Discretion and Corruption in Public Procurement

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Abstract

This paper investigates the determinants and consequences of increasing a buyer's discretion in public procurement. I study the role of discretion in the context of a Hungarian policy reform which removed the obligation of using an open auction for contracts under a certain anticipated value. Below this threshold, buyers can use an alternative "high-discretion" procedure to purchase goods and services. At the threshold, I document large discontinuities in procurement outcomes, but I also find a discontinuity in the density of anticipated contract value, indicating that public agencies set contract values strategically to avoid auctions. I exploit the time variation of the policy reform to estimate the effects of increased discretion and find that discretion increases the price of contracts and decreases the productivity of contractors. I use a structural model to identify discretion's impact on rents from corruption and to simulate the effect of alternative value thresholds. I find that the actual threshold redistributes about 2 percent of the total contract value from taxpayers to firms and decreases the average productivity of contractors by approximately 1.6 percent. My simulations suggest that the optimal threshold would be about a third of the actual.

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1 Introduction

Corruption and lack of competition are widely considered as major impediments to efficient public spending. To overcome these challenges most developed countries have introduced formalized procedures, such as open auctions, to award contracts to providers of goods and services. In addition to creating strong incentives for bidders to reveal their true costs, auction is widely considered the most transparent procedure for limiting procurers' ability to engage in corruption or political favoritism (Chong, Staropoli, and Yvrande-Billon (2011), Tran (2010)). The role of transparency is not exhausted in limiting rent extraction, it may also decrease misallocation of resources associated with corruption. However, auctions usually take more time and have higher administrative cost than simpler and less formalized modes of procurement, such as direct negotiations. Moreover, a growing theoretical literature emphasizes that, due to information asymmetries and non-contractible dimensions of quality, providing more discretionary power to buyers can improve procurement outcomes (Manelli and Vincent (1995), Bajari and Tadelis (2001), Kang and Miller (2015)).

Despite its importance, due to data limitations, empirical evidence on the efficiency effects of different procurement procedures is still scarce. Indeed, to my knowledge, all existing work investigates the effect of discretion on tender level characteristics and fails to provide firm level evidence on the selection of contractors. Identification problems also constrain the supply of reliable evidence. Since procurement procedures are endogenously determined, simple correlations between procurement procedures and outcomes fail to address their causal relationships. For example, it is reasonable to assume that corrupt buyers value discretion in the selection of contractors more than their honest counterparts, which would confuse the effect of discretion with the effect of corruption.

This paper fills this gap by addressing both data and identification limitations. To directly address quality of selected contractors, I link a large database of public procurement in Hungary to two additional firm level datasets. First, I match procurement contracts with the balance sheets of bidding firms, which enables me to study several firm level outcomes, such as the productivity of the winning firm. Second, I link procurement contracts to the political connections of bidding firms (created by Koren, Szeidl, Szucs, and Vedres (2015)), which is measured by identifying politicians among firm representatives. Measuring political connections allows me to investigate the effect of political favoritism on the choice of procurement procedure. To deal with the endogeneity of procedure selection, I combine the exogenous variation of a policy reform with a model of procuring agencies' procedural decisions. I structurally estimate the model to identify discretion induced gains in private rents captured by public officials and to evaluate the welfare consequences of alternative policies.

I analyze the impact of buyer discretion in the context of a Hungarian policy reform enacted in 2011, which relaxed the obligation of using an open auction when the anticipated contract value is less than 25 million Hungarian Forint (HUF, about 90,000 USD). Below the 25-million threshold, buyers could choose an invitational procedure, which provides them discretionary power to exclude bidders from participating in the tender.

I start my analysis by providing three important reduced form findings to illustrate public agencies' reaction

to the policy reform. First, I compare the distribution of anticipated contract values before and after the policy reform was introduced. I find a large spike right below the value threshold in the post-reform period which was absent prior to the reform. This excess mass of procurement tenders seems to originate from above the threshold where there is a missing mass relative to the pre-reform period. This change in the distribution suggests that some public agencies set the contract value strategically to gain access to the high-discretion procedure. Second, I show that procuring agencies choose high-discretion procedures more often if at least one of the bidders is politically connected to the governing party. This result suggests that the demand for discretion is at least partially driven by procurers' desire to favor politically connected firms. Third, following Coviello, Guglielmo, and Spagnolo (2017), I use regression discontinuity design to document that procurement outcomes are different on the two sides of the value threshold. I find that the normalized price of the contract, measured by the ratio of the winning bid and the anticipated contract value, is 9 percent larger below than above the threshold. Also, for contracts below the threshold, buyers choose smaller, younger, and about 32 percent less productive firms than for contracts on the other side of the threshold. Selected firms below the threshold are more likely to be domestic, local, and politically connected than contractors above the threshold.

The RD estimates show interesting differences in procurement outcomes between the two sides of the threshold, but these differences cannot be interpreted as the causal effects of high discretion. The ideal experiment to estimate the causal effects would require a random assignment of procurement procedures to tenders which the RDD fails to deliver. As a result of the strategic determination of the contract values mentioned above, the comparability of units on the two sides of the threshold brakes down.

For example, there are good reasons to think that corrupt agencies have a larger demand for discretion, so we may find more of them below than above the threshold. Similarly, less competent agencies may feel the obligation of using open auctions more burdensome than their more competent counterparts, creating a difference in the average competence of agencies on the two sides of the threshold. Consequently, discontinuities in outcomes reflect the sum of the causal effect of discretion and the sorting of tenders around the threshold.

In order to disentangle the causal effects from the effects of sorting, I exploit time variation in procurement rules created by the policy reform. Since the reform introduced high-discretion procedure only below the threshold, one can use a difference-in-differences design to measure the impacts of discretion. In this approach, the treatment group consists of tenders below the threshold where the new policy made the high-discretion procedure available, while the control group is made of tenders above the threshold where there was no change in regulations. However, even the upper tail of the value distribution is effected by the policy change through the outgoing selection of tenders, contaminating our control group. To deal with this problem, I combine the difference-in-differences design with a Roy (1951) model which describes the joint decision of contract value and procurement procedure.

I estimate the model in two steps. In the first step, I estimate the extent of sorting into high discretion non-parametrically by incorporating information on the changes of contract value distributions. In the second

step, I use a control function approach to disentangle the causal effects of discretion from the effects of sorting. The logic of the identification is somewhat similar to Diamond and Persson (2016) who estimate the effect of teacher grade manipulation on student outcomes by comparing both the outcomes and the grade distributions to manipulation free counterfactuals. However, unlike Diamond and Persson, I have the pre-reform period to generate these counterfactuals. If we compare open auctions across time periods, we find a large compositional change below the threshold where discretion becomes easily available and generates large sorting into the high-discretion procedure. Conversely, above the threshold, as we move further from it, discretion requires more distortion of the contract value, making sorting less popular. The comparison of outcomes of open auctions across time at different points of the contract value distribution, exposed to a varying degree of compositional change, identifies the effects of sorting.

The results of the semi-parametric selection correction model are smaller than the discontinuities at the threshold. My estimates suggest that discretion increases the price of contracts by 8 percent and decreases the productivity of contractors by 12 percent. I detect a substantial sorting of low-productivity tenders into the high-discretion procedure, meaning that procurers of tenders where the winning firm would have been less productive even if open auction had been used choose high discretion more often. This finding is consistent with the practices of corrupt procuring agencies for two reasons. First, less productive contractors could be a consequence of corruption since not even auctions are perfectly immune to manipulations resulting in the selection of less efficient but politically favored firms. Second, corrupt agencies might prefer discretion to avoid costly manipulation of auctions. Moreover, this sorting contradicts with any complementarity between the procurers' competence and their preference for discretion since agencies with a high demand for discretion have a tendency to select less productive contractors.

Manipulation of contract values is a challenge in estimating the effect of discretion, but it is an opportunity to understand why procurers choose high discretion even at the expense of buying a smaller amount of goods or services.[1] Since the high-discretion procedure is not available above the threshold, the size of the excess mass below the threshold provides information on the trade-off between choosing high discretion and obtaining more contract value. To obtain a meaningful measure of this trade-off, I structurally estimate my Roy model describing procurement decisions. Unlike in the semi-parametric approach mentioned above, I estimate the demand for discretion parametrically, which requires more functional form assumptions, but allows for more economic interpretations. The two main goals of the parametric approach are the following. First, it identifies the effect of discretion on private rents captured by procurers. These rents are identified by comparing spikes below the threshold for tenders with and without politically connected bidders. More specifically, this variation allows me to estimate the extra contract value that agencies are willing to sacrifice to gain high discretion if a politically connected firm participates in the tender. Second, the identification of the trade-off between discretion and contract value enables me to simulate the effect of alternative procurement thresholds and find its optimal value.

[1] Similarly in spirit to Saez (2010), which estimates tax elasticity using the bunching at kinks of the income tax schedule.

The structural estimates of the model confirm the semi-parametric results. I find that discretion increases prices by 6 percent and decreases the average productivity of contractors by 10 percent. Moreover, my model estimates directly confirm that corruption increases the demand for discretion. I find that when a politically connected firm participates, procurers are willing to sacrifice 25 percentage points more value to increase discretion than in tenders with only unconnected bidders.

I use my parametric model to conduct a few policy simulations. The model highlights that the introduction of a value threshold affects average prices and productivities through two main channels. First, it affects agencies' procedure choices by making the high-discretion procedure available, which directly increases the price of contracts and decreases the productivity of contractors. Second, in addition to procurement procedures it also changes the distribution of contract values which has an opposite effect on the productivity of contractors. Due to the specific nature of sorting, it disproportionately decreases contract values of low productivity (and probably more corrupt) tenders. This means that although discretion makes inefficient contracts even less efficient, it also makes them smaller and reduces their weight in total procurement spending.

I find that for low thresholds (below 15 million HUF) the second effect dominates and the introduction of the threshold increases average productivity. However, for larger thresholds, the opposite effect dominates. The policy simulations suggest that the optimal threshold would be around 6 million HUF (about 21,000 USD). The policy reform introduced in 2011 decreased average productivity of public spending, hence increased aggregate production cost by 1.6 percent. Also, it increased the price of every dollar of anticipated public spending by 2 cents.

This paper speaks most directly to a small but growing literature investigating the effects of discretion in public procurement (see Chever and Moore (2012), Chever, Saussier, and Yvrande-Billon (2017), Lalive and Schmutzler (2011), Coviello et al. (2017)). I contribute to this literature in two dimensions. First, having access to the balance sheets of bidding firms, I study direct measures of contractor quality which allow a more reliable assessment of efficiency consequences. Second, using exogenous variation of the policy reform and a model of selection correction, I improve the identification of the causal effects of discretion.

My study also contributes to a line of research investigating the determinants of the demand for discretion. For example, Palguta and Pertold (2014) document manipulation of contract values to avoid auctions in the Czech Republic and finds a higher fraction of anonymously owned firms among the winners of manipulated contracts. Tóth and Hajdú (2017) document similar anomalies in contract values in Hungary and link them to an increased risk of corruption. Chong et al. (2011) study public procurement contracts undertaken by French municipalities and finds a positive correlation between political competition and the use of auctions. Gerardino, Litschig, and Pomeranz (2017) find that rigorous audits increase procurers demand for high-discretion procedures. I complement these studies by establishing a direct link between high-discretion procedures and corruption.

I also build on the literature of political favoritism in procurement (Brogaard, Denes, and Duchin (2015), Goldman, Rocholl, and So (2013), Muraközy and Telegdy (2016), Baltrunaite (2016)). My main contribution to

this line of research is showing the importance of buyer's discretion in promoting favoritism. I also contribute to works quantifying the welfare consequences of favoritism (Mironov and Zhuravskaya (2015), Schoenherr (2015), Szeidl and Szucs (2017), Bandiera, Prat, and Valletti (2009)) by providing a structural framework to simulate the effects of alternative policies.

Finally, this paper is closely related to a literature investigating the effects of specific policies on corruption, such as Di Tella and Schargrodsky (2003), Olken (2007), Ferraz and Finan (2008), Avis, Ferraz, and Finan (2016) which measure the effect of government audits on local public spending. I complement this body of research by documenting the importance of transparent procurement procedures in fighting corruption.

The rest of the paper is organized as follows. Section 2 describes the institutional context and my data. Section 3 presents my reduced-form evidence. Section 4 presents the model of procuring decisions. In section 5, I describe my semi-parametric approach to estimate the model and I report the results. Section 6 presents the structural estimation of the model. In Section 7, I quantify the welfare consequences of alternative procurement policies. Section 8 concludes.

2 Context and data

2.1 Public Procurement in Hungary

Hungary is one of the new member states of the European Union. Before Hungary's 2004 accession to the EU, its national procurement legislation has been gradually harmonized with the European directives. An explicit goal of the EU directives was to improve the transparency and competitiveness of the procurement process. In line with these efforts, the Procurement Act of 2003 named open auction as the most desired procurement procedure, which could be avoided only under very specific circumstances. Indeed, during the 2003-2011 period more than two thirds of public procurement contracts were awarded through open auctions.

During my study period, Hungary had two consecutive administrations. Between 2002 and 2010 a Socialist-Liberal coalition was governing Hungary. After series of scandals involving the prime minister, the Socialist government suffered a large decline in popularity. In 2010, the Conservative opposition won a landslide victory, capturing two thirds of parliamentary seats. Relying on its unprecedented political power, the new conservative administration enacted a long list of new laws, including a reform of public procurement regulations.

Although open auctions are widely considered the most transparent form of public procurement, they are typically slower and more costly to organize than simplified procedures providing more discretion. Since the temptation to engage in corruption increases in the contract value, many countries, including the United States and most EU countries, use procurement thresholds providing simplified procedures for small value contracts. Following these examples, in 2011 the Hungarian parliament accepted a new Public Procurement Act enabling government agencies to choose an invitational procedure as long as the anticipated contract value was below 25 million HUF (about

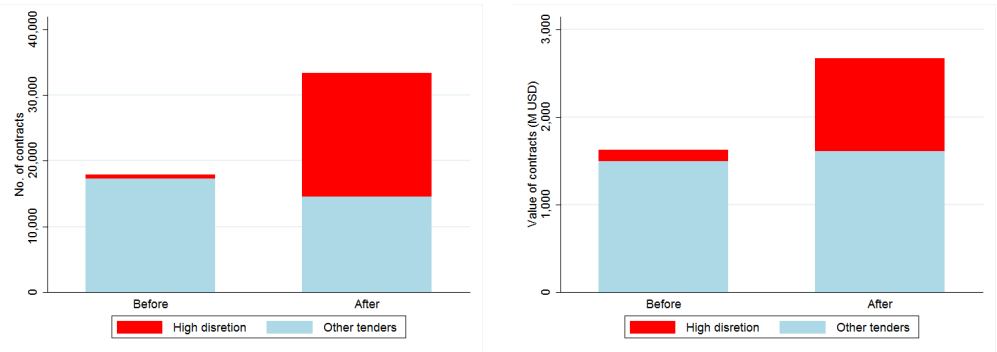
90,000 USD).[2] The anticipated value of a contract is set by the procuring agency before the procedure is selected by way of matching the approximate cost of the purchase. The simplified procedure mentioned above provides the buyer more discretion to pre-select potential applicants,[3] which clearly makes the procurement procedure simpler and faster, but comes at the cost of less transparency and higher risk of corruption.

2.2 Data and descriptive stats

The primary source of data is the cleaned public records of all Hungarian procurement contracts for the 2009-2014 period. This dataset contains the anticipated and actual procured value of the contracts and the identity of all bidders. Since the 25-million threshold applies only to non-construction tenders, I restrict my attention to them. From the total 51,000 contracts, I exclude 276 observations where the number of bidders exceeds 30, because the high number of bidders suggests a framework agreement instead of an individual project.

Figure 1 shows the number (panel a) and aggregate value (panel b) of contracts awarded using either an invitational (which provides high discretion) or any other procedures. Other procedures mostly consist of open auctions, but negotiation with announcement and a few other special procedures also belong to this category. Negotiation with announcement is also considered a highly competitive procedure, since it is open to all applicants meeting the requirements listed in the announcement. Panel (a) shows that the total number of contracts is about 18,000 in the pre-reform and 33,000 in the post-reform period. High-discretion tenders give only a negligible share before (about 3.5 percent) but more than half of total contracts after the reform. Similarly, the share of value procured using a high-discretion procedure goes up from 6 percent of 1.6 billion dollars spent in the pre-reform period to more than a third of 2.6 billion spent in the post period.

Figure 1: Number and aggregate value of high-discretion and other tenders



a) Number of contracts b) Value of contracts

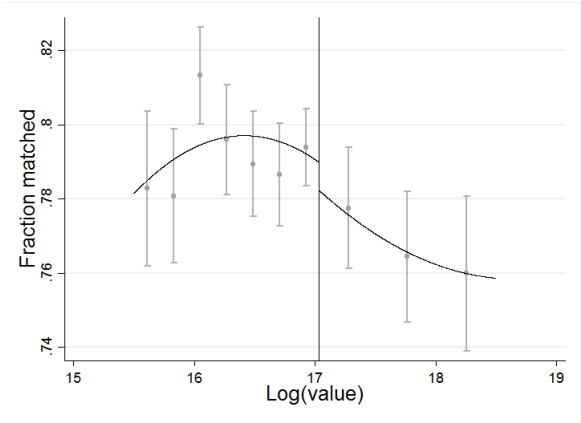
To evaluate the selection of contractors, I use the names of awarded firms to link them to their balance sheet data. I was able to match almost 80% of my sample of contracts to the corresponding balance sheet of the winning firm. Although the imperfect match of contracts to balance sheets may raise concerns of sample selection bias, the

[2] In the 2011-13 period the invitational procedure took the form of a direct negotiation without an announcement. From November 2013 procurers could also choose a simplified version of auction where only invited firms can bid.

[3] To maintain a minimum level of competition, public agencies using invitational procedures have to invite at least three firms.

procedure type does not seem to correlate with the success of matching. Indeed, Figure 2 shows no discontinuity in the fraction of contracts matched at the 25-million threshold, which means that from the perspective of procedural choice, the matching was as good as random.

Figure 2: Discontinuity in matching of datasets



Throughout my analysis, I look at two main groups of procurement outcomes. The first group is tender level characteristics measuring the competitiveness and the price of public purchases. I operationalize competition by the number of firms participating in the procurement tender. This could be the number of bidders in case of an auction or the number of firms involved in the negotiation. The other important tender level characteristic is the normalized price of the contract, calculated by the log-ratio of actual and anticipated contract values (similar to the winning rebate used by Coviello et al. (2017)). This captures the percentage deviation of the winning bid from the anticipated price (which should be an expert estimate of the market price of the product or service purchased).[4]

Access to balance sheets of winning firms allows me to analyze different measures of contractor quality. As proxies of firm quality, I use the size and the age of the awarded firm. Each of these variables are widely used proxies for productivity, since more productive firms grow larger and live longer (Syverson (2011)). As a more direct measure of productivity, I calculate the total factor productivity of contractors. Following a very standard approach, similar to Hsieh and Klenow (2009), I assume that firms have a Cobb-Douglas production function, which gives a simple expression for the logarithmic total factor productivity,

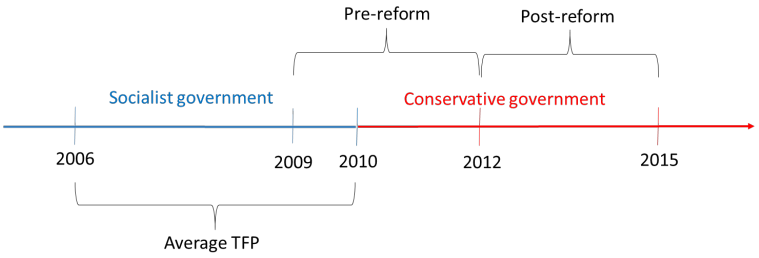
$$\log TFP = \log \frac{Y}{L} - \bar{\alpha} \log \frac{K}{L},$$

where Y is the added value of the firm, L is employment, K is equity of the firm, and $\bar{\alpha}$ is the one digit industry average of capital income share, measured by $\alpha = 1 - \frac{wage\ bill}{Y}$. Calculating the TFP of a firm from its balance sheet raises a possible concern.

[4]In about 7 percent of all tenders the winning bid was less then a third of the anticipated contract value. Checking a few announcements manually suggested that sometimes the winning bid records the unit price while the anticipated value approximates total costs resulting in extreme low normalized prices. To correct these mistakes, for tenders with normalized prices below -1 (meaning that winning bid is less than third of the anticipated value), I imputed the average normalized price of their period-procedure-contract value cell.

Connected firms could win overpriced procurement contracts or get access to preferential loans that could artificially inflate their productivity. This could create a spurious correlation with discretion if connected firms win high-discretion tenders more often. To avoid this problem, I compute the average lagged TFP of each winning firm in the 2006-2009 period. As the timeline of events in Figure 3 shows, I calculate average productivity for the last legislative period before the conservative government which enacted the reform, came to power. Since the conservative party was not in the position of favoring firms before 2010, the right-connected firms' lagged TFP is free of the effect of political favors.

Figure 3: Timeline



Using the Hungarian Company Register, I create indicators for domestic and local firms. A firm is classified as domestic if the majority of its owners are domestic entities. A bidder is local in a given tender if its HQ is located in the same city as the procuring agency.

An important part of the research design relies on identifying political connections of bidding firms. To document political connections, I use a measure created by Koren, Szeidl, Szucs, and Vedres (2015). In this paper, we create a measure of political connections for the 500 firms with the largest procurement revenue during the 2006-2014 period.[5]

Research assistants manually checked the connections between the firm and any of the parliamentary parties in a few different datasets. First, they looked for matches in the full names of firm representatives and political candidates. We obtained the names of firm representatives from the Hungarian Company Register. Firm representatives include three main groups. (1) Representatives who can sign legal documents in the name of the firms, typically top managers. (2) Owners. (3) Board members. To get the names of political candidates, we used digitized public records of all national and local elections during the 1990-2014 period. In the case of matching names, we relied on our assistants personal judgment in determining whether the name was rare enough to classify the firm as politically connected. Second, assistants made manual Google searches on the names of each company to find any mention of personal connections between the firm and political parties in national or local news.

We classified a firm as politically connected if any of the previous two steps produced evidence on the political connections of the company. For more details of the connection measure see Koren et al. (2015). In this paper, I focus on the connections to the conservative party because it was in power during the whole post-reform period.

[5]During the 2009-14 period 406 of the 500 top procurement winners have won a non-construction tender.

Table 1: Descriptive stats for high-discretion and other tenders

	High-discretion	Other tender	All
	Panel A - Tender characteristics		
Log(anticipated value)	16.36	16.74	16.60
Number of bidders	2.25	2.88	2.64
Log(price/value)	-0.068	-0.190	-0.153
At least one checked bidder	0.153	0.305	0.248
At least one connected bidder	0.035	0.044	0.040
	Panel B - Winner characteristics		
Log(TFP)	6.58	6.86	6.77
Log(Employment)	2.45	3.23	2.93
Firm Age	13.1	15.1	14.35
Domestic	0.915	0.805	0.847
Local	0.392	0.370	0.378
Connected	0.576	0.382	0.445

Note: The fraction of connected winners is computed for tenders with at least one connected participant.

This classification divides procurement tenders into three groups. (1) Tenders with no checked bidder. (2) Tenders with at least one checked but no connected bidder. (3) Tenders with at least one checked and connected bidder.

Table 1 reports the averages of all variables described above for high-discretion and other tenders separately. Panel A of Table 1 displays tender level characteristics. The value of high-discretion tenders are somewhat smaller than the average value of other tenders, which is a direct consequence of the compliance with the value threshold. Table 1 documents a lower level of competition and a higher average price, when a high-discretion procedure is used.

It also shows that checked firms (top 500 procurement winners) are more likely to participate in other tenders, hence the fraction of tenders with connected participants is also higher for other tenders. This is not surprising, since high-discretion procedures are limited to relatively small contracts, and checked firms are more attracted by bigger contracts. On the other hand, conditional on having at least one large competitor, the fraction of tenders with at least one connected firm is larger for the high-discretion tenders. This means that connected firms are over-represented among checked firms in high-discretion tenders, which can be the sign of an increased level of political favoritism.

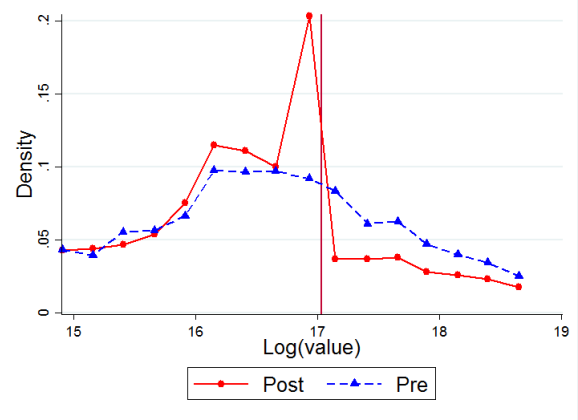
Panel B of Table 1 reports the averages of winner level characteristics. It shows that contractors awarded in a high-discretion procedure tend to be smaller, younger, and less productive than contractors of other tenders. These numbers suggest an unfavorable selection of contractors when a high-discretion procedure is used. The ownership of winning firms also differs across different procedures. High discretion is associated with a higher chance of a domestic, local, and connected winners. These results suggest that discretion gives rise to political motives in the selection of contractors.

3 Reduced form evidence

3.1 Distribution of contract values

Figure 4 illustrates the distribution of anticipated contract values. The dashed line shows the pre-reform distribution, the solid line depicts the post-reform distribution.

Figure 4: Distribution of anticipated values



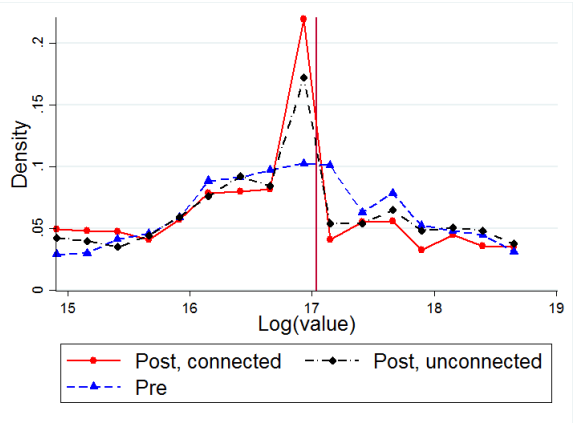
The left tails of the pre- and post-reform distributions are very similar, but in the post-reform period there is a large spike below the threshold, which was absent before the reform. The excess mass of the spike seems to originate from above the threshold where there is a missing mass relative to the pre-reform period. The main finding in the figure is that some buyers strategically anticipated contract value right below the threshold in order to avoid the open auction requirement. This claim is further supported by Figure A.1, which shows that if we exclude high-discretion tenders, the spike below the threshold disappears even in the post-reform period.

A possible way of manipulating the size of a contract is cutting a larger project into multiple smaller pieces. Although plausible, this does not seem to be the dominant form of manipulation in this context. Figure A.2 plots the distribution of project values, aggregated to agency-contractor-year cells, and shows a very similar picture to Figure 4. This suggests that agencies are willing to make real distortions to the size of their projects to simplify the procedure or to obtain more discretion over the selection of contractors.

Procuring public officials may prefer to avoid open auctions for multiple reasons. On one hand, the invitational procedure is faster and associated with lower administrative costs than an open auction, which requires a public announcement and the review of potentially more applications. On the other hand, high discretion provides more opportunities to extract private rents through corruption. Figure 5 provides suggestive evidence that the demand for high discretion is at least partially driven by agencies desire to favor politically connected firms. It plots the distribution of anticipated contract values for tenders with at least one "checked" participant because I only have data on the political connections of the hand-checked firms. The dashed line depicts the value distribution for the pre-reform period. The post reform distribution is displayed separately for tenders with at least one connected bidder (solid line) and tenders with only unconnected bidders (dashed-dotted line). The figure shows that the excess

mass below the threshold is larger for tenders with connected participants, suggesting that political favoritism is an important factor in the choice of high discretion.

Figure 5: Distribution of anticipated values by connection status

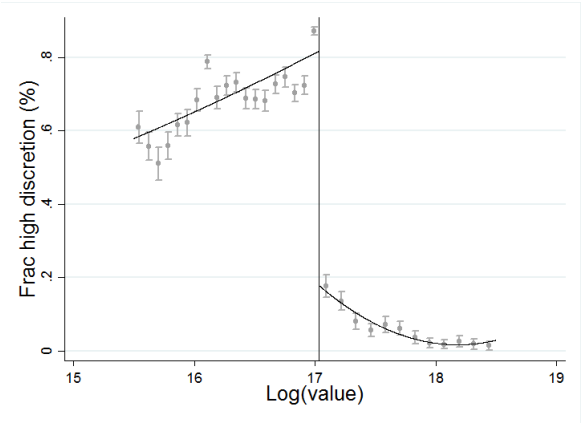


Since firms' participation decisions are made after the procedure is selected Figure 5 is consistent with an alternative interpretation. It is possible that the causal link between connected participation and high-discretion procedure goes the other direction and connected firms are attracted more to high-discretion tenders. To rule out this interpretation, in Figure A.3, I plot the contract value distribution (in the post-reform period) for product categories with more (where connected firms participate in more than 20 percent of tenders) and less connected firms separatelly. Figure A.3 shows a very similar pattern to Figure 5. Since the product category of a firm's output is more exogenous than participation choice the similarity of the two graphs supports the original favoritism interpretation.

3.2 Impact of high discretion

The procurement reform of 2011 has introduced a discontinuity in the procurement regulations at 25 million HUF. Before I present my empirical strategy investigating the causal effects of high discretion, I study how this discontinuity affected the overall behavior. First, I look at compliance of procuring agencies with the new law. Figure 6 shows the first stage relationship plotting the share of high-discretion procedures as a function of anticipated value. The large discontinuity in Figure 6 is a direct consequence of the post-reform legislation, which relaxes the strict requirements of invitational procedures below, but not above, the threshold.

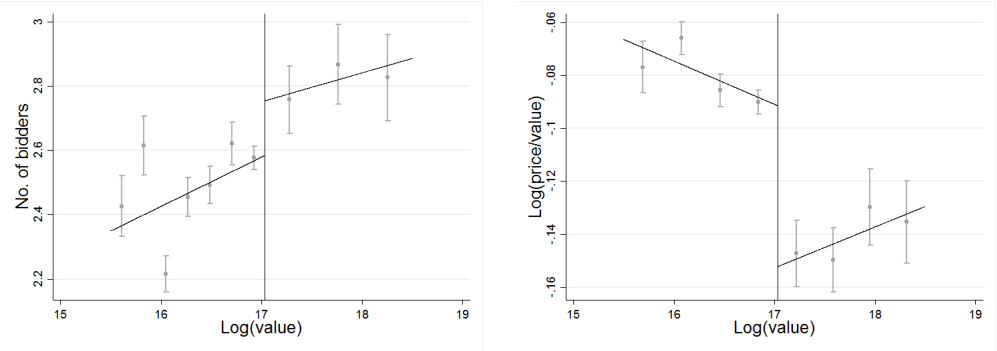
Figure 6: Fraction of high-discretion procedures



Next, I check whether the discontinuity in procurement regulations induces discontinuities in important tender and winning firm level characteristics.

Tender level characteristics. I start presenting my results with tender level characteristics. Figure 7 provides graphical evidence on the discontinuity of tender level outcomes at the 25 million threshold. Figure 7a plots the number of firms participating in the tender. It shows a very small discontinuity, which suggests that discretion has a limited effect on firm entry. On the other hand, Figure 7b reports a clear discontinuity in normalized prices and shows that the price of a dollar of anticipated contract value is substantially higher below than above the threshold. The large drop of average normalized price at the threshold is especially interesting given that we see no discontinuity in entry. The difference in prices on the two sides of the threshold is not simply the consequence of different levels of competition, but is driven by other factors such as a change in the level of corruption or in the composition of the applicant pool.

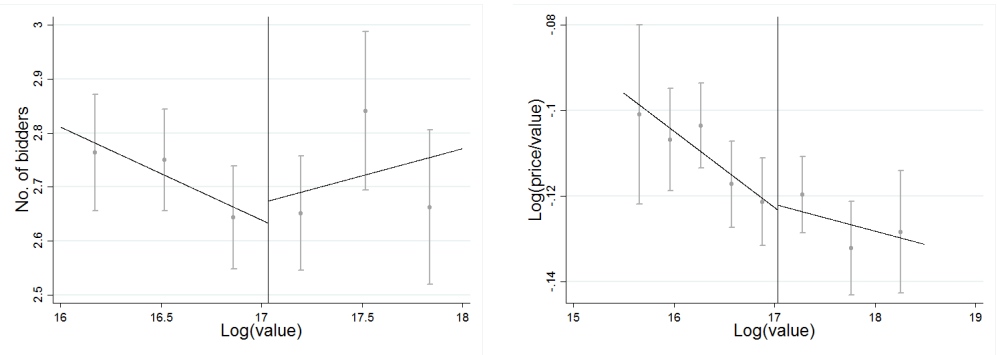
Figure 7: Discontinuity in tender outcomes



a) No. of bidders b) Normalized price

To prove that the discontinuities in Figure 7 are really consequences of the policy reform, I conduct a placebo test and produce the similar graphs using data from the pre-reform period. The results of the placebo test are reported in Figure 8. It shows no discontinuities in the number of bidders or prices, confirming that discontinuities after the reform are driven by the change in the availability of the high-discretion procedure.

Figure 8: Discontinuity in tender outcomes, pre-reform



a) No. of bidders b) Normalized price

To quantify the size of discontinuities in procurement outcomes, I run the following local linear regressions,

$$Y_i = \alpha + \beta \cdot 1\left(\log \frac{V_i}{T} > 0\right) + \gamma \cdot \log \frac{V_i}{T} + \zeta \cdot \log \frac{V_i}{T} \cdot 1\left(\log \frac{V_i}{T} > 0\right) + \varepsilon_i. \tag{1}$$

My left hand side variables are the tender level characteristics introduced above. The running variable is the logarithmic anticipated value normalized to zero at the threshold. I estimate Equation 1 using triangular kernel and the optimal bandwidth selection rule proposed by Calonico, Cattaneo, and Titiunik (2012).

Results are reported in Panel A of Table 2. Column 1 shows that tenders above the threshold have slightly more bidders, though the difference is not significant. Column 2, on the other hand, documents that prices of tenders above the threshold are 6.4 percent larger than below.

I determine the implied correlations of procurement outcomes and discretion by estimating the following fuzzy RD specifications:

$$Y_i = \eta + \mu \cdot D_i + \rho \cdot \log \frac{V_i}{T} + \xi \cdot \log \frac{V_i}{T} \cdot 1\left(\log \frac{V_i}{T} > 0\right) + \nu_i, \tag{2}$$

where the excluded instrument is an indicator for the contract value being above the threshold. The first stage equation is similar to Equation 1, with discretion being on the left-hand side.

Fuzzy RD results are shown in Panel B of Table 2. Column 1 confirms the graphical evidence by documenting a weak and marginally significant negative relationship between discretion and firm entry. Column 2 shows that high-discretion procedures are associated with 9 percent higher prices.

Winning firm level characteristics. Since procurement contracts are linked to the balance sheets of winning firms, I can study relationships between procurement procedures and some key observables of the selected contractors. Similarly to the graphs above, Figure 9 plots winning firm characteristics as a function of anticipated contract value. Figure 9a shows the logarithmic total factor productivity of the winning firm and documents a vast difference in the average productivity of contractors on the two sides of the threshold. Similarly, Figure 9b-c reports large discontinuities in log-employment and firm age, which are also widely used proxies of firm productivity. Figure

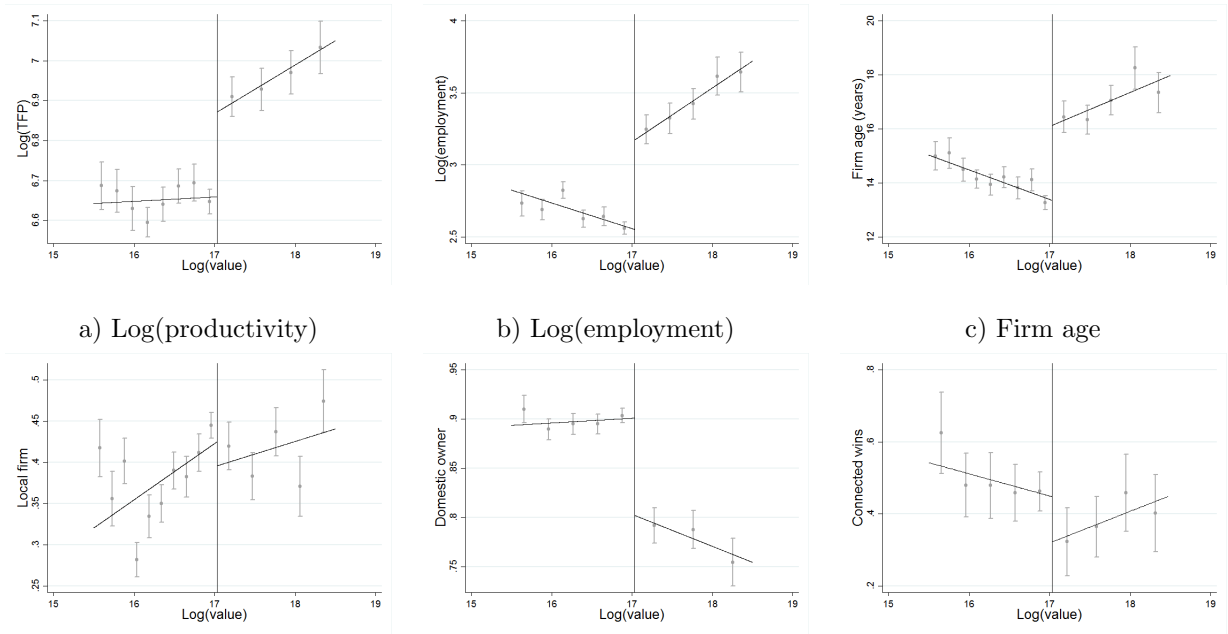
Table 2: Discontinuities in tender level outcomes

	Panel A - Reduced form results	
	Tender characteristics	
	No. of bidders	Normalized price
	(1)	(2)
1(value>threshold)	0.133	-0.0593***
	(0.0887)	(0.00803)
	Panel B - Second stage results	
High discretion	-0.239*	0.0894***
	(0.137)	(0.0136)
	Panel C - First stage results	
	Dep. var.: High discretion	
1(value>threshold)	-0.670***	-0.663***
	(0.0136)	(0.0116)
Observations	45,956	44,679

Note: Each observation is an individual contract. The sample consists of all non-construction tenders for 2009-2014. Robust standard errors in parentheses.
* p<0.10,** p<0.05, *** p<0.01

9d documents a slight drop in the concentration of local firms at the threshold, while Figure 9e shows a large discontinuity in the fraction of domestic winners. These results are consistent with corruption being stronger below the threshold, since local and domestic firms are more likely to have political connections providing them superior bribing technology. I can confirm this claim more directly by using my measure of political connections. Figure 9f plots the fraction of politically connected winners conditional on having at least one connected applicant. It shows that below the threshold, where the high-discretion procedure is available, connected bidders have a better chance of being awarded a contract.

Figure 9: Discontinuity in winner outcomes

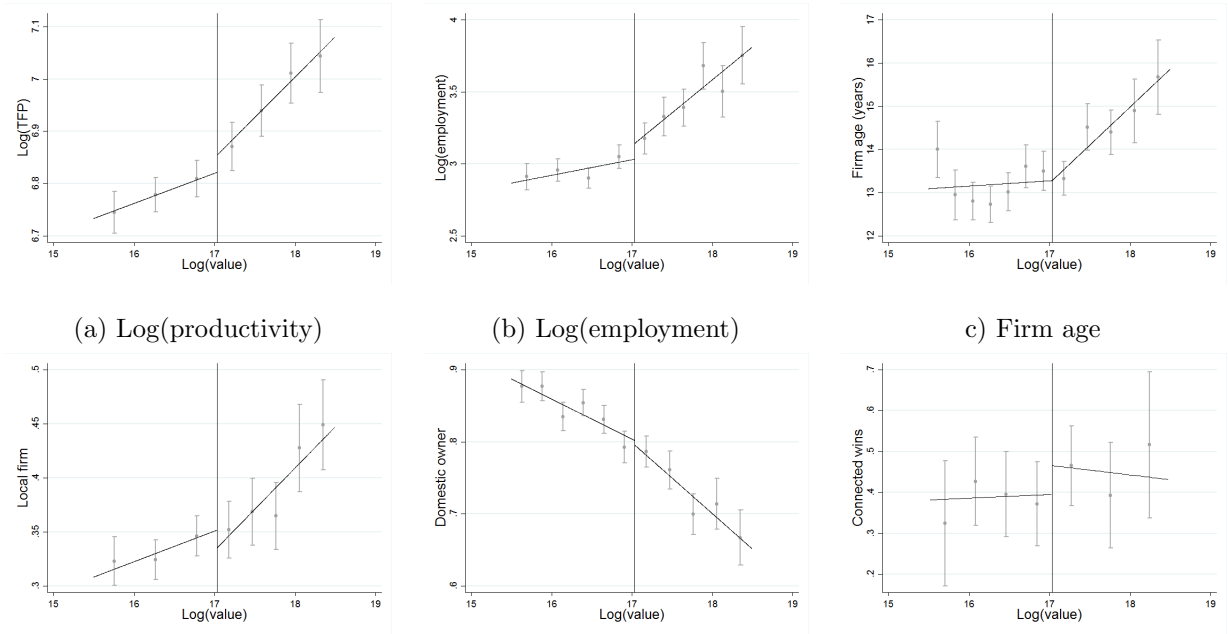


a) Log(productivity) b) Log(employment) c) Firm age

d) Local firm e) Domestic owner f) Politically connected firm

Similarly to the tender level characteristics, I report a placebo test using observations from the pre-reform period in Figure 10. This shows that discontinuities were absent before the reform, with the exception of Figure 10f which documents an opposite direction jump in the winning chances of connected firms.

Figure 10: Discontinuity in winner outcomes, pre-reform



(a) Log(productivity) (b) Log(employment) c) Firm age

d) Local firm e) Domestic owner f) Politically connected firm

For winner characteristics, I also run regressions specified by Equation 1, but now Y_i denotes variables plotted in Figure 9. Results are reported in columns 1-6 of Table 3. Column 1 estimates a 20-percent gap in the average

Table 3: Discontinuities in winning firm level outcomes

	Panel A - Reduced form results					
	Winner characteristics					
	Log(prod)	Log(emp)	Firm Age	Local firm	Domestic firm	Connected firm
	(1)	(2)	(3)	(4)	(5)	(6)
1(value>threshold)	0.207***	0.669***	2.819***	-0.0427**	-0.117***	-0.189***
	(0.0331)	(0.0649)	(0.320)	(0.0179)	(0.0151)	(0.0660)
	Panel B - Second stage results					
High discretion	-0.326***	-1.015***	-4.578***	0.0662**	0.176***	0.280***
	(0.0602)	(0.103)	(0.572)	(0.0302)	(0.0226)	(0.0916)
	Panel C - First stage results					
	Dep. var.: High discretion					
1(value>threshold)	-0.667***	-0.665***	-0.660***	-0.654***	-0.664***	-0.663***
	(0.0145)	(0.0140)	(0.0125)	(0.0141)	(0.0132)	(0.0461)
Observations	29,944	35,030	35,937	34,485	35,937	2,280

Note: Each observation is an individual contract. The sample consists of all non-construction tenders for 2009-2014. Robust standard errors in parentheses.
* p<0.10,** p<0.05, *** p<0.01.

productivity of winning firms between the two sides of the threshold. Columns 2-6 show that winners below the threshold are almost 50 percent smaller, 2.8 years younger, more likely to be local by 4, domestic by 12, and politically connected by 19 percentage points.

Similarly to tender level characteristics, I use the fuzzy RDD described by Equation 2 to estimate the implied correlations of winner characteristics and discretion. Panel B of Table 3 presents the results. Column 1 shows that contractors selected in high-discretion procedures are less productive by 32 percent than contractors selected in open auctions. Results in columns 2-6 imply substantial differences in other variables too. Estimates suggest that winning firms have about 64 percent less employees, and are 4.6 years younger if they are awarded in high-discretion procedures. Contractors selected in high-discretion procedures are more likely to be local by 7 and domestic by 18 percentage points. Moreover, connected firms have a 28-percentage point higher chance to win in a high-discretion procedure.

To check the robustness of results to the bandwidth selection, Figure A.4 plots estimates of local linear regressions with different bandwidth.

Discussion. Although we see strong discontinuities at the 25-million threshold, it is still unclear whether discretion has a causal effect on procurement outcomes. The ideal experiment would randomly allocate the procurement procedure to tenders and observe the difference in prices and selection of winning firms. However, since we see a clear manipulation of contract values around the threshold, the regression discontinuity design can easily fail to provide a random assignment of tenders and agencies to the two sides of the threshold. If a specific group of public agencies has a higher demand for discretion and sorts below the threshold, then comparability of tenders on the two sides of the threshold brakes down. In this case, the discontinuities above do not reflect the true causal effects

of discretion, but they are at least partially driven by the compositional differences between the two sides of the threshold.

Composition of tenders on the two sides of the threshold can differ for multiple reasons. Since discretion helps to handpick the winner of a tender, it is very likely that corrupt procurers have a stronger preference for discretion and are more willing to manipulate contract values to obtain them. At the same time, corrupt agencies would select less productive contractors even if they used open auctions since they optimize for bribing instead of production technology. Similarly, it is reasonable to assume that incompetent agencies find open auctions excessively burdensome, hence sort below the threshold. This also results in a selection bias, since incompetent agencies are less efficient at finding suitable contractors anyway. Both stories would clearly introduce an upward bias (in absolute terms) into the RD estimates.

On the other hand, if procurement contracts are exposed to serious contracting difficulties, then discretion and competence of the buying agency are complements. This complementarity would imply the sorting of the most competent agencies into discretion, since they benefit the most from the flexibility of high-discretion procedures. This reasoning would imply that RDD underestimates the effects of discretion.

4 Model of procurement

To deal with the endogeneity of the agencies' procurement decisions and to shed some light on the determinants of the demand for high discretion, I propose a simple model describing the joint decision of contract value and procurement procedure. The model is built around the idea that public agencies potentially trade lower prices of open auctions to lower administrative costs and higher rents provided by high-discretion procedures. The model formalizes the intuition that procurers with large demands for goods and services may choose suboptimal quantities in order to avoid the obligation to use open auctions. The model investigates how corruption affects this trade-off between choosing a high-discretion procedure and signing a larger value contract.

The procuring agency simultaneously determines the anticipated contract value V and the type of procurement procedure D. She potentially interacts with two types of firms, politically connected and unconnected. As a result of the two firm types, the applicant pool of a tender could consist of (1) only unconnected firms ($C = 0$) or (2) at least one connected firm ($C = 1$).

The selected firm pays a given percentage of the price P to the agency in bribes. Since the agency's bargaining power depends on her discretion, the kickback scheme is a function of procedure type, $Bribe = \beta(D) \cdot P$. I assume that politically connected firms have a superior bribing technology, so they pay a larger kickback at all procedures, $\beta^{c}(D) > \beta^{uc}(D)$.

The utility of the agency is additively separable in public and private benefits and the cost of the procedure,

$$U(V, D) = \lambda \log(V - P) + (1 - \lambda) E[\log(Bribe)] - c(D), \tag{3}$$

where λ is the weight on public benefit. The public benefit is given by the log difference between the contract value and the price paid. The private benefit is the expected value of log bribes. Since the contract can be awarded to two types of firms, the agency's expected utility from bribes is given by

$$E\left[\log\left(Bribe\right)\right] = q\left(D,C\right)\log\left(\beta^{c}\left(D\right)P\right) + \left[1-q\left(D,C\right)\right]\log\left(\beta^{uc}\left(D\right)P\right), \tag{4}$$

where $q\left(D,C\right)$ is the probability of a connected winner as a function of the procurement procedure and the type of the applicant pool. This probability is positive only if there is at least one connected firm among the bidders ($C=1$), so $0 = q\left(D,0\right) < q\left(D,1\right)$.

Since this model focuses on the procuring agency's behavior, I abstract away from the bidding behavior of potential contractors and assume that the winning bid is linear in the value with a procedure specific coefficient,

$$P = \alpha\left(D\right)V. \tag{5}$$

By substituting Equation 4 and 5 into Equation 3 we get

$$U\left(V,\,D\right) = \log V + \lambda\log\left(1-\alpha\left(D\right)\right) + \left(1-\lambda\right)\log\alpha\left(D\right) + \left(1-\lambda\right)\log\beta^{u}\left(D\right) + \left(1-\lambda\right)q\left(D,C\right)\log\frac{\beta^{c}\left(D\right)}{\beta^{uc}\left(D\right)}.$$

Unfortunately, my data and empirical design will be insufficient to separately identify all parameters of the utility function. However, some interesting and meaningful functions of parameters can be identified even without recovering the primitives of the model. The following equation rewrites the utility as a function of variables I can directly estimate from the data.

$$U\left(V,\,D\right) = \log V + b\cdot D + \pi\cdot D\cdot C + const, \tag{6}$$

where $b \equiv c\left(0\right) - c\left(1\right) + \lambda\log\frac{1-\alpha(1)}{1-\alpha(0)} + \left(1-\lambda\right)\log\frac{\alpha(1)}{\alpha(0)} + \left(1-\lambda\right)\log\frac{\beta^{u}(1)}{\beta^{u}(0)}$ is the net benefit of high discretion relative to open auction, picking up all factors affecting the relative desirability of different procurement procedures in tenders with politically unconnected bidders. b summarizes discretion's impact on the agency's utility through its effect on prices, administrative costs, and bribes collected from unconnected firms. $const \equiv \lambda\log\left(1-\alpha\left(0\right)\right) + \left(1-\lambda\right)\log\alpha\left(0\right) + \left(1-\lambda\right)\log\beta^{uc}\left(0\right) - c\left(0\right) + \left(1-\lambda\right)q\left(0,C\right)\log\frac{\beta^{c}(0)}{\beta^{uc}(0)}$ is a constant unaffected by the optimal choice of procurement procedure and contract value. $\log V + const$ captures the agency's utility from choosing contract value V and using an open auction.

The parameter of primary interest is

$$\pi \equiv \left(1-\lambda\right)\left(q\left(1,1\right)\log\frac{\beta^{c}\left(1\right)}{\beta^{uc}\left(1\right)} - q\left(0,1\right)\log\frac{\beta^{c}\left(0\right)}{\beta^{uc}\left(0\right)}\right),$$

which measures discretion's effect on the expected value of extra private rents collected from connected firms. An alternative interpretation of π is that it measures the extra contract value agencies are willing to sacrifice to gain high discretion if a politically connected firm participates in the tender. Discretion potentially affects extra expected rents from connected firms through two margins. First it can influence the probability that a connected firm wins, $q(1,1) \neq q(0,1)$. Second, it can influence the premium paid by connected firms, $\frac{\beta^c(1)}{\beta^{uc}(1)} \neq \frac{\beta^c(0)}{\beta^{uc}(0)}$. Discretion yields the extra rent, π, only if there is at least one connected bidder, since $q(D,0) = 0$ for all D. π gives a lower bound on the effects of discretion on private rents, since having more discretion might also increase the bribes collected from unconnected bidders, which is loaded to the parameter b.

The procuring agency has a budget B and makes her decision under two alternative regimes. Under the first regime, which was in effect before the policy reform, high-discretion procedures are not available, meaning that $D = 0$. The second regime, similar to the legislation in the post-reform period, allows the procuring agency to choose high-discretion procedures ($D = 1$) if the value is below a given threshold, T, but above the threshold open auction is still compulsory. As a result, the optimization problem of the agency in the post-reform period is the following:

$$\max_{V,\,D} \{\log V + b \cdot D + \pi \cdot D \cdot C + const\}$$

$$st.:\ V \leq \begin{cases} B & if\ D = 0 \\ \min\{B,\, T\} & if\ D = 1 \end{cases}$$

The solutions to the agency's problem under the two regimes are summarized by Proposition 1.

Proposition 1

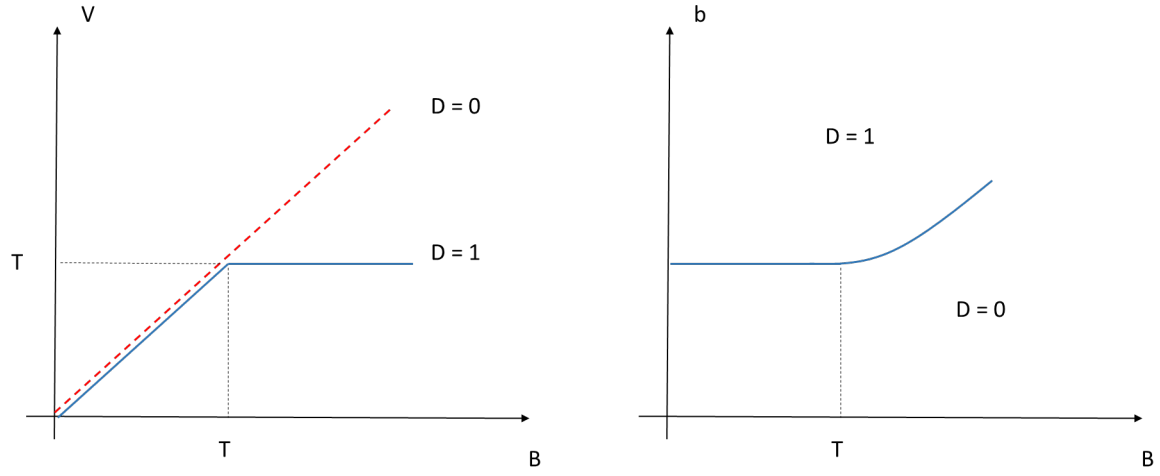
Regime 1: $V^* = B$ and $D^* = 0$

Regime 2: $V^* = B^{1-D^* \cdot 1(B>T)} \cdot T^{D^* \cdot 1(B>T)}$ and $D^* = 1\left(b + \pi \cdot C \geq 1(B > T) \cdot \log \frac{B}{T}\right)$

Proof See Appendix.

The solution for the pre-period is very straightforward and directly follows from the fact that the utility in Equation 6 is strictly increasing in the contract value. In this case, the budget constraint is always binding and the contract value is equal to B. It is easier to highlight the intuition behind the solution in the post-period by considering the decision on the two choice variables sequentially. Assume that the agency has already chosen the procurement procedure and now considering contract value. Her optimal choice is plotted in Figure 11a. The dashed line represents optimal contract value conditional on using an open auction as a function of the budget. Just like in the pre-period, the full budget is utilized. On the other hand, if the agency has chosen a high-discretion procedure, the value cannot grow without bounds and caps at T even for large values of B. The agency utilizes the whole budget as long as it is small, but for larger budgets it chooses a contract value equal to the threshold.

Figure 11: Solution of the model



a) Optimal contract value

b) Optimal procurement procedure

The choice of the procedure depends on two parameters, the net benefit of discretion b and the budget B. As long as the budget constraint is binding, the agency chooses high discretion if the net benefit of discretion is positive (or bigger than $-\pi$ for tenders with connected participants). When the procedure constraint is binding the agency needs to consider, in addition to the net benefit of discretion, the opportunity cost of forgone contract value. Consequently, as the budget gets large, the critical value of b, above which she chooses high discretion, is increasing in B. This is illustrated by Figure 11b where the public agency chooses high discretion in the region above the curve.

5 Semi-parametric selection correction

This section combines exogenous variation of the procurement reform with the model outlined in the previous section to disentangle the causal impacts of discretion from the sorting of tenders. Since the focus of this section is to correct for possible selection of tenders into the high-discretion procedure, I will estimate demand for discretion non-parametrically. The non-parametric approach relaxes functional form assumptions made in the previous section but provides less insights into the demand for discretion. In the next section, I propose a fully parametric approach to estimate the model which requires the functional form assumptions of Section 4 but allows for richer economic interpretation of the demand function.

Since we are interested in the effects of discretion on procurement outcomes, we want to estimate the following set of equations

$$Y_i^s = \delta_s \cdot D_i + f_s(B_i) + \tau_s \cdot Post_i + u_i^s, \tag{7}$$

where Y_i^s is either the normalized price ($s = 1$) or the log-productivity of the winning firm ($s = 2$). D_i is an indicator for the high-discretion procedure, $f_s(B_i)$ is some function of the procurement budget, and $Post_i$ is a

dummy for the post-reform period. An important assumption of Equation 7 is that $f_s(B_i)$ is time invariant, hence time effect is constant for all budgets. This assumption is supported by Figure A.6 and Table A.2, which show evidence on the stability of the functional form prior to the introduction of the procurement threshold.

As we have seen in Section 3, the main empirical challenge lies in the endogeneity of the procurement decisions. Since public agencies control procurement procedures and contract values, the observed V_i does not necessarily equal the budget and D_i might be correlated with the error term. These problems make the OLS estimate of δ_s inconsistent.

I address the problem of self-selection into the high-discretion procedure by estimating Equation 7 together with selection equations implied by the solutions of the procurement model. The selection equation on contract values is given by

$$\log V_i = \log T \cdot D_i \cdot 1(B_i > T) + \log B_i \left[1 - D_i \cdot 1(B_i > T)\right]. \tag{8}$$

Equation 8 says that the agency utilizes the whole budget unless she chooses high discretion and the budget exceeds the procurement threshold, in which case she sets the value equal to the threshold. Since I estimate the demand for discretion non-parametrically, the selection equation for the procurement procedure can be written in a more general form:

$$D_i = 1(d_i > h(B_i)) \cdot Post_i, \tag{9}$$

where the solution of the model in the previous section is a special case with

$$d_i = \frac{b_i - E[b_i]}{Sd[b_i]}$$

$$h(B_i) = \frac{1}{Sd[b_i]}\left(-E[b_i] - \pi C_i + 1(B_i > T)\log\frac{B_i}{T}\right).$$

Equation 9 says that the procuring agency chooses a high-discretion procedure in the post-reform period if her latent utility from discretion denoted by d_i exceeds a budget specific critical value. I assume that the budget has a discrete support, $B_i \in \{B_1, \ldots, B_N\}$, and I discretize the observations of contract values using the same bins. B_i is independent from the residuals of the outcome equations, and the latent utility d_i. This does not introduce a new restriction into the data generating process, since $h(\cdot)$ is an arbitrary function which picks up any correlation between B_i and D_i. I assume that d_i and u_i^s are jointly normally distributed with the variance-covariance matrix $Var(u,d) = \begin{bmatrix} \sigma_u^2 & \rho_{u,d}\sigma_u \\ \rho_{u,d}\sigma_u & 1 \end{bmatrix}$.

An important implication of Equation 8 is that all manipulators choose $D_i = 1$ and are clustered in the bin right below the threshold. So if we exclude observations with $V_i = T$ and $D_i = 1$, we are left with observations where the contract value is equal to the exogenous budget ($V_i = B_i$). As a result of this, conditional expected outcome of

open auctions with $V_i = v$ is given by

$$E\left[Y_i^s \mid D_i = 0,\, B_i = v,\, Post_i\right] = f_s\left(v\right) + \tau^s \cdot Post_i + E\left[u_i^s \mid D_i = 0,\, B_i = v\right]$$

$$= f_s\left(v\right) + \tau^s \cdot Post_i + E\left[u_i^s \mid d_i < h\left(v\right)\right] \cdot Post_i$$

$$= f_s\left(v\right) + \tau^s \cdot Post_i - \rho_{u,d}\sigma_u \lambda^+\left[\Phi^{-1}\left(P\left(v\right)\right)\right] \cdot Post_i, \tag{10}$$

where $P\left(v\right) \equiv \Pr\left(D_i = 0 \mid B_i = v,\, Post_i = 1\right) = \Phi\left(h\left(v\right)\right)$, $\lambda^+\left(z\right) \equiv \frac{\phi(z)}{\Phi(z)}$. Similarly the expected outcome conditional on choosing high discretion (which we only have in the post reform period) for $V_i = v < T$ is given by

$$E\left[Y_i^s \mid D_i = 1,\, B_i = v,\, Post_i = 1\right] = \delta_s + f\left(v\right) + \tau^s + E\left[u_i^s \mid D_i = 1,\, B_i = v\right]$$

$$= \delta_s + f_s\left(v\right) + \tau^s + E\left[u_i^s \mid v_i > h\left(v\right)\right]$$

$$= \delta_s + f_s\left(v\right) + \tau^s + \rho_{u,d}\sigma_d \lambda^-\left[\Phi^{-1}\left(P\left(v\right)\right)\right], \tag{11}$$

where $\lambda^-\left(z\right) \equiv \frac{\phi(z)}{1-\Phi(z)}$. If we have an estimate on $P\left(v\right)$ we can construct the following control function:

$$CF\left(B_i = v,\, Post_i\right) = D_i \cdot \lambda^-\left[\Phi^{-1}\left(P\left(v\right)\right)\right] - \left(1 - D_i\right) \cdot \lambda^+\left[\Phi^{-1}\left(P\left(v\right)\right)\right] \cdot Post_i. \tag{12}$$

It follows from Equation 10 and 11 that if we include the control function into Equation 7 then the OLS estimate of δ_s identifies the true causal effect,

$$\hat{\delta}_s \equiv E\left[Y_i^s \mid D_i = 1,\, B_i = v,\, Post_i = 1,\, CF\left(v,\, 1\right)\right] - E\left[Y_i^s \mid D_i = 0,\, B_i = v,\, Post_i = 1,\, CF\left(v,\, 1\right)\right]$$

$$= \delta_s + f_s\left(v\right) + \tau^s \cdot Post_i + \rho_{u,d}\sigma_u CF\left(v,\, 1\right) - f_s\left(v\right)\tau^s \cdot Post_i - \rho_{u,d}\sigma_u CF\left(v,\, 1\right) = \delta_s$$

Obtaining an estimate of $P\left(v\right)$ is straightforward as long as $v < T$, since neither open nor high-discretion procedures manipulate contract value. Probability of an open auction is simply given by

$$P\left(v\right) \equiv \frac{\Pr\left(B_i = v,\, D_i = 0 \mid Post_i = 1\right)}{\Pr\left(B_i = v \mid Post_i = 1\right)} = \frac{\Pr\left(V_i = v,\, D_i = 0 \mid Post_i = 1\right)}{\Pr\left(V_i = v \mid Post_i = 1\right)}. \tag{13}$$

On the other hand, for $v > T$, we cannot estimate $P\left(v\right)$ the same way. In this region $\Pr\left(B_i = v \mid Post_i = 1\right)$ is not equal to $\Pr\left(V_i = v \mid Post_i = 1\right)$, because high-discretion tenders bunch below the threshold. In order to obtain an estimate of $P\left(v\right)$, I assume that the pre-reform contract value distribution is a good benchmark for the post-reform budget distribution, formally $\Pr\left(B_i = v \mid Post_i = 1\right) = \Pr\left(V_i = v \mid Post_i = 0\right)$.This assumption means that all changes in value distributions across the two periods were driven by the policy reform. Consequently, for

$v > T$ the fraction of open auctions is given by

$$P(v) \equiv \frac{\Pr(B_i = v,\, D_i = 0 \mid Post_i = 1)}{\Pr(B_i = v \mid Post_i = 1)} = \frac{\Pr(V_i = v \mid Post_i = 1)}{\Pr(V_i = v \mid Post_i = 0)}. \tag{14}$$

Following Heckman (1979), I estimate the model in two steps. First, I discretize the contract value space and estimate $P(v)$ non-parametrically for each grid of V_i using Equations 13 and 14. Second, I exclude observations with $D_i = 1$ and $V_i = T$ and estimate Equation 7 including the control function by OLS. Note that the excluded instrument is the interaction of budget and time, since I estimate a saturated model of budget and time in the first stage but their effects are additively separable in the second stage. The exclusion restriction relies on the assumption that $f_s(\cdot)$ function in Equation 7 is stable across the two time periods. I approximate $f_s(\cdot)$ with a linear function of log-value for prices and a quadratic function for productivities.[6]

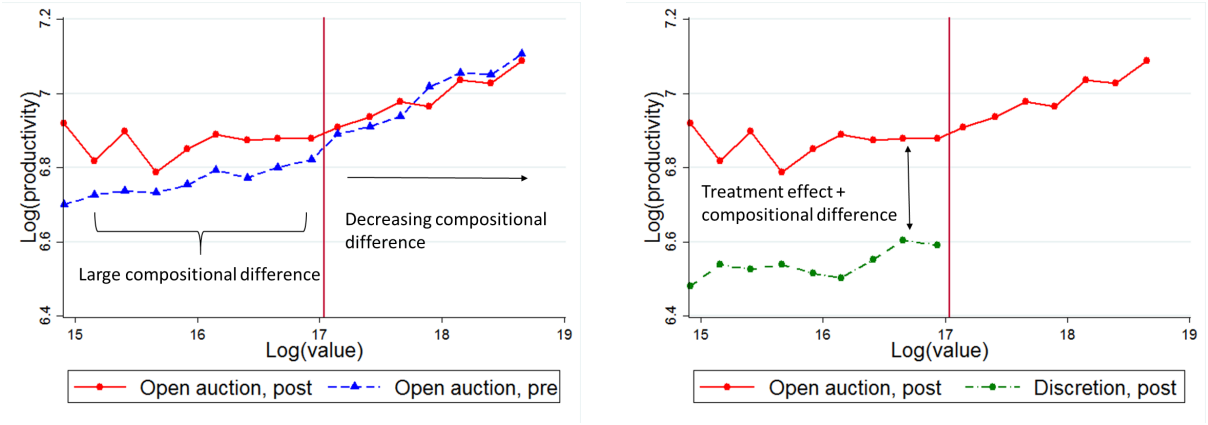
Identification. Figure 12 illustrates the logic of the identification. Figure 12a shows logarithmic productivity of open auction winners as a function of contract value for the pre- and post-period, separately. The difference between the outcomes of the two periods are driven by the time effect and the change in the composition of tenders across time periods. The assumption that function $f_s(\cdot)$ in Equation 7 is time invariant implies that in the absence of sorting the two curves might differ, but need to be parallel to each other. However, sorting can create differences in the shapes of the two curves, since different points of the value distribution are exposed to varying degrees of sorting.

Indeed, below the threshold, where the high-discretion procedure is easily available, composition of tenders have changed markedly between the pre- and the post-period. On the other hand, above the threshold, the further the budget of the tender is from the threshold, the more contract value needs to be sacrificed to gain high discretion over the selection of contractors. As a result, as we move further from the threshold, the change in the composition of tenders between time periods becomes smaller, which explains the closing gap between the two curves.

Once we have the effect of sorting, we can compare outcomes across different procedures to identify the treatment effect of discretion. This comparison is illustrated by Figure 12b, which plots log-productivity of open auctions and high-discretion procedures in the post-period. The difference between the outcomes of open auctions and high-discretion procedures is explained by the sum of the sorting and the treatment effect. Consequently, by knowing the effect of sorting, we can partial out the effect of discretion.

[6] My selection of functional forms is based on Figure A.5 and Table A.1, which show outcomes as a function of log-value in the pre-reform period. It suggests that prices can be approximated with a first-order polynomial, while productivities can be approximated with a second-order polynomial of $\log \frac{V_i}{T}$.

Figure 12: Identification



a) Log-productivity by period for open auctions b) Log-productivity by procedure in the post-period

The empirical strategy presented here assumes that the high-discretion procedure is not available above the threshold, although in the data a small fraction tenders uses high-discretion procedures even above the threshold. To estimate this model, I classify all observations above the threshold as open auctions. This discrepancy with the data could introduce a downward bias in the estimated effects of discretion, since it makes me overestimate $P(v)$ in the first step. In the appendix, I present a modified version of the model, which allows for high discretion even above the threshold.

5.1 Results of the semi-parametric model

Results of the semi-parametric selection correction model are reported in Table 4. Column 1 shows the simple OLS estimate on normalized price. Column 2 modifies the specification of column 1 to correct for the sorting of tenders by including the control function. Columns 3-4 show similar specifications on the productivity of the winning firm.

The 5 percent increase in the normalized price reported by column 1 is smaller than the discontinuity at the threshold reported in the previous section. This difference can be explained by the fact that the specification in column 1 identifies an average treatment effect instead of a LATE at the threshold. Column 2 finds that discretion increases price by 8 percent. This is a larger effect than the one reported in column 1, suggesting that low-price tenders sort into high discretion. This finding suggests that open auction is avoided because of the increased price competition it brings. It is in line with the corruption interpretation of sorting, since a stronger price competition results in less rents shared, hence it creates more incentives to reach out for discretion. Column 3 shows a 30 percent loss in productivity if a high-discretion procedure is used which is consistent with the RD estimate. Column 4 finds a much smaller 12 percent decrease in the productivity of contractors. This reduction of the treatment effect relative to column 3 is explained by a clear selection of low-productivity tenders into high-discretion procedures.

This means that discretion attracts tenders where productivity of winners would have been low even if open auctions were used. This finding is consistent with corruption being an important driver of sorting. Althought open auctions strenghten economic efficiency they do not fully rule out political motivations in the selection of contractors.

Table 4: Semi-parametric selection correction estimates

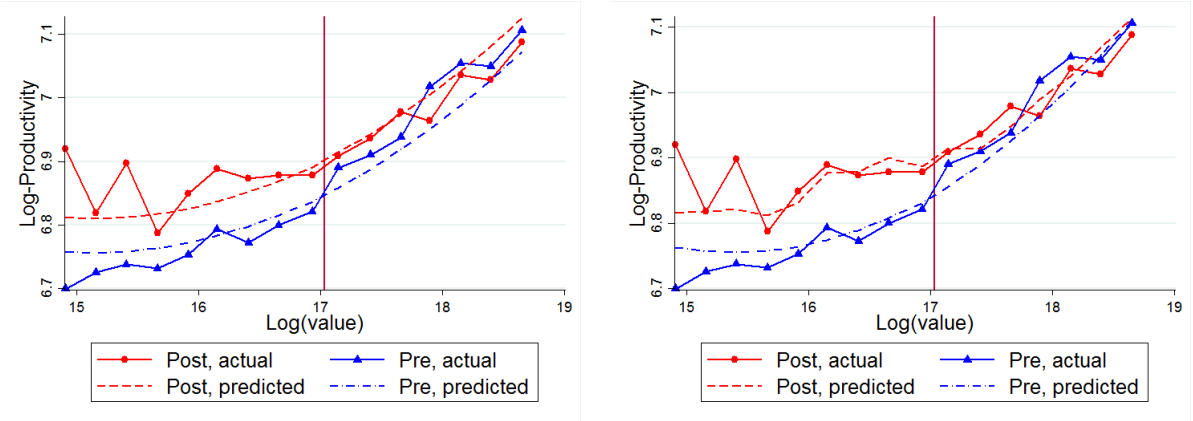
	Normalized price		Log(TFP)	
	(1)	(2)	(3)	(4)
High discretion	0.0514***	0.0783***	-0.300***	-0.115*
	(0.00326)	(0.0140)	(0.0145)	(0.0691)
Post reform	-0.00727**	-0.0234***	0.0537***	-0.0573
	(0.00304)	(0.00852)	(0.0119)	(0.0427)
Control Function		-0.0187**		-0.126***
		(0.00941)		(0.0457)
Functional form	Lin	Lin	Quad	Quad
Observations	45,908	45,908	31,557	31,557

Note: Each observation is an individual contract. The sample consist of all non-construction tenders for 2009-2014. Bootstrapped standard errors in parentheses.
* p<0.10,** p<0.05, *** p<0.01

Indeed, there is an abundance of anecdotal evidence suggesting that by tayloring requirements corrupt agencies can favor politically connected firms even if they are less productive. Corrupt agencies' ability to manipulate auctions and their preference for discretion (to avoid the costs of manipulating auctions) together can generate the sorting I find. Moreover, the nature of the sorting is inconsistent with the existence of any complementarity between discretion and competence of agencies, since agencies with high demands for discretion seem to be less efficient in selecting productive contractors.

Model predictions. To provide a sense of the fit of each model, I report the predicted log-probability for open auctions under each specification. Figure 13a plots log-productivity of contractors using the specification of column 3 for the pre- and post-period, respectively. The model without selection has a hard time replicating the differences in the gaps between the two curves below and above the threshold. However, the specification of column 4 plotted by Figure 13b provides a good fit for all contract values. Similar figures for the normalized price is reported in Figure A.7.

Figure 13: Model predictions



a) Model without selection

b) Model with selection

6 Structural estimation

The semi-parametric selection correction results of the previous section suggest that discretion increases the prices of contracts and decreases the productivity of selected contractors. If discretion has such a detrimental effect on public interests, why would any procurer choose a high-discretion procedure? To dig deeper into the determinants of the demand for discretion, I estimate the model of Section 4 parametrically. This parametric approach enables me to identify the trade-off between obtaining more discretion and choosing more contract value. There are two main goals of this excercise. First, by estimating the effect of political favoritism on this trade-off, I can express discretion's effect on private rents in terms of forgone contract value. Second, I can use this trade-off to simulate the effects of alternative procurement thresholds.

The selection equation on contract values is the same as Equation 8 of the previous section,

$$\log V_i = \log T \cdot D_i \cdot 1\left(B_i > T\right) + \log B_i \left[1 - D_i \cdot 1\left(B_i > T\right)\right].$$

However, the the selection equation on the procurement procedure uses the functional form assumptions of Section 4:

$$D_i = 1\left(b_i + \pi C_i + \phi L_i \geq 1\left(B_i > T\right) \log \frac{B_i}{T}\right) \cdot Post_i, \tag{15}$$

where L_i is an indicator for having at least one checked bidder, and C_i is a dummy for at least one connected firm bidding. The two residuals are the net benefit from high discretion b_i and the maximum value of the project B_i.

I estimate the two-outcome equations described by Equation 8 together with the selection equations given by Equation 9 and 15 under the following distributional assumptions. Just like in the semi-parametric model, I assume that B_i has a discrete support, with probability weights of $\Pr\left(B_j\right) \equiv q_j$. B_i is independent from b_i and u_i, whose joint distribution is given by

$$\left(b_i,\, u_i\right)' \sim N\left(\left(\mu, 0, 0\right)', \Omega\right),$$

where μ is the mean of b_i and Ω is an arbitrary variance-covariance matrix. Similarly to the semi-parametric approach, the correlation structure between b_i and u_i captures the selection of tenders into high-discretion procedures.

The vector of parameters θ consists of: (i) the average net benefit from high discretion μ, a benefit shifter for tenders with checked bidders ϕ, and the extra private rent from tenders with connected bidders π; (ii) the vector of the effects of discretion $\delta = \left(\delta_1,\, \delta_2\right)'$, the vector of time effects $\tau = \left(\tau_1,\, \tau_2\right)'$; (iii) the variance-covariance matrix of the $\left(b_i,\, u_i\right)$ residual vector Ω; (iv) probability weights $q_j's$. I estimate the parameter vector θ with maximum likelihood method.

The likelihood of the observations from the pre-reform period is given by,

$$L\left[Y_i,\, V_i = B_j \mid \theta,\, Post_i = 0\right] = g\left(\hat{u}_i\right) q_j,$$

were $\hat{u}_i \equiv Y_i - \delta D_i - f\left(V_i\right) - \tau \cdot Post_i$ is the predicted residual of Equation 7. If the contract was awarded after 2011, the likelihood takes the following form,

$$L\left[Y_i,\, D_i,\, V_i = B_j \mid \theta,\, Post_i = 1\right] = \left\{\left(1 - D_i\right) G\left[1\left(B_j > T\right) \log \frac{B_j}{T} - \pi C_i - \phi L_i\right] + D_i\left[1 - G\left(-rC_i - \phi L_i\right)\right]\right\} g\left(\hat{u}_i\right) q_j$$

$$+ D_i \cdot 1\left(k_j = T\right) \left\{\sum_{k_l > T}\left[1 - G\left(\log \frac{B_l}{T} - \pi C_i - \phi L_i\right)\right] g\left(\hat{u}_i\right) q_l\right\},$$

where $g\left(\cdot\right)$ is the pdf of u_i and $G\left(\cdot\right)$ is the cdf of $b_i \mid u_i$. I estimate the parameter vector θ which maximizes the likelihood function,

$$\mathcal{L} = \prod_{i=1}^{n} L\left[Y_i,\, V_i = B_j \mid \theta,\, Post_i = 0\right]^{1 - Post_i} L\left[Y_i,\, D_i,\, V_i = B_j \mid \theta,\, Post_i = 1\right]^{Post_i}.$$

Identification. The separate identification of the causal effects of discretion, the time effects and the effects of sorting are based on the same variations used in the identification of the semi-parametric selection correction model.

The added value of the parametric approach is the identification of the trade-off between discretion and contract value and the effect of political favoritism on this trade-off. We can get a sense of the importance of obtaining high discretion in terms of forgone contract value if we analyze the gap between the right tales of the pre and the post-period contract value distributions. If the gap closes fast as we move away from the threshold, then firms are not willing to sacrifice a lot of contract value to obtain discretion. Conversely, if the gap closes slowly, then firms are willing to sacrifice a lot of contract value to get discretion.

The π parameter, measuring the effect of discretion on the rents from corruption, is identified from the comparison of the size of spikes below the threshold across tenders with and without politically connected participants. From the excess bunching of tenders with connected firms, the model quantifies the amount of extra contract value agencies are willing to sacrifice to help connected firms win.

6.1 Structural results

Table 5 reports the estimates of the structural parameters.

Impact of discretion. The structural results confirm the findings of the semi-parametric selection correction model by estimating very similar effects on procurement outcomes. I find that discretion increases normalized price by 6 percent. Similarly to the semi-parametric results, the effect on winner productivity is also much smaller than

Table 5: Structural estimates

	Log(price/value)	Log(TFP)
Effects of discretion (δ)	0.057	-0.097
	(0.038)	(0.038)
Correlation of benefit and residual ($\rho_{b,u}$)	-0.043	-0.144
	(0.098)	(0.033)
Private rent from favoritism (π)	0.248	
	(0.040)	

Note: Each observation is an individual contract. The sample consist of all non-construction tenders for 2009-2014.

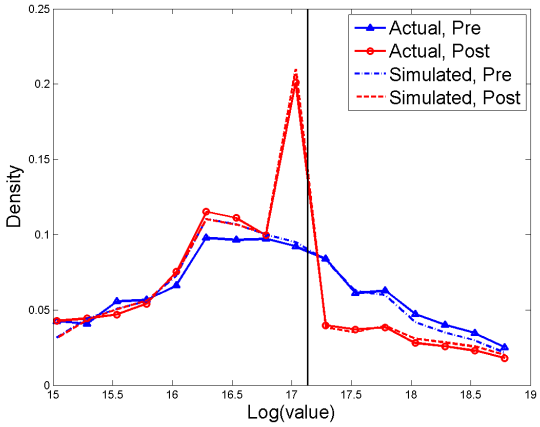
the discontinuity at the threshold. I find that discretion decreases the average productivity of contractors by 10 percent. These results support the importance of transparency in public procurement.

Sorting into discretion. My model estimates detect a weak sorting of low-price tenders into the high-discretion procedure. The correlation coefficient is less precisely estimated but consistent with the parameter of the control function in the semi-structural estimation. The model estimates a substantial sorting of low-productivity tenders into high-discretion procedures. The size of the negative correlation between the net benefit of high discretion and the productivity residual is consistent with the selection coefficient detected in column 4 of Table 3.

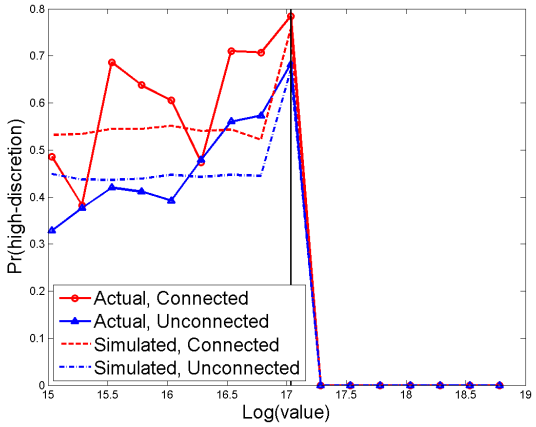
Favoritism and the demand for discretion. The main goal of the parametric estimation was to establish a direct link between discretion and corruption and measure the effect of high-discretion procedures on rent extraction. Parameter π provides a lower bound on the gain in private rents by measuring the effect of discretion on the extra rents collected from connected firms. The estimate of π indicates that public agencies are willing to sacrifice 25 percentage points more contract value to choose high discretion if there is a connected bidder, meaning that the demand for discretion is substantially inflated by the participation of connected firms.

Model predictions. To provide a sense of the fit of the model, I report model simulations on important moments of the data. Figure 14 illustrates the performance of the model in predicting the distributions of the two decision variables. Figure 14a shows the simulated and empirical distribution of logarithmic contract values for the pre- and post-reform periods separately. We see that the model fits the data very well, replicating the spike and the missing mass very precisely. Figure 14b plots the fraction of high-discretion procedures as a function of log-value for two groups of tenders in the post-reform period. In both groups there is at least one checked bidder. The group depicted by the dashed-dotted line has only unconnected participants, while the dashed line stands for tenders with at least one connected bidder. Although the model fails to account for the slight increasing trend in the fraction of high-discretion procedures, it correctly predicts the spike below the threshold and the gap between the two groups of tenders.

Figure 14: Simulated and empirical distributions of decision variables



(a) Density of log-value



(b) Fraction of high-discretion in the post-period

7 Welfare

In this section I use my structural model to conduct policy simulations. I calculate the effects of numerous alternative procurement thresholds (among them, the actual threshold introduced in 2011) relative to the benchmark policy of requiring open auctions for all contract values. The structural estimates on normalized price and productivity allow me to assess two important consequences of different threshold policies. First, by measuring the average price of one dollar of anticipated contract value, which is equivalent to the value weighted average of the normalized price,[7] I quantify the transfer from taxpayers to contractors. Second, the value weighted average of contractor productivity is a good measure of overall efficiency of public purchases. Indeed, as long as the production function of the representative contractor is homogeneous of degree one, the change of its total factor productivity is equal to the reciprocal of the change in aggregate production costs.

Hence, the transfer and the efficiency effects are given by

$$W_s = \frac{E_{Y,V}\left[\exp\left(Y_i^s\right)\cdot V_i \mid \theta,\, T\right]/E_V\left[V_i \mid \theta,\, T\right]}{E_{Y,V}\left[\exp\left(Y_i^s\right)\cdot V_i \mid \theta,\, \underline{T}\right]/E_V\left[V_i \mid \theta,\, \underline{T}\right]} - 1, \tag{16}$$

where the numerator is the value weighted expectation of the procurement outcome (normalized price for the transfer and TFP for the efficiency effect) conditional on a given threshold T. The denominator is the value weighted expectation of the outcome under the benchmark policy of a zero value threshold, $\underline{T} \equiv 0$, which implies the obligation to use an open auction for all values.

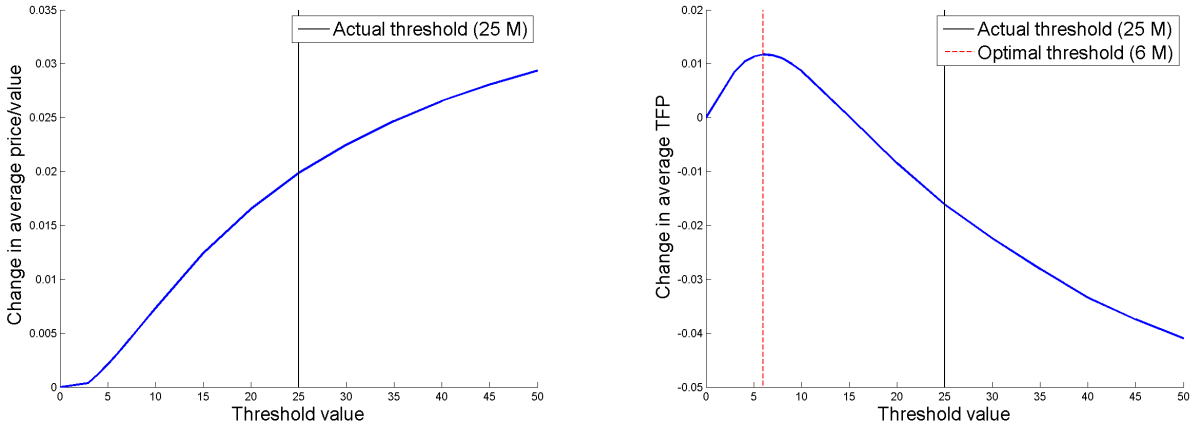
Introduction of a threshold affects outcomes through two different channels. First, the availability of the high-discretion procedure has a direct positive effect on prices and a negative effect on productivity. Second, as we have seen in Figure 4, the introduction of a value threshold changes the distribution of contract values. More

[7] Average price of one dollar of anticipated contract value is the same as the value weighted average of the price-value ratio, $\frac{\sum P_i}{\sum V_i} = \sum \frac{P_i}{V_i}\frac{V_i}{\sum V_i}$.

specifically, the bunching of contracts below the threshold increases the fraction of small value contracts, which has an opposite effect on average productivity. Given the sorting of low productivity (and probably more corrupt) tenders into high-discretion procedures, the introduction of a value threshold disproportionately decreases the size of tenders with low-productivity winners. Although discretion directly decreases productivity, it can also increase aggregate production costs by making inefficient procurers spend less. Equation 16 measures the aggregate effect of all channels.

I parametrize the model with the structural estimates reported in Table 6 and conduct simulations with a number of different thresholds. The distributions of contract values for three selected procurement regimes, 6 million HUF, 25 million HUF, and 50 million HUF, are plotted in Figure A.8. I compute the transfer and efficiency effects by calculating the sample analogues of Equation 16 for the simulated samples. Results are plotted in Figure 15. Figure 15a shows that the introduction of a procurement threshold always transfers money from taxpayers to firms and that this transfer increases in the value of the threshold. It increases from zero at the no threshold to 2 percent at the 25-million, and 3 percent at the 50-million threshold. Procurement thresholds have a non-monotonous effect on efficiency. Figure 15b presents that small procurement thresholds increase the value weighted average productivity of contractors, hence decreasing aggregate production cost. The efficiency effect turns negative for larger procurement thresholds above 15 million HUF. I find that the policy reform of 2011 decreased productivity, accordingly increasing production costs, by 1.6 percent. The effect would increase to as large as 4 percent with a 50-million threshold. The simulations suggest an optimal threshold of about 6 million, which would result in a one percent increase of average productivity relative to the no-threshold benchmark.

Figure 15: Transfer and efficiency effects of different thresholds



(a) Transfer effect

(b) Efficiency effect

An important limitation of the welfare simulations is that they do not take into account higher administrative costs of auctions. Administrative costs would reduce the efficiency loss from high-discretion environments and would potentially increase the optimal value threshold. On the other hand, it seems very likely that if an online system for public auctions is already set up, which is the case in our setup, then the extra administrative costs of auctions

are negligible relative to the 12 percent increase in production costs suggested by column 4 of Table 6.

The interpretation of the effect on production costs as a welfare effect is based on two implicit assumptions. First, contractors of public agencies hire from the same job market. Indeed, if contractors hired people who would be unemployed otherwise, the loss in GDP would be smaller. Second, allocation of contracts by public agencies does not affect the firms' private market shares. It can easily be violated if there are strong economies of scale or capacity constraints. In the presence of market share spillovers, the procurement reform has an ambiguous effect on the average productivity of private markets. Consequently, the full effect on the GDP can be either smaller or larger than the effect on average public productivity.

8 Conclusion

In this paper, I estimated the effects of buyers' discretion on the prices of contracts and the productivity of contractors in public procurement. I overcome the problem of tenders sorting into high-discretion procedures by exploiting the introduction of a value threshold to semi-parametrically estimate a selection correction model. I find that discretion increases prices and decreases productivity of selected contractors. I document that tenders, where the productivity of the winning firm is low, are more likely to be awarded by high-discretion procedures. This selection suggests that corruption and shirking might be important determinants of the demand for discretion. Moreover, the structural estimation of procurement decisions sheds more light on the determinants of the demand for discretion. I provide strong suggestive evidence for the link between discretion and favoritism by showing that agencies choose discretion more often if politically connected firms participate in the tender. Finally, I use my model to quantify the transfer and welfare consequences of the procurement reform. I find that the reform transferred 2 percent of total procured value from taxpayers to firms and decreased average productivity of public spending by 1.6 percent.

I conclude by discussing some broader implications of my results. Although corruption is considered a major impediment to economic growth, we have very limited reliable evidence on the welfare consequences of corruption and political favoritism. This paper documents a clear negative relationship between an important tool of political favoritism and the efficiency of public spending. Moreover, it contributes to our knowledge about the effects of specific policies on corruption by highlighting the usefulness of transparency in limiting political favoritism.

References

Eric Avis, Claudio Ferraz, and Frederico Finan. Do government audits reduce corruption? 2016.

Patrick Bajari and Steven Tadelis. Incentives versus transaction costs: A theory of procurement contracts. *Rand Journal of Economics*, pages 387–407, 2001.

Audinga Baltrunaite. Political finance reform and public procurement: Evidence from Lithuania. *Institute for International Economic Studies, Stockholm University*, 2016.

Oriana Bandiera, Andrea Prat, and Tommaso Valletti. Active and passive waste in government spending: Evidence from a policy experiment. *The American Economic Review*, pages 1278–1308, 2009.

Jonathan Brogaard, Matthew Denes, and Ran Duchin. Political connections, incentives and innovation: Evidence from contract-level data. *Unpublished working paper*, 2015.

Sebastian Calonico, Matias D Cattaneo, and Rocio Titiunik. Robust nonparametric bias-corrected inference in the regression discontinuity design. *University of Michigan Working Paper*, 2012.

Lisa Chever and John Moore. When more discretionary power improves public procurement efficiency: An empirical analysis of auctions with negotiation and reduction of formalism. In *EALE Conference 2012*, 2012.

Lisa Chever, Stéphane Saussier, and Anne Yvrande-Billon. The law of small numbers: Investigating the benefits of restricted auctions for public procurement. *Applied Economics*, 49(42):4241–4260, 2017.

Eshien Chong, Carine Staropoli, and A Yvrande-Billon. The auction versus negotiation tradeoff in public procurement under political scrutiny. Technical report, mimeo, 2011.

Decio Coviello, Andrea Guglielmo, and Giancarlo Spagnolo. The effect of discretion on procurement performance. *Management Science*, 2017.

Rafael Di Tella and Ernesto Schargrodsky. The role of wages and auditing during a crackdown on corruption in the city of Buenos Aires. *The Journal of Law and Economics*, 46(1):269–292, 2003.

Rebecca Diamond and Petra Persson. The long-term consequences of teacher discretion in grading of high-stakes tests, 2016.

Claudio Ferraz and Frederico Finan. Exposing corrupt politicians: The effects of Brazil's publicly released audits on electoral outcomes. *The Quarterly Journal of Economics*, 123(2):703–745, 2008.

Maria Paula Gerardino, Stephan Litschig, and Dina Pomeranz. Can audits backfire? Evidence from public procurement in Chile. *NBER Working Paper No. 23978*, 2017.

Eitan Goldman, Jörg Rocholl, and Jongil So. Politically connected boards of directors and the allocation of procurement contracts. *Review of Finance*, 17(5):1617–1648, 2013.

James J Heckman. Sample selection bias as a specification error. *Econometrica*, 47(1):153–161, 1979.

Chang-Tai Hsieh and Peter J Klenow. Misallocation and manufacturing TFP in China and India. *The Quarterly Journal of Economics*, 124(4):1403–1448, 2009.

Karam Kang and Robert A Miller. Winning by default: Why is there so little competition in government procurement?, 2015.

Miklos Koren, Adam Szeidl, Ferenc Szucs, and Balazs Vedres. Political favor exchange in a democracy. *Unpublished working paper*, 2015.

Rafael Lalive and Armin Schmutzler. Auctions vs negotiations in public procurement: Which works better? 2011.

Alejandro M Manelli and Daniel R Vincent. Optimal procurement mechanisms. *Econometrica*, pages 591–620, 1995.

Maxim Mironov and Ekaterina Zhuravskaya. Corruption in procurement and the political cycle in tunneling: Evidence from financial transactions data. 2015.

Balázs Muraközy and Álmos Telegdy. Political incentives and state subsidy allocation: Evidence from Hungarian municipalities. *European Economic Review*, 89:324–344, 2016.

Benjamin A Olken. Monitoring corruption: Evidence from a field experiment in Indonesia. *Journal of Political Economy*, 115(2):200–249, 2007.

Ján Palguta and Filip Pertold. Corruption and manipulation of public procurement: Evidence from the introduction of discretionary thresholds. *Prague: CERGE-EI*, 2014.

Andrew Donald Roy. Some thoughts on the distribution of earnings. *Oxford Economic Papers*, 3(2):135–146, 1951.

Emmanuel Saez. Do taxpayers bunch at kink points? *American Economic Journal: Economic Policy*, 2(3):180–212, 2010.

David Schoenherr. Political connections and allocative distortions. 2015.

Chad Syverson. What determines productivity? *Journal of Economic Literature*, 49(2):326–365, 2011.

Adam Szeidl and Ferenc Szucs. Media capture through favor exchange. 2017.

István János Tóth and Miklós Hajdú. Versenyerosseg, tarsadalmi vesztesegek es a 25 millio forintos ertekhatar rejtelye. *CRCB-WP/2017:1*, 2017.

Anh Tran. Which regulations reduce corruption? Evidence from the internal records of a bribe-paying firm. *Journal of Development Economics*, 2010.

Appendix

A.1 Reduced form evidence

Figure A.1: Distribution of anticipated values for other tenders

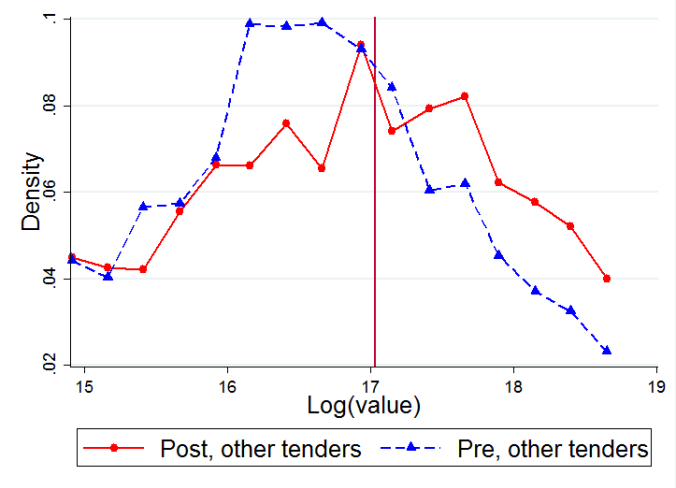


Figure A.2: Distribution of anticipated values for agency-firm-year cells

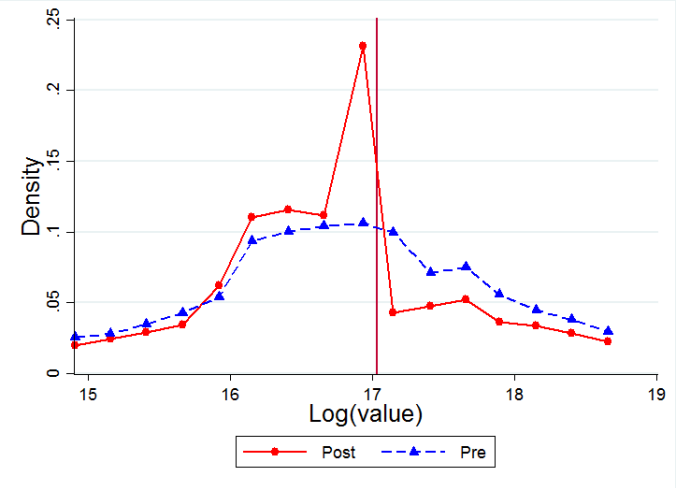


Figure A.3: Distribution of anticipated values for different product categories

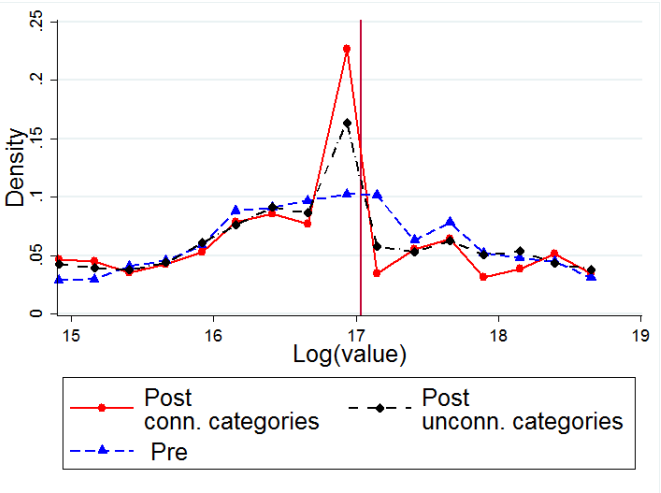
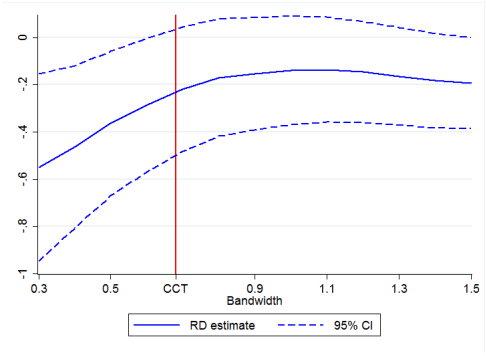
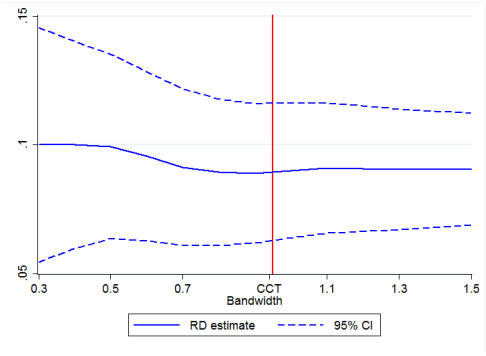


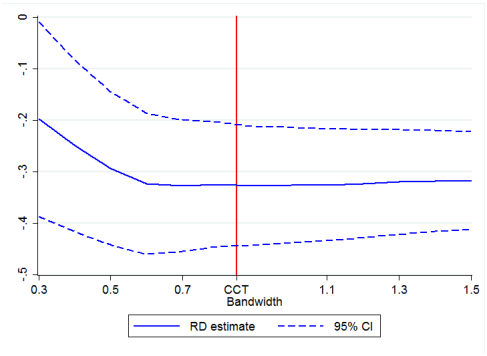
Figure A.4: RD results with different bandwidth



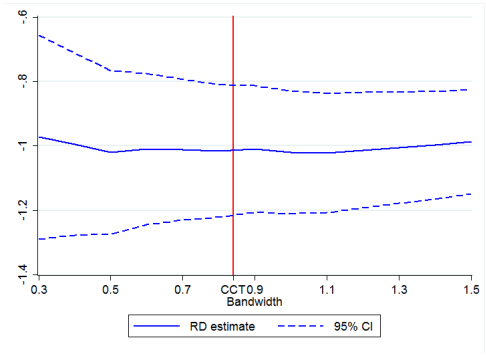
(a) No. of bidders



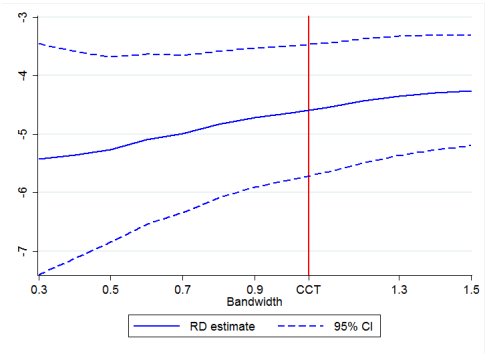
(b) Normalized price



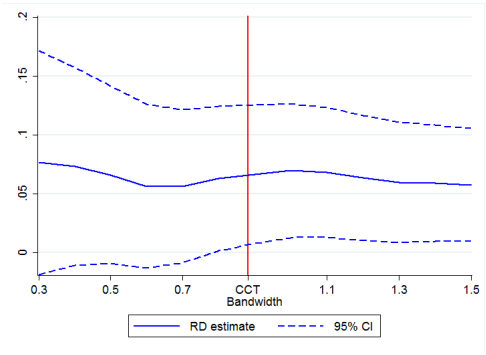
(c) Log(productivity)



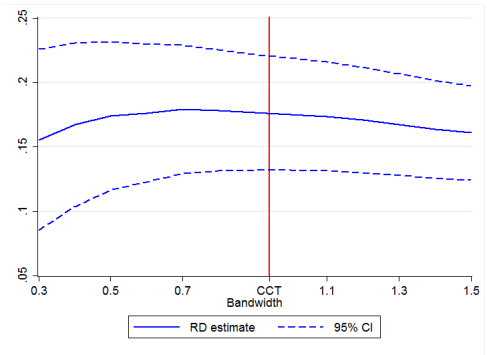
(d) Log(employment)



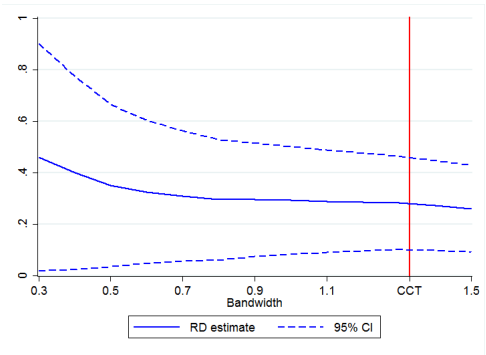
(e) Firm age



(f) Local firm



(g) Domestic owner



(h) Connected firm

Table A.1: Functional form selection

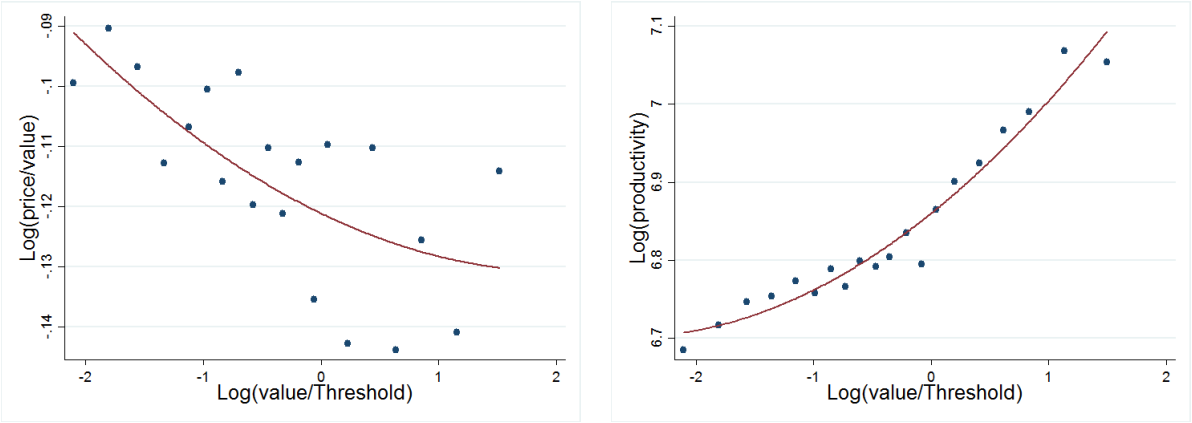
	Log(price/value) (1)	Log(TFP) (2)
Log(Value/Threshold)	-0.00950***	0.120***
	(0.00238)	(0.00701)
Log(Value/Threshold) Squared	0.00227	0.0231***
	(0.00194)	(0.00537)
Constant	-0.121***	6.859***
	(0.00242)	(0.00747)
Observations	17,936	17,936

Note: Each observation is an idividual contract. The sample consist of all non-construction tenders for 2009-2011. Robust standard errors in parentheses.
* p<0.10,** p<0.05, *** p<0.01

A.2 Functional form selection and stability

The selection of the functional form of $f_s(\cdot)$ in Equation 7 is motivated by Fiure A.4, which plots the binscatter graphs of procurement outcomes as a function of log-value normalized to zero at the threshold in the pre-reform period. The functional form selection is based on the pre-period, because that period is free of contract value manipulation. The graph suggests that the functional form can be approximated with a linear and a quadratic function of the normalized log-value for price and log-productivity, respectively. Table A.1 confirms the selection by regressing outcomes on a second-order polynomial of normalized log-value. Table A.1 finds that for the normalized price only the log-value is significant, while for log-productivity both the coefficient of log-value and log-value-squared are statistically significantly different from zero.

Figure A.5: Outcomes as a function of contract value, pre-period



(a) Normalized price

(b) Log(productivity)

I check the stability of function $f_s(\cdot)$ in Equation 7 by comparing estimates of $f_s(\cdot)$ at different time periods before the reform. I check for the stability of the functional form by estimating the functional form in the pre-reform period and check whether the coefficients produce a good fit of the functional form in other periods too. First, I

Table A.2: Functional form stability

	Normalized price		Log(productivity)	
	(1)	(2)	(3)	(4)
Predicted outcome	1.090***	1.534***	1.112***	0.611***
	(0.399)	(0.218)	(0.135)	(0.0894)
p-value of coeff = 1	[0.822]	[0.014]	[0.405]	[0.000]
Period	2006-08	2012-14	2006-08	2012-14
Observations	5,281	14,542	4,177	10,064

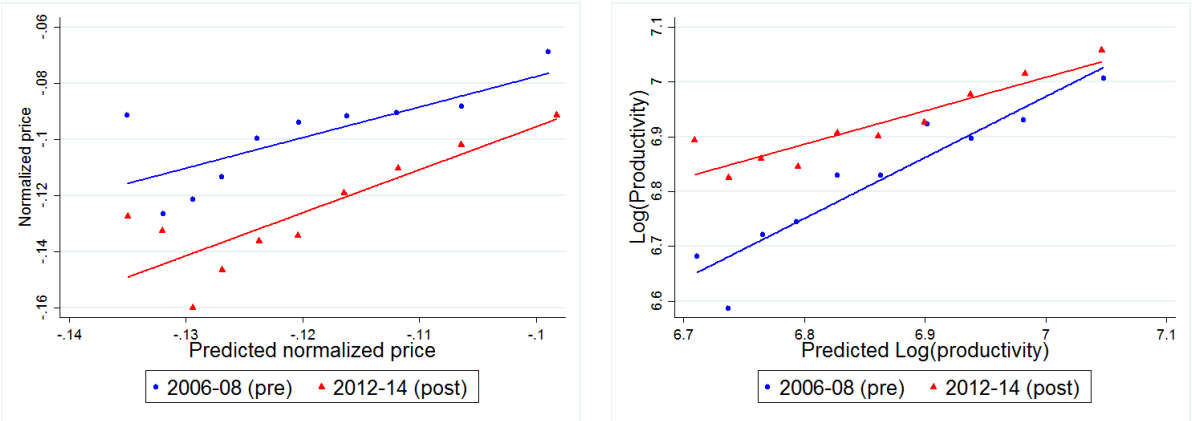
Note: Each observation is an individual contract. The sample in column 1 and 3 consists of all non-construction tenders for 2006-08, while the sample in column 2 and 4 consists of all non-construction tenders for 2012-14. The predicted values are calculated using coefficients from a regression of outcomes on a second order polynomial of log-value in the 2009-11 period. Robust standard errors in parentheses.
* p<0.10,** p<0.05, *** p<0.01

regress procurement outcomes on a second order polynomial of log-value and use estimated coefficients to create predicted values in two other periods.

Figure A.6 shows binscatter graphs of procurement outcomes in different periods as a function of the predicted values. The blue dots depict the three year period prior to the pre-period (2006-2008), while the red dots depict the post-reform period (2012-14). If a period has the same functional form as the pre-reform period, then the outcome is a linear function of the predicted values with the coefficient being equal to one. The blue dots scatter around the 45 degree line for both outcomes, confirming that the functional form was stable before the reform. On the other hand, in the post-reform period the the slopes are different from the 45 degree line.

Table A.2 confirms this by reporting regressions of the outcomes on the predicted values. It shows that in the 2006-08 period the slope is statictically indistinguishable from one, while in the post-period it is significantly different from one.

Figure A.6: Functional form stability

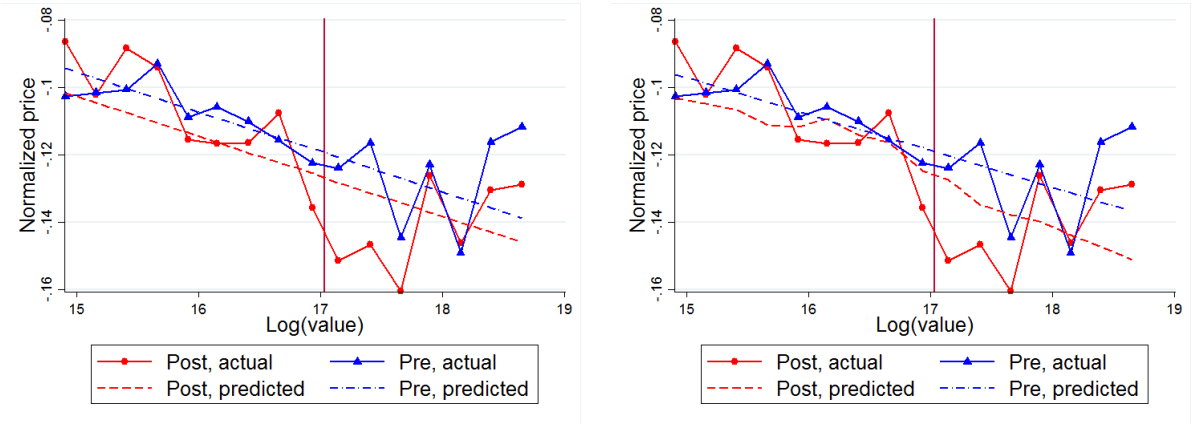


a) Normalized price

b) Log(productivity)

A.3 Semi-parametric model prediction

Figure A.7: Model predictions, normalized price



a) Model without selection

b) Model with selection

A.4 Selection correction with discretion above the threshold

In the semi-parametric selection model of Section 5, I assumed that all tenders above the 25-million threshold use open auctions. This is not fully consistent with the data, since a few tenders, entitled to special exemptions, use a high-discretion procedure even above the threshold. In the benchmark version of the model I classify all observations above the threshold as open auctions. Now, I modify the model to account for high-discretion procedures above the threshold.

I assume that a randomly selected subgroup of potential manipulators obtain a special exemption and chooses a high-discretion procedure without bunching below the threshold. This changes the way I compute $p(v)$ if $v > T$, since now the ratio of probability densities of the two periods do not capture the fraction of open auctions. In the absence of special examptions $p(v)$ is given by

$$P(v) \equiv \frac{\Pr(B_i = v,\, D_i = 0 \mid Post_i = 1)}{\Pr(B_i = v \mid Post_i = 1)} = \frac{\Pr(V_i = v,\, D_i = 0 \mid Post_i = 1)}{\Pr(V_i = v \mid Post_i = 0)}.$$

Other than this difference semi-parametric estimation procedure remains the same as in Section 5.

The results are reported in Table A.3. Column 1 and 2 find very similar effects to the benchmark model on normalized price. The simple OLS estimate in column 3 is also very similar to the corresponding results of Table 3. However, column 4 finds a somewhat larger 14 percent decrease in the average productivity of contractors. This increase in the strength of the effects suggests that the benchmark results slightly underestimate effects of discretion.

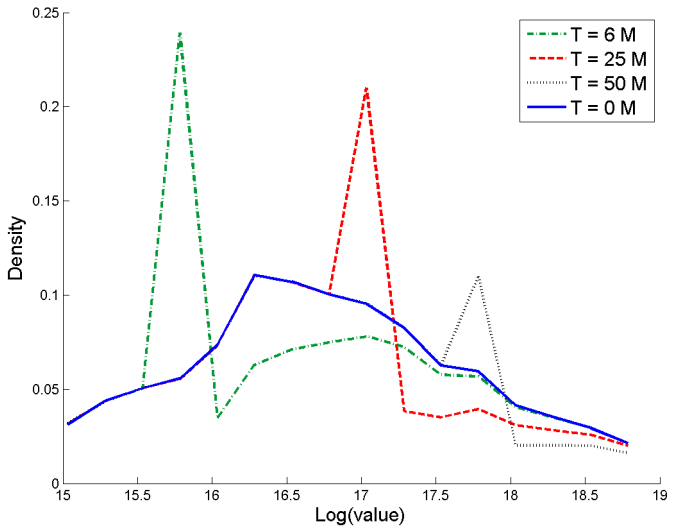
Table A.3: Semi-parametric selection correction estimates, high discretion above the threshold

	Log(price/value)		Log(TFP)	
	(1)	(2)	(3)	(4)
High discretion	0.0512***	0.0749***	-0.303***	-0.144**
	(0.00323)	(0.0145)	(0.0144)	(0.0730)
Post reform	-0.00802***	-0.0224**	0.0597***	-0.0361
	(0.00307)	(0.00889)	(0.0120)	(0.0453)
Control Function		-0.0161*		-0.106**
		(0.00955)		(0.0478)
Functional form	Lin	Lin	Quad	Quad
Observations	45,908	45,908	31,557	31,557

Note: Each observation is an individual contract. The sample consist of all non-construction tenders for 2009-2014. Bootstrapped standard errors in parentheses. * p<0.10,** p<0.05, *** p<0.01

A.5 Simulation of different procurement thresholds

Figure A.8: Distribution of contract values for different policy regimes



A.6 Proofs

Proof of Proposition 1. As it is pointed out in Section 4, the solution of the model under Regime 1 is very straightforward. The agency has to use an open auction and she only chooses the optimal contract value, which she sets equal to the budget, since her utility function is increasing in the contract value.

Under Regime 2, she also chooses as large contract value as she could. This is equal to the budget for open auctions and equal to the minimum of the budget and the procurement threshold for high-discretion procedures. Consequently, the optimal contract value is given by

$$V^* = B^{1-D^*\cdot 1(B>T)} \cdot T^{D^*\cdot 1(B>T)}.$$

She chooses a high-discretion procedure if it yields a higher utility than using an open auctions:

$$U\left(\min\left\{B,T\right\},1\right) \geq U\left(B,0\right)$$

$$\log B + 1\left(B > T\right)\log\frac{T}{B} + b + \pi C \geq \log B.$$

As a result the solution on optimal procedure is given by:

$$D^{*} = 1\left(b + \pi \cdot C \geq 1\left(B > T\right)\log\frac{B}{T}\right).$$