characteristics are observable to the government. These characteristics capture the non-pecuniary factors in award allocation, and thus, for clarity, we assume that they do not have a direct impact on execution costs. In the model, we assume that a firm's efficiency type and characteristics are exogenously drawn from the firm distribution. While firms could strategically adjust their characteristics to some extent in reality, doing so is very costly. The four ideological characteristics of interest are highly persistent in the data. Therefore, we take the equilibrium firm distribution as given and focus on how firms with different characteristics perform in government procurement competition.

At the beginning of the auction game, the government decides whether to solicit competitive bids from firms. If non-competitive solicitation is chosen, a firm selected at random is awarded the project without any competition. Soliciting competitive bids means that the procurement project is under full and open competition. In this case, multiple firms can potentially arrive, competing for the award. Introducing competition allows the government to find a more favorable firm and lowers the government's expected cost; however, it incurs an ex-ante fixed cost for the government. By allowing the government to make the solicitation choice, our model captures the procuring agency's discretion in choosing the extent of competition, permitted under federal regulations. Moreover, some parameters governing the distribution of firms can be directly identified based on the contracts that do not employ full and open competition in the data, even though our main focus in structural estimation is on the contracts that employ full and open competition.

For the procurement project implemented via full and open competition, the government optimally designs the auction's mechanism, which includes payment terms for a menu of contracts as well as how the winner is selected. To capture potential payment adjustments, we allow the payment terms to depend on the random contract outcome realized at the project completion. By the revelation principle, we focus on the optimal mechanism that induces a truth-telling equilibrium: firms' hidden efficiency types are perfectly inferred by the government based on their rational choices of contracts. Even though firms differ in both efficiency types and multi-dimensional characteristics, we can analytically characterize the optimal mechanism design. Importantly, our analytical solutions clearly illustrate how firm characteristics affect the selection of the winner as well as the payments to the winner.

To estimate the model, we construct a novel dataset by linking contract-level data from FPDS with multiple data sources that provide information on firm characteristics. We consider four ideological characteristics that may influence the government's procurement decisions: the political alignment between the firm and the procuring subagency, the firm's carbon emission, the firm's female leadership ratio, and the firm's connection to China. We measure a firm's political affiliation primarily based on firms' Political Action Committee (PAC) donation data from the U.S. Federal Election Commission (FEC). A firm is defined as Republican-leaning (Democratic-leaning) when more than two thirds of its PAC donations go to the Republican (Democratic) party. Otherwise, the firm is defined as non-partisan. For firms that do not make PAC donations, we measure their political affiliations based on the L2 voter registration data of the firms' key executives. Moreover, for each contract's procuring subagency in FPDS, we measure its political affiliation based on the political affiliation of the subagency head, which is obtained from the L2 voter registration data and various official sources, such as government websites. Carbon emission data is obtained from the Trucost database. As discussed in Bolton and Kacperczyk (2021, 2023), Trucost is one of the leading providers of information on firm-level carbon and other greenhouse gas emissions. A firm's female leadership ratio is defined as the proportion of females among the firm's key executives. We obtain data on firms' supply-chain relationships from the FactSet Revere database, which provides the most comprehensive coverage available (Gofman, Segal and Wu, 2020). A firm is defined to be connected to China if it has a supplier or customer based in China. In addition to the four ideological characteristics, we also include three control characteristics: the firm's past contracting experience with the procuring subagency, the firm's brand value obtained from the BAV Group, and the firm's size.

Leveraging this dataset, we structurally estimate the model using a Bayesian approach for three representative industries, including the IT, office management, and transportation and logistics industries. For each industry, we first externally estimate firm distributions and contract outcome distributions without relying on the model's structure. Plugging the estimated distributions into the model, we jointly estimate the remaining parameters using a Markov chain Monte Carlo (MCMC) procedure. In the estimation, to address the endogeneity issue from characteristics considered by the government but not included in the dataset, we specify the residual term as a latent variable in addition to the observed characteristics. The MCMC procedure estimates the joint posterior distribution of the model parameters and the latent variable for each observation, conditioning on the observed data. Because the Bayesian MCMC approach can deal with latent heterogeneity with relatively low dimension, instrumental variables are not necessary for estimation.

Using the estimated model, we perform quantitative analysis to examine the role of the four ideological characteristics in government procurement. In the baseline estimation, we first evaluate the impact of a firm's ideological characteristics on its performance in procurement projects under full and open competition. We find that firms with different ideological characteristics have significantly different average cash flows from government procurement. For instance, in the IT industry, relative to the median firm, a one-standard-deviation lower average carbon emission is associated with 12.61% higher average cash flow from government procurement, while this number is 6.74% for the female leadership ratio. These results indicate that firms with lower carbon emission and firms with a lower female leadership ratio are favored by the government and have a significant competitive advantage in government procurement in the IT industry. In contrast, the effects of political alignment and connection to China are much smaller. In the office management industry, the effects are the largest for the female leadership ratio, followed by the political alignment. A one-standard-deviation lower average female leadership ratio is associated with 21.21% higher average cash flow from government procurement, while a one-standard-deviation lower average political alignment is associated with 11.75% lower average cash flow. This indicates that firms with a lower female leadership ratio and firms that are politically aligned with the procuring subagency are favored by the government and thus have an advantage in procurement competition. In comparison, in the transportation and logistics industry, firms that are politically aligned with the procuring subagency have a disadvantage, while firms with lower carbon emission and firms with no connection to China have an advantage. In particular, a one-standard-deviation lower average political alignment is associated with 11.08% higher average cash flow from government procurement. This number is 15.21% for carbon emission and 4.60% for the connection to China.

We further evaluate the two channels that affect the firm's average cash flow from government procurement. First, firms with different ideological characteristics have different probabilities of winning government procurement contracts. Second, different firms also receive different cash flows conditional on winning, since the government optimally designs the payment terms contingent on firm characteristics. We find that the first channel is the main driver of the difference in the average cash flow, while the effect of the second channel is smaller. For instance, in the IT industry, a one-standard-deviation lower average carbon emission is associated with a 14.73% increase in the average winning probability and a 2.84% increase in the average cash flow conditional on winning. The combined effect is a 12.61% increase in the average cash flow from government procurement.

Then, we evaluate how government valuation of a firm's ideological characteristics affects firm performance in government procurement. Specifically, we quantify how firms' average cash flows from government procurement would change in the counterfactual experiments where the government ignores each of the four ideological characteristics when it selects the winning contractor. We find that the effect exhibits significant heterogeneity across different firms. In the counterfactual experiment where the government ignores an ideological characteristic, the change in the average cash flow is more negative for firms that are favored by the government due to this characteristic in the baseline. This is simply because, in the counterfactual, these firms are no longer favored by the government for this characteristic. For instance, when the government ignores firms' carbon emission in the IT industry, the firm with low average carbon emission experiences an 8.24% decrease in its average cash flow from government procurement. In contrast, the firm with high average carbon emission experiences a 4.70% increase. These significantly different effects are consistent with the finding that, in the baseline, firms with low (high) carbon emission are favored (disfavored) by the government in the IT industry. In general, when an ideological characteristic is more important in the baseline, the effect of the government ignoring it when selecting the winning contractor exhibits larger heterogeneity across firms.

Related Literature. Our paper contributes to the literature on customer capital in finance. Prior research has studied the role of the product market in determining firm performance and corporate policies (e.g., Banerjee, Dasgupta and Kim, 2008; Larkin, 2013; Belo, Lin and Vitorino, 2014; Gourio and Rudanko, 2014; Foster, Haltiwanger and Syverson, 2016; Dou et al., 2021*b*). In particular, Belo et al. (2022) decompose firm value into different components and find that brand capital accounts for a significant portion. We focus specifically on a firm's ideological alignment with customers and examine the role of a firm's ideological customer capital in firm profitability and valuation through government procurement.

Our paper also contributes to the literature on the intersection of finance and industrial organization. Earlier works focus on the interplay between competition, corporate financing, and contracting, such as Titman (1984); Bolton and Scharfstein (1990); Bolton and Whinston (1993); Dasgupta and Titman (1998). Recently, researchers have examined competition through the lens of mergers and acquisitions, product differentiation, asset returns, financial distress, and industry dynamics (Hoberg and Phillips, 2010, 2016; He and Matvos, 2016; Corhay, Kung and Schmid, 2020; Dai, Jiang and Wang, 2022; Dou and Ji, 2021; Dou, Ji and Wu, 2021, 2022; Dou, Wang and Wang, 2022; Chen et al., 2024*a*,*b*). Our paper contributes to this literature by studying firms' competition in government procurement and structurally identifying the competitive advantage attributed to different firm ideological characteristics.

Our paper is related to the literature that studies the important role of the government in determining firm performance and valuation. Pástor and Veronesi (2012, 2013) study the impact of uncertainty about government policy on stock prices. Belo, Gala and Li (2013) study the cross-sectional asset pricing implications of political cycles based on a novel measure of industry exposure to government spending using industry-level data from the U.S. National Income and Product Accounts (NIPA) input-output accounts. Belo and Yu (2013) and Goldman (2020) respectively focus on the financial implications of government investments and government purchases. Brown and Huang (2020) provide evidence indicating that political access is important to corporations. Pástor and Veronesi (2020) relate political cycles to stock returns. Our paper focuses on U.S. federal government procurement. Using a structural estimation approach, our results based on contract-level micro data shed light on how a firm's ideological characteristics and government valuation of these characteristics affect firm performance in the context of a particular type of government spending, i.e., procurement.

Our paper is related to the literature that studies the public procurement process. Prior research has found that discretion plays a significant role in determining procurement outcomes (e.g., Coviello, Guglielmo and Spagnolo, 2018; Baltrunaite et al., 2021; Bandiera et al., 2021). The buyers' decisions can be driven by non-price criteria either explicitly specified in the solicitation or implicitly motivated by various underlying reasons (e.g., Bandiera, Prat and Valletti, 2009; Krasnokutskaya and Seim, 2011; Coviello and Gagliarducci, 2017; Liebman and Mahoney, 2017; Spenkuch, Teso and Xu, 2023). Several papers develop structural models to study the implications of competition for procurement outcomes (e.g., Bhattacharya, 2021; Carril, Gonzalez-Lira and Walker, 2022; Kang and Miller, 2022). In particular, Kang and Miller (2022) structurally estimates an auction game in the IT industry to understand why there is little competition in government procurement. Our model significantly differs from theirs by incorporating multi-dimensional characteristics of firms to examine the role of a firm's ideological customer capital in government procurement.[1] This modeling specification requires us to jointly determine and structurally estimate optimal contract terms and the winner selection rule in the government's mechanism design problem. In contrast, the winner selection rule can be trivially and separately determined in the absence of multidimensional characteristics. Because winner selection cannot be separately determined in our model, the non-pecuniary component of the government's costs must be estimated jointly with other parameters, which complicates structural identification. Furthermore, estimating such a model requires us to construct a new dataset that links contract-level data from FPDS with various firm characteristics gathered from other data sources, which itself represents a valuable contribution to the literature.

2 Institutional Background and Data

To examine the value of a firm's ideological customer capital through government procurement, we construct a new dataset that matches the contract-level procurement data from FPDS with the firm-level characteristics data collected from various sources. Our data

[1] Che (1993) and Branco (1997) are among the first attempts to analyze the optimal auction design where bidders have two-dimensional types. Asker and Cantillon (2008, 2010) study a fully general multidimensional setting and use a simple example to demonstrate the challenge in designing optimal auctions with multidimensional types. These studies all assume that bidders are risk-neutral and have multidimensional private types. Our model differs from them by allowing risk-averse bidders and assuming that bidders have one-dimensional private type but multidimensional observable characteristics. In addition, unlike previous theoretical studies, we also take our model to data using a structural estimation approach.

include both public and private firms. In this section, we detail the federal procurement process and our dataset.

2.1 Institutional Background

The implementation of a federal procurement project involves four phases.

Phase 1. The procuring agency first identifies its specific needs and requirements, and plans for the corresponding procurement project.

Phase 2. The procuring agency then determines the most appropriate competition and solicitation strategy for the solicitation process. In particular, for the projects over which it has discretion, the procuring agency decides whether they are implemented via competitive or non-competitive solicitation.[2] The regulation states competitive solicitations as the default solicitation requirement (FAR 6.1), which corresponds to full and open competition. In this case, the procuring agency actively seeks out and engages with multiple firms that may be interested in bidding before issuing the formal solicitation notice. If the procuring agency instead implements such projects via non-competitive solicitations, the agency is required to specify and certify the circumstances for limited competition (FAR 6.2 and 6.3). These circumstances can include discretionary reasons such as copyrights, brand name, follow-on acquisition, and urgency.

Once the competitive nature of the solicitation is determined, the procuring agency also chooses the specific solicitation procedure. Among the available procedures, the procuring agency generally has a broad range of discretion over the contracting process, except in cases of sealed bidding, simplified acquisition, and other uncommon procedures.[3] This discretion over the contracting process effectively allows the procuring agency to determine the contract terms and, in competitive solicitations, the selection criteria of the winning firm. More specifically, the procuring agency can discuss with each bidding firm to enhance its understanding of the firm's bid before determining the appropriate contract terms and making the award.

[2]Exceptions are those projects where statutory requirements mandate non-competitive solicitations. These statutory requirements include, for example, set-aside requirements for small business, domestic regulations, and international agreements.

[3]In sealed bidding, the project is typically awarded based solely on price factors to the lowest bidder. In simplified acquisition, the procuring agency follows pre-determined streamlined processes for certain contracts and has limited discretion over the contracting process. Other uncommon procedures such as two-step bidding operate under distinct rules.

Phase 3. The procuring agency then collects and evaluates firms' bids, and awards the project to a winner. In competitive solicitations, the procuring agency selects a winner among all bidding firms based on a combination of price and non-price factors to achieve the best value for the government. In non-competitive solicitations, typically only one firm bids and is awarded the project by default.

Phase 4. The procuring agency finally signs the contract with the winning contractor. Upon signing the contract, there is an initial agreement between the two parties on a base payment that the government is obligated to pay the contractor in the future, as well as a base duration for the expected completion of the project. However, there can be ex-post adjustments in duration and payment as the contract progresses and gets modified (e.g., Gagnepain, Ivaldi and Martimort, 2013; Bajari, Houghton and Tadelis, 2014; Spenkuch, Teso and Xu, 2023). Therefore, the final duration and payment are often different from their base amounts in the initial agreement. These subsequent modifications address uncertainties during project execution, and often reflect the contractor's ability to manage delivery timelines and control costs.

2.2 Procurement Data

The U.S. federal procurement data is from FPDS. This data is commonly used in the literature (Tahoun, 2014; Liebman and Mahoney, 2017; Brogaard, Denes and Duchin, 2021; Bhattacharya, 2021), and covers nearly all federal procurement contracts.

Following Kang and Miller (2022) and Spenkuch, Teso and Xu (2023), we study definitive contracts and purchase orders, and exclude contracts associated with indefinite delivery vehicles (IDVs). Both definitive contracts and purchase orders are one-time direct contract awards that specify definitive payments, quantities, and schedules, making them suitable for our analysis.[4] We filter the sample with the following criteria. First, per our discussion in Subsection 2.1, we focus on contracts awarded via competitive solicitations.[5] Second, we exclude contracts that follow sealed bidding, simplified acquisition, and other uncommon

[4] In contrast, IDVs reflect long-running contractual arrangements, which include the initial parent IDV contract and follow-on contracts (i.e., task/delivery orders) placed under it. In the initial parent contract, there are typically no defined payments, quantities, or schedules. The follow-on contracts specify payments and quantities, but are placed subject to limited competition and evaluation criteria due to the agreements in the parent contract. Since the payments are not specified in the initial parent contract and the winner selection is limited in the follow-on contracts, these contracts are not suitable for our analysis of how firms' characteristics of interest affect government procurement outcomes.

[5] To improve the precision of externally estimated distributions, we also use the contracts awarded via non-competitive solicitations due to discretionary reasons. The structural estimation and main results focus only on contracts awarded via competitive solicitations.

solicitation procedures, for which the government has limited discretion over the contracting process (Bajari, McMillan and Tadelis, 2009). Third, we exclude contracts not performed domestically in the U.S. because they have different cost structures. Fourth, we exclude contracts with incomplete, inconsistent, or inadmissible information. See Online Appendix A.2 for more details.

As discussed in Subsection 2.1, for each contract, there could be subsequent modifications to the contract terms specified in the initial contract. FPDS records both the initial entry of each contract and the subsequent entries of follow-up modifications. We construct payment and duration variables from these entries for each contract. Regarding contract payments, we measure the base payment as the obligated amount that the government needs to pay the contractor in the initial entry of the contract, and the variable payment as the sum of the obligated amounts across the subsequent entries of the contract.[6] The final payment is the sum of the base and variable payments. Regarding contract durations, we measure the base duration as the difference between the contract's effective initiation date and its expected completion date in the initial entry of the contract. We measure the variable duration as the difference between the expected completion date recorded in the initial entry of the contract and that recorded in the last entry of the contract. The final duration is the sum of the base and variable durations.

In a procurement project, different firms will have varying execution costs to achieve the required outcome, leading them to request different contract types. If a firm is efficient, it will have low execution costs and thus will request low government payments when bidding on the project. Conversely, if a firm is inefficient, it will have high execution costs and thus will request high payments. Because our goal is to examine the role of a firm's ideological characteristics in government procurement competition when firms differ in both pecuniary costs and non-pecuniary characteristics, it is important to construct an empirical measure for the efficiency types of contracting firms. This is challenging because a firm's efficiency type is private information and not directly observable. To tackle this issue, we use the contract type agreed upon by the contractor and the government to infer the firm's efficiency type. Specifically, the contractor is considered as a low-efficiency firm if the type of its associate contract is not firm-fixed-price or performance-based; we refer to the contract as a low-efficiency contract. Otherwise, the contractor is considered as a high-efficiency firm and its associated contract is referred to as a high-efficiency contract. Intuitively, low-efficiency firms would be reluctant to choose firm-fixed-price contracts, because these contracts typically establish a payment structure that is not subject to adjustments based on the contractor's cost experience during project execution. As a result, contractors usually must

[6] We winsorize the base and variable payments at 1% and 99% to avoid extreme outliers.

bear most unanticipated cost overruns. In addition, low-efficiency firms would be reluctant to choose performance-based contracts, because, similar to firm-fixed-price contracts, the payments specified in these contracts are not based on the contractor's cost experience during project execution. Instead, payments are based on the contractor's performance outcomes. As a result, contractors usually must bear unanticipated cost overruns to achieve required outcomes. In contrast, high-efficiency firms prefer choosing firm-fixed-price and performance-based contracts over other types of contracts, simply because these contracts reward firms that have the ability to control costs and deliver outcomes effectively. Therefore, by examining whether contract types are firm-fixed-price or performance-based, we are able to indirectly infer contractors' private efficiency types.

We focus on the procurement contracts from 2000 to 2020 in three industries – the IT, office management, and transportation and logistics industries. These three industries play a vital role in government procurement, representing a significant share of public spending and procurement contracts. These industries are frequently referenced in various procurement reform debates (e.g., IT modernization, green procurement) and are critical for maintaining the government's administrative functions. Moreover, the three industries are representative of diverse government contracting practices, differing substantially in their technology developments, cost structures, operational models, and non-pecuniary priorities. Thus, by focusing on these industries, we are able to perform systematic cross-industry studies in public procurement, generating results that are potentially helpful for policy making.

2.3 Firm Characteristics Data

Motivated by the literature, we consider four characteristics related to a firm's ideological customer capital that could significantly affect procurement outcomes – the political alignment between the firm and the procuring subagency, the firm's carbon emission, the ratio of females in the firm's leadership, and the firm's connection to China. For example, Brown and Huang (2020) and Child et al. (2021) find that politically connected firms win more procurement contracts in the U.S. Cingano and Pinotti (2013) find similar results for Italian government procurement. With growing climate mandates (e.g., EU Green Public Procurement), environmental concerns of the government are also vital to firms competing for procurement contracts (e.g., Flammer, 2018). Orser, Riding and Weeks (2019) and Orser et al. (2021) find evidence of gender-based barriers in securing government procurement contracts. Finally, a firm's connection to China can be an important factor in federal procurement competition, because geopolitical relations and national security concerns have long been integrated into U.S. policies such as the Buy American Act (e.g., Weiss and Thurbon, 2006).

When selecting the winner of a procurement project, the government likely considers these characteristics, because they are directly related to the government's ideological beliefs and socio-political goals. For instance, a firm's political alignment is tied to the government's political benefits; its carbon emission is tied to the government's agenda on sustainability; its female leadership ratio is tied to the government's gender bias; and its connection to China is tied to the government's geopolitical relations and national security concerns. Despite being intuitive and empirically relevant, the four characteristics of interest may not be equally important in every industry or across the entire sample period. For example, because environmental concerns are mostly emphasized recently, firms' carbon emission may not play an important role in determining procurement outcomes in our sample starting from 2000. Similarly, firms' connections to China may not be an important factor during procurement competition in the office management industry, because this industry involves low-risk projects with minimal national security concerns. Thus, evaluating the role of the four ideological characteristics in procurement competition calls us to estimate a structural model followed in this paper.

Below, we explain the construction of each firm characteristic.

Political Alignment. We construct the political alignment between the firm and the procuring subagency in three steps. First, we measure a firm's political affiliation as follows. Building on the insight of the literature (e.g., Cooper, Gulen and Ovtchinnikov, 2010; Hutton, Jiang and Kumar, 2015), we use firms' PAC donation data from FEC. FEC requires firms to register their PACs and provides a comprehensive record of firms' PAC donations to political candidates and campaigns in the U.S. We calculate each firm's PAC donations to the Republican and Democratic parties, respectively, over the last five years. A firm is defined as Republican-leaning (Democratic-leaning) if more than two thirds of its PAC donations go to the Republican (Democratic) party. Otherwise, the firm is defined as non-partisan. Because not all firms make PAC donations, we supplement this measure with the voter registration data of firms' key executives, following the insights of Fos, Kempf and Tsoutsoura (2022) and Spenkuch, Teso and Xu (2023). Specifically, we obtain the voter registration data from L2 Inc., which provides year-by-year snapshots of registered voter information in all 50 U.S. states and the District of Columbia. The voter information includes their names, ages, genders, addresses, and political affiliations. Based on this data, we find the political affiliations of the key executives of the firms in our procurement data, where each firm's key executives are identified based on a comprehensive set of databases, including the ExecuComp database, the Capital IQ People Intelligence database, the BoardEx database, and the Revelio Labs database.[7] The matching is based on the executives' names, ages, and addresses, following a procedure similar to that of Spenkuch, Teso and Xu (2023). Then, for each firm, we classify its key executives into three groups based on their political affiliations (i.e., Republican, Democratic, and non-partisan). The political affiliation of the firm is defined as the political affiliation of the group with the largest number of executives. More details are provided in Online Appendix A.1.

Second, we measure the political affiliation of a procuring subagency using the political affiliation of the subagency head.[8] For each contract, we collect the information on the current head of the procuring subagency from multiple sources, including official government websites, the Marquis Who's Who database, the Nexis Uni database, and the U.S. Government Manuals. The political affiliations of approximately 40% of the subagency heads in our sample can be directly obtained from these sources. For the remaining subagency heads, we use the L2 voter registration data to identify their political affiliations, as discussed above.

Third, we define a firm to be politically aligned with the procuring subagency if the political affiliation of the firm is the same as that of the subagency, and politically misaligned otherwise.

Carbon Emission. Carbon emission data is obtained from the Trucost database. As discussed by Bolton and Kacperczyk (2021, 2023), Trucost is one of the leading providers of information on firm-level carbon and other greenhouse gas emissions. The database adheres to the Greenhouse Gas Protocol, which establishes the standards for emission measurements, and reports scope 1, scope 2, and scope 3 emissions.[9] We use the logarithm of the total emission intensity of all three scopes to measure a firm's carbon emission.

Female Leadership Ratio. The ratio of females in the firm's leadership is defined as the proportion of females among the firm's key executives. As discussed in the construction of a firm's political affiliation, the firm's executives are identified based on a comprehensive set of databases. These databases also provide executive gender information. In cases where this information is missing, we supplement it with the matched L2 voter registration data.

China Connection. We obtain data on firm-level supplier-customer relationships from the FactSet Revere database, which provides the most comprehensive coverage available

[7] For firms whose executive information is not available in the four databases, we use OpenAI to identify their key executives.

[8] If the political affiliation of the subagency head is unavailable, we use the political affiliation of the head of the parent agency.

[9] See https://ghgprotocol.org.

according to Gofman, Segal and Wu (2020). The database records a firm's supplier and customer relationships, including their start and end dates. We define a firm to be connected to China if it had a supplier or customer based in China as of the end of the previous calendar year, and not connected otherwise.

Control Variables. In addition to the four ideological characteristics, we also include three more firm characteristics as control variables. First, because the procuring subagency likely prefers contractors it has worked with due to familiarity, we control for a firm's past experience with the subagency. In particular, we define a firm to have past experience if it has contracting experience with the procuring subagency in the past two years. Second, because the government may consider a firm's general reputation and consumer perception, we control for a firm's brand value. The brand value data is from the BAV Group, which is considered as the world's most comprehensive database of consumer brand perception. This database constructs the brand stature measure to evaluate the overall customer loyalty to a brand. Following Dou et al. (2021*b*), we track the brand ownership by firms over time. For firms owning multiple brands, we compute the average brand stature across all owned brands. For firms with missing BAV brand stature values, we estimate their brand stature values from non-missing cases via a non-parametric k-nearest-neighbor estimation following Chen, Dou and Qiao (2013) and Dou et al. (2021*a*). The estimation is based on other brand value measures in the literature and relevant accounting information obtained from the Compustat database and the S&P Capital IQ platform.[10] We use the logarithm of each firm's brand stature to measure its brand value. Lastly, we also control for a firm's size in the estimation. We measure a firm's size with the logarithm of its total assets, obtained from the Compustat database and the S&P Capital IQ platform.

2.4 Summary Statistics

Table 1 reports the summary statistics of our contract-level sample for each industry. The average number of competitive bids for a contract ranges from 2.33 to 3.82 across the three industries. This indicates that the government often needs to select a winner from multiple competing firms in procurement projects. This allows us to evaluate how a firm's ideological characteristics affect its competitiveness and performance in government procurement competition. The average payment and duration exhibit large variation across

[10]Specifically, we use the following variables: brand capital from Belo et al. (2022), organizational capital from Eisfeldt and Papanikolaou (2014), customer capital from He, Mostrom and Sufi (2024), knowledge capital from Falato et al. (2022), physical capital stock from Bloom (2009), total assets, total revenue, cost of goods sold, and firm age. Online Appendix A.1 details the estimation procedure.

Table 1: Summary statistics of the final sample.

	IT		Office		T&L	
	Mean	IQR	Mean	IQR	Mean	IQR
Number of bids	2.33	(2.00)	2.39	(2.00)	3.82	(3.00)
Payment (in thous. 2010 $)						
Base	231.99	(86.86)	30.77	(16.98)	257.65	(57.10)
Variable ($\mathbb{1}_{\text{zero}}$)[a]	0.72	(1.00)	0.76	(0.00)	0.78	(0.00)
Variable (non-zero)	612.57	(99.31)	8.21	(5.50)	1,021.94	(40.01)
Final	405.73	(93.43)	32.78	(17.40)	481.27	(61.86)
Duration (in days)						
Base	616.36	(902.00)	116.28	(96.00)	153.35	(244.00)
Variable ($\mathbb{1}_{\text{zero}}$)[a]	0.76	(0.00)	0.88	(0.00)	0.86	(0.00)
Variable (non-zero)	353.80	(691.00)	320.29	(442.00)	460.22	(713.75)
Final	701.78	(1,070)	155.46	(109.00)	218.58	(257.00)
High-efficiency contract[a]	0.69	(1.00)	0.85	(0.00)	0.50	(1.00)
Firm ideological characteristics						
Political alignment[a]	0.40	(1.00)	0.49	(1.00)	0.33	(1.00)
Carbon emission	4.86	(0.57)	5.44	(0.94)	5.71	(0.60)
Female leadershio ratio	0.08	(0.17)	0.11	(0.20)	0.07	(0.17)
China connection[a]	0.14	(0.00)	0.05	(0.00)	0.03	(0.00)
Other firm characteristics						
Past experience[a]	0.79	(0.00)	0.65	(1.00)	0.71	(1.00)
Brand value	0.99	(0.55)	1.21	(0.68)	1.20	(0.66)
Firm size	10.04	(3.01)	9.26	(1.82)	9.83	(2.18)
Number of contracts	5,306		515		882	

Note: This table reports the mean and the interquartile range (IQR) of each variable in our contract-level sample ([a]indicator variables). The payments are measured in thousand 2010 CPI-adjusted dollars and the durations are measured in days. The rows labeled "Variable ($\mathbb{1}_{\text{zero}}$)" and "Variable (non-zero)" report the summary statistics of the indicator variable of zero variable payment (or duration) and those of non-zero variable payment (or duration), respectively. The columns labeled "IT", "Office", and "T&L" report the summary statistics for the IT, office management, and transportation and logistics industries, respectively.

industries. For instance, the average base payment is the largest in the transportation and logistics industry ($257.65 thousand 2010 dollars), and the smallest in the office management industry ($30.77 thousand 2010 dollars). Importantly, approximately 15–25% of contracts have subsequent modifications in payment or duration after contract initiations. Thus, the average base payment (duration) can be much smaller than the average final payment (duration). For instance, in the IT industry, the average base payment is $231.99 thousand 2010 dollars, 43% lower than the average final payment, and the average base duration is 616.36 days, 12% shorter than the average final duration. The proportion of high-efficiency contracts varies considerably across industries. The office management industry has the highest proportion of high-efficiency contracts (85%), followed by the IT industry, while 50%

of the contracts are labeled as high-efficiency in the transportation and logistics industry. Across the three industries, the proportion of contracts awarded to politically aligned firms ranges from 33% to 49%. The average carbon emission and female leadership ratio of the contracting firms exhibit moderate variation across industries, with the average carbon emission ranging from 4.86 to 5.71 and the average female leadership ratio ranging from 7% to 11%. Finally, in the IT industry, 14% of the contracts are awarded to firms connected to China through supplier-customer relationships, compared to just 3–5% in the other two industries.

3 Model

Our analysis focuses on the contracts where the government has the discretion to implement the format of competitive bids and determine the contracting process. This motivates us to develop a model that involves an optimal mechanism design problem rather than a simple first-price or second-price auction.[11] In particular, we develop a model to characterize the 4-phase procurement process elaborated in Section 2.1 as a non-cooperative game. The government is assigned with a project, and decides whether to solicit competitive bids from firms. Depending on whether competitive solicitation is implemented, the government optimally designs the auction mechanism and firms submit their bids. Then, the government selects a winner from competing firms and signs the contract. Finally, the government honors payments according to the contract, allowing for ex-post adjustments.

Below, in Subsection 3.1, we introduce firms' characteristics and distribution. In Subsection 3.2, we present the timeline of the procurement process, modeled as a non-cooperative game between firms and the government. In Subsection 3.3, we describe the mechanism design problem faced by the government. In Subsection 3.4, we present the solution to the mechanism design problem and discuss the intuitions. Finally, in Subsection 3.5, we pin down the government's optimal decision on competitive solicitation.

[11]The implications of different forms of auctions for the seller's expected revenue have been studied in the literature (e.g., Vickrey, 1961; Riley and Samuelson, 1981). For example, if both the seller and buyers are risk neutral and the buyers' valuation is independently drawn from the same distribution, then standard auctions, such as the English auction, the Dutch auction, the Vickre auction, and the first-price sealed bid auction, all yield the same expected revenue (Bolton and Dewatripont, 2005). However, the expected revenue of these auctions may still be lower than the optimal auction, especially when buyers are risk-averse (e.g., Matthews, 1983; Maskin and Riley, 1984).

3.1 Firms

Firms are heterogeneous and differ from each other in their unobservable efficiency type and observable characteristic. Efficiency type is private information and unobservable to the government; it directly determines the cost incurred by the firm when executing the project. We consider two efficiency types, denoted by k, with $k = H$ and $k = L$ representing high and low efficiency, respectively.

Projects are heterogeneous in their size, denoted by z. A type$-k$ firm would incur both an initial cost and an uncertain variable cost to execute the project. Both costs are proportional to the size of the project.[12] Specifically, the initial cost is $\gamma_k z$, which is private information and depends on the efficiency type k. The variable cost is $c(s)z$, depending on the uncertain outcome s, which is randomly drawn from a type$-k$-dependent probability density function (PDF), denoted by $f_k(s)$. The outcome s is realized upon the completion of the project, and is observable to both the firm and the government. The outcome s captures various events that can potentially affect a firm's project execution cost. We assume that the realized value of s is an informative signal about a firm's efficiency type:

$$f_H(s) \neq f_L(s) \;\text{ for some }\; s. \tag{1}$$

However, the signal is imperfect as $f_H(s)$ and $f_L(s)$ share a common support.

We assume that the high-efficiency type has both a lower initial cost and expected variable cost than the low-efficiency type:

$$\gamma_H < \gamma_L \;\text{ and }\; \int c(s) f_H(s)\mathrm{d}s < \int c(s) f_L(s)\mathrm{d}s. \tag{2}$$

Thus, high-efficiency firms also have a lower expected total cost. Denote a type$-k$ firm's expected total cost for executing the project of size z as $C(k)z$, where

$$C(k) = \gamma_k + \int c(s) f_k(s)\mathrm{d}s. \tag{3}$$

In addition, firms differ in their characteristic, denoted by x. Different from the hidden efficiency type, the value of x is perfectly observable to the government. The characteristic could be firms' political alignment with the government, carbon emission, etc. It can affect a firm's chance to win government contracts, even though it does not directly affect the firm's execution cost. To capture this in our model, we specify that the winning firm's x

[12] Assuming a cost proportional to the size of the project follows the literature (e.g., Bhattacharya, 2021). This assumption ensures that the government's expected cost under optimal mechanism design is homogeneous of degree one in project size.

determines the non-pecuniary utility derived by the government (see Section 3.3).

Let $g(k, x)$ denote the PDF of the hidden efficiency type k and observable characteristic x. This joint distribution is common knowledge. To simplify algebra, we focus on one-dimensional characteristic x and outcome s. However, none of the equations would change if x and s are multidimensional, except for making both notations represent vectors. In Section 4, we will consider multidimensional x when conducting the structural estimation.

3.2 Procurement Process as a Non-Cooperative Game

During the procurement process, the government and firms play a non-cooperative game with a Bayesian equilibrium. Similar to the institutional features discussed in Section 2.1, the entire procurement process involves four phases, as illustrated in Figure 1.

Phase 1. At the beginning, the solicitation cost per unit of project size η is randomly drawn from a distribution $\varphi(\eta)$ and the project size z is randomly drawn from a distribution $\varsigma(z)$.

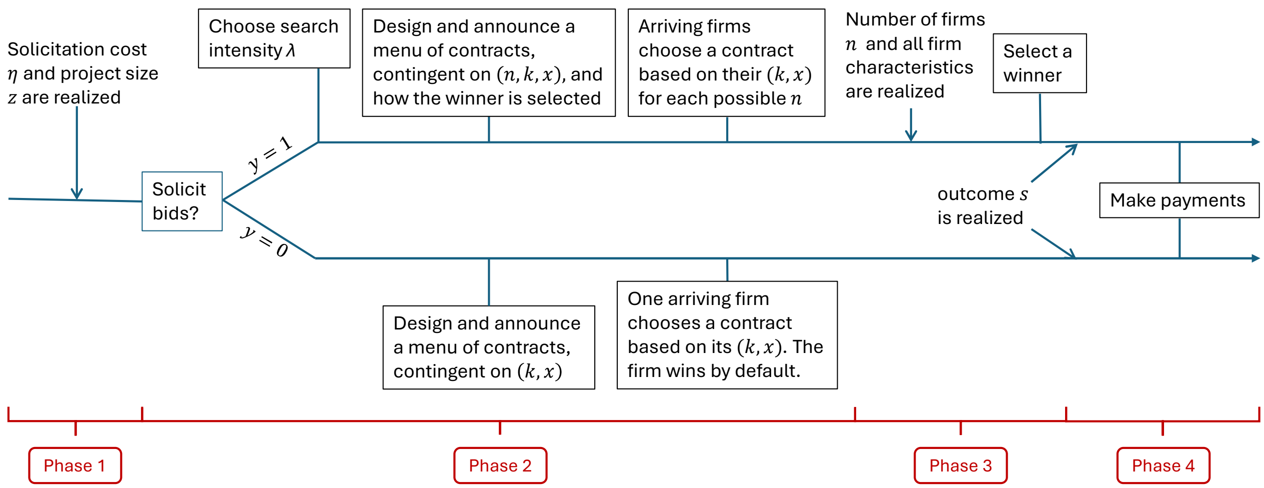
Phase 2. Depending on the realized values of η and z, the government optimally decides whether to solicit competitive bids from firms.[13] There are two cases, corresponding to competitive solicitation ($y = 1$) and non-competitive solicitation ($y = 0$). Then, the government designs the optimal auction mechanism, which includes a menu of contracts from which participating firms choose, and in the case of competitive solicitation, a winner selection rule. Here, we describe the timeline of Phase 2 and briefly describe the government's decisions. We will detail the mechanism design problem in Section 3.3 and the solicitation decision in Section 3.5.

In the case of competitive solicitation ($y = 1$), at the beginning, the government decides how intensely to search for firms. If it chooses a search intensity λ, a search cost of $\frac{1}{2}\kappa\lambda^2$ is incurred by the government per unit of project size. The search intensity λ determines the number of arriving firms, denoted by n, that will participate in bidding. We assume that $n - 1$ follows a Poisson distribution with rate λ. Thus, the probability for n firms to arrive is $\frac{\lambda^{n-1}e^{-\lambda}}{(n-1)!}$. This guarantees that at least one firm will arrive and bid.

The government designs a menu of contracts contingent on n, the firm's observable characteristic x and the firm's reported (unobservable) efficiency type $\widetilde{k}$, as well as how the winner is selected.[14] We specify the contracts to depend on n because its value is unknown

[13]As discussed in Section 2.1, in practice, the competition strategy is typically determined before specific bidding firms are known. Thus, we model it as an ex-ante decision for the government.

[14]In principle, the government can design a more general contract contingent on n as well as the observable



Note: Events included in boxes involve decision making either by the government or firms. Events not included in boxes represent randomly realized outcomes.

Figure 1: Timeline of the procurement process.

when the government designs these contracts. As detailed in Section 3.3, the menu of contracts is designed to satisfy the individual rationality (IR) constraints and the incentive compatibility (IC) constraints. The IR constraints ensure that all n firms will participate and submit their competitive bids. The IC constraints ensure that all n firms are truth-telling, that is, the efficiency type $\widetilde{k}$ reported by each firm is the same as the firm's true hidden efficiency type k. Focusing on this truth-telling equilibrium is without loss of generality due to the revelation principle in mechanism design. For the remainder of this paper, we simplify the algebra by using the notation k to represent both a firm's true efficiency type and its reported one to the government. Besides the menu of contracts, the government also determines how to select the winner contingent on the realized number of arriving firms n and the reported efficiency types and characteristics of all n firms.

Next, firms arrive to participate in competitive bidding, with their efficiency type k and characteristic x being randomly drawn from the distribution $g(k, x)$. Upon the arrival of each firm, the government presents the firm a menu of contracts that matches the firm's

characteristic x and reported efficiency type $\widetilde{k}$ of all n firms. In Online Appendix D, we show that the government's expected payment corresponding to the optimal contract in this general contract setting is not lower than that in the restricted contract setting considered here. Specifically, we prove two results: First, in the restricted contract setting, there always exists a feasible contract that allows the government to achieve an expected payment that equals the expected payment corresponding to the optimal contract in the general contract setting. Second, we show that the government's expected payment corresponding to the optimal contract in the general contract setting is the same regardless of whether the government discloses all firms' x to each participating firm. But, disclosure results in a higher variance of the government's realized payment. Thus, the government would prefer no disclosure if it displays a certain degree of risk aversion. This result is weaker than that found in the literature, for example, Milgrom and Weber (1982) and McClellan (2023) show that revealing information about the identities of bidders could reduce the auctioneer's revenue.

observable characteristic x, from which the firm chooses one contract. These contracts differ in contract terms, which are contingent on the firm's reported efficiency type k and the number of arriving firms n. Because n remains unknown until all firms arrive, the firm's decision on which contract to choose is equivalent to its decision on which efficiency type k to report. In other words, by reporting a particular value of k to the government, firms are essentially choosing contracts for each $n = 1, 2, \cdots$. Based on the reported efficiency type k and the firm's observable characteristic x, the government commits to matching the firm with the contract of (n, k, x), contingent on the realized value of n.[15]

In the case of non-competitive solicitation ($y = 0$), only one firm will arrive. Anticipating this, the government designs a menu of contracts contingent on the firm's efficiency type k and characteristic x. The designed contracts are identical to those associated with $n = 1$ in the competitive solicitation case ($y = 1$). Thus, as in the competitive solicitation case, when the firm arrives, it truthfully reports its efficiency type k, which is randomly drawn from the distribution $g(k, x)$ together with its characteristic x.

Phase 3. In the case of competitive solicitation ($y = 1$), the number of arriving firms n is realized, alongside each firm's reported efficiency type and characteristic. The contract is then awarded to a winner among the n competing firms based on the winner selection rule determined in Phase 2. In the case of non-competitive solicitation ($y = 0$), the only arriving firm is awarded the contract corresponding to its k and x.

Phase 4. The outcome s is realized and the government makes the payment to the winner according to its chosen contract, allowing for ex-post adjustments based on s.

3.3 Problem of Mechanism Design

We now present the mechanism design problem in the competitive solicitation case ($y = 1$) in Phase 2 described in Section 3.2. The number of competing firms $n \geq 1$ is randomly drawn from the Poisson distribution. The problem in the non-competitive solicitation case ($y = 0$) is similar to that in the competitive solicitation case with $n = 1$.

In the following, we first describe the payment terms of contracts, the winner selection rule, and the payoff to firms and government for any given $n \geq 1$. We then formulate the mechanism design problem.

[15]This commitment can be easily enforced because n is public information in the Federal Procurement Data System. The firm can always choose to quit if the government violates its commitment.

Payment Terms of Contracts. As discussed in Section 2, a federal procurement contract specifies the base payment from the initial entry of the contract, which can be further modified through subsequent payment adjustments until the completion of the project. To capture these features, we assume that the realized outcome s of the project is not only observable but also contractible. We consider contracts that include both a fixed payment and a variable payment that depends on s.

Because firms' costs to execute the project are proportional to the project size z, the fixed and variable payments made by the government under optimal mechanism design should also be proportional to z. Thus, for any given $n \geq 1$, let $p^n(k, x)$ denote the fixed payment term and $q^n(s; k, x)$ the variable payment term for each unit of project size. The fixed payment and variable payment are $p^n(k, x)z$ and $q^n(s; k, x)z$, respectively. The superscript n explicitly captures the dependence of contract terms on the number of competing firms n. Both $p^n(k, x)$ and $q^n(s; k, x)$ are functions of the firm's observable characteristic x and reported (unobservable) efficiency type k. This indicates that a firm of characteristic x and truthfully reporting its efficiency type k will be automatically matched with the contract with fixed payment term $p^n(k, x)$ and variable payment term $q^n(s; k, x)$. As discussed in Section 3.2, even though firms are allowed to freely choose their contracts, this specification of contract terms is without loss of generality because of the revelation principle. Moreover, the variable payment term $q^n(s; k, x)$ depends on the realized outcome s, which is informative about the firm's efficiency type k. Intuitively, this allows the government to achieve higher expected payoff by better separating firms of different efficiency types (see Section 3.4).

Winner Selection Rule. In addition to the payment terms, the government specifies a winner selection rule, which is announced to all firms at the beginning (see Figure 1). We characterize the winner selection rule following the standard practice in auction design (Myerson, 1981). Consider n firms whose reported efficiency types and characteristics are summarized by n-dimensional vectors $\boldsymbol{k} \equiv \{k_1, \cdots, k_n\}$ and $\boldsymbol{x} \equiv \{x_1, \cdots, x_n\}$. The winner selection rule is defined by $\{\phi_i^n(\boldsymbol{k}, \boldsymbol{x})\}_{i=1}^n$ for all $(\boldsymbol{k}, \boldsymbol{x})$. Conditional on $(\boldsymbol{k}, \boldsymbol{x})$, the variable $\phi_i^n(\boldsymbol{k}, \boldsymbol{x})$ represents the winning probability for each firm i. The winning probabilities $\{\phi_i^n(\boldsymbol{k}, \boldsymbol{x})\}_{i=1}^n$ can depend on the vectors $\boldsymbol{k}$ and $\boldsymbol{x}$ because when the government selects the winner, the characteristics and reported efficiency types of all n firms are already known to the government (see Figure 1). However, the winning probabilities $\{\phi_i^n(\boldsymbol{k}, \boldsymbol{x})\}_{i=1}^n$ do not depend on project size z because the government's expected cost under optimal mechanism design is homogeneous of degree one in project size.

The government is allocating a single project, thus only one firm will be the winner. This implies the following feasibility constraint. For all $(\boldsymbol{k}, \boldsymbol{x})$,

$$\sum_{i=1}^{n} \phi_i^n(\boldsymbol{k}, \boldsymbol{x}) = 1, \ \text{ and } \ \phi_i \geq 0 \ \text{ for } \ i = 1, \cdots, n. \tag{4}$$

As illustrated in Figure 1, when a firm arrives and chooses a contract, the firm does not observe the characteristics or reported efficiency types of other firms. However, the firm is aware of the winner selection rule, $\{\phi_i^n(\boldsymbol{k}, \boldsymbol{x})\}_{i=1}^n$ for all $(\boldsymbol{k}, \boldsymbol{x})$. Based on the winner selection rule, each firm i knows its ex-ante expected probability of winning the contract, which is given by

$$\Phi_i^n(k_i, x_i) = \mathbb{E}\left[\phi_i^n(\boldsymbol{k}, \boldsymbol{x}) | k_i, x_i\right], \tag{5}$$

where the expectation is taken over the other $n-1$ firms' k_j and x_j for $j \neq i$, with each firm's (k_j, x_j) independently drawn from the distribution $g(k, x)$.

Without loss of generality, we impose a regularity condition for the winner selection rule. For all $(\boldsymbol{k}, \boldsymbol{x})$, we require

$$\phi_i^n(\boldsymbol{k}, \boldsymbol{x}) = \phi_j^n(\boldsymbol{k}, \boldsymbol{x}), \ \text{ if } \ k_i = k_j \text{ and } x_i = x_j. \tag{6}$$

This condition implies that for any firms with identical efficiency type and characteristic, their winning probabilities must be the same. Imposing the regularity condition (6) implies that ties are broken randomly when the government chooses winners. Given (6), it is valid to denote by $\Phi^n(k, x)$ the expected winning probability for a firm with reported type k and characteristic x.

Payoff to Firms and the Government. We now describe the payoff to risk-averse firms and the risk-neutral government for any given $n \geq 1$. We model firms with quasilinear preferences, following the standard practice in the mechanism design literature. The firm would derive zero utility if it does not win the contract or if it chooses to opt out of the procurement process. If a project of size z is awarded to a firm of characteristic x and truthfully reported efficiency type k, when outcome s is realized upon the completion of the project, the firm will derive utility $u^n(s; k, x)z$, where

$$u^n(s; k, x) = p^n(k, x) - \gamma_k + \psi(q^n(s; k, x) - c(s)). \tag{7}$$

The function $\psi(\cdot)$ is increasing and concave, with $\psi(0) = 0$, $\psi'(0) = 1$, $\psi' > 0$, and $\psi'' < 0$. The term $p^n(k, x) - \gamma_k$ captures the utility derived from the fixed payoff per unit of project size, which is the fixed payment $p^n(k, x)$ made by the government minus the fixed cost γ_k

incurred by the firm. The term $\psi(q^n(s;k,x) - c(s))$ captures the utility derived from the variable payoff per unit of project size, which depends on the realized outcome s; it depends on the difference between the variable payment $q^n(s;k,x)$ and the variable cost $c(s)$. The specification of $\psi'' < 0$ captures firms' risk aversion in a procurement context (e.g., Arve and Martimort, 2016), which could be a result of liquidity constraints (e.g., Bolton, Chen and Wang, 2011). We normalize $\psi'(0) = 1$, which indicates that when the variable payoff term is zero, the marginal value of variable payoff is equal to the marginal value of fixed payoff, which is 1. We further impose a constraint on the variable payoff term to capture limited liability or firms' bankruptcy constraints:

$$q^n(s;k,x) - c(s) \geq M, \quad \text{for all} \;\; s, k, \text{ and } x, \tag{8}$$

where $M \leq 0$ is a parameter determining the lower bound of net variable payoff per unit of project size. For example, if $M = 0$, then intuitively, this constraint implies that firm's variable payoff cannot be negative, indicating that in situations where the firm incurs additional costs (i.e., $c(s) > 0$), the government will make sufficient variable payment to cover the cost; Conversely, in situations where the firm saves costs (i.e., $c(s) < 0$), the government cannot require the firm to return more than the amount of savings.[16]

For the contract awarded to the firm of (k, x), when outcome s is realized upon the completion of the project, the government will incur a cost equal to $G(s;k,x)z$, where

$$G(s;k,x) = b(x) + h^n(s;k,x), \tag{9}$$

with

$$h^n(s;k,x) = p^n(k,x) + q^n(s;k,x), \tag{10}$$

where the first term $b(x)$ in (9) captures a non-pecuniary component, reflecting the government officer's preference for certain firm characteristic x. For example, if x represents the winner's political party affiliation, then the government officer would derive a positive value of $b(x)$ if they belong to different parties and a negative value if they are in the same party. The second term $h^n(s;k,x)$ in (9) captures the government's payment to the winner per unit of project size, which is the sum of the fixed and variable payment terms as given by (10). The linear dependence of the government's cost on the variable payment term $q^n(s;k,x)$ captures a risk-neutral government.

[16]Technically speaking, the constraint restricts the government's ability to separate firms with different hidden efficiency types by ruling out the mechanism design that imposes large penalties on type$-H$ winners for outcomes that would be very unlikely for type$-L$ firms. With this constraint, it would be difficult for the government to achieve an expected total cost that is very close to the first best.

IC and IR Constraints. For any $n \geq 1$, let $U^n(k, x; z)$ denote the expected utility of a firm with characteristic x and truthfully reported efficiency type k, when it is competing for a project of size z. Thus,

$$U^n(k, x; z) = \Phi^n(k, x) \int u^n(s; k, x) z f_k(s) \mathrm{d}s, \tag{11}$$

where $u^n(s; k, x)$ is given by (7) and $\Phi^n(k, x)$ is the firm's expected winning probability given by (5). Conditional on winning, the firm's expected utility is $\int u^n(s; k, x) z f_k(s) \mathrm{d}s$.

To ensure that the firm truthfully reports its hidden efficiency type k, the contract terms must satisfy the IC constraints:

$$U^n(k, x; z) \geq \Phi^n(k', x) \int \left[p^n(k', x) - \gamma_k + \psi(q^n(s; k', x) - c(s)) \right] z f_k(s) \mathrm{d}s, \tag{12}$$

where the notation $k' \neq k$ represents a misreported type, with $k' \in \{H, L\}$, and $\Phi^n(k', x)$ is the expected winning probability when the firm reports k'. The right-hand side of the equation captures the expected utility that firm i would obtain by misreporting its efficiency type as k'. Clearly, by misreporting the type, the firm can distort the winning probability and the payment terms offered by the government. The IC constraints (12) indicate that the firm is weakly better off by truthfully reporting its efficiency type k.

Moreover, the contract terms are designed to satisfy the firm's IR constraints to ensure participation:

$$U^n(k, x; z) \geq 0, \tag{13}$$

where the firm's outside option is normalized to have zero value. The IR constraints (13) indicate that firms are weakly better off by submitting their competitive bids.

Optimal Mechanism Design. Consider a project of size z. In the competitive solicitation case ($y = 1$), given the government's choice of search intensity λ, the number of competing firms $n \geq 1$ is randomly drawn, with $n - 1$ follows a Poisson distribution with rate λ. In the non-competitive solicitation case ($y = 0$), the number of firms is $n = 1$. Thus, the non-competitive solicitation is a special case of competitive solicitation. In the following, we focus on describing the optimal mechanism design for competitive solicitation.

For each $n \geq 1$, the government optimally designs the payment terms, $p^n(k, x)$ and $q^n(s; k, x)$ for all k, x, and s, and the winner selection rule $\{\phi_i^n(\boldsymbol{k}, \boldsymbol{x})\}_{i=1}^n$ for all $\boldsymbol{k}$ and $\boldsymbol{x}$ to minimize its expected cost:

$$H(z) = \min_{\substack{p^n(k,x), q^n(s;k,x), \\ \{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n \text{ for } n \geq 1}} \sum_{n=1}^{\infty} \frac{\lambda^{n-1} e^{-\lambda}}{(n-1)!} \mathbb{E}\left[\sum_{i=1}^n \phi_i^n(\boldsymbol{k},\boldsymbol{x}) \left(b(x_i) + \int h^n(s;k_i,x_i) f_{k_i}(s) \mathrm{d}s \right) z \right], \tag{14}$$

subject to the feasibility constraints (4), the regularity constraint (6), the limited liability constraints (8), IC constraints (12), and IR constraints (13) for all $n \geq 1$. The expectation $\mathbb{E}[\cdot]$ is taken over $(\boldsymbol{k},\boldsymbol{x})$, i.e., all n firms' k_i and x_i, with each firm's (k_i, x_i) independently drawn from the distribution $g(k,x)$.

Note that the constraints facing the government in optimal mechanism design, as described in (4), (6), (8), (12), and (13), do not include any interaction terms across different values of n. Therefore, the mechanism design problem for each $n \geq 1$ can be solved separately. In particular, for each $n \geq 1$, the government optimally designs the payment terms, $p^n(k,x)$ and $q^n(s;k,x)$ for all k, x, and s, and the winner selection rule $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ for all $\boldsymbol{k}$ and $\boldsymbol{x}$ to minimize its expected cost conditional on n:

$$H(n;z) = \min_{p^n(k,x), q^n(s;k,x), \{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n} \mathbb{E}\left[\sum_{i=1}^n \phi_i^n(\boldsymbol{k},\boldsymbol{x}) \left(b(x_i) + \int h^n(s;k_i,x_i) f_{k_i}(s) \mathrm{d}s \right) z \right], \tag{15}$$

subject to the constraints (4), (6), (8), (12), and (13), where $\mathbb{E}[\cdot]$ is taken over $(\boldsymbol{k},\boldsymbol{x})$.

The term within the expectation operator $\mathbb{E}[\cdot]$ in equation (15) captures the government's expected cost conditional on the realized $(\boldsymbol{k},\boldsymbol{x})$. Intuitively, for any $(\boldsymbol{k},\boldsymbol{x})$, given payment terms, $p^n(k,x)$ and $q^n(s;k,x)$, for $k \in \{H, L\}$ and all x, the government should choose $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ such that the project is awarded to the firm with the lowest cost, $\left(b(x) + \int h^n(s;k,x) f_k(s) \mathrm{d}s\right) z$, among the n competing firms, and ties are broken randomly. However, the problem is difficult for two reasons: First, the values of $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ for all possible realizations of $(\boldsymbol{k},\boldsymbol{x})$ should be designed jointly, as reflected by the expectation $\mathbb{E}[\cdot]$ over $(\boldsymbol{k},\boldsymbol{x})$. This is because firms have to know $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ for all $(\boldsymbol{k},\boldsymbol{x})$ in order to compute the expected winning probabilities (5) used in the IC and IR constraints, (12) and (13). Second, the winner selection rule, $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ for all $(\boldsymbol{k},\boldsymbol{x})$, should be jointly optimized with payment terms, $p^n(k,x)$ and $q^n(s;k,x)$.

To provide more intuitions, we can rewrite the government's objective function (15) as follows:

$$
\begin{aligned}
H(n;z) &= \min_{p^n(k,x),q^n(s;k,x),\phi_i^n(\boldsymbol{k},\boldsymbol{x})} \mathbb{E}\left[\sum_{i=1}^{n} \mathbb{E}\left[\phi_i^n(\boldsymbol{k},\boldsymbol{x})|k_i,x_i\right]\left(b(x_i)+\int h^n(s;k_i,x_i)f_{k_i}(s)\mathrm{d}s\right)z\right] \\
&= \min_{p^n(k,x),q^n(s;k,x),\Phi^n(k,x)} \sum_{i=1}^{n}\mathbb{E}\left[\Phi^n(k_i,x_i)\left(b(x_i)+\int h^n(s;k_i,x_i)f_{k_i}(s)\mathrm{d}s\right)z\right] \\
&= \min_{p^n(k,x),q^n(s;k,x),\Phi^n(k,x)} \int n\Phi^n(k,x)g(k,x)\left(b(x)+\int h^n(s;k,x)f_k(s)\mathrm{d}s\right)z\mathrm{d}k\mathrm{d}x,
\end{aligned}
\tag{16}
$$

where the last equality is obtained because firms are symmetric ex-ante and the expectation is taken over (k,x) based on the unconditional distribution $g(k,x)$. In equation (16), the term, $(b(x)+\int h^n(s;k,x)f_k(s)\mathrm{d}s)\,z$, captures the government's payment to a winner of (k,x); the term $n\Phi^n(k,x)g(k,x)$ captures the unconditional probability density of having such a winner, which is the unconditional probability density $g(k,x)$ for a firm with (k,x) to arrive, multiplied by the firm's expected probability of winning $\Phi^n(k,x)$, multiplied by n (because there are n arriving firms in total). Equation (16) implies that the government chooses payment terms, $p^n(k,x)$, $q^n(s;k,x)$, and expected winning probabilities, $\Phi^n(k,x)$, for each firm of (k,x) to minimize the probability weighted sum of payments. Intuitively, the government places a larger weight on minimizing the payment to a winner of (k,x) if this winner has a higher unconditional probability density $g(k,x)$ to arrive or a higher probability $\Phi^n(k,x)$ to win the contract.

3.4 Solution to Mechanism Design

In this subsection, we clarify the intuitions behind the solution to the optimal mechanism design in two steps. First, we discuss the intuitions for the optimal design of payment terms, given the optimal winner selection rule. Second, we discuss the intuitions for the optimal design of the winner selection rule, given the optimal payment terms. In Online Appendix B, we explain the intuitions in more detail by comparing our model to the simplified model without risk aversion or multidimensional heterogeneity, and show that it is the joint consideration of the two that makes the problem challenging to analyze. In Online Appendix C, we solve our model analytically and present the mathematical proofs.

Design of Payment Terms. We first discuss the optimal design of payment terms, $p^n(k,x)$ and $q^n(s;k,x)$ for all k, x, and s, given the optimal winner selection rule.

We start by analyzing the role of the variable payment term $q^n(s;k,x)$. Intuitively, the government can better separate type$-H$ firms from type$-L$ firms by making $q^n(s;k,x)$ depend on outcome s, because s is informative about firms' efficiency types, given assumption (1). To deter firms of the other type from misreporting as type$-k$ firms, the government can design $q^n(s;k,x)$ to reward outcomes that are more likely to occur for type$-k$ winners, and minimize the payment to outcomes that are less likely for type$-k$ winners. This contract design uses the information contained in s to make type$-k$ contracts less attractive to firms of the other type and extract these firms' potential surplus by reducing the right-hand side of their IC constraints (12). However, the use of the variable payment term $q^n(s;k,x)$ is not without its cost. Because $\psi'(0) = 1$ and $\psi'' < 0$ in a firm's utility (7), firms are risk-averse and have diminishing returns from the variable payoff term $q^n(s;k,x) - c(s)$. That is, firms discount any positive variable payoff and enlarge any negative variable payoff. Consequently, to achieve the same level of utility for a firm, it is optimal for the government to set the variable payoff at zero so that the marginal utilities of the fixed and variable payment terms are equalized at 1. Deviations from zero variable payoff would be costly for the government, and the marginal cost increases with the magnitude of the deviation. Therefore, when designing the optimal variable payment term $q^n(s;k,x)$, the government balances the benefit from deterring misreporting and the cost due to the diminishing returns of the firm's utility. Specifically, the government uses $q^n(s;k,x)$ to deter misreporting until the marginal cost exceeds the marginal benefit or the limited liability constraints (8) bind, and the marginal cost is equalized for all s with non-binding limited liability constraints.

We now focus on the incentives of type$-L$ firms to misreport as type$-H$. Intuitively, compared to type$-H$ firms, type$-L$ firms incur a larger cost when executing the project and would demand a larger payment to cover the cost. Thus, type$-L$ firms have no incentive to misreport their type as H. Their IC constraint is always satisfied, and there is no need to use $q^n(s;H,x)$ to deter type$-L$ firms from misreporting as type$-H$. Therefore, it is optimal for the government to set the variable payoff to type$-H$ firms at zero, which pins down the variable payment term to type$-H$ firms as follows:

$$q^n(s;H,x) = c(s), \quad \text{for all} \quad s. \tag{17}$$

Because type$-L$ firms have no incentive to misreport their type, the government can extract all surplus from them. That is, the IR constraint for type$-L$ firms should be binding; if it is slack, then we can simply reduce the fixed payment to type$-L$ firms, which reduces the government's expected cost while still satisfying the IC and IR constraints, (12) and (13), for both type$-H$ and type$-L$ firms. The binding IR constraint for type$-L$ firms helps pin down the fixed payment term to type$-L$ firms as follows:

$$p^n(L,x) = \gamma_L - \int \psi(q^n(s;L,x) - c(s)) f_L(s) \mathrm{d}s. \tag{18}$$

Next, we focus on the incentives of type$-H$ firms to misreport as type$-L$. Intuitively, type$-H$ firms may have the incentive to misreport their type as L to obtain a larger payment. Thus, the government uses the variable payment term to type$-L$ firms, $q^n(s;L,x)$, to reduce the misreporting incentives of type$-H$ firms and extract their surplus, when the marginal benefit from deterring misreporting exceeds the marginal cost due to the diminishing returns of the firm's utility. There are two cases, depending on the fixed cost difference between efficiency types, $\gamma_L - \gamma_H$.

If $\gamma_L - \gamma_H < \gamma(x)$ where $\gamma(x)$ is formally defined in (26), meaning that the efficiency difference between the two types is small, then the government only needs to use $q^n(s;L,x)$ to a small extent to extract all surplus from type$-H$ firms. In this case, the marginal cost of using $q^n(s;L,x)$ is always smaller than the marginal benefit until all surplus of type$-H$ firms is extracted. Thus, when $\gamma_L - \gamma_H$ is small, the government uses $q^n(s;L,x)$ to deter all misreporting incentives of type$-H$ firms and extract all their surplus, implying that both the IC and IR constraints, (12) and (13), for type$-H$ firms bind. Given $q^n(s;H,x)$ in (17), the binding IR constraint pins down the fixed payment term to type$-H$ firms as follows:

$$p^n(H,x) = \gamma_H. \tag{19}$$

Given (19), the variable payment term to type$-L$ firms, $q^n(s;L,x)$, is determined by the binding IC constraint for type$-H$ firms and the equalized marginal cost of using $q^n(s;L,x)$ for all s that satisfy the limited liability constraints (8):

$$q^n(s;L,x) = \begin{cases} c(s) + (\psi')^{-1}\left(\frac{1-\tilde{\pi}}{1-\tilde{\pi} f_H(s)/f_L(s)}\right), & \text{if } \frac{f_H(s)}{f_L(s)} \leq m(\tilde{\pi}), \\ c(s) + M, & \text{otherwise,} \end{cases} \tag{20}$$

where

$$m(\pi) = \frac{1}{\pi} - \frac{1-\pi}{\pi \psi'(M)}, \tag{21}$$

and $\tilde{\pi}$ is the root of the following equation

$$A(\pi) = \gamma_L - \gamma_H, \tag{22}$$

with

$$A(\pi) = \int \psi \left((\psi')^{-1} \left(\frac{1-\pi}{1-\pi f_H(s)/f_L(s)} \right) \mathbb{1}_{\frac{f_H(s)}{f_L(s)} \le m(\pi)} + M \mathbb{1}_{\frac{f_H(s)}{f_L(s)} > m(\pi)} \right) [f_L(s) - f_H(s)] \mathrm{d}s. \tag{23}$$

The intuition for the optimal design of (20) is as follows: $q^n(s; L, x)$ is set to reward outcomes that are more likely to occur for type$-L$ winners (i.e., $q^n(s; L, x) > c(s)$ when $f_H(s) \le f_L(s)$) and punish outcomes that are more likely for type$-H$ winners subject to the limited liability constraint (8) (i.e., $c(s) + M \le q^n(s; L, x) < c(s)$ when $f_H(s) \ge f_L(s)$).

If $\gamma_L - \gamma_H > \gamma(x)$, meaning that the efficiency difference between the two types is large, then the government needs to use $q^n(s; L, x)$ to a large extent to extract all surplus from type$-H$ firms. This is too costly due to the diminishing returns of the firm's utility. Thus, the government uses $q^n(s; L, x)$ to deter misreporting incentives of type$-H$ firms until it is too costly and leaves some surplus to type$-H$ firms by increasing their fixed payment term $p^n(H, x)$. This implies that the IC constraint (12) for type$-H$ firms binds, while the IR constraint (13) does not. The optimal variable payment term to type$-L$ firms, $q^n(s; L, x)$, is given by the fact that the marginal cost of using $q^n(s; L, x)$ equals the marginal benefit, subject to the limited liability constraints (8):

$$q^n(s; L, x) = \begin{cases} c(s) + (\psi')^{-1} \left(\frac{1-\pi(x)}{1-\pi(x) f_H(s)/f_L(s)} \right), & \text{if } \frac{f_H(s)}{f_L(s)} \le m(\pi(x)), \\ c(s) + M, & \text{otherwise,} \end{cases} \tag{24}$$

where $\pi(x) = g(H, x) / \sum_{k=H,L} g(k, x)$, representing the arrival probability of a type$-H$ firm, conditional on its characteristic being x. Plugging (24) into the binding IC constraint (12), we derive the optimal fixed payment term to type$-H$ firms as

$$p^n(H, x) = \gamma_H + \frac{\Phi^n(L, x)}{\Phi^n(H, x)} \left(\gamma_L - \gamma_H - \int \psi(q^n(s; L, x) - c(s)) [f_L(s) - f_H(s)] \mathrm{d}s \right), \tag{25}$$

where the second term on the right-hand side of (25) captures the surplus (i.e., information rent) of type$-H$ winners. The cutoff $\gamma(x)$ that distinguishes the two cases is determined by

$$\gamma(x) = A(\pi(x)), \tag{26}$$

which implies that when $\gamma_L - \gamma_H = \gamma(x)$, the government is just able to extract all surplus from type$-H$ firms as the fixed payment term to type$-H$ firms in (25) just becomes equal to their fixed cost γ_H.

Design of Winner Selection Rule. We now discuss the optimal design of the winner selection rule, $\{\phi_i^n(\boldsymbol{k},\boldsymbol{x})\}_{i=1}^n$ for all $(\boldsymbol{k},\boldsymbol{x})$, given optimal payment terms.

Substituting the optimal payment terms $p^n(k,x)$ and $q^n(s;k,x)$ (equations (17), (18), (19), (20), (24), and (25)) into (15), we obtain

$$H(n;z) = \min_{\phi_i^n(\boldsymbol{k},\boldsymbol{x})} \mathbb{E}\left[\sum_{i=1}^n \phi_i^n(\boldsymbol{k},\boldsymbol{x})\left[b(x_i)+C(k_i)+\mathbb{1}_{k_i=L}\Upsilon(x_i)\right]z\right], \tag{27}$$

where

$$\begin{aligned}\Upsilon(x) =& \frac{\pi(x)}{1-\pi(x)}\left(\gamma_L-\gamma_H-\int\psi(q^n(s;L,x)-c(s))[f_L(s)-f_H(s)]\mathrm{d}s\right)\\ &+\int\left[q^n(s;L,x)-c(s)-\psi(q^n(s;L,x)-c(s))\right]f_L(s)\mathrm{d}s.\end{aligned} \tag{28}$$

Therefore, for the government to minimize its expected cost in (27), the optimal winner selection rule should award the project to the firm with the lowest $b(x)+C(k)+\mathbb{1}_{k=L}\Upsilon(x)$ among the n firms for any realized $(\boldsymbol{k},\boldsymbol{x})$, assuming that ties are broken randomly. Specifically, define

$$\mathcal{C}(\boldsymbol{k},\boldsymbol{x}) = \left\{i \,\middle|\, b(x_i)+C(k_i)+\mathbb{1}_{k_i=L}\Upsilon(x_i) = \min_{j=1,\cdots,n} b(x_j)+C(k_j)+\mathbb{1}_{k_j=L}\Upsilon(x_j)\right\} \tag{29}$$

as the set of firms that have the lowest $b(x)+C(k)+\mathbb{1}_{k=L}\Upsilon(x)$ among the n competing firms of $(\boldsymbol{k},\boldsymbol{x})$. The optimal winner selection rule is designed as follows: For any $(\boldsymbol{k},\boldsymbol{x})$, set $\phi_i^n(\boldsymbol{k},\boldsymbol{x}) = 1/|\mathcal{C}(\boldsymbol{k},\boldsymbol{x})|$ for all $i\in\mathcal{C}(\boldsymbol{k},\boldsymbol{x})$ and $\phi_i^n(\boldsymbol{k},\boldsymbol{x}) = 0$ for all $i\notin\mathcal{C}(\boldsymbol{k},\boldsymbol{x})$.

The value $b(x)+C(k)+\mathbb{1}_{k=L}\Upsilon(x)$ has three components. The first component, $b(x)$, captures the non-pecuniary component in the government's cost (9) when the government selects a winner with the characteristic x. The second component, $C(k)$, captures the execution cost of the firm when the government selects a type$-k$ winner. The third component, $\mathbb{1}_{k=L}\Upsilon(x)$, captures the additional cost $\Upsilon(x)$ on selecting type$-L$ firms that essentially arises from the fact that type$-H$ firms have the incentive to misreport as type$-L$. To elaborate, as shown in (28), there are two sources of additional costs. The first additional cost, captured by the first term in (28), reflects the positive externality of increasing type$-L$ firms' winning probability on the payment to type$-H$ firms. The government internalizes this spillover effect when designing the optimal winner selection rule. Intuitively, if the winner selection rule is designed to assign a higher probability for type$-L$ firms of characteristic x,[17] it would motivate type$-H$ firms with the same x to misreport their type as L. To keep the

[17] When firms have multidimensional heterogeneity (k,x), the government may design a winner selection rule to favor type$-L$ firms if these firms have favorable x.

IC constraint (12) for type$-H$ firms satisfied and deter them from misreporting their type, the government has to increase the payment to type$-H$ firms, effectively increasing their informational rent. The second additional cost, captured by the second term in (28), reflects the fact that, when the government designs the variable payments to deter type$-H$ firms' incentive to misreport their type as L, there are diminishing returns in making variable payments to type$-L$ firms. In other words, to satisfy type$-L$ firms' IR constraint, the government's expected payment to type$-L$ firms has to exceed these firms' expected execution cost $C(L)$.

3.5 Solicitation Decision

Having described the problem of mechanism design for any given $n \geq 1$, we now present the government's solicitation problem at the beginning of Phase 2 described in Section 3.2. As shown in Figure 1, at the beginning of the game, the solicitation cost per unit of project size η is randomly drawn. Then, the government decides whether to solicit competitive bids.

If the government solicits competitive bids ($y = 1$), it optimally chooses search intensity λ, to minimize the expected total cost of procurement:

$$V(1;z) = \min_{\lambda} \sum_{n=1}^{\infty} \frac{\lambda^{n-1} e^{-\lambda}}{(n-1)!} H(n;z) + \frac{1}{2}\kappa\lambda^2 z + \eta z, \tag{30}$$

where $H(n;z)$ is given by (15). The term $\frac{\lambda^{n-1}e^{-\lambda}}{(n-1)!}$ is the probability for n firms to arrive, with $n-1$ following a Poisson distribution with rate λ; the terms $\frac{1}{2}\kappa\lambda^2 z$ and ηz capture the government's search cost and solicitation cost, respectively.

If the government does not solicit competitive bids ($y = 0$), the expected total cost of procurement is:

$$V(0;z) = H(1;z), \tag{31}$$

because only one firm will arrive and the firm wins by default.

The solicitation decision is determined by

$$y = \mathbb{1}(V(1;z) < V(0;z)), \tag{32}$$

where $\mathbb{1}(\cdot)$ is an indicator function.

4 Structural Estimation

Using contract-level data, we structurally estimate the model parameters via a Bayesian approach for each industry separately. Subsection 4.1 parameterizes the model. Subsection 4.2 presents the Bayesian estimation procedure and discusses identification. Subsection 4.3 presents the estimation results.

4.1 Parametrization

We specify $\psi(\cdot)$ in the firm's utility function (7) as follows:

$$\psi(r) = e^{a}\left[1 - \exp\left(-r/e^{a}\right)\right]. \tag{33}$$

This functional specification follows Kang and Miller (2022) and is similar to the exponential utility. A higher value of the parameter a implies a lower degree of diminishing returns for the variable payoff term.

For the project size z, we assume that it follows a log-normal distribution with parameters μ_z and σ_z. For each contract in the data, the duration adjustment since project initiation captures the realized observable outcome s in the model. We compute the duration adjustment as the variable duration scaled by the base duration to make the duration adjustments comparable across contracts. Because a large proportion of contracts do not have any duration adjustments, we specify the conditional outcome distribution $f_k(s)$ as follows:

$$f_k(s) = \zeta_k \delta(s) + (1-\zeta_k)\frac{1}{\sqrt{2\pi\sigma_k^2}}\exp\left(-\frac{(s-\mu_k)^2}{2\sigma_k^2}\right), \tag{34}$$

where $k \in \{L, H\}$ and $\delta(s)$ is the Dirac delta function. The specification (34) implies that with probability ζ_k, duration adjustment does not occur. Conditioning on the occurrence of duration adjustments, the magnitude of duration adjustment follows a normal distribution with mean μ_k and standard deviation σ_k. We specify a cubic cost function for the variable cost $c(s)$, which provides sufficient flexibility to capture potential nonlinearity in duration adjustment costs. Specifically, we specify $c(s)$ as follows:

$$c(s) = \alpha_1 s + \alpha_2 s^2 + \alpha_3 s^3. \tag{35}$$

As discussed in Section 3.1, our model can accommodate multidimensional characteristics. Thus, with a slight abuse of notation, we use $x = (x_{\text{poli}}, x_{\text{emit}}, x_{\text{fem}}, x_{\text{china}}, x_{\text{past}}, x_{\text{brand}}, x_{\text{size}}, \epsilon)$

to denote the vector of characteristics for a firm. We consider seven firm characteristics that can potentially affect the non-pecuniary component of the government's cost (9). First, we include four ideological characteristics. The dummy variable x_{poli} denotes whether the political affiliation of a firm is aligned with that of the procuring subagency, which equals 1 if the two are aligned and 0 otherwise. The variable x_{emit} denotes a firm's carbon emission. The variable x_{fem} denotes the ratio of females among a firm's executives. The dummy variable x_{china} denotes whether a firm is connected to China through supply-chain relationships, which equals 1 if it is connected and 0 otherwise. Second, we include three control variables. The dummy variable x_{past} denotes whether a firm has contracting experience with the procuring subagency in the past two years, which captures a firm's past experience with the subagency. The variable x_{brand} denotes a firm's brand value. The variable x_{size} denotes a firm's size, measured by the logged total assets. Additionally, to account for characteristics considered by the government but not observed by the econometrician, we include a residual term, ϵ. For the tractability of the estimation, we specify ϵ as a dummy variable that equals 1 if a firm's unobserved characteristics incur a high non-pecuniary cost for the government and 0 otherwise. Since ϵ is unobserved and needs to be estimated, in Subsection 4.2, we use a Bayesian approach to jointly estimate the posterior of the structural parameters and ϵ for each observation. We specify a linear function for $b(x)$ in (9),

$$b(x) = \sum_{l \in \mathcal{L}} \beta_l x_l + \beta_\epsilon \epsilon, \quad \mathcal{L} = \{\text{poli}, \text{emit}, \text{fem}, \text{china}, \text{past}, \text{brand}, \text{size}\}, \tag{36}$$

where the weight coefficient β_l determines the non-pecuniary component associated with the characteristic x_l for $l \in \mathcal{L}$ and the coefficient β_ϵ determines that associated with the residual term ϵ.

We normalize carbon emission x_{emit}, brand value x_{brand}, and firm size x_{size} to the unit interval $[0, 1]$ via affine transformation,[18] so that all characteristics have the same range. This normalization is without loss of generality. First, given the government's winner selection rule in (29) and the linear specification of $b(x)$ in (36), when firms with different x_l compete, the government selects the winning firm solely based on the relative difference in x_l across firms. The absolute level of x_l is irrelevant. Therefore, adding a constant to x_l does not affect any results. Second, scaling x_l by a factor would scale the estimated β_l by the inverse of the factor, leaving the magnitude of $\beta_l x_l$ unchanged. Because the government selects the winning firm solely based on the relative difference in $\beta_l x_l$ across firms, this rescaling does not affect any results in Section 5.

[18]Specifically, the value of each characteristic x_l for $l \in \{\text{emit}, \text{brand}, \text{size}\}$ is normalized via the affine transformation $(x_l - lb_l)/(ub_l - lb_l)$, where lb_l and ub_l are respectively the lower and upper bounds of the original value of x_l in the entire data.

Regarding the firm distribution $g(k, x)$, we do not impose parametric assumptions on the joint distribution of the seven characteristics observed by the econometrician, $\{x_l\}_{l\in\mathcal{L}}$, and estimate their distribution non-parametrically. For the efficiency type k, its distribution conditional on the characteristics x is part of the model solution (see equation (24)). Therefore, given that k is a dummy variable, we specify the conditional probability of a firm being high-efficiency as a logistic function:

$$\Pr\left(k = H \mid \{x_l\}_{l\in\mathcal{L}}\right) = \frac{\exp\left(\omega_0 + \sum_{l\in\mathcal{L}} \omega_l x_l\right)}{1 + \exp\left(\omega_0 + \sum_{l\in\mathcal{L}} \omega_l x_l\right)}, \tag{37}$$

where ω_0 is the intercept term and ω_l is the coefficient on x_l for $l \in \mathcal{L}$. Similarly, since the unobserved characteristic ϵ is also a dummy variable, we specify the conditional probability of $\epsilon = 0$ as a logistic function:

$$\Pr\left(\epsilon = 0 \mid \{x_l\}_{l\in\mathcal{L}}\right) = \frac{\exp\left(\widetilde{\omega}_0 + \sum_{l\in\mathcal{L}} \widetilde{\omega}_l x_l\right)}{1 + \exp\left(\widetilde{\omega}_0 + \sum_{l\in\mathcal{L}} \widetilde{\omega}_l x_l\right)}, \tag{38}$$

where $\widetilde{\omega}_0$ is the intercept term and $\widetilde{\omega}_l$ is the coefficient on x_l for $l \in \mathcal{L}$.

In the model, conditional on other contract variables s, k, x, and n, the variation in both the base payment $p^n(k, x)z$ and the variable payment $q^n(s; k, x)z$ is driven solely by the project size z. Thus, any noise not captured by the model (e.g., measurement error) would result in a likelihood of zero. To address this issue, in the estimation, we specify the observed variable payment in the data as $q^n(s; k, x)z \cdot e$, where e is a noise term. Because the observed variable payment has a mass point at zero (see Table 2.4), we assume that $e = 0$ with probability ζ_e, and with probability $1 - \zeta_e$, it follows a normal distribution with mean one and standard deviation σ_e.

Finally, without loss of generality, we normalize the fixed cost parameter γ_H to 1 and focus on estimating the parameter γ_L. This is because what matters in our model is the fixed cost ratio between efficiency types, γ_L/γ_H. The role of the parameter γ_H is to determine the average level of the base payment $p^n(k, x)z$. However, the parameter μ_z also plays the role of determining the average base payment by affecting $\mathbb{E}[z]$. Therefore, the normalization of $\gamma_H \equiv 1$ is without loss of generality. As a result, $\gamma_L \equiv \gamma_L/\gamma_H$ can be interpreted as the fixed cost ratio between efficiency types.

4.2 Estimation and Identification

We estimate the model in two steps. First, we externally estimate the firm distribution of the seven observed characteristics $\{x_l\}_{l\in\mathcal{L}}$ and the efficiency type k, as well as the conditional distribution of the outcome, $f_k(s)$, in (34). While the focus of the structural estimation is on contracts awarded via competitive solicitations (i.e., $y = 1$), we also use data from contracts awarded via non-competitive solicitations (i.e., $y = 0$) in this step to more accurately estimate these distributions. Second, given the estimated distributions, we employ a Bayesian approach to jointly estimate the posterior of the structural parameters and the unobserved characteristic ϵ for each observation.

Estimates for Firm Distributions. We estimate the firm distribution of the seven observed characteristics $\{x_l\}_{l\in\mathcal{L}}$ and the efficiency type k using the empirical distribution of contracting firms conditional on non-competitive solicitation. Per our model specification in Section 3.2, in the non-competitive solicitation case, the winning firm is randomly drawn from the firm distribution, allowing us to directly uncover this distribution. The joint distribution of the seven characteristics $\{x_l\}_{l\in\mathcal{L}}$ is estimated non-parametrically. Specifically, the dummy variables, including the firm's political alignment with the subagency, connection to China, and past contracting experience, are each classified into 2 categories by construction. The continuous variables, including the firm's carbon emission, female leadership ratio, brand value, and size, are each discretized into 20 equally spaced bins. Then, the joint distribution is estimated by computing the empirical frequency of observations falling into each grid and assuming the continuous variables are uniformly distributed within each grid. The conditional distribution of the efficiency type k given the characteristics is estimated using the logistic model specified in (37). This estimation approach flexibly captures the empirical firm distribution. Online Appendix E presents the detailed estimates.

Estimates for Outcome Distributions. Because both the outcome s (i.e., duration adjustment) and the efficiency type k are observed, we directly estimate the conditional outcome distribution, $f_k(s)$, in (34) from the data. Specifically, the parameter ζ_k is identified by the proportion of type$-k$ contracts without duration adjustments (i.e., $s = 0$). The parameters μ_k and σ_k are identified by the mean and standard deviation of the non-zero duration adjustments (i.e., $s \neq 0$) among the type$-k$ contracts. Table 2 presents the estimates for each industry.

Bayesian Estimation. Given the estimated distributions above, the remaining structural parameters are estimated using a Bayesian approach. We denote the vector of remaining parameters by θ, which contains the parameters γ_L, α_1, α_2, α_3, $\{\beta_l\}_{l\in\mathcal{L}}$, β_ϵ, κ, μ_z, σ_z, a, M, ζ_e, σ_e, $\{\widetilde{\omega}_l\}_{l\in\mathcal{L}}$, and $\widetilde{\omega}_0$. In the Bayesian estimation, the observable variables include $data_i = (n_i, k_i, \{x_{l,i}\}_{l\in\mathcal{L}}, s_i, p_i, q_i)$ for the contracts indexed by $i = 1, \ldots, N$. Here, n_i is the

Table 2: Estimates for outcome distributions.

Parameter	Symbol	IT	Office	T&L
Prop. of type$-L$ contracts, no duration adj.	ζ_L	0.71	0.77	0.82
Prop. of type$-H$ contracts, no duration adj.	ζ_H	0.76	0.87	0.82
Mean of duration adj. of type$-L$ contracts	μ_L	1.94	2.33	2.19
Mean of duration adj. of type$-H$ contracts	μ_H	1.99	2.49	1.88
Standard deviation of duration adj. of type$-L$ contracts	σ_L	2.68	3.64	3.42
Standard deviation of duration adj. of type$-H$ contracts	σ_H	3.04	3.72	2.84

Note: This table reports the estimates of the parameters governing the conditional outcome distribution, $f_k(s)$, in (34). The columns labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

number of bids for contract i, k_i is the winning firm's efficiency type, $\{x_{l,i}\}_{l\in\mathcal{L}}$ denotes the seven observed characteristics of the winning firm, s_i is the duration adjustment, p_i is the base payment, and q_i is the variable payment. Then, given a realization of the unobserved characteristics for all observations, $\{\epsilon_i\}_{i=1}^N$, the model-implied likelihood of $\{data_i, \epsilon_i\}_{i=1}^N$ can be factorized as follows:

$$P\left(\{data_i, \epsilon_i\}_{i=1}^N \middle| \theta\right) = \prod_{i=1}^N P\left(data_i, \epsilon_i | \theta\right), \tag{39}$$

$$\text{where } P\left(data_i, \epsilon_i|\theta\right) = P\left(n_i|\theta\right) \times P\left(k_i, \{x_{l,i}\}_{l\in\mathcal{L}}, \epsilon_i | \theta, n_i\right) \times P\left(s_i|\theta, k_i\right) \tag{40}$$
$$\times P\left(p_i|\theta, k_i, \{x_{l,i}\}_{l\in\mathcal{L}}, \epsilon_i, n_i\right) \times P\left(q_i|\theta, p_i, s_i, k_i, \{x_{l,i}\}_{l\in\mathcal{L}}, \epsilon_i, n_i\right).$$

We summarize each component of (40) below. First, $n_i - 1$ conditioning on the parameters θ follows a Poisson distribution with rate λ. The rate λ is determined in (30) depending on the parameters θ.

Second, the likelihood of the winning firm's efficiency type k_i and characteristics x_i, conditioning on θ and n_i, is given by

$$P\left(k_i, x_i|\theta, n_i\right) = n_i \Phi^{n_i}(k_i, x_i) g(k_i, x_i), \tag{41}$$

where $\Phi^n(k, x)$ is the firm's expected winning probability given by (5) and $g(k, x)$ is the PDF of the firm distribution.

Third, the likelihood of the duration adjustment s_i is already estimated externally in the first step of the estimation. The likelihood of the base payment p_i, conditioning on θ, k_i, x_i and n_i, is a log-normal distribution. Specifically, the observed base payment p_i is equal to the base payment per unit of project size, $p^{n_i}(k_i, x_i)$, multiplied by the project size z_i that follows a log-normal distribution with parameters μ_z and σ_z.

Finally, the likelihood of the variable payment q_i, conditioning on θ and the other variables, is computed as follows. As specified in Subsection 4.1, the observed variable payment q_i is equal to the product of the variable payment per unit of project size, $q^{n_i}(s_i; k_i, x_i)$, the project size z_i, and the noise term e_i. The noise term e_i follows a mixture distribution: with probability ζ_e, it is zero, and with probability $1 - \zeta_e$, it follows a normal distribution with mean one and standard deviation σ_e.

Given the likelihood function, we employ a Bayesian MCMC approach to estimate the joint posterior, $P\left(\theta, \{\epsilon_i\}_{i=1}^N \middle| \{data_i\}_{i=1}^N\right)$. Specifically, we implement the Metropolis-Hastings algorithm with the following procedure.

Step 1: In each iteration o, for each observation i, we first update the posterior of ϵ_i conditioning on the parameters by

$$P\left(\epsilon_i \middle| data_i, \theta^{(o-1)}\right) = \frac{P\left(data_i, \epsilon_i \middle| \theta^{(o-1)}\right)}{\sum_{\epsilon=0}^{1} P\left(data_i, \epsilon \middle| \theta^{(o-1)}\right)}, \tag{42}$$

where $\theta^{(o-1)}$ is the parameter vector simulated from iteration $o-1$ and $P\left(data_i, \epsilon_i | \theta\right)$ is given in (40). We then draw the realization of $\epsilon_i^{(o)}$ from the binary distribution with weights given by (42).

Step 2: In the same iteration o, based on the updated draws of $\{\epsilon_i^{(o)}\}_{i=1}^N$ from step 1, the posterior of θ conditioning on $\{\epsilon_i\}_{i=1}^N$ satisfies

$$P\left(\theta \middle| \{data_i\}_{i=1}^N, \{\epsilon_i^{(o)}\}_{i=1}^N\right) \propto \prod_{i=1}^N P\left(data_i, \epsilon_i^{(o)} \middle| \theta\right) P(\theta), \tag{43}$$

where $P(\theta)$ is the prior on θ. We then update the draws of the parameters θ using the random walk Metropolis-Hastings algorithm and compute the acceptance/rejection threshold:

$$\alpha(\theta^{(o-1)}, \theta^{(o)}) = \min\left\{ \frac{\prod_{i=1}^N P\left(data_i, \epsilon_i^{(o)} \middle| \theta^{(o)}\right) P\left(\theta^{(o)}\right)}{\prod_{i=1}^N P\left(data_i, \epsilon_i^{(o)} \middle| \theta^{(o-1)}\right) P\left(\theta^{(o-1)}\right)}, 1 \right\}, \tag{44}$$

where $\theta^{(o)}$ is the vector of proposed parameters using a Gaussian proposal distribution.

Step 3: We proceed to iteration $o+1$, and repeat step 1 and step 2 by simulating the realizations of $\{\epsilon_i^{(o+1)}\}_{i=1}^N$ and model parameters $\theta^{(o+1)}$ based on updated posteriors.

Identification of Parameters. In the Bayesian estimation, the parameters θ are jointly estimated based on the likelihood of all observed data. Below, we make a heuristic identification argument and discuss the empirical patterns in the data that intuitively identify the parameters.

The parameter κ determines the government's search cost in the competitive solicitation case. A higher search cost implies that fewer firms will arrive and submit competitive bids. Thus, the value of κ is identified by the average number of competitive bids for the procurement projects implemented via full and open competition.

The parameters μ_z and σ_z determine the mean and standard deviation of the project size z. Because z directly affects the base payment $p^n(k,x)z$, the parameters μ_z and σ_z are identified by the mean and standard deviation of the base payment. Since the parameter γ_H is normalized to 1, the parameter γ_L determines the fixed cost ratio between efficiency types. Because the firm's fixed cost directly affects its base payment (see equations (18), (19) and (25)), the ratio of the average base payments between efficiency types helps identify γ_L.

The parameter ζ_e determines the probability of the noise term e being zero. Because we specify the observed variable payment as $q^n(s;k,x)ze$, the parameter ζ_e is identified by the probability of the observed variable payment being zero. According to (17), the observed variable payment to type$-H$ firms, $q^n(s;H,x)ze$, is equal to $c(s)ze$. The parameters α_1, α_2 and α_3 determine the variable cost function $c(s)$ in (35), and the parameter σ_e governs the variance of the noise term e. Thus, given the estimates of μ_z, σ_z and ζ_e, the parameters α_1, α_2, α_3 and σ_e jointly determine the distribution of the observed variable payment to type$-H$ firms. As a result, these parameters can be identified using the conditional first and second moments of the observed variable payment to type$-H$ firms given the outcome s.[19] According to (20) and (24), the variable payment term to type$-L$ firms, $q^n(s;L,x)$, is informative about the function $\psi(\cdot)$ and the lower bound of the variable payoff term, M. Thus, the parameter a in (33) and the parameter M can be identified by the mean and standard deviation of the observed variable payment to type$-L$ firms. Intuitively, a higher M increases the minimum variable payoff term, and therefore increases the average variable payment to type$-L$ firms. The parameter a directly determines the degree of diminishing returns for the variable payoff term. When a is higher, there is a lower degree of diminishing returns. Per the discussion of payment terms in Section 3.4, in this case, the government will more intensively use variable payments to deter type$-H$ firms from misreporting their type because the cost of doing so is lower. That is, the government will further increase the rewards to outcomes more likely for type$-L$ firms and reduce the payments to outcomes

[19]The conditional first and second moments of the observed variable payment to type$-H$ firms, $q^n(s;H,x)ze$, given the outcome s, are

$$\mathbb{E}\left[q^n(s;H,x)ze|s\right] = (1-\zeta_e)\mathbb{E}[z]c(s) \quad \text{and} \tag{45}$$

$$\mathbb{E}\left[(q^n(s;H,x)ze)^2\middle|s\right] = (1-\zeta_e)(1+\sigma_e^2)\mathbb{E}[z^2]c^2(s), \tag{46}$$

respectively. Given the estimates of μ_z, σ_z and ζ_e, (45) and (46) directly identify $c(s)$ and σ_e.

more likely for type$-H$ firms. This leads to higher variation in the variable payment to type$-L$ firms across outcome s, and thus a larger standard deviation of the observed variable payments across type$-L$ contracts.

The parameters $\{\beta_l\}_{l\in\mathcal{L}}$ and β_ϵ in (36) determine the government's preference for firm characteristics when selecting the winning firm. Given the estimates of firms' pecuniary execution costs, $\{\beta_l\}_{l\in\mathcal{L}}$ and β_ϵ jointly determine the ex-post distribution of the winning firm's characteristics. For the characteristic x_l, a larger magnitude of β_l implies that the government focuses more on x_l and therefore places more weight over x_l when selecting the winner among competing firms. That is, β_l directly affects the ex-post distribution of the winning firm's x_l under full and open competition. Thus, the value of β_l can be identified by the mean of x_l among winning firms in the procurement projects implemented via full and open competition. The parameter β_ϵ is identified by the residual variation in the ex-post distribution of the winning firms that is not explained by $\{\beta_l\}_{l\in\mathcal{L}}$.

4.3 Estimation Results

The MCMC algorithm simulates a Markov chain for each model parameter from the posterior distribution. Table 3 reports the point estimates and the standard errors of the key parameters of interest for each industry, and Table 4 reports the remaining parameter estimates obtained from the MCMC algorithm. We compute the point estimate as the mean of the parameter draws along the Markov chain and the standard error as the standard deviation of the parameter draws.

According to the estimates of the fixed cost ratio between efficiency types, γ_L, in Table 3, low-efficiency firms incur significantly larger pecuniary costs when executing procurement projects compared to high-efficiency firms. The fixed cost ratio is estimated to be the smallest in the office management industry at 1.51. A possible reason for this low fixed cost ratio is that the office management industry relies less on technology and has more homogeneous production processes. In contrast, other industries are estimated to have high fixed cost ratios, potentially because firms in these industries have unequal access to cost-saving technologies (e.g., automated logistics hubs in the transportation and logistics industry) and specialized personnel (e.g., AI engineers in the IT industry). The estimates of the parameters α_1, α_2, and α_3 show that the firm's variable cost depends on the outcome s, and the variable cost structure varies across industries.

The parameters $\{\beta_l\}_{l\in\mathcal{L}}$ and β_ϵ determine the government's preference for firm characteristics. If β_l is positive, it indicates that firms with lower x_l are associated with a lower value of the non-pecuniary component, $b(x)$, in (36). Thus, these firms are favored by the govern-

Table 3: Estimates of the key parameters of interest.

A. Firm parameters

	Fixed cost	Variable cost		
	γ_L	α_1	α_2	α_3
IT	2.89	5.18	−0.97	0.05
	(0.07)	(0.02)	(0.01)	(0.01)
Office	1.51	0.25	0.03	0.01
	(0.06)	(0.01)	(0.01)	(0.00)
T&L	6.96	1.71	−0.59	0.05
	(0.01)	(0.01)	(0.01)	(0.00)

B. Government parameters

	Weight coefficient on firm characteristics								Search cost
	β_{poli}	β_{emit}	β_{fem}	β_{china}	β_{past}	β_{brand}	β_{size}	β_{ϵ}	κ
IT	−3.14	83.92	33.25	6.22	−14.14	−26.21	8.34	54.53	7.21
	(0.94)	(0.37)	(0.69)	(0.67)	(0.30)	(0.34)	(0.43)	(86.21)	(5.77)
Office	−2.50	−0.78	12.28	−0.35	−1.33	−5.09	8.21	6.52	0.84
	(0.23)	(0.59)	(0.32)	(0.29)	(0.22)	(0.26)	(0.62)	(0.00)	(0.11)
T&L	11.46	13.78	9.82	5.56	−10.26	−0.51	−11.26	81.85	2.61
	(0.21)	(0.33)	(0.45)	(0.32)	(0.20)	(0.35)	(0.30)	(22.89)	(1.62)

Note: This table reports the point estimates and the standard errors of the key parameters of interest, obtained from the MCMC algorithm. Panel A shows the firm parameters, including the fixed cost ratio between efficiency types, γ_L, and the coefficients $(\alpha_1, \alpha_2, \alpha_3)$ in the variable cost function $c(s)$ in (35). Panel B shows the government parameters, including the weight coefficients, $\{\beta_l\}_{l\in\mathcal{L}}$ and β_ϵ, on firm characteristics in the non-pecuniary component of the government's cost $b(x)$ in (36) and the government's search cost parameter κ. The rows labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

ment and have an advantage in procurement competition. For instance, according to Table 3, $\beta_{\text{emit}} = 83.92$ in the IT industry, suggesting that firms with lower carbon emission are favored by the government and have a competitive advantage. Furthermore, all else equal, a larger magnitude of the weight parameter β_l indicates a stronger government preference regarding the characteristic x_l, making x_l more important in procurement competition. However, the relative magnitude of these weight parameters alone does not determine the relative importance of these characteristics in procurement competition. Their relative importance also depends on the variation in both the pecuniary cost and all the non-pecuniary characteristics in the firm distribution. This is because each firm is competing against other firms from the firm distribution and they are evaluated by the government based on all factors. Within each industry, it may not be the case that a particular characteristic x_l is more important, if the corresponding β_l is estimated to be larger in magnitude than the other characteristics.

This is because the variation in x_l across firms also affects its relative importance.[20] Further, across different industries, it may not be the case that x_l is more important in a particular industry, if the corresponding β_l is estimated to be larger in magnitude than its values in the other industries. This is because the government's winner selection rule (29) considers all firm characteristics as well as the difference in pecuniary costs between efficiency types.[21] Therefore, to evaluate the impact of each ideological characteristic on firms' procurement outcomes and examine their importance in procurement competition, we conduct simulation studies based on our estimated model in Section 5.

Finally, Table 3 shows that the government's search cost κ varies across industries. The IT industry has the highest search cost among the three industries, likely due to its high requirements for technical skills, specialized expertise, and security compliance. In comparison, the office management industry has the lowest search cost, possibly because this industry has lower technical requirements and more standardized projects.

5 Results

In this section, we use the estimated model to conduct quantitative analysis. In Subsection 5.1, we examine the impact of a firm's ideological characteristics on its cash flows from government procurement in the baseline estimation. In Subsection 5.2, we run counterfactual experiments to quantify how government valuation of the ideological characteristics affects firm performance in government procurement. While our model in Section 3 is a static model which allows us to estimate the government's preference for ideological characteristics using contract-level data, our quantitative analysis employs a simulation procedure to compute firms' procurement outcomes over time.

Specifically, for a focal firm in an experiment, we simulate its efficiency type and characteristics over time as follows: for the efficiency type or each of the binary characteristics, we specify a Markov process; for each of the continuous characteristics, we specify an AR(1) process. For every government procurement project in a given year, the focal firm may be randomly selected to participate in bidding. Conditional on the firm participating in bidding, given its efficiency type k and characteristics x at the time and the number of bids n, the firm's expected probability of winning the contract is given by $\Phi^n(k, x)$ (see

[20]For example, if x_l has very small variation across firms, then x_l would not be very important, even if its corresponding β_l is estimated to be large. This is simply because the value of x_l is similar across different firms.

[21]For example, if the government puts large weights on the other characteristics or the difference in pecuniary costs between efficiency types is very large in a particular industry, then x_l would not be very important, even if its corresponding β_l is estimated to be large. This is simply because the other factors are very important in this particular industry.

Table 4: Estimates of the remaining parameters.

	Project size		Parameters related to variable payments			
	μ_z	σ_z	a	M	ζ_e	σ_e
IT	2.51	1.72	2.25	−2.80	0.43	1.40
	(0.02)	(0.02)	(0.00)	(0.13)	(0.01)	(0.05)
Office	2.24	1.15	0.17	−0.32	0.29	3.51
	(0.06)	(0.05)	(0.13)	(0.11)	(0.03)	(0.27)
T&L	1.79	1.56	5.42	−1.06	0.63	128
	(0.07)	(0.04)	(0.09)	(0.02)	(0.02)	(1.43)

	Distribution of ϵ							
	$\widetilde{\omega}_{\text{poli}}$	$\widetilde{\omega}_{\text{emit}}$	$\widetilde{\omega}_{\text{fem}}$	$\widetilde{\omega}_{\text{china}}$	$\widetilde{\omega}_{\text{past}}$	$\widetilde{\omega}_{\text{brand}}$	$\widetilde{\omega}_{\text{size}}$	$\widetilde{\omega}_0$
IT	0.28	−0.21	−0.16	0.10	−0.18	0.43	−0.24	−0.80
	(0.01)	(0.01)	(0.05)	(0.03)	(0.02)	(0.03)	(0.04)	(0.04)
Office	−0.89	−0.32	0.89	0.26	−0.58	1.18	0.10	−1.94
	(0.55)	(0.33)	(0.24)	(0.20)	(0.47)	(0.33)	(0.43)	(0.24)
T&L	2.23	−0.04	−2.86	−1.09	0.88	0.76	4.72	−4.45
	(0.23)	(0.22)	(0.15)	(0.22)	(0.13)	(0.16)	(0.19)	(0.19)

Note: This table reports the point estimates and the standard errors of the remaining parameters not reported in Table 3, obtained from the MCMC algorithm. The top panel shows the parameters that govern the distribution of the project size z, (μ_z, σ_z), the degree of diminishing returns for the variable payoff term a, the lower bound of the variable payoff term M, and the parameters that govern the distribution of the noise term e, (ζ_e, σ_e). The bottom panel shows the parameters, $\{\widetilde{\omega}_l\}_{l\in\mathcal{L}}$ and $\widetilde{\omega}_0$, which govern the distribution of the unobserved characteristic value ϵ in (38). The rows labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

equation (5)). Conditional on the firm winning the contract, given the project size z and the realized contract outcome s, the firm receives a cash flow equal to the total payments minus the total execution cost, given by $(p^n(k,x) - \gamma_k + q^n(s;k,x) - c(s))\,z$. We compute the focal firm's expected cash flow, expected winning probability, and expected cash flow conditional on winning in each year. We then compute the time-series averages of these quantities in each simulation. Finally, we quantify the focal firm's average cash flow, average winning probability, and average cash flow conditional on winning in government procurement by averaging each of these quantities across 100,000 simulations. Online Appendix F details the simulation procedure.

5.1 Impact of Firm Ideological Characteristics

In this subsection, based on the baseline estimation, we examine the role of a firm's ideological customer capital in government procurement for each industry. Specifically, we focus on procurement projects implemented via full and open competition (i.e., $y = 1$), and quantify the difference in the average cash flow from government procurement across firms

Table 5: Impact of firm ideological characteristics on the cash flow from procurement.

(%)	x_{poli}	x_{emit}	x_{fem}	x_{china}
IT	−1.68	12.61	6.74	1.63
Office	−11.75	−0.51	21.21	0.68
T&L	11.08	15.21	0.82	4.60

Note: This table reports the percentage difference (%) in the firm's average cash flow from government procurement relative to the median firm. The columns labeled as "x_{poli}", "x_{emit}", "x_{fem}", and "x_{china}" report the results for the firm with a one-standard-deviation lower average value in political alignment x_{poli}, carbon emission x_{emit}, female leadership ratio x_{fem}, and China connection x_{china}, respectively. In each panel, the rows labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

with different ideological characteristics (i.e., political alignment, carbon emission, female leadership ratio, and China connection).

We use the median firm as the benchmark, which is defined as follows. We construct a firm-year panel for the contracting firms in each industry, including firms' efficiency types and characteristics.[22] Based on the panel, we compute the time-series averages of the firm variables for each firm. Then, we fit a Beta distribution to the cross-section of each variable's time-series average. The median firm is defined to have average efficiency type and characteristics set at the median values of their respective fitted Beta distributions. Then, for each of the four ideological characteristics, we examine the firm with an average characteristic value one standard deviation below the median, and compute the percentage differences in the firm's procurement outcomes relative to the benchmark median firm via the simulation procedure above.

Overall Impact on Average Cash Flow from Procurement. Table 5 reports the percentage difference in the firm's average cash flow from government procurement relative to the median firm. Intuitively, if the firm with a lower average characteristic x_l can derive a larger average cash flow from government procurement, it indicates that firms with lower x_l are favored by the government and have a competitive advantage. The magnitude of the difference in the average cash flow indicates the importance of the corresponding ideological characteristic in procurement competition.

For instance, in the IT industry, relative to the median firm, a one-standard-deviation lower average political alignment is associated with 1.68% lower average cash flow from

[22] In the contract-level sample, a firm's efficiency type k, political alignment with the procuring subagency x_{poli}, and past experience with the subagency x_{past} are defined at the contract level. To construct the firm-year panel, we assume that during periods without a contract, the firm's efficiency type and the political affiliation of its last contracted procuring subagency remain unchanged until the next contract, and the firm has past contracting experience for the first two years after each contract.

government procurement. This indicates that firms that are politically aligned are slightly favored by the government. This is likely due to the political benefits of working with political allies, such as strengthened alliances and smoother implementation of government operations. However, in the IT industry, the potential consequences of a failed project (e.g., an unsuccessful software deployment) could be severe, resulting in intense public scrutiny. This mitigates the government's preference for politically aligned firms. In comparison, the effects of carbon emission and the female leadership ratio are much larger. A one-standard-deviation lower average carbon emission is associated with 12.61% higher average cash flow, while this number is 6.74% for the female leadership ratio. This indicates that the government strongly favors firms with lower carbon emission and firms with a lower female leadership ratio. Intuitively, because the IT industry is highly energy-intensive, prioritizing low-emission firms aligns with the government agenda on sustainability and helps reduce the large carbon footprint of IT infrastructure. The competitive advantage of firms with a lower female leadership ratio may reflect a persistent gender stereotype. This could arise from the unconscious bias that associates male-dominated leadership with rigorous technical backgrounds (e.g., IT engineers and developers). Finally, a one-standard-deviation lower average China connection is associated with 1.63% higher average cash flow from government procurement, indicating that firms connected to China have a slight disadvantage in procurement competition. This is likely due to national security concerns. However, because global IT supply chains and technology developments are deeply intertwined with China, this concern is not very important in the IT industry.

In the office management industry, firms that are politically aligned and firms with a lower female leadership ratio are strongly favored by the government and have a significant competitive advantage. Specifically, a one-standard-deviation lower average political alignment is associated with 11.75% lower average cash flow from government procurement, while a one-standard-deviation lower average female leadership ratio is associated with 21.21% higher average cash flow. Intuitively, projects in the office management industry are mostly standardized and low-risk, thereby subject to less scrutiny. As a result, firms that are politically aligned are strongly favored by the government for the political benefits. Firms with a lower female leadership ratio have an advantage, likely due to the persistence of traditional gender roles. The management of physical facilities and office operations is historically seen as a male-dominated field.

In the transportation and logistics industry, a one-standard-deviation lower average political alignment is associated with 11.08% higher average cash flow from government procurement. This suggests that politically misaligned firms have an advantage. This is potentially because projects in this industry are critical to government operation, highly

Table 6: Two channels of the impact on the cash flow from procurement.

(%)	x_{poli}	x_{emit}	x_{fem}	x_{china}
		A. Average winning probability		
IT	−1.79	14.73	7.60	2.52
Office	−10.43	−1.62	19.90	−0.29
T&L	14.32	9.01	3.88	4.93
		B. Average cash flow conditional on winning		
IT	−0.70	2.84	2.08	−0.20
Office	−3.91	0.57	6.09	0.62
T&L	1.54	1.87	1.85	0.68
		C. Average cash flow (fixing payments)		
IT	−1.39	10.63	5.65	1.82
Office	−8.46	−1.32	13.41	−0.20
T&L	11.80	5.87	3.44	3.43
		D. Average cash flow (fixing winning probabilities)		
IT	−0.34	1.02	0.83	−0.32
Office	−5.47	0.88	6.16	1.10
T&L	−0.18	9.09	−3.82	0.99

Note: This table reports the percentage differences (%) in the firm's procurement outcomes relative to the median firm. The columns labeled as "x_{poli}", "x_{emit}", "x_{fem}", and "x_{china}" report the results for the firm with a one-standard-deviation lower average value in political alignment x_{poli}, carbon emission x_{emit}, female leadership ratio x_{fem}, and China connection x_{china}, respectively. In each panel, the rows labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

visible, and often subject to spending criticisms. Due to this high level of scrutiny, awarding the projects to political allies could become a political liability and invite accusations of cronyism. The firm's carbon emission and China connection are also important in this industry. A one-standard-deviation lower average carbon emission is associated with 15.21% higher average cash flow, while this number is 4.60% for the connection to China. Similar to the IT industry, the transportation and logistics industry is characterized by high energy usage and heavy emissions. Thus, the government favors firms with lower carbon emission for sustainability reasons. Firms connected to China have a disadvantage for security reasons, because this industry involves the movement of critical goods and the operation of essential logistical infrastructure.

Two Channels of the Impact on Average Cash Flow. The total difference in the firm's average cash flow quantified in Table 5 is a result of two channels. First, firms with different ideological characteristics have different probabilities of winning government procurement contracts. Second, different firms also receive different cash flows conditional on winning, since the government optimally designs the payment terms contingent on firm characteristics. To examine the impact of each channel, we compute the percentage differences in the firm's average winning probability and average cash flow conditional on winning relative to the median firm, using the simulation procedure. In addition, we compute the percentage difference in the firm's average cash flow if only winning probabilities are different (i.e., fixing payments at the median firm level) or if only payments are different (i.e., fixing winning probabilities at the median firm level). Table 6 reports the results.

To interpret the results, we focus on the firm with lower average carbon emission in the IT industry (see the column labeled as "x_{emit}" and the rows labeled as "IT" in Table 6) as an example, since similar patterns hold in the other scenarios. Panels A and B of Table 6 show that, relative to the median firm, a one-standard-deviation lower average carbon emission is associated with a 14.73% increase in the average winning probability and a 2.84% increase in the average cash flow conditional on winning. In total, the combined effect is a 12.61% increase in the average cash flow from government procurement (see Table 5). In Panels C and D of Table 6, we decompose the total difference in the average cash flow into the two channels. We find that the difference in winning probabilities alone with fixed payments can account for a 10.63% increase in the average cash flow, whereas the difference in payments alone with fixed winning probabilities can only account for a 1.02% increase. These results indicate that the difference in the average cash flow is mostly driven by the difference in winning probabilities, while the difference in cash flows conditional on winning is small.

Intuitively, for the firm with a lower average x_l, whether it has a higher or lower average winning probability mainly depends on the sign of the coefficient β_l. If β_l is positive, it indicates that firms with lower x_l are favored by the government and thus would have a higher average winning probability. For instance, β_{emit} is positive in the IT industry (see Table 3). Therefore, a one-standard-deviation lower average carbon emission is associated with a 14.73% increase in the average winning probability. The magnitude of the difference in the average winning probability depends on the extent of competition and the relative importance of x_l in procurement competition. When there are more competitors and x_l is more important in procurement competition, the difference in x_l can lead to a larger difference in the firm's competitiveness and average winning probability.

As for the difference in the average cash flow conditional on winning, its sign can be indeterminate. This is because the characteristic x_l affects both the base and variable payments to the firm in the government's optimal contract design. First, x_l affects the firm's incentives to misreport its efficiency type, thereby affecting its base payments. If a firm is favored by the government due to x_l, the efficiency type matters less for the firm to win.

Consequently, there are stronger incentives for the high-efficiency firm to misreport its type, which increases its informational rents and thus base payments. Second, x_l affects the variable payments by affecting the government's perceived probability of the firm being high-efficiency (i.e., $\pi(x)$ in (24)). The overall difference in the average cash flow conditional on winning depends on which effect dominates. For instance, in the IT industry, a one-standard-deviation lower average carbon emission is associated with a 2.84% increase in the average cash flow conditional on winning. This is mainly because the firm with lower average carbon emission is favored by the government and relies less on the efficiency type to win, which increases its misreporting incentives and thus base payments.

5.2 Impact of Government Valuation of Ideological Characteristics

In this subsection, we evaluate how government valuation of a firm's ideological characteristics affects firm performance in government procurement. Specifically, focusing on projects implemented via full and open competition, we quantify how firms' average cash flows from government procurement would change if the government ignores each of the four ideological characteristics (i.e., political alignment, carbon emission, female leadership ratio, and China connection) when it selects the winning contractor. The four corresponding counterfactual experiments are conducted by setting $\beta_{\text{poli}} = 0$, $\beta_{\text{emit}} = 0$, $\beta_{\text{fem}} = 0$, and $\beta_{\text{china}} = 0$ in $b(x)$ in the government's objective (16), respectively.[23] In the counterfactual experiment where the government ignores the ideological characteristic x_l (i.e., setting $\beta_l = 0$ in $b(x)$ in (16)), we consider three focal firms which only differ in their average x_l. Given the fitted Beta distribution of the time-series average of x_l across firms, we set the average x_l of the three focal firms at the median minus one standard deviation, the median, and the median plus one standard deviation, respectively. The averages of the other firm variables are set at their median levels. Table 7 reports the percentage changes in the three focal firms' average cash flows from government procurement in each counterfactual experiment relative to the baseline.

According to Panel A of Table 7, in the IT industry, when the government ignores firms' political alignment, the average cash flow from government procurement increases by 0.90%, decreases by 0.75%, and decreases by 2.34%, for the firm with low, median, and high average political alignment, respectively. The heterogeneous effect across different

[23] In principle, if the government ignores one of the ideological characteristics, it will also affect the extent of competition in procurement. For example, it will lower the optimal search intensity λ in projects under full and open competition due to reduced benefit of competition (see equation (30)). Here, in these four counterfactual experiments, we hold the extent of competition as that in the baseline estimation. Our counterfactuals seek to uncover and quantify the impact of government valuation of ideological characteristics, holding the extent of competition unchanged.

Table 7: Impact of government valuation of ideological characteristics.

(%)	$\beta_{\text{poli}} = 0$	$\beta_{\text{emit}} = 0$	$\beta_{\text{fem}} = 0$	$\beta_{\text{china}} = 0$
		A. IT		
Firm with low x_l	0.90	−12.57	−10.81	−1.99
Firm with median x_l	−0.75	−1.49	−4.74	−0.10
Firm with high x_l	−2.34	7.58	0.94	1.84
		B. Office		
Firm with low x_l	6.89	2.15	−34.99	0.26
Firm with median x_l	−5.17	−0.47	−18.65	−0.74
Firm with high x_l	−14.76	−3.04	2.37	−1.76
		C. T&L		
Firm with low x_l	−22.26	−5.85	−5.55	−0.94
Firm with median x_l	−13.47	−1.42	−2.15	3.00
Firm with high x_l	−2.43	2.40	1.88	7.32

Note: This table reports the percentage changes (%) in the three focal firms' average cash flows from government procurement when the government ignores each of the four ideological characteristics. The columns labeled "$\beta_{\text{poli}} = 0$", "$\beta_{\text{emit}} = 0$", "$\beta_{\text{fem}} = 0$", and "$\beta_{\text{china}} = 0$" correspond to the counterfactual experiments where the government ignores the firm's political alignment x_{poli}, carbon emission x_{emit}, female leadership ratio x_{fem}, and China connection x_{china}, respectively. In the counterfactual experiment where the government ignores x_l (i.e., setting β_l=0), the rows labeled "Firm with low x_l", "Firm with median x_l", and "Firm with high x_l" report the results for the focal firm whose average x_l is set at the median minus one standard deviation, the median, and the median plus one standard deviation, respectively. Panels A, B, and C report the results for the IT, office management, and transportation and logistics industries, respectively.

firms is because each focal firm's competitiveness changes heterogeneously when moving from the baseline to the counterfactual. In the baseline estimation, on average, firms with low political alignment are disfavored by the government, while firms with high political alignment are favored. In the counterfactual where the government ignores firms' political alignment, the firm with low average political alignment becomes more competitive because the government no longer disfavors it due to its low political alignment. This leads to a 0.90% increase in its average cash flow from government procurement. In contrast, the firm with high average political alignment is no longer favored and becomes less competitive. This leads to a 2.34% decrease in its average cash flow. For the firm with median average political alignment, its average cash flow decreases by 0.75%. This suggests that this firm becomes slightly less competitive in the counterfactual.[24] Overall, because the government favors firms that are politically aligned in the baseline, the effect of the government ignoring firms'

[24]For example, it could be the case that some competitors have lower political alignment than the median firm but their other characteristics are slightly preferred by the government. In the baseline where the government favors firms with higher political alignment, the median firm would win over these competitors. In the counterfactual where the government ignores firms' political alignment, the median firm would lose to these competitors.

political alignment is more negative for the firm with higher average political alignment. When the government ignores firms' carbon emission in the IT industry, the average cash flow from government procurement decreases by 12.57%, decreases by 1.49%, and increases by 7.58%, for the firm with low, median, and high average carbon emission, respectively. The effect is more negative for the firm with lower average carbon emission, as the government favors low-emission firms in the baseline. Similarly, when the government ignores firms' female leadership ratios or connections to China, the effect is more negative for the firm favored in the baseline (i.e., the firm with lower average female leadership ratio or the firm with lower average China connection).

Within the IT industry, the cross-firm heterogeneity of the effect on the average cash flow varies in magnitude across the four counterfactual experiments. The heterogeneity is the largest when the government ignores firms' carbon emission ($7.58\% - (-12.57\%) = 20.15\%$ between firms with low and high average carbon emission), followed by when it ignores firms' female leadership ratios ($0.94\% - (-10.81\%) = 11.75\%$ between firms with low and high average female leadership ratio). This is consistent with the results in Subsection 5.1, which show that a firm's carbon emission and female leadership ratio are relatively more important in the IT industry in the baseline estimation. Intuitively, when the ideological characteristic x_l is more important in the baseline, firms are favored or disfavored by the government due to x_l to a greater extent. Therefore, when the government ignores x_l in the counterfactual, firms' relative competitiveness is affected to a greater extent, and the change in the average cash flow would exhibit greater heterogeneity across different firms.

In the office management industry (see Panel B of Table 7), the heterogeneity is the largest when the government ignores firms' female leadership ratios (a 37.36% spread in the effect on the average cash flow), followed by when it ignores firms' political alignment (21.64%). In the transportation and logistics industry (see Panel C of Table 7), the heterogeneity is the largest when the government ignores firms' political alignment (19.83%), followed by when it ignores firms' China connections (8.26%) and carbon emission (8.24%). These results are consistent with the findings in Subsection 5.1.

6 Conclusion

As customers' ideological beliefs significantly affect their purchasing decisions, a firm's ideological customer capital has become a crucial determinant of firm profitability and valuation. To value a firm's ideological customer capital, we use federal government procurement as the setting and examine how a firm's ideological characteristics determine its performance in government procurement competition. We develop a structural framework in which public procurement is modeled as an auction game between the government and multiple competing firms with hidden efficiency types and multidimensional characteristics.

We estimate the model using a novel dataset by linking contract-level data from FPDS with multiple data sources that provide information on the firm's ideological characteristics that may influence the government's procurement decisions: the political alignment between the firm and the procuring subagency, the firm's carbon emission, the firm's female leadership ratio, and the firm's connection to China. Through the lens of the estimated model, we find that a firm's political ideology, sustainability, gender composition, and exposure to China play significant roles in determining its cash flows from government procurement. Moreover, government valuation of these ideological characteristics affects firms heterogeneously. These effects exhibit substantial variation across industries.

References

Arve, Malin, and David Martimort. 2016. "Dynamic Procurement under Uncertainty: Optimal Design and Implications for Incomplete Contracts." *American Economic Review*, 106(11): 3238–3274.

Asker, John, and Estelle Cantillon. 2008. "Properties of scoring auctions." *The RAND Journal of Economics*, 39(1): 69–85.

Asker, John, and Estelle Cantillon. 2010. "Procurement when price and quality matter." *The Rand journal of economics*, 41(1): 1–34.

Bajari, Patrick, Robert McMillan, and Steven Tadelis. 2009. "Auctions versus negotiations in procurement: an empirical analysis." *The Journal of Law, Economics, & Organization*, 25(2): 372–399.

Bajari, Patrick, Stephanie Houghton, and Steven Tadelis. 2014. "Bidding for incomplete contracts: An empirical analysis of adaptation costs." *American economic review*, 104(4): 1288–1319.

Baltrunaite, Audinga, Cristina Giorgiantonio, Sauro Mocetti, and Tommaso Orlando. 2021. "Discretion and supplier selection in public procurement." *Journal of Law, Economics, and Organization*, 37(1): 134–166.

Bandiera, Oriana, Andrea Prat, and Tommaso Valletti. 2009. "Active and Passive Waste in Government Spending: Evidence from a Policy Experiment." *American Economic Review*, 99(4): 1278–1308.

Bandiera, Oriana, Michael Carlos Best, Adnan Qadir Khan, and Andrea Prat. 2021. "The allocation of authority in organizations: A field experiment with bureaucrats." *Quarterly Journal of Economics*, 136(4): 2195–2242.

Banerjee, Shantanu, Sudipto Dasgupta, and Yungsan Kim. 2008. "Buyer-supplier relationships and the stakeholder theory of capital structure." *Journal of finance*, 63(5): 2507–2552.

Belo, Frederico, and Jianfeng Yu. 2013. "Government investment and the stock market." *Journal of Monetary Economics*, 60(3): 325–339.

Belo, Frederico, Vito D Gala, and Jun Li. 2013. "Government spending, political cycles, and the cross section of stock returns." *Journal of financial economics*, 107(2): 305–324.

Belo, Frederico, Vito D Gala, Juliana Salomao, and Maria Ana Vitorino. 2022. "Decomposing firm value." *Journal of Financial Economics*, 143(2): 619–639.

Belo, Frederico, Xiaoji Lin, and Maria Ana Vitorino. 2014. "Brand capital and firm value." *Review of Economic Dynamics*, 17(1): 150–169.

Bhattacharya, Vivek. 2021. "An Empirical Model of R&D Procurement Contests: An Analysis of the DOD SBIR Program." *Econometrica*, 89(5): 2189–2224.

Bloom, Nicholas. 2009. "The impact of uncertainty shocks." *econometrica*, 77(3): 623–685.

Bolton, Patrick, and David S Scharfstein. 1990. "A theory of predation based on agency problems in financial contracting." *American economic review*, 93–106.

Bolton, Patrick, and Marcin Kacperczyk. 2021. "Do investors care about carbon risk?" *Journal of financial economics*, 142(2): 517–549.

Bolton, Patrick, and Marcin Kacperczyk. 2023. "Global pricing of carbon-transition risk." *The Journal of Finance*, 78(6): 3677–3754.

Bolton, Patrick, and Mathias Dewatripont. 2005. *Contract Theory.* Vol. 1 of *MIT Press Books*, The MIT Press.

Bolton, Patrick, and Michael D Whinston. 1993. "Incomplete contracts, vertical integration, and supply assurance." *Review of Economic Studies*, 60(1): 121–148.

Bolton, Patrick, Hui Chen, and Neng Wang. 2011. "A Unified Theory of Tobin's q, Corporate Investment, Financing, and Risk Management." *Journal of Finance*, 66(5): 1545–1578.

Branco, Fernando. 1997. "The design of multidimensional auctions." *The RAND Journal of Economics*, 63–81.

Brogaard, Jonathan, Matthew Denes, and Ran Duchin. 2021. "Political influence and the renegotiation of government contracts." *The Review of Financial Studies*, 34(6): 3095–3137.

Brown, Jeffrey R., and Jiekun Huang. 2020. "All the president's friends: Political access and firm value." *Journal of Financial Economics*, 138(2): 415–431.

Carril, Rodrigo, Andres Gonzalez-Lira, and Michael S. Walker. 2022. "Competition under incomplete contracts and the design of procurement policies." Department of Economics and Business, Universitat Pompeu Fabra Economics Working Papers 1824.

Chen, Hui, Winston Wei Dou, Hongye Guo, and Yan Ji. 2024*a*. "Feedback and Contagion through Distressed Competition." *Journal of Finance*, forthcoming.

Chen, Hui, Winston Wei Dou, Hongye Guo, and Yan Ji. 2024*b*. "Industry Distress Anomaly." Working Papers.

Chen, Lisha, Winston Wei Dou, and Zhihua Qiao. 2013. "Ensemble subsampling for imbalanced multivariate two-sample tests." *Journal of the American Statistical Association*, 108(504): 1308–1323.

Che, Yeon-Koo. 1993. "Design competition through multidimensional auctions." *The RAND Journal of Economics*, 668–680.

Child, Travers Barclay, Nadia Massoud, Mario Schabus, and Yifan Zhou. 2021. "Surprise election for Trump connections." *Journal of Financial Economics*, 140(2): 676–697.

Cingano, Federico, and Paolo Pinotti. 2013. "Politicians at work: The private returns and social costs of political connections." *Journal of the European Economic Association*, 11(2): 433–465.

Cooper, Michael J, Huseyin Gulen, and Alexei V Ovtchinnikov. 2010. "Corporate political contributions and stock returns." *Journal of Finance*, 65(2): 687–724.

Corhay, Alexandre, Howard Kung, and Lukas Schmid. 2020. "Competition, Markups, and Predictable Returns." *The Review of Financial Studies*, 33(12): 5906–5939.

Coviello, Decio, Andrea Guglielmo, and Giancarlo Spagnolo. 2018. "The effect of discretion on procurement performance." *Management Science*, 64(2): 715–738.

Coviello, Decio, and Stefano Gagliarducci. 2017. "Tenure in office and public procurement." *American Economic Journal: Economic Policy*, 9(3): 59–105.

Dai, Min, Zhaoli Jiang, and Neng Wang. 2022. "Strategic Real Option Exercising and Second-Mover Advantage." Working paper.

Dasgupta, Sudipto, and Sheridan Titman. 1998. "Pricing strategy and financial policy." *Review of Financial Studies*, 11(4): 705–737.

Dou, Winston Wei, and Yan Ji. 2021. "External Financing and Customer Capital: A Financial Theory of Markups." *Management Science*, 67(9): 5569–5585.

Dou, Winston Wei, Lucian A Taylor, Wei Wang, and Wenyu Wang. 2021*a*. "Dissecting bankruptcy frictions." *Journal of Financial Economics*, 142(3): 975–1000.

Dou, Winston Wei, Wei Wang, and Wenyu Wang. 2022. "The cost of intermediary market power for distressed borrowers." *Jacobs Levy Equity Management Center for Quantitative Financial Research Paper*.

Dou, Winston Wei, Yan Ji, and Wei Wu. 2021. "Competition, Profitability, and Discount Rates." *Journal of Financial Economics*, 140(2): 582–620.

Dou, Winston Wei, Yan Ji, and Wei Wu. 2022. "The Oligopoly Lucas Tree." *Review of Financial Studies*, 35(8): 3867–3921.

Dou, Winston Wei, Yan Ji, David Reibstein, and Wei Wu. 2021*b*. "Inalienable customer capital, corporate liquidity, and stock returns." *Journal of Finance*, 76(1): 211–265.

Eisfeldt, Andrea L, and Dimitris Papanikolaou. 2014. "The value and ownership of intangible capital." *American Economic Review*, 104(5): 189–194.

Falato, Antonio, Dalida Kadyrzhanova, Jae Sim, and Roberto Steri. 2022. "Rising intangible capital, shrinking debt capacity, and the US corporate savings glut." *The Journal of Finance*, 77(5): 2799–2852.

Flammer, Caroline. 2018. "Competing for government procurement contracts: The role of corporate social responsibility." *Strategic Management Journal*, 39(5): 1299–1324.

Foster, Lucia, John Haltiwanger, and Chad Syverson. 2016. "The slow growth of new plants: Learning about demand?" *Economica*, 83(329): 91–129.

Fos, Vyacheslav, Elisabeth Kempf, and Margarita Tsoutsoura. 2022. "The political polarization of corporate America." National Bureau of Economic Research.

Gagnepain, Philippe, Marc Ivaldi, and David Martimort. 2013. "The cost of contract renegotiation: Evidence from the local public sector." *American Economic Review*, 103(6): 2352–2383.

Gofman, Michael, Gill Segal, and Youchang Wu. 2020. "Production networks and stock returns: The role of vertical creative destruction." *The Review of Financial Studies*, 33(12): 5856–5905.

Goldman, Jim. 2020. "Government as customer of last resort: The stabilizing effects of government purchases on firms." *Review of Financial Studies*, 33(2): 610–643.

Gourio, Francois, and Leena Rudanko. 2014. "Customer capital." *Review of Economic Studies*, 81(3): 1102–1136.

He, Bianca, Lauren I Mostrom, and Amir Sufi. 2024. "Investing in Customer Capital." National Bureau of Economic Research.

He, Zhiguo, and Gregor Matvos. 2016. "Debt and Creative Destruction: Why Could Subsidizing Corporate Debt Be Optimal?" *Management Science*, 62(2): 303–325.

Hoberg, Gerard, and Gordon Phillips. 2010. "Product market synergies and competition in mergers and acquisitions: A text-based analysis." *Review of Financial Studies*, 23(10): 3773–3811.

Hoberg, Gerard, and Gordon Phillips. 2016. "Text-based network industries and endogenous product differentiation." *Journal of political economy*, 124(5): 1423–1465.

Hutton, Irena, Danling Jiang, and Alok Kumar. 2015. "Political values, culture, and corporate litigation." *Management Science*, 61(12): 2905–2925.

Kang, Karam, and Robert A Miller. 2022. "Winning by Default: Why is There So Little Competition in Government Procurement?" *The Review of Economic Studies*, 89(3): 1495–1556.

Krasnokutskaya, Elena, and Katja Seim. 2011. "Bid Preference Programs and Participation in Highway Procurement Auctions." *American Economic Review*, 101(6): 2653–2686.

Larkin, Yelena. 2013. "Brand perception, cash flow stability, and financial policy." *Journal of Financial Economics*, 110(1): 232–253.

Liebman, Jeffrey B, and Neale Mahoney. 2017. "Do expiring budgets lead to wasteful year-end spending? Evidence from federal procurement." *American Economic Review*, 107(11): 3510–3549.

Maskin, Eric S, and John G Riley. 1984. "Optimal Auctions with Risk Averse Buyers." *Econometrica*, 52(6): 1473–1518.

Matthews, Steven A. 1983. "Selling to risk averse buyers with unobservable tastes." *Journal of Economic Theory*, 30(2): 370–400.

McClellan, Andrew. 2023. "Knowing your opponents: Information disclosure and auction design." *Games and Economic Behavior*, 140: 173–180.

Milgrom, Paul, and Robert J Weber. 1982. "The value of information in a sealed-bid auction." *Journal of Mathematical Economics*, 10(1): 105–114.

Myerson, Roger B. 1981. "Optimal auction design." *Mathematics of operations research*, 6(1): 58–73.

Orser, Barbara, Allan Riding, and Julie Weeks. 2019. "The efficacy of gender-based federal procurement policies in the United States." *International Journal of Gender and Entrepreneurship*, 11(1): 6–37.

Orser, Barbara, Xiaolu Liao, Allan L Riding, Quang Duong, and Jerome Catimel. 2021. "Gender-responsive public procurement: strategies to support women-owned enterprises." *Journal of Public Procurement*, 21(3): 260–284.

Pástor, L'uboš, and Pietro Veronesi. 2012. "Uncertainty about government policy and stock prices." *Journal of Finance*, 67(4): 1219–1264.

Pástor, L'uboš, and Pietro Veronesi. 2013. "Political uncertainty and risk premia." *Journal of financial Economics*, 110(3): 520–545.

Pástor, L'uboš, and Pietro Veronesi. 2020. "Political cycles and stock returns." *Journal of Political Economy*, 128(11): 4011–4045.

Riley, John, and William F Samuelson. 1981. "Optimal Auctions." *American Economic Review*, 71(3): 381–92.

Spenkuch, Jörg L, Edoardo Teso, and Guo Xu. 2023. "Ideology and performance in public organizations." *Econometrica*, 91(4): 1171–1203.

Tahoun, Ahmed. 2014. "The role of stock ownership by US members of Congress on the market for political favors." *Journal of Financial Economics*, 111(1): 86–110.

Titman, Sheridan. 1984. "The effect of capital structure on a firm's liquidation decision." *Journal of financial economics*, 13(1): 137–151.

Vickrey, William. 1961. "Counterspeculation, Auctions, And Competitive Sealed Tenders." *Journal of Finance*, 16(1): 8–37.

Weiss, Linda, and Elizabeth Thurbon. 2006. "The business of buying American: Public procurement as trade strategy in the USA." *Review of International Political Economy*, 13(5): 701–724.