Ideological Customer Capital: Measurement and Asset Pricing Implications

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Abstract

Ideological customer capital—the customer base loyal to a firm's brand due to shared ideology—acts as a critical intangible asset that directly drives the firm's cash flows. We use federal procurement to measure a firm's ideological customer capital attributed to the government and study its asset pricing implications. The U.S. government is a major customer and has the discretion to consider ideological factors in procurement. Leveraging detailed contract-level data, we develop and structurally estimate a procurement auction model and find that a firm's procurement revenues are significantly driven by its ideological alignment with the government, specifically regarding its political leaning, sustainability, gender composition, and exposure to China. Constructing a model-implied measure of firm-level ideological customer capital, we show that firms with higher levels of this capital are significantly less exposed to aggregate cash flow risk.

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

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1 Introduction

Ideological customer capital—the customer base loyal to a firm's brand due to shared ideology–acts as a critical intangible asset that directly drives cash flows, profitability, and valuation. While previous studies highlight the broader role of customer capital in determining asset prices (e.g., Dou et al., 2021; Belo et al., 2022), they do not distinguish between its underlying components. Consequently, the specific role of ideological customer capital and its distinct asset pricing implications remain largely unexplored.

Measuring a firm's ideological customer capital presents a significant empirical challenge as it requires isolating the cash flows generated specifically by the ideological alignment between a firm and its customers. Because a firm's customer base typically holds heterogeneous beliefs, it is difficult to construct an aggregate measure that accurately reflects the alignment between these diverse customers and the firm's ideological characteristics. Furthermore, to study asset pricing implications, we must quantify how specific ideological factors impact a firm's cash flows—a relationship that is rarely observable in consumer markets. To address this challenge, we focus on the single largest customer in the U.S.: the federal government, whose procurement contracts constitute a substantial portion of cash flows for many firms. During the procurement process, government agencies exercise discretion and can consider various ideological factors when making awarding decisions. By combining detailed contract-level data on procurement outcomes with the ideological characteristics of firms, we can infer how shared ideology drives a firm's cash flows. This empirical setting allows us to construct an empirical measure of firms' ideological customer capital attributed to their relationship with the federal government.

We make two major contributions. First, we construct a novel dataset that allows us to measure a firm's ideological customer capital derived from the federal government. This dataset links contract-level procurement data from the Federal Procurement Data System (FPDS) with firm-level data on characteristics that reflect the core socio-political goals and ideological considerations of the U.S. government. Specifically, these characteristics include the firm's political alignment with the procuring agency, environmental sustainability (proxied by carbon emissions), gender diversity (captured by female leadership), and exposure to China. Second, we develop and structurally estimate a procurement auction model to quantify firms' expected cash flows resulting from their ideological alignment with the government. Using these model-implied expected cash flows, we construct a firm-level measure of government-linked ideological customer capital and examine its asset pricing implications. We demonstrate that firms with higher ideological customer capital exhibit significantly lower exposure to aggregate cash flow risk, measured following Cohen, Polk and Vuolteenaho (2009) and Santos and Veronesi (2010). This is because firms possessing government-favored ideological characteristics secure a larger proportion of their cash flows from federal procurement, a revenue source that remains highly stable across business cycles.

A typical 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. In particular, 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. Finally, the winning contractor executes the project, and adjustments in payment or schedule may occur before project completion.

Our procurement auction model aims to capture above institutional features of federal 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 and capture the non-pecuniary factors considered by the government in award allocation. 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. Thus, the government optimally designs the auction mechanism, which includes payment terms for a menu of contracts and how the winner is selected. To capture potential payment adjustments, we allow the payment terms to depend on the random contract outcome realized upon 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.

We structurally estimate the model using our novel dataset that links contract-level data from FPDS to firm characteristics data from multiple sources. Specifically, we employ a Bayesian approach and separately estimate the model 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 structural parameters using a Markov chain Monte Carlo (MCMC) procedure. In the estimation, to address the endogeneity issue arising 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 structural parameters and the latent variable for each observation, conditional on the observed data. Because the Bayesian MCMC approach can deal with latent heterogeneity of a relatively low dimension, instrumental variables are not necessary for estimation.

We use the estimated model to construct measures of ideological customer capital attributed to the government, based on firms' expected cash flows from procurement. Specifically, for each firm-year in our sample, we compute the expected cash flow from procurement conditional on the four ideological characteristics, as well as conditional on each ideological characteristic. We aggregate each of the five cash flow measures to the parent-firm level and scale the five totals by the parent firm's income. We use these five measures to proxy for the importance of the overall ideological customer capital associated with all four ideological characteristics and the importance of the ideological customer capital associated with each ideological characteristic.

To better understand what affects our measures, we quantitatively examine the determinants of firms' expected cash flows from procurement and quantify their effects. We first examine the impact of the four ideological characteristics in the baseline model. Focusing on procurement projects under full and open competition, we find that firms with different ideological characteristics have significantly different average cash flows from procurement.

For instance, in the IT industry, relative to the median firm, a one-standard-deviation lower average carbon emission is associated with 10.06% higher average cash flow from procurement, while this number is 9.62% for the female leadership presence. These results indicate that firms with lower carbon emission and firms with a lower female leadership presence are favored by the government 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 female leadership presence, followed by political alignment. A one-standard-deviation lower average female leadership presence is associated with 17.67% higher average cash flow from procurement, while a one-standard-deviation lower average political alignment is associated with 9.02% lower average cash flow. This indicates that firms with a lower female leadership presence and firms that are politically aligned with the procuring subagency 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 19.41% higher average cash flow from procurement. This number is 12.16% for carbon emission and 6.89% for connection to China.

Then, we examine the impact of government valuation of firms' ideological characteristics. In the counterfactual experiment where the government ignores an ideological characteristic when selecting the winning contractor, firms' average cash flows from procurement change significantly relative to the baseline. This change is more negative for firms that are favored by the government due to this ideological characteristic in the baseline. This is simply because, in the counterfactual, these firms are no longer favored by the government due to this characteristic. For instance, when the government ignores firms' carbon emission in the IT industry, the firm with low average carbon emission experiences an 8.41% decrease in its average cash flow from procurement. In contrast, the firm with high average carbon emission experiences an 8.90% increase. These heterogeneous 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 exhibits greater heterogeneity across firms.

Using the five measures of ideological customer capital, we investigate their asset pricing implications by examining how these measures affect a firm's exposure to aggregate cash flow risk. We focus on aggregate cash flow risk because our measures are explicitly constructed based on firms' expected cash flows from procurement and the most direct economic channel through which these measures can affect asset prices is the cash flow channel. Prior studies have documented that firm cash flows and stock returns load positively on aggregate cash flow on average and that this risk carries a positive price (Campbell and Vuolteenaho, 2004; Hansen, Heaton and Li, 2008; Cohen, Polk and Vuolteenaho, 2009; Santos and Veronesi, 2010). We find that, for all five measures, firms with higher ideological customer capital are less positively exposed to aggregate cash flow risk. This is because these firms have ideological characteristics that are favored by the government and can derive a larger proportion of their cash flows from procurement, which are more stable over business cycles. This makes these firms less negatively impacted by economic downturns and thus less exposed to aggregate cash flow risk.

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, corporate policies, and asset prices (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; Belo et al., 2022). In particular, existing studies rely on brand survey data (e.g., Dou et al., 2021) or accounting data (e.g., Belo et al., 2022) to measure a firm's customer capital and examine its asset pricing implications. We use government procurement as the setting to measure a firm's ideological customer capital attributed to the government, and investigate its specific role in determining asset prices.

Our paper is related to the literature that studies the important role of the government in determining firm performance and asset prices. 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) focus respectively 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 procurement. Based on firms' expected cash flows from procurement, we construct measures of ideological customer capital attributed to the government and study the implications for asset prices.

Since we use government procurement as the setting to measure ideological customer capital, our paper is also 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). Shen and Xu (2025) find that firm characteristics can affect the firm's ability to win procurement contracts and thus have significant implications for firm cash flow and valuation. Building on this insight, we investigate the role of ideological customer capital in government procurement and its asset pricing implications, using a structural approach. Several papers develop structural models to study the procurement process (e.g., Bhattacharya, 2021; Carril, Gonzalez-Lira and Walker, 2022; Kang and Miller, 2022). In particular, Kang and Miller (2022) structurally estimate 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.

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 (e.g., Hoberg and Phillips, 2010, 2016; He and Matvos, 2016; Corhay, Kung and Schmid, 2020; Dou and Ji, 2021; Dou, Ji and Wu, 2021, 2022; Dou, Wang and Wang, 2022; Chen et al., 2024). Our paper contributes to this literature by studying firms' competition in government procurement and structurally identifying the competitive

[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.

advantage attributed to different firm ideological characteristics.

2 Institutional Background and Data

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

[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

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.

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). Thus, the final duration and payment are often different from the 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 are 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

operate under distinct rules.

[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

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 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 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 associated contract is not firm-fixed-price or performance-based; we refer to the contract as a

limited in the follow-on contracts, these contracts are not suitable for our analysis of how firms' ideological characteristics affect firms' competitiveness and performance in procurement.

[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.

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

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 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 can 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 are the primary focus of the government's ideological considerations – the political alignment between the firm and the procuring subagency, the firm's carbon emission, the presence of females in the firm's leadership, and the firm's connection to China. For example, studies have found that politically connected firms win more procurement contracts in the U.S. (Brown and Huang, 2020; Child et al., 2021; Shen and Xu, 2025). 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 considers these characteristics, because they are directly related to the government's ideological beliefs and socio-political goals. However, 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 to the government in the office management industry, because this industry involves low-risk projects with minimal national security concerns. Thus, to evaluate the role of the four ideological characteristics in procurement competition and construct measures of ideological customer capital attributed to the government, we 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 Presence. We define a firm's female leadership presence as a dummy variable, which equals 1 if any of the firm's key executives is female and 0 otherwise.

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

[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.

calendar year, and not connected otherwise.

Control Variables. In addition to the four ideological characteristics, we include three additional 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 (Dou et al., 2021). 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 structurally evaluate the role of a firm's ideological characteristics in procurement competition. The average payment and duration exhibit large variation across 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 $231.96 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 presence of the contracting firms exhibit moderate variation across industries, with the average carbon emission ranging from 4.86 to 5.71 and the proportion of contracts awarded to firms with female leadership ranging from

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 $)						
Base	231.96	(86.86)	30.77	(16.98)	257.65	(57.10)
Variable ($\mathbb{1}_{\text{zero}}$)[a]	0.72	(1.00)	0.76	(0.00)	0.78	(0.00)
Variable (non-zero)	612.55	(99.31)	8.21	(5.50)	1,021.94	(40.01)
Final	405.70	(93.43)	32.78	(17.40)	481.27	(61.86)
Duration (in days)						
Base	616.36	(902.00)	116.28	(96.00)	153.35	(244.00)
Variable ($\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 leadership presence[a]	0.32	(1.00)	0.38	(1.00)	0.33	(1.00)
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 that 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.

32% to 38%. 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.[10] 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.

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.[11] 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

[10]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 Vickrey 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).

[11]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.

realized value of s is an informative signal about a firm's efficiency type:

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

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:

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

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

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

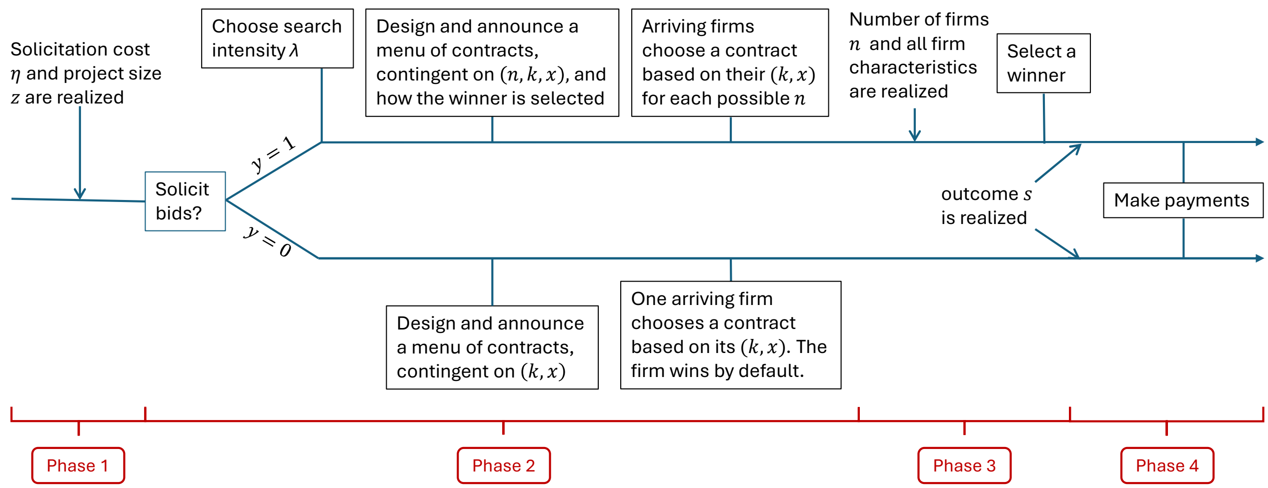
In addition, firms differ in their characteristic, denoted by x. Different from the hidden efficiency type, the value of x is perfectly observable to the government. The characteristic could be firms' political alignment with the government, carbon emission, etc. It can affect a firm's chance to win 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 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 $\varsigma(z)$.



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.

Phase 2. Depending on the realized values of η and z, the government optimally decides whether to solicit competitive bids from firms.[12] 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.[13] We specify the contracts to depend on n because its value is unknown

[12]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.

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

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 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.[14]

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.

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.

[14] 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.

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.

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 $(\boldsymbol{k},\boldsymbol{x})$,

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

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

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

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 a 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.[15]

[15] 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 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.

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.

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.

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, $\left(b(x) + \int h^n(s;k,x) f_k(s) \mathrm{d}s\right) z$, 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):

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

where

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

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

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

with

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

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 $f_H(s) \leq f_L(s)$) and punish outcomes that are more likely for type$-H$ winners subject to the limited liability constraint (8) (i.e., $c(s) + M \leq q^n(s; L, x) < c(s)$ when $f_H(s) \geq f_L(s)$).

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):

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

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 $\Upsilon(x)$ of 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,[16] it would motivate type$-H$ firms with the same x to misreport their type as L. To keep the 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

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

[16]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.

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.

We assume that the project size z is drawn from a log-normal distribution with parameters μ_z and σ_z, and the solicitation cost per unit of project size η is drawn from an exponential distribution with mean ν. For each contract in the data, its 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. Conditional 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 dummy variable x_{fem} denotes whether a firm has female executives, which equals 1 if it does and 0 otherwise. 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. To make the estimation tractable, 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,[17] 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

[17] 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.

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 Sections 5 and 6.

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 1), 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 three steps. First, we externally estimate the ex-ante distribution of the seven observed firm 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 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. Third, we calibrate the auxiliary parameter ν, which determines the average solicitation cost, by matching the proportion of contracts awarded via competitive solicitations in the sample.

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, female leadership presence, connection to China, and past contracting experience, are each classified into 2 categories by construction. The continuous variables, including the firm's carbon emission, 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.

Table 2: Estimates for outcome distributions and average solicitation cost.

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
Mean of solicitation cost	ν	43.13	3.61	49.77

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

Bayesian Estimation. In the second step of our estimation, we estimate the structural parameters using a Bayesian approach, given the externally estimated firm and outcome distributions in the first step. We denote the vector of structural 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 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, $n_i - 1$ conditional 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, conditional 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, conditional 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, conditional on θ and the other variables, is computed as follows. As specified in Section 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 conditional 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 conditional on $\{\epsilon_i\}_{i=1}^N$ satisfies

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

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.[18] 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

[18]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

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

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

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

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 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 $\{\beta_l\}_{l\in\mathcal{L}}$.

Estimates of Average Solicitation Cost. In the third step of our estimation, given the estimates of all other parameters, we calibrate the auxiliary parameter ν to match the proportion of procurement projects implemented via full and open competition. Per our discussion of the government's solicitation decision in Section 3.5, the average solicitation cost ν determines the likelihood of the government soliciting competitive bids and is therefore identified by the proportion of competitively solicited projects. The results are presented in Table 2.

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.

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	4.20	1.62	−0.18	0.01
	(0.23)	(0.09)	(0.07)	(0.01)
Office	1.75	0.45	−0.22	0.02
	(0.16)	(0.02)	(0.01)	(0.00)
T&L	5.17	1.98	−0.74	0.06
	(1.24)	(0.02)	(0.05)	(0.01)

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	−8.07	100.34	34.31	13.51	−14.99	−12.17	−6.10	85.53	10.11
	(1.53)	(2.96)	(2.81)	(5.17)	(2.92)	(2.81)	(2.95)	(7.10)	(0.78)
Office	−2.51	0.99	6.31	−0.65	−4.21	−9.67	7.38	8.12	0.90
	(0.82)	(1.90)	(1.20)	(1.08)	(1.09)	(2.55)	(1.92)	(1.51)	(0.14)
T&L	14.39	7.86	1.86	6.75	−2.02	−9.66	−28.36	105.81	2.80
	(2.81)	(1.12)	(0.77)	(1.31)	(1.95)	(2.30)	(8.57)	(142.78)	(3.33)

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.

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 1.75. 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 government and have an advantage in procurement competition. For instance, according to Table 3, $\beta_{\text{emit}} = 100.34$ 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 those of the other characteristics. This is because the variation in x_l across firms also affects its relative importance.[19] 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.[20] In Section 5.2, we evaluate the impact of each ideological characteristic on firms' cash flows from procurement and examine their importance in procurement competition.

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. The search cost and the solicitation cost directly determine the intensive and extensive margins of competition, which play a significant role in procurement outcomes. In Online Appendix F.2, we conduct counterfactual experiments to examine the impact of competition on firm performance in government procurement.

[19] 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.

[20] 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	2.15	1.73	2.54	−3.80	0.44	2.23
	(0.06)	(0.02)	(0.12)	(0.51)	(0.01)	(0.19)
Office	2.13	1.16	0.40	−0.24	0.28	5.47
	(0.08)	(0.04)	(0.16)	(0.10)	(0.03)	(0.66)
T&L	2.07	1.55	5.10	−0.61	0.64	142
	(0.23)	(0.04)	(0.25)	(0.35)	(0.02)	(15.88)

	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	0.11	−0.78	1.02	0.27	0.06	0.74	−0.06	−1.77
	(0.09)	(0.11)	(0.07)	(0.16)	(0.11)	(0.20)	(0.21)	(0.17)
Office	−1.34	2.67	4.29	1.95	−4.00	−0.20	−5.22	−0.35
	(0.87)	(2.39)	(0.72)	(1.10)	(0.87)	(2.12)	(1.93)	(1.78)
T&L	3.66	5.88	0.37	−1.70	2.36	−0.80	2.96	−7.10
	(0.83)	(2.10)	(0.30)	(0.51)	(0.66)	(0.47)	(0.47)	(1.73)

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.

5 Measuring Ideological Customer Capital

To investigate the asset pricing implications of ideological customer capital attributed to the government, we use the estimated model to construct the measures in this section. In Subsection 5.1, we detail the construction of the measures based on firms' expected cash flows from procurement. In Subsection 5.2, we examine the determinants of firms' cash flows from procurement and quantify their effects using the estimated model.

5.1 Construction of the Measures

Measuring a firm's ideological customer capital attributed to the government presents several challenges. First, it requires detailed, multi-dimensional data on firm ideological characteristics that capture the government's core ideological considerations. We overcome this challenge with our novel dataset that links contract-level procurement data from FPDS to firm-level ideological characteristics data from multiple sources (i.e., political alignment, carbon emissions, female leadership presence, and China connections). Second, because cash flows generated by a firm's ideological customer capital are not directly observable, measuring ideological customer capital requires us to estimate these cash flows from the data. Ideological characteristics alone cannot cleanly capture these cash flow effects, and raw realized cash flows are heavily confounded by other random factors. To overcome the confounding noise in the raw data, we structurally estimate a procurement auction model using our novel dataset. Leveraging the estimated model, we can estimate firms' expected cash flows from procurement conditional on their ideological characteristics, and construct measures of ideological customer capital attributed to the government based on these cash flow estimates.

We first construct an overall measure of ideological customer capital associated with all four ideological characteristics. We build a firm-year panel of the contracting firms' efficiency types and characteristics for each industry, based on the contract-level estimation sample.[21] For each firm-year in the panels, we compute the firm's expected cash flow from procurement projects under full and open competition (i.e., $y = 1$) conditional on all four ideological characteristics. Specifically, we assume that there are N_{proc} procurement projects under full and open competition on average each year, and there are a total of N_{firm} firms that may be randomly solicited to bid for each project.[22] We compute a firm's annual expected cash flow from procurement conditional on its ideological characteristics as

$$N_{\text{proc}}\mathbb{E}\left[\frac{n}{N_{\text{firm}}}\Phi^n(k,x)\left(p^n(k,x)-\gamma_k+q^n(s;k,x)-c(s)\right)z\,\middle|\,x_{\text{poli}},x_{\text{emit}},x_{\text{fem}},x_{\text{china}}\right], \tag{47}$$

where the expectation computes the firm's expected cash flow from each project and is taken over the number of bids n, the contract outcome s, the project size z, and the firm's efficiency type k and characteristics x. In (47), n/N_{firm} is the probability of the firm being solicited to bid in a project, $\Phi^n(k,x)$ is the expected probability of the firm winning the contract conditional on bidding (see Equation (5)), and $(p^n(k,x)-\gamma_k+q^n(s;k,x)-c(s))\,z$ is the cash flow the firm can derive from a project conditional on winning.

To examine the implications for stock returns, we aggregate the contracting firms' expected cash flows from procurement to the parent firm level. Specifically, we match each contracting firm to its ultimate parent firm in the Center for Research in Security Prices (CRSP) database. For each parent firm and year, we sum the expected cash flows from procurement across all subsidiaries, and scale this sum by the parent firm's average earnings before interest and taxes over the current and past four years. We use this measure to proxy the importance of the parent firm's overall ideological customer capital.

[21]Online Appendix A.3 details the construction of the firm-year panels.

[22]For each industry, we set N_{proc} as the average annual number of projects under full and open competition in the sample, and we set $N_{\text{firm}} = 50$.

In addition to this overall measure, we construct four separate measures of ideological customer capital, each associated with one ideological characteristic. First, for each contracting firm, we compute its annual expected cash flow from procurement conditional on each ideological characteristic individually. That is, for each $l \in \{\text{poli, emit, fem, china}\}$, we compute

$$N_{\text{proc}}\mathbb{E}\left[\frac{n}{N_{\text{firm}}}\Phi^{n}(k,x)\left(p^{n}(k,x)-\gamma_{k}+q^{n}(s;k,x)-c(s)\right)z\middle|x_{l}\right]. \tag{48}$$

Then, we follow the identical aggregation procedure as the overall measure to construct four separate measures at the parent firm level. Each of these four measures captures the importance of the parent firm's ideological customer capital associated with one specific ideological characteristic.

5.2 Determinants of Cash Flows from Procurement

To better understand what could affect our measures based on cash flows from procurement, we use the estimated model to examine the determinants of firms' expected cash flows from procurement and quantify their respective effects. Specifically, we employ a simulation procedure to simulate firms' efficiency types and characteristics over time and quantify their average cash flows from procurement.[23]

Impact of Firm Ideological Characteristics. We first examine the impact of a firm's ideological characteristics by quantifying the difference in the average cash flow from procurement among firms with different ideological characteristics, based on the baseline estimation. Specifically, for each industry, we define the benchmark median firm as follows. Based on the panel of the contracting firms described in Section 5.1, we compute the time-series averages of the firm variables (i.e., the efficiency type and characteristics) for each firm. Then, we fit a Beta distribution to the cross-section of each variable's time-series average. For the median firm, the time-series averages of the firm variables are set at the median values of their respective fitted Beta distributions. Then, for each ideological characteristic x_l, we consider a firm that differs from the median firm only in that its average x_l is one

[23]Because the ideological characteristics can be binary or continuous, we employ a simulation procedure to quantitatively compare their effects by varying their time-series averages. In one simulation, we simulate each focal firm's 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. Then, we compute the focal firm's expected cash flow from procurement in each year, and compute the time-series average. We obtain the firm's average expected cash flow from procurement by simulating this process 100,000 times and averaging the results. Online Appendix F.1 details the simulation procedure.

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

(%)	x_{poli}	x_{emit}	x_{fem}	x_{china}
IT	−2.77	10.06	9.62	2.92
Office	−9.02	2.97	17.67	0.42
T&L	19.41	12.16	−0.38	6.89

Note: This table reports the percentage difference (%) in the firm's average cash flow from 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 presence x_{fem}, and China connection x_{china}, respectively. The rows labeled "IT", "Office", and "T&L" report the results for the IT, office management, and transportation and logistics industries, respectively.

standard deviation below the median, and compute the percentage differences in this firm's average cash flow from procurement relative to the median firm. Table 5 reports the results. Intuitively, if the firm with a lower average x_l can derive a larger average cash flow from 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.[24]

For instance, in the IT industry, relative to the median firm, a one-standard-deviation lower average political alignment is associated with 2.77% lower average cash flow from 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 presence are much larger. A one-standard-deviation lower average carbon emission is associated with 10.06% higher average cash flow, while this number is 9.62% for the female leadership presence. This indicates that the government strongly favors firms with lower carbon emission and firms with a lower female leadership presence. 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 presence may reflect a persistent gender stereotype. This could arise from the unconscious bias that associates male-dominated leadership with

[24]The difference in the average cash flow is a result of two channels. First, firms with different ideological characteristics have different probabilities of winning 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 examine the impact of each channel in Online Appendix F.2, and find that the difference in the average cash flow is mainly driven by the difference in winning probabilities.

rigorous technical backgrounds (e.g., IT engineers and developers). Finally, a one-standard-deviation lower average China connection is associated with 2.92% higher average cash flow from 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.

According to Table 5, in the office management industry, firms that are politically aligned and firms with a lower female leadership presence are strongly favored by the government and have a significant competitive advantage. 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 presence 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, politically misaligned firms have an advantage. This is potentially because projects in this industry are critical to government operation, highly 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. 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.

Impact of Government Valuation of Ideological Characteristics. We then evaluate how government valuation of a firm's ideological characteristics affects firms' cash flows from procurement. Specifically, we quantify how firms' average cash flows from procurement would change if the government ignores each of the four ideological characteristics 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.[25] In the counterfactual experiment where the government

[25]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. In Online Appendix F.2, we evaluate the impact of competition on firms' cash flows from procurement.

Table 6: 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	1.52	−8.41	−18.76	−2.83
Firm with median x_l	−1.32	0.39	−10.93	−0.02
Firm with high x_l	−4.00	8.90	−1.42	2.96
		B. Office		
Firm with low x_l	5.17	−0.59	−24.38	0.40
Firm with median x_l	−3.78	0.11	−9.66	−1.01
Firm with high x_l	−11.28	0.82	11.43	−2.43
		C. T&L		
Firm with low x_l	−40.09	−4.01	−2.67	−1.18
Firm with median x_l	−28.27	−0.56	−0.12	4.67
Firm with high x_l	−10.73	2.86	2.39	11.39

Note: This table reports the percentage changes (%) in focal firms' average cash flows from 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 presence 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.

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. We compute the percentage changes in the three focal firms' average cash flows from procurement relative to the baseline. Table 6 reports the results for each counterfactual experiment.

According to panel A of Table 6, in the IT industry, when the government ignores firms' political alignment, the average cash flow from procurement increases by 1.52%, decreases by 1.32%, and decreases by 4.00%, for the firm with low, median, and high average political alignment, respectively. The heterogeneous effect across different firms is because each focal firm's competitiveness changes heterogeneously when moving from the baseline to the counterfactual. In the baseline, the government favors firms that are politically aligned. When the government ignores firms' political alignment, politically aligned firms are no longer favored and become less competitive. Thus, the effect of the government ignoring firms' political alignment is more negative for the firm with higher average political alignment. Similarly, when the government ignores one of the other ideological characteristics in the IT industry, the effect is more negative for the firm favored in the baseline (i.e., the firm with lower average carbon emission, the firm with lower average female leadership presence, 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 ($8.90\% - (-8.41\%) = 17.31\%$ between firms with low and high average carbon emission) or female leadership presence (17.34% between firms with low and high average female leadership presence). This is consistent with previous results, which show that a firm's carbon emission and female leadership presence are relatively more important in the IT industry in the baseline estimation. Intuitively, when the government ignores a characteristic that is more important in the baseline, it affects firms' relative competitiveness to a greater extent. Thus, the change in the average cash flow would exhibit greater heterogeneity across different firms. According to Table 6, in the office management industry, the heterogeneity is the largest when the government ignores firms' female leadership presence (a 35.81% spread in the effect on the average cash flow), followed by when it ignores firms' political alignment (16.46%). In the transportation and logistics industry (see Panel C of Table 6), the heterogeneity is the largest when the government ignores firms' political alignment (29.36%), followed by when it ignores firms' China connections (12.58%) and carbon emission (6.87%). These results are also consistent with previous findings on the relative impact of each ideological characteristic in the baseline.

6 Asset Pricing Implications

In this section, we investigate the asset pricing implications of the measures of ideological customer capital attributed to the government, defined in Section 5. We obtain data on stock returns, dividends, and CPI from CRSP, and accounting data from Compustat. Risk-free rates are obtained from the Kenneth R. French's Data Library.

Specifically, we examine how our measures of ideological customer capital affect firms' exposures to aggregate cash flow risk. We focus on aggregate cash flow risk because our measures are explicitly constructed based on firms' expected cash flows from procurement and the most direct economic channel through which these measures can affect asset prices is the cash flow channel. Intuitively, firms' cash flows derived from procurement due to their ideological alignment with the government can exhibit very different cyclical patterns

Table 7: Asset pricing implications.

	(1) Overall	(2)	(3)	(4)	(5)
		Individual Ideological Characteristic			
		x_{poli}	x_{emit}	x_{fem}	x_{china}
			A. Log ROE		
$\sum_{j=0}^{N} \phi^j x_{t-j}$	1.729	1.731	1.729	1.729	1.730
	(0.150)	(0.150)	(0.150)	(0.150)	(0.150)
$\text{ICC}_{i,t-1}$	0.765	0.863	0.780	0.728	0.783
	(0.067)	(0.084)	(0.072)	(0.066)	(0.072)
$\sum_{j=0}^{N} \phi^j x_{t-j} \times \text{ICC}_{i,t-1}$	-2.184	-2.484	-2.241	-2.088	-2.248
	(0.231)	(0.300)	(0.256)	(0.229)	(0.255)
			B. Dividend growth		
$\sum_{j=0}^{N} \phi^j x_{t-j}$	0.732	0.733	0.732	0.732	0.732
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
$\text{ICC}_{i,t-1}$	0.581	0.630	0.583	0.542	0.586
	(0.190)	(0.224)	(0.200)	(0.190)	(0.198)
$\sum_{j=0}^{N} \phi^j x_{t-j} \times \text{ICC}_{i,t-1}$	-1.399	-1.517	-1.404	-1.299	-1.411
	(0.478)	(0.562)	(0.504)	(0.480)	(0.499)

Note: This table reports the estimates for different specifications of regression (49). Column (1) reports the results for the overall ideological customer capital measure. Columns (2)-(5) report the results for the ideological customer capital measure associated with political alignment, carbon emission, female leadership presence, and China connection, respectively. Panels A and B use the market's log ROE and log dividend growth to compute the measure of aggregate cash flow, respectively. The number of observations is 3,656 for all specifications. Robust standard errors are reported in brackets.

compared to aggregate cash flow. Consequently, a firm's ideological customer capital can significantly affect its exposure to aggregate cash flow risk, which in turn affects the risk premium demanded by investors. Prior studies have shown that firm cash flows and stock returns load positively on aggregate cash flow on average, and that aggregate cash flow risk is positively priced (Campbell and Vuolteenaho, 2004; Hansen, Heaton and Li, 2008; Cohen, Polk and Vuolteenaho, 2009; Santos and Veronesi, 2010). Thus, investors would demand a higher risk premium when holding stocks of firms that are more positively exposed to aggregate cash flow, and a lower risk premium for those that are less positively exposed. Building on this insight, we empirically test whether and how our measures of ideological customer capital affect the exposure of a firm's excess stock return to aggregate cash flow. Specifically, we follow Cohen, Polk and Vuolteenaho (2009) and Santos and Veronesi (2010) and use the market's accumulated log return on equity (ROE) and accumulated log dividend growth as proxies for aggregate cash flow. To examine firms' exposures to aggregate cash flow, we run the following regression:

$$\sum_{j=0}^{N} \phi^j r_{i,t-j} = \beta_0 + \beta_1 \sum_{j=0}^{N} \phi^j x_{t-j} + \beta_2 \text{ICC}_{i,t-1} + \beta_3 \sum_{j=0}^{N} \phi^j x_{t-j} \times \text{ICC}_{i,t-1} + \epsilon_{i,t}, \quad (49)$$

where $r_{i,t-j}$ is the log excess return of firm i in year $t-j$, x_{t-j} is the market's log ROE or log dividend growth in year $t-j$, and $\text{ICC}_{i,t-1}$ is firm i's ideological customer capital measure in year $t-1$. To separately examine the implications of the overall ideological customer capital measure and the four separate measures associated with each ideological characteristic, we run regression (49) for each of the five measures. Here, $\phi = 0.95$ is a discount, and $N = 4$ is the number of years over which the accumulated growth is computed. The coefficient of interest, β_3, captures how ideological customer capital affects the exposure of firm excess return to aggregate cash flow.

Table 7 presents the results for regression (49). Column (1) shows that, for the overall measure, β_3 is estimated to be significantly negative in both specifications. This indicates that the overall ideological customer capital attributed to the government significantly reduces firm exposure to aggregate cash flow risk. This effect is also economically significant. A one-standard-deviation increase in the overall ideological customer capital measure from the unconditional mean is associated with a 21.8% decrease in the exposure to aggregate cash flow risk. Since this risk is positively priced, our results indicate that firms with higher ideological customer capital are less positively exposed to aggregate cash flow risk and thus would have a lower risk premium. This is because these firms have ideological characteristics that are favored by the government and can derive a larger proportion of their cash flows from procurement, which are more stable over business cycles. This makes them less negatively impacted by economic downturns and reduces their exposures to aggregate cash flow risk. As a result, investors would demand a lower risk premium when holding stocks of firms with higher ideological customer capital.

Columns (2)-(5) of Table 7 show that β_3 is also estimated to be significantly negative for the four measures of ideological customer capital associated with one specific ideological characteristic (i.e., political alignment, carbon emission, female leadership presence, and China connection). Therefore, our results indicate that firms with higher ideological customer capital associated with each ideological characteristic are less positively exposed to aggregate cash flow risk. Similar to the discussion on the overall measure above, this is because these firms can derive a larger proportion of their cash flows from procurement, which are more stable over business cycles.

7 Conclusion

As customers' ideological beliefs significantly affect their purchasing decisions, a firm's ideological customer capital has become pivotal to its profitability and valuation. Using federal procurement as the setting, we construct measures of ideological customer capital attributed to the government and investigate the asset pricing implications.

To construct the measures, we build a novel dataset by linking contract-level data from FPDS with data on firm ideological characteristics that capture the government's core ideological considerations: the political alignment between the firm and the procuring subagency, the firm's carbon emission, the firm's female leadership presence, and the firm's connection to China. We develop and structurally estimate a framework in which federal procurement is modeled as an auction game between the government and multiple competing firms with hidden efficiency types and multidimensional characteristics. The estimated model shows that a firm's ideological characteristics and government valuation of these ideological characteristics play significant roles in determining the firm's cash flows from procurement, though the effects exhibit substantial heterogeneity across industries.

Using the estimated model, we construct measures of ideological customer capital attributed to the government, based on firms' expected cash flows from procurement conditional on their ideological characteristics. We then investigate the asset pricing implications of these measures. We find that, for both the overall measure associated with all four ideological characteristics and the measures associated with one specific characteristic, firms with higher ideological customer capital are less positively exposed to aggregate cash flow risk. Since this risk is positively priced, investors would ask for a lower risk premium when holding these stocks.

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