Small firm policies in procurement:

New evidence from drug procurement auctions in Brazil

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November 28, 2019

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Abstract

Small firm policies are used extensively in government procurement. Buyers make use of preference margin or set aside policies. Prior research found that restricting entry to small businesses can reduce efficiency and revenue substantially while increasing firm participation. A different policy suggests that small firms should have the right to undercut the prospected winner after the auction, conditional on that they have not been bidding too weak during the auction. In this context, we analyze this policy using Brazilian e-auctions for pharmaceutical drugs, where either the right to undercut or set-asides have been extensively used for many years. We compare both policies regarding their effect on the participation decisions of firms, their bidding behavior, and the final price.

JEL classification: D44, H57, L73, Q23

Keywords: public procurement, small firm policies

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1   Introduction

It is a common aim of public policy to enable the participation of small businesses in public procurement. Small businesses might be less efficient than big firms, however they make up for a large share of local employment and added value in most economies. There is a debate whether procurement agencies should conduct some auctions only for small businesses (set-asides) or have auctions with all firms where small businesses are subsidized (e.g. by a preference margin). Both policies can cause quite substantial changes in the behavior of firms and market outcomes (see for example Krasnokutskaya and Seim (2011)). Set-asides have the potential to increase participation of small firms, thereby increasing competition among them, at the detriment of having a pool of less efficient firms. Subsidies can induce small firms to participate without excluding more efficient firms from the process. Overall, the combined effects on participation, efficiency and prices depend on the environment and thus additional empirical evidence is helpful.

In this paper, we investigate the effect of setasides and the potential to substitute them partially with preference margins. We focus on the Brazilian market, where public institutions source pharmaceutical drugs over a Federal procurement service provider called "ComprasNet". Investigating the case of Brazil has several advantages. First, the Brazilian market is mature and large. From 2006 to 2013, the Brazilian Federal Government purchased nearly 23 billion drug packaging units. The total medicine expenditure, adjusted for inflation, was USD 14.7 billion (BRL 34.6 billion) during the period (see Luz et al. (2017)). Second, there is a well-established practice of procurement auctions. Any public institution willing to source drugs, with few exceptions,[1] has to run an electronic tender called "Pregao". Third, two different schemes to favor small firms are employed: a right to undercut for small firms (if their bid is not to far from the winner's bid) and set-asides. This environment allows us to address empirically how each format affects participation and prices.

For both policies, we study how they affect the market outcome in terms of participation and

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[1]   This is in a number of cases related to patents, emergency or small value (corresponding to a range of US$1.9k to US$5.1k from 2004 to 2018, according to the current exchange rate, or $4.2k to $4.7k from July 2018 on, after the thresholds were finally adjusted for inflation).

price level. Firms have to decide whether they prepare a bid for the auction or not. Before making the decision to participate in the auction, firms are not aware of all the information they need to submit a bid. They need to request price quotes of the merchandise or their inputs from upstream suppliers (either manufacturers or importers) and reserve production capacity or inventories for the case of winning the auction. For all this, there is a cost and firms only enter the auction if they expect this cost to be covered. Once firms decide to participate, bidding is organized as follows: Firms submit a sealed bid. If there is more then one bidder, the open bid phase starts and firms may submit several bids to undercut their previous offer. This phase is closed by a random clock, started when the number of bids decrease to an unknown rate.[2] Assuming an independent private value paradigm, all bidders should have a dominant strategy of bidding up to their valuation . From a theoretical perspective, this auction is efficient as the bidder with the highest value wins the auction (as long as the random closure time is not binding).

We then make use of a unique administrative data set of about 20,000 publicly competitively awarded procurement contracts by Federal public bodies in Brazil between 2004 and 2016 from the ComprasNet's Data Warehouse. It contains information on all purchases made by the Federal government, either through pooled procurement (known in Brazil as "price registration") or through a standard individual procurement. We considered only the public purchases made on the following procurement formats: Immediate Purchases of a Single Buyer and Framework Contracts with many buyers. The former account for 15 percent of all auctions considered here. The analysis focuses on purchases of pharmaceuticals which have also been subsidized in the "Farmacia Popular" Program.[3] Generally, for pharmaceuticals products all items are well described, standardized and codified following the Brazilian Catalog of Materials and Services classification.

We estimate then entry and bidding behavior. This allows us to compare the auction outcome across policies and to measure changes in prices. Our findings will provide insights towards

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[2]   For details, see Oliveira et al. (2019).
[3]   This is a program whereby any valid prescription can be filled in a private pharmacy with reimbursement from the Public Health Service, mostly under a copayment regime.

optimally designing procurement auctions, balancing conflicting aims of lowering expenditure, achieving efficiency gains and enabling participation of small firms.

The paper is organized as follows. The subsequent section discusses the related literature. The institutional environment of the Brazilian market is described in section 3 along with the data used. The fourth section comprises the description of the data. The empirical approach is described in Section 5, and the empirical analysis is conducted in Section 6. Section 7 concludes.

2 Related Literature

We describe the related literature in two subsections. We start with work on policies that support small firms such as bid preferences, design of the auction and set asides in Section 2.1. Then, we describe papers on Brazilian procurement auctions in Section 2.2.

2.1 Small firm policies

Bid preferences in procurement auctions are one policy that supports firms from a particular group, eg, small firms, by giving them an advantage in bidding. The favored group typically is less efficient and has higher cost. Other policies are auction designs that may favor the entry of small firms and set asides.

Bid preferences

Papers analyzing bid preferences focus then on the trade-off between supporting high-cost companies — which may entail higher procurement costs for the government — and providing incentives to non-favored firms to bid more aggressively against the strengthened favored group. Some papers study a third effect, the potential effect on firms' incentives to participate in an auction.

Marion (2007) studies bid preferences for small business in highway procurement auctions in California and their impact on the cost of procurement for the government. He identifies the impact of preferences on bidding behavior and procurement costs by exploiting the distinc-

tion between state-funded auctions where bid preferences are used and Federal-funded auctions where this program is not implemented. The results of the empirical analysis show that procurement costs are 3.8 percent higher in preference projects, compared to similar non-preference projects. The difference is explained by the reduced participation of large firms in preference auctions. The results also show that the participation patterns is responsible for a 3.6 percent increase in the procurement cost.

Krasnokutskaya and Seim (2011) consider that attributing this difference to the California Small Business Preference program is complicated by the fact, among others, that Federal-funded auctions employ another preferential treatment program. The authors take this into account and provide an alternative estimate. Using the same sample of auctions as Marion (2007), the authors estimate a structural bidding model, and use the model to simulate alternative preference policies. The results show that the subsidy program has a very small effect and would increase procurement cost by less than one percent. However, when participation is taken into account, the program would increase the procurement costs by 7.8 percent.

Auction design

Another way to support small firms could be the auction design. As equilibrium strategies do not differ for small and large firms in open auctions, but do differ in first-price auctions, the auction format may influence the entry behavior of firms. While it is a dominant strategy in open auctions to bid one's valuation irrespective of whether bidders' (private) valuations are symmetric or asymmetric, this is not true for first-price sealed-bid auctions. In that format and when bidders' valuations are asymmetric, bidders with higher cost bid more aggressively. This may lead to a higher probability of winning for high cost firms and thus a higher probability of entry of these firms (Maskin and Riley, 2000).

Athey et al. (2011) study entry and bidding in timber sales auction. Some of these auctions are run as open auctions and others are run as first-price auctions. The results of their descriptive empirical analysis show that sealed bidding has a positive effect on small firms entry, and has little effect on entry of big firms. Therefore, the sealed bid format increases the prob-

ability of winning of small firms. The results also show that prices are higher in sealed bid auctions. Estimating a private value auction model with endogenous participation confirms the descriptive results and shows that sealed bid auctions raise more revenue. The results also show that the allocation is distorted away from efficiency and in favor of small firms with, however, small effects (less than one percent). Accounting for equilibrium entry behavior shows larger magnitudes.

Set asides

Another special treatment that has been implemented to help small businesses in procurement auctions are set aside auctions. Nakabayashi (2013) studies the effect of set aside auctions on procurement cost using a sample of public procurement auctions for civil engineering projects in Japan. He estimates an asymmetric first-price auction model with affiliated private values and runs a counterfactual analysis. The results show that the set aside program improves participation from small and medium sized firms without substantially increasing the effective procurement cost. The results further show that around 40% of small and medium enterprises would exit the procurement market if the set asides were removed.

Athey et al. (2013) analyze the implementation of set aside auctions and subsidies in the US Federal government's timber sales program. The authors compare both policies which are used to achieve distributional goals by helping the weaker bidders, eg, small firms, but set asides auction are relatively more costly than subsidy in unrestricted auctions. The estimates, based on a structural model, suggest that designating a sale as a set-aside increases small business participation, but at the cost of substantially reducing efficiency and revenue. It is more efficient to provide subsidies to small bidders. This would increase revenue and small bidder profit, with little efficiency cost.

2.2 Brazilian procurement auctions

We analyze small firm programs in procurement auctions in Brazil using a sample of pharmaceutical drugs from ComprasNet. We are, however, not the first to use this data. There are,

for example, two studies that focus on how the ending rule in these auctions impacts prices (Celiktemur and Szerman, 2012; Oliveira et al., 2019).

Celiktemur and Szerman (2012) study Brazilian procurement auctions between 2006 and 2010. During this period, two ending rules have been in use in ComprasNet and they changed three times. There was a random close ending rule from 27/06/2004 to 15/04/2006 (period I) and from 13/09/2010 to 16/12/2010 (period III), and a quasi-hard close ending rule from 15/04/2006 to 13/09/2010 (period II) and after 16/12/2010. When the end is random, the auction duration is drawn from a known distribution, but the realisations remain unknown to the bidders until the auction closes. A quasi-hard end means that the duration of the ending phase is extended by a random amount of time when a participant bids close to ending time. Bidders and auctioneers cannot know the end of the random phase but know when it starts. Celiktemur and Szerman (2012) show that due to the random end firms defer bidding to the end phase of the auction. Bid snipping with 70% of the bids occurs in random phase in period 1, and 85% in period 2 and lead to suboptimal prices when auctions are closed in the heat of bidding and suggest that this effect could be offset or outweighed by increased participation since randomness increases the chances of weak bidders to win the auction. Finally, they show that by changing from random close to quasi-hard close set up, the winning bid decreases significantly.

Oliveira et al. (2019) investigate what would happen if the random closing rule was replaced by another rule in terms of prices. They show that the duration of the random phase has a negative impact on prices and a positive one on the number of bids received. Thus, they also conclude that closing the auction randomly does not produce optimal prices, essentially when closing within seconds. They show that the lowest prices came when discounts were larger rather than more frequent. Thus, they propose to increase the average and minimum length of the random phase and to require a minimum decrement over the bidder's previous bid in order to minimize prices in electronic reverse auctions.

3 Institutional Background

3.1 Organization of the auctions

According to the Brazilian procurement legislation, Federal Law no 8.666/93, any level of Brazilian government (Federal, state or municipal) must use competitive tendering as a procedure to make a purchase of a good, perform a work, or acquire a service through third parties. We consider here the Open Hybrid Competitive Bidding ('Pregão') which is a reverse first-price sealed-bid auction followed by a reverse English auction in which any supplier is allowed to submit a bid.

Thus, we consider the following steps of the procurement process:

1. Firms decide to enter the auction

2. Conditional on entry, firms decide the level of the sealed bid they submit.

3. After the sealed bids are revealed, the suppliers are able to improve their bids until the auction finishes[4]

Firms have to decide whether they prepare a bid for the auction or not. Before making the decision to participate in the auction, firms are not aware of all the information they need to submit a bid. They need to request price quotes from their own suppliers, secure inventories for filling the orders, and make sure that their legal status and tax compliance is well documented. Accountants and legal attorneys are particularly important in this phase, besides the salespeople in charge of placing the bids.

Once they want to participate, firms have to submit a sealed bid in order to get into the open bid phase. For the electronic auctions, it appears that there is no restriction[5] in terms of level

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[4]   Regardless of placing a bid during the open bid phase, firms are eligible to be awarded. It depends on the qualification of the bidders with the best bids.

[5]   The Decree 3.555/2000, which regulates the "pregão presencial", provides for exclusion. Art. 11 "VI - the auctioneer will proceed to open the envelopes containing the price proposals and will classify the author of the proposal of lowest price and those who have submitted proposals in successive amounts and higher by up to ten percent, relative to the lowest price; VII - when at least three written price proposals are not verified in the conditions defined in the previous section, the auctioneer will classify the best subsequent proposals up to a maximum of three, so that their authors participate in the verbal bids, whichever prices

of the bid in order to proceed to the next stage. In this sense, the sealed bid phase matters only if it turns out that there is just one single bidder.

If there is more then one bidder, firms get in the open bid phase and may submit several bids. All bidders have a dominant strategy of bidding up to their valuation. This auction is efficient as the bidder with the highest value / lowest marginal cost wins the auction.[6]

3.2 Small Firm Policies

First, we describe the definition of a small and micro business (SMB) – see Table 1. Since 2006, a firm is regarded as micro if its turnover is lower than 360,000 BRL and as small if its turnover is strictly greater than 360,000 BRL and lower than 3,600,000 BRL. This last threshold increased in 2016 up to 4,800,000. A SMB, since 2006, may register to a preferential tax regime, Simples Nacional.

Second, we describe the regulation in public procurement favoring SMBs. In 2006, two measures were implemented:

1. a bid preference regime. A SMB would win the auction not only if their bid was the lowest or, but also if they were the second-ranked bidder and their own bid was at most 10% higher than the best-ranked bid at the closure time, as long as they exercised their right to undercut the current winner in due time.

2. a differentiated and simplified treatment MIGHT be granted to SMB. A set aside auction MIGHT take place for SMBs if the reserve total price was below 80,000BRL, or for a quota up to 25% of the annual object purchases (merchandise or service) procured.

In 2014, a change in regulation was implemented, according to which the differentiated treatment SHOULD be granted to SMBs. Since 2006, no differentiated treatment has been applied in case of less than three eligible SMB competitors, or in case the treatment would not be

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were offered in the written proposals" (Brazil, 2000 apud Fiuza and Medeiros (2014)). In turn, Decree No. 5,450 / 2005, which regulates the electronic "pregão", does not contain any device that restricts the number of participants between the sealed bid and open bid phases (Fiuza and Medeiros, 2014).

[6]   We do not consider here the case that the lowest bidder may not be awarded for now.

advantageous.

It is worth noting that, as from 2006 , the treatment would not take place if it was not expressly provided for in the bidding notice or if the purchasing agency was able to replace the tender with a direct purchase (the legislation provides for a great number of such cases, related to patents, market exclusivity, emergency and so on), but one such case of direct purchase was excluded in 2014: small value — in this case, the purchase must be made from a SMB without bidding, as long as the price is compatible with the market price or previous government purchases[7].

Table 1: Regulation change in Brazilian public procurement

Date	Legislation	About
1993	Federal procurement law 8.666/93	Open competitive bidding
2002	Law 10.520/02	Reserve auction + Electronic reverse auctions
2005	Decree	Electronic reverse auctions become mandatory
2006	Supplementary Law 123/2006	special treatment MAY be granted to SMB
2014	Supplementary Law 147/2014	special treatment SHALL be granted to SMB

4 Data

This section provides a description of our data. We start with a description of the data sources and how we construct our sample in Subsection 4.1. We then describe our data at the auction level in Subsection 4.2 and at the firm level in Subsection 4.3.

4.1 Sources

We study Brazilian public procurement auctions conducted between 2004 and 2018 using data from the ComprasNet's Data Warehouse. It contains information on all purchases made by the Federal government, either through pooled procurement (price registration) or through a standard individual procurement.[8]

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[7]   For more details, we refer the reader to Subsection A.3 in the Appendix.

[8]   This data set also includes information on all purchases made by state and local governments through pooled procurement, in which the Federal government participates, either as a managing agency or as a mere participating agency.

We consider only the public purchases made on the following procurement formats: immediate purchases of a single buyer and framework contracts with many buyers. We exclude presential auctions. The analysis was limited to the purchases of pharmaceuticals which are also subsidized in the "Farmacia Popular" program. Generally, for pharmaceutical products all items are well described, standardized and codified following the Brazilian Catalog of Materials and Services classification.

In the following, we will describe first the characteristics of the auctions and then turn to a more detailed description on the firm level. For this, we have created a data set of potential bidders, which we aggregated to the auction level for subsection 4.2.

4.2   Auction level statistics

Table 2 gives descriptive statistics at the auction level. The unit of observation is one lot, which for simplification we will just refer to as an auction. The data stem from 13,010 lots (or auctions) which are tendered by 536 different buyers for drugs of 22 different active ingredients. There are 1,206 distinct suppliers participating in the tenders.

As described earlier, there were two changes in the law, one in 2007 and the other one in 2014. We observe that six percent of all auctions were held before the introduction of the first Small Business Act in 2007, 53 percent between 2007 and 2014, and 41 percent after the second regulatory change in 2014. 20 percent of all auctions are set aside auction lots, three quarters of which were done after 2014 (15 percent of the whole sample).

Regarding the lot characteristics, 94 percent of the auctions are framework contracts; the maximum duration of a framework agreement is one year[9] – we report the unconditional mean including zeros for non-framework contracts. The mean price per auction is around 67 thousand BRL and the lot size is on average 350 thousands units. 96 percent of all auctions have a lot value below 80 thousand BRL and therefore eligible to be a set aside.

To obtain buyer characteristics, we construct a measure for the experience of the auctioneer.

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[9]   The statutory time limit for the agreement is one year, although in theory a member of the pool could be able to sign a contract longer than that; we have not found any such situation in our sample.

Table 2: Descriptive statistics

	Mean	S.D.	Min.	Med	Max	Obs.
SMB policies						
Small Business Act (2007)	0.94	0.24	0.00	1.00	1.00	13010
Small Business Act (2014)	0.41	0.49	0.00	0.00	1.00	13010
Set-Aside Auction (SBA 2007)	0.20	0.40	0.00	0.00	1.00	13010
Set-Aside Auction (SBA 2014)	0.15	0.36	0.00	0.00	1.00	13010
Duration of open bidding phase (minutes)	80.57	254.32	2.00	44.00	5929.00	13010
Framework contract	0.94	0.23	0.00	1.00	1.00	13010
Framework contract length	339.38	87.01	0.00	364.00	366.00	13010
Total est. price (in 1000 BRL)	66.82	956.13	0.00	1.00	62010.31	13010
Lot quantity in 1000	348.95	4320.88	0.00	1.50	1.0e+05	13010
Lot value above 80k BRL	0.04	0.19	0.00	0.00	1.00	13010
Buyer characteristics						
Auctioneer experience, total	7.72	13.28	1.00	3.00	87.00	13010
Lot Buyer HHI	0.92	0.19	0.05	1.00	1.00	13010
Lot # Buyers	1.45	1.50	1.00	1.00	44.00	13010
Participation						
# bids per bidder	3.21	6.02	0.00	2.00	125.00	13010
# Bidders (Potential)	20.79	11.29	1.00	19.00	69.00	13010
# Bidders (Sealed phase)	5.50	3.88	1.00	5.00	39.00	13010
# Bidders (Open phase active)	3.00	2.58	0.00	3.00	27.00	13010

We define this measure as the number of past auctions the auctioneer has participated in. In our sample, an auctioneer has participated on average in eight auctions, with a median of three auctions. A buyer may be representing a consortium of different entities, if the auction is for a framework agreement. On average, a buyer represents 1.45 different entities, and the quantity-adjusted concentration measured by an Herfindahl-Hirschman-Index is on average 0.92. This means that while there may be some other entities represented in the consortium, most of the quantity goes largely to one consortium member.

Finally, we construct measures of bidder participation. We calculate the number of bids each firm submits during the bidding process as well as the number of potential bidders, the number of bidders in the sealed bidding phase and the number of active bidders in the open phase. We observe on average 21 potential bidders. Out of these, 5.5 firms submit a sealed bid and hence participate. If we only look at firms that submit bids in the open phase, we find on average three participants. Finally, participants submit on average three bids in the open phase.

In Table 3, we compare the characteristics of our auction sample across time. For this, we divide our sample in three parts reflecting the different regulatory regimes. We first observe that before 2007, there were no set-aside auctions. After the first regulatory change that favors small firms, we see that 9 percent of the auctions in our sample were set-asides. This further increased after the new regulation in 2014, after which 37 percent of auctions were set-asides. This suggests that the 2014 regulation led to a higher enforcement of set aside auctions.

We also note that the average duration of an auction became shorter over time. We also observe that the lot size (quantity) tends to get smaller. For the other characteristics there is no clear pattern. Buyers seem to be less concentrated over time, with auctioneers being less experienced.

Finally, looking at participation, we observe that the average number of potential bidders and the average number of bidders engaging in the open phase is increasing over time. A substantial part of this increase in participation is driven by SMB: Overall, the number of potential SMBs increases, as well as the number of SMBs submitting a bid and actively participating in the open phase of the auction. In turn, we see that among the winners of auctions, the share of SMB has greatly increased from 21 percent in the old regime to 74 percent in the second regulation.

In Table 4, we look in more detail at the aggregate participation decisions, distinguishing three periods (2006-07, 2007-14, 2014-18) and two types of auctions (set aside and not set aside). For comparison, we also report the full sample results in the second column. As the number of potential bidders is increasing over time, the average number of potential bidders is at first sight higher for set asides than for non-set asides (20.56 vs. 21.70). Once we exclude the pre-set-aside period, this does not hold anymore. We find that there are fewer potential bidders (20.34 vs 19.56 before 2014, 22.48 vs. 22.37 after 2014) in set-asides auctions. Focusing on SMB only, we note the reverse pattern. For set asides auctions, there were more potential bidders compared to non-set-aside auctions before (12.05 vs. 10.14) and after the second regulation (15.22 vs. 13.70). The same pattern we observe for actual participation (submitting a sealed bid and being active in the open bid phase). While there are generally more firms participating in non-set-aside auctions, the number of SMB participating in set-aside auctions is distinctively

Table 3: Descriptive statistics (mean)

	old regime 2006-07	1st regulation 2007-14	2nd regulation 2014-18
	Mean	Mean	Mean
auction's type			
Set-Aside Auction (SBA 2007)	0.00	0.09	0.37
Duration of open bidding phase (minutes)	123.86	89.83	62.14
Lot characteristics			
Framework contract	0.79	0.94	0.97
Framework contract length	269.95	335.95	354.43
Total est. price (in 1000 BRL)	61.31	75.38	56.77
Lot quantity in 1000	629.77	430.05	202.62
Lot value above 80k BRL	0.05	0.04	0.04
Buyer characteristics			
Auctioneer experience, total	10.55	8.70	6.03
Lot Buyer HHI	0.99	0.96	0.86
Lot # Buyers	1.09	1.25	1.77
Participation			
# bids per bidder	2.96	2.86	3.69
# Bidders (Potential)	14.40	20.27	22.44
# Bidders (Sealed phase)	5.72	5.40	5.58
# Bidders (Open phase active)	2.09	2.70	3.51
# SMB (Potential)	3.64	10.32	14.26
# SMB (Sealed phase)	1.33	2.82	4.20
# SMB (Open phase active)	0.40	1.41	2.70
# SMB (winning)	0.21	0.54	0.74
Observations	825	6821	5364

higher. While by definition set asides are only won by SMB, the share of SMB winning a non-set-aside increases over time.

Table 4: Participation

	All	Non-SA	2006-07	2007-14	2014-18	SA	2007-14	2014-18
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
# bids per bidder	3.21	2.89	2.96	2.71	3.21	4.48	4.34	4.53
# Bidders (Potential)	20.79	20.56	14.40	20.34	22.48	21.70	19.56	22.37
# Bidders (Sealed phase)	5.50	5.79	5.72	5.61	6.12	4.34	3.32	4.66
# Bidders (Open phase active)	3.00	3.02	2.09	2.77	3.70	2.92	2.02	3.20
# SMB (Potential)	11.52	10.78	3.64	10.14	13.70	14.46	12.05	15.22
# SMB (Sealed phase)	3.29	3.03	1.33	2.77	3.92	4.34	3.32	4.66
# SMB (Open phase active)	1.88	1.61	0.40	1.35	2.40	2.92	2.02	3.20
# SMB (winning)	0.60	0.47	0.21	0.47	0.55	1.00	1.00	1.00
Observations	13010	10402	825	6195	3382	2608	626	1982

4.3 Firm level statistics

In this subsection, we describe the characteristics of firms in our sample and their behavior in the auctions. Table 5 contains the respective statistics. In our sample of potential participants to the auctions, we see that 60% of firms are SMB and 8% are producers. The average capital value amounts to 18 Million BRL. The distance between the supplier and buyer is around 1164 km in average. In terms of bidding behavior, we note that 28% of firms have submitted a sealed bid. In our sample (we restricted our sample to e-auctions), all firms submitting a sealed bid qualify to the open bid phase. Not all of these are very active though - 45 percent only submit one open bid (which is presumably their initial sealed bid). On average, firms submit three bids in the open phase. Finally, we also report bid levels per unit, which due to the heterogeneity between drug types are not necessarily comparable. Still despite this heterogeneity, we see that the last open bid of firms is on average lower than the sealed bid, and the final price is on average lower than the average last open bid.

Table 5: Bidder level descriptive statistics

	Mean	S.D.	Min.	Med	Max	Obs.
Firm characteristics						
SMB	0.60	0.49	0.00	1.00	1.00	251614
Producer	0.08	0.26	0.00	0.00	1.00	251614
Cap.val. (Million BRL)	18.14	92.73	0.00	0.35	1633.00	217231
Distance Supplier-Buyer	1164.37	887.39	0.00	1002.69	4162.56	250471
Firm behavior						
Sealed bid submitted	0.28	0.45	0.00	0.00	1.00	251614
Open bid submitted	1.00	0.00	1.00	1.00	1.00	71499
Only one open bid	0.45	0.50	0.00	0.00	1.00	71499
# bids per bidder	3.00	5.47	0.00	2.00	126.00	71924
Bid levels						
Sealed bid (unit)	9.52	729.79	0.00	0.40	1.8e+05	71922
Last open bid (unit)	6.83	667.77	0.00	0.18	1.8e+05	71499
Final price (unit)	4.01	11.88	0.01	0.10	900.00	13010

We decompose these statistics across regulatory regimes and auction types in table 6. As before, we observe that along time the share of SMBs among potential bidders increases. By definition, the share of SMBs in set-asides is 100 percent in this sample as here we excluded the firms which may not bid. The share of firms producing a drug is higher in non-set-aside auctions. Looking at participation rates, one notes that before 2007, 40 percent of firms eligible firms

Table 6: Bidder behavior SA/NSA

	All	Non-SA	2006-07	2007-14	2014-18	SA	2007-14	2014-18
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Firm characteristics								
SMB	0.60	0.52	0.25	0.50	0.61	1.00	1.00	1.00
Producer	0.08	0.08	0.10	0.10	0.06	0.02	0.05	0.02
Cap.val. (Million BRL)	18.14	21.35	55.29	28.82	6.30	0.67	0.69	0.67
Distance Supplier-Buyer	1164.37	1153.60	906.98	1076.65	1318.75	1225.52	1008.44	1279.92
Firm behavior								
Sealed bid submitted	0.28	0.28	0.40	0.28	0.27	0.30	0.28	0.31
Open bid submitted	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Only one open bid	0.45	0.48	0.63	0.51	0.40	0.33	0.39	0.31
# bids per bidder	3.00	2.71	2.91	2.53	2.96	4.59	4.34	4.64
Bid levels								
Sealed bid (unit)	9.52	10.30	6.52	5.70	18.94	5.36	5.16	5.40
Last open bid (unit)	6.83	7.39	5.42	4.29	13.05	3.87	3.64	3.92
Final price (unit)	4.01	4.05	4.48	3.76	4.48	3.87	3.44	4.00
Observations	251614	213913	11882	126019	76012	37701	7543	30158

joined the auctions, while this share decreased subsequently. Moreover, it seems that set-asides have become more successful in attracting eligible bidders: while between 2007 and 2014 the two forms attracted around 28 percent of firms, after 2014 set-asides attracted 4 percentage point more participants. We also notice that the bids in the different phases and the final price decreased on average after the first regulation, but skyrocketed during the second regulation in non set aside auctions. We have the same variation in bid and final prices between the two regulations in the set aside auctions.

4.4 Money left on the table

Before describing our empirical approach, we finally comment on another auction outcome: The distance between the final bids of the winner and the firm that was just not winning the auction. We report this variable in absolute and relative terms, and distinguishing by auctions when the right to undercut was invoked or not, and the different regulatory regimes (SA/NSA) and time periods. This analysis is complicated by the fact that sometimes firms which are supposed winners may not be able to supply the documentation; we only considered firms able to supply. The right to undercut was proposed and accepted 318 times (114 SMB were involved), but only 255 times (103 SMB) it led a SMB to win. The others were disqualified. We further dropped cases when the relative distance was higher than 95 percent. The descriptive

statistics for median "money left on the table" can be found in table 7.

We notice that in an average auction in our sample, the relative difference between the winning and the next lowest bid is around 8 percent. When the right to undercut was invoked, this difference collapses to around 0.5 percent, as small firms then only just undercut the big firms. Comparing set-asides and non-set-asides where no right to undercut was invoked, we note that the relative difference in set-asides was half as much as in non-set-asides before 2014 (5.26 vs. 10 percent) but then converged (9.09 vs. 8.50 percent).

Table 7: Money left on the table ($<=95\%$) by period: Med

	All	SA	before 2014	after 2014	Non-SA	before 2014	after 2014
	Med	Med	Med	Med	Med	Med	Med
All auctions	8.19	8.18	5.26	9.09	8.50	9.09	7.69
Right to undercut invoked	0.53	.	.	.	0.53	0.72	0.14
Right to undercut not invoked	8.89	8.18	5.26	9.09	9.17	10.00	8.50
Observations	11673	2246	512	1734	8667	5554	3113

5 Empirical approach

5.1 Supplier behavior

Right to undercut We now explain our strategy for identifying econometrically how the type of small firm policy affects participation and prices of suppliers in the auctions. Our approach relies on using variation over time in the participation and pricing decisions for different regulatory regimes. We estimate a linear model with observations at the level of the supplier (f) and auction (a) level, occurring in different locations (s) for different active ingredients (d) and points in time (t):

$$
\begin{aligned}
y_{f,a,d,s,t} &= \beta_1' X_{f,a,d,s,t} + \beta_2 SBA2007_t + \beta_3 SBA2014_t \\
&\quad + \beta_4 SMB_{f,t} + \beta_5 SBA2007_t \cdot SMB_{f,t} + \beta_6 SBA2014_t \cdot SMB_{f,t} \\
&\quad + \varepsilon_f + \varepsilon_d + \varepsilon_s + \varepsilon_t + \epsilon_{f,a,s,t}.
\end{aligned}
\tag{1}
$$

where $y_{f,a,t}$ is an outcome of a suppliers decision regarding participation, the level of the sealed bid and the level of the final bid. $X_{f,a,t}$ is a vector measuring different auction and firm characteristics. The $SBA2007_t$ and $SBA2014_t$ indicators are supposed to measure the average change in firm behavior subsequent to the introduction of a new policy. To identify the effect of the policy on the behavior of small firms, we add an interaction of the SBA indicators and $SMB_{f,t}$, the latter being an indicator variable whether firm f is considered as a micro or small firm at the time of bidding. Note that suppliers firm size can change over time, therefore we also control for $SMB_{f,t}$ without the interaction. Other unobserved factors could also affect the decision of suppliers. To control for time-constant unobserved heterogeneity between suppliers, we employ supplier fixed effects ε_f. Second, to rule out that unobserved time-invariant heterogeneity among drug markets and locations drives our result, we employ drug market (ε_d) and buyer-state fixed effects (ε_s). By this, we essentially compare the behavior of suppliers in auctions of different buyers within the same drug market in a state both, before and after the regulatory change. Third, we also control for overall changes in supplier behavior at the national level by employing year fixed effects (ε_t).[10] The error term captures determinants of the decisions that are not accounted for in the controls. Getting an unbiased estimate of the the policy's impact on small firms (β_5 and β_6) requires the regulatory changes (SBA) to be uncorrelated with those determinants. The standard errors are clustered at the auction level and are robust to heteroscedasticity.

Comparison of small firm policies As the set aside policy was introduced at the same time as the right to undercut, one can compare how these policies affect the participation and pricing decision of small suppliers. For this, using a sample of only small suppliers, we estimate first

$$
\begin{aligned}
y_{f,a,s,t} = {} & \beta_1' X_{f,a,s,t} + \beta_2 SBA2007_t + \beta_3 SBA2014_t \\
& + \beta_4 SBA2007_t \cdot Setaside_{a,s,t} + \beta_5 SBA2014_t \cdot Setaside_{a,s,t} \\
& + \varepsilon_f + \varepsilon_s + \varepsilon_t + \epsilon_{f,a,s,t}.
\end{aligned}
\tag{2}
$$

---

[10] This comes at the expenses that the coefficient β_2, measuring the average change in behavior for all suppliers, is only interpretable within the year of the change. Therefore we do not report it in the tables.

where the coefficients β_4 and β_5 allow us to see how small firms act differently in set-aside auctions after the introduction of the Small Business Act 2007 and 2014, compared to standard auctions which have just the right to undercut.

To get an impression how these effects compare to big firms, we also estimate the more extensive model using the whole sample of SMBs using the specification

$$
\begin{aligned}
y_{f,a,d,s,t} \;=\; & \beta_1' X_{f,a,d,s,t} + \beta_2 SBA2007_t + \beta_3 SBA2014_t + \beta_4 SMB_{f,t} \\
& + \beta_5 SBA2007_t \cdot SMB_{f,t} + \beta_6 SBA2014_t \cdot SMB_{f,t} \\
& + \beta_7 SBA2007_t \cdot SMB_{f,t} \cdot Setaside_{a,s,t} + \beta_8 SBA2014_t \cdot SMB_{f,t} \cdot Setaside_{a,s,t} \\
& + \varepsilon_f + \varepsilon_d + \varepsilon_s + \varepsilon_t + \epsilon_{f,a,s,t}.
\end{aligned}
\tag{3}
$$

In this specification, the coefficients β_5 and β_6 are conceptually similar to the coefficients β_5 and β_6 in specification (1), and the coefficients β_7 and β_8 reflect the similar finding of β_4 and β_5 of specification (2).

5.2 Buyer behavior

Complementary to our investigation of supplier behavior, we study as well how buyers make use of the possibility to do set asides, and how this changes due to the change of the Small Business Act in 2014. For this, we estimate the following equation:

$$
SetAside_{a,s,t} = \beta_1' X_{a,s,t} + \beta_2 SBA2007_t + \beta_4 SBA2014_t \cdot Z_{a,s,t} + \varepsilon_s + \varepsilon_t + \epsilon_{a,s,t}.
\tag{4}
$$

6 Results

6.1 The buyers' decision to do set-aside auction

We estimate first the decision to do a set aside auction using equation 4. Estimation is done with a linear probability model as this eases computation with fixed effects. The sample focuses

naturally on auctions implemented since 2007. Table 8 reports the results. The specifications differ in the amount of fixed effects included.[11] We describe the coefficients for the "strictest" specification in column (3). Lots which are framework contracts and which form part of a bigger batch are significantly less likely to be auctioned as a set aside. Similarly, set asides are less likely the more experience the auctioneer has, and the more potential bidders are available. Conversely, if there are many SMB in 150km distance to the buyer, this increases significantly the likelihood of a set aside. By having one more a potential bidder decreases the probability to do a set aside auction by 1%, but if this bidder is small or micro and in an 150km area, then the likelihood is increased by 3%. While the threshold of 80000 BRL does not play a role before 2014, we see that after the new regulation in 2014 being above the threshold decreases the likelihood of a set aside significantly by 34 percentage points.

Table 8: Different regressions on set aside auction (SBA 2007)

	(1)		(2)		(3)	
	β	SE	β	SE	β	SE
Framework contract	−0.18***	(0.04)	−0.16***	(0.04)	−0.15***	(0.04)
Framework contract length	−0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Total value of batch	−0.00***	(0.00)	−0.00***	(0.00)	−0.00***	(0.00)
Total est. price (in 1000 BRL)	0.00*	(0.00)	0.00**	(0.00)	−0.00	(0.00)
Lot quantity in 1000	0.00***	(0.00)	−0.00	(0.00)	0.00	(0.00)
Lot value above 80k BRL	−0.07***	(0.01)	−0.01	(0.01)	−0.01	(0.01)
SBA (2014)*above 80K	−0.31***	(0.01)	−0.33***	(0.01)	−0.34***	(0.01)
Number of lots in batch	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Auctioneer experience, total	−0.21***	(0.04)	−0.15***	(0.03)	−0.16***	(0.04)
# Bidders (Potential)	−0.00*	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)
# SMB (Pot.) in 150km radius area	0.02***	(0.00)	0.02***	(0.00)	0.03***	(0.00)
Constant	0.44***	(0.05)	0.49***	(0.03)	0.47***	(0.04)
Regulation change	Yes		Yes		Yes	
Year FE	Yes		Yes		Yes	
API FE	No		Yes		Yes	
State FE	No		No		Yes	
Observations	12185		12185		12185	
R^2	0.18		0.20		0.25	
R^2 within	0.05		0.05		0.05	

Dependent variables: Indicator "Auction is a Set Aside". Unit of observation: Auction. Regressions include fixed effects as indicated in the lower panel. Standard errors are robust to heteroscedasticity and adjusted for serial correlation inside clusters.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

---

[11] In table 13 in Annex E we also apply stricter fixed effects (product rather than the active ingredient) and find results qualitatively unaffected.

6.2 Supplier behavior

6.2.1 Non set aside auctions

In the following, we discuss how the behavior of suppliers differs across the different type of auctions and time periods. In the first analysis, we focus only on non-set-aside auctions. These existed before the implementation of the Small Business Act 2007 already and have only been modified in the sense that the right to undercut was introduced for small firms. For this purpose, we estimate equation 1 for different dependent variables: first, the decision to participate, second, the (log of the) level of the last open bid, third, the (log of the) resulting price level, and finally, our measure for the relative amount of "money left on the table". We report the corresponding results in table 9.

We comment first now on the first specification on the effects on participation. Note that while we use firm fixed effects, the status of being a small firm may change over time. We see that that if the same firm becomes small over time, this increases its the probability to participate to the auction by 15 percentage points. When the first regulation favoring small firms is implemented in 2007, the likelihood of participation increases by 2 percentage points, and by further 1 percentage point in 2014. Focusing now on the level of the last open bid, we again see that when a firm becomes small, it bids more aggressive (10.4 percent less , given by 100(exp(-0.11)-1)=-10.4%). With the second regulation (2014), small firms further bid more aggressively, bidding 11.3% less, while the first regulation does not have any significant effect. The effect of other control variables on bidding is comparable to the effect on the participation decision. Interestingly, we do not see any significant differences for small firms regarding the final price resulting from the auctions, and also there is not difference in the money left on the table (with common significance levels).

Besides these main results, we see that generally participation is positively affected by a higher quantity of the lot, a higher engineer estimate for the price, and a lower buyer fragmentation. For SMBs, the effect of quantity is significantly smaller. If the engineer estimate increases by 1%, the participation increases by 0.03%, the last open bid by 0.27%, the final price by 0.25% and the money left on the table by 1.52% As for the competition, it impacts only the last open

bids and the prices. If there is one more potential bidder, then those prices decrease by 1% both of them.

We conclude by noting that the right to undercut does not have a direct impact on the final price. However, as entry into auctions decreases prices, and the right to undercut triggers more participation, there is an indirect price decreasing effect.

Table 9: Regression on non set aside auctions

	(1) Part.		(2) Last Op. bid		(3) Fin. price		(4) Money left on table	
	β	SE	β	SE	β	SE	β	SE
SMB	0.15***	(0.01)	−0.11**	(0.05)	0.04	(0.09)	4.36	(6.79)
SMB*SBA 2007	0.02**	(0.01)	−0.07	(0.05)	−0.08	(0.09)	−11.83*	(6.52)
SMB*SBA 2014	0.01**	(0.01)	−0.12***	(0.02)	−0.02	(0.03)	2.20	(1.84)
Framework contract	−0.03*	(0.02)	−0.24***	(0.06)	0.03	(0.09)	−3.86	(5.69)
Framework contract length	0.00***	(0.00)	0.00	(0.00)	−0.00**	(0.00)	0.02	(0.01)
Engineer estimate (Log, unit)	0.03***	(0.00)	0.27***	(0.01)	0.25***	(0.01)	1.53***	(0.42)
Log(Quantity)	0.05***	(0.00)	−0.04***	(0.00)	−0.08***	(0.00)	−2.14***	(0.23)
Log(Qty)*SMB	−0.02***	(0.00)	0.02***	(0.00)	0.01	(0.00)	0.53**	(0.27)
Auctioneer experience, total	−0.00***	(0.00)	0.00	(0.00)	0.00***	(0.00)	−0.01	(0.03)
Lot Buyer HHI	−0.02***	(0.01)	−0.03	(0.03)	0.02	(0.04)	4.09*	(2.28)
Lot # Buyers	−0.00	(0.00)	0.01***	(0.00)	0.00	(0.00)	0.19	(0.27)
Distance Supplier-Buyer	−0.00***	(0.00)	0.00***	(0.00)	0.00	(0.00)	−0.00	(0.00)
Lots won last year	0.01***	(0.00)	−0.01***	(0.00)	−0.00***	(0.00)	0.07*	(0.04)
# Bidders (Potential)	−0.00***	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)	−0.03	(0.07)
Share SMB (Potential)	0.04***	(0.01)	0.01	(0.05)	0.10*	(0.05)	1.80	(3.06)
(Pot)Comp Distance	−0.00***	(0.00)	−0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)
(Pot)Comp Lots won LY	0.00	(0.00)	0.00***	(0.00)	−0.00***	(0.00)	−0.03	(0.02)
Duration of open bidding phase (minutes)			0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)
Constant	0.08***	(0.02)	−0.40***	(0.07)	−0.48***	(0.09)	34.38***	(5.23)
Firm FE	Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes	
API FE	Yes		Yes		Yes		Yes	
Regulation change	Yes		Yes		Yes		Yes	
State FE	Yes		Yes		Yes		Yes	
Observations	212791		59058		10099		9191	
R^2	0.20		0.87		0.95		0.24	
R^2 within	0.05		0.10		0.22		0.02	

Dependent variables: participation (column1), last open bid (column (2)), final price (column (3)) and relative discount when only active firms bidding lower than the estimated price (column (4)). Unit of observation: bid level (column 1 -3), auction level (column 4). Regressions include fixed effects at firm level. Standard errors are robust to heteroscedasticity and adjusted for serial correlation inside clusters. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.2.2 Comparing different policies only for small firms

We focus now only on how the decisions of small firms differ across auction formats. For this purpose, we estimate equation 2, again for the different dependent variables: first, the decision to participate, second, the (log of the) level of the last open bid, third, the (log of the) resulting price level, and finally, our measure for the relative amount of "money left on the table". We report the corresponding results in table 10.

We find that when an auctioneer uses a set aside auction in 2007, this had a more positive impact on the decision of the SMB to participate to the auction compared to the introduction of the right to undercut. In comparison to non-set-asides in 2007, the likelihood of the participation of small firms increased by 3 percentage points. With the reform in 2014, this difference did not change significantly.

While the evidence about the effect on the last open bid is mixed, we see that if an SMB wins, the price is significantly higher in a set aside auction 2007 (by 11 percent). Only with the reform in 2014, this direct price effect is reversed by 18 percent, such that the net direct price effect of having a set aside vs. a non-set aside becomes negative. Regarding the difference of the winning and the next lowest bid, we see that the change in 2014 is associated with a higher discount by the winning firm.

Summarizing, we see that, first, the implementation of the set aside auctions with the first regulation increased the participation of SMBs; second, this implementation had a direct price increasing effect. The net effect of the indirect negative price effect via increased participation and the price increasing effect needs to be assessed further. Moreover, we notice that the change in regulation in 2014 has no additional impact on small firm participation but has a negative one on the level of last open bids (decreased by 9%), final price (decreased by 16.5%) and money on the table (increased by 5.2%).

Table 10: Regression on SMB only

	(1) Part.		(2) Last Op. bid		(3) Fin. price		(4) Money left on table	
	β	SE	β	SE	β	SE	β	SE
Set-Aside Auction (SBA 2007)	0.03***	(0.01)	0.03	(0.03)	0.11***	(0.04)	−2.95	(2.13)
Set-Aside Auction (SBA 2014)	−0.00	(0.01)	−0.09**	(0.04)	−0.18***	(0.04)	5.20**	(2.36)
Framework contract	−0.01	(0.02)	−0.51***	(0.10)	−0.10	(0.16)	10.65	(10.19)
Framework contract length	0.00**	(0.00)	0.00	(0.00)	−0.00	(0.00)	−0.02	(0.03)
Engineer estimate (Log, unit)	0.05***	(0.00)	0.31***	(0.01)	0.27***	(0.01)	1.70***	(0.50)
Log(Quantity)	0.03***	(0.00)	−0.02***	(0.00)	−0.06***	(0.01)	−1.13***	(0.29)
Auctioneer experience, total	−0.00***	(0.00)	0.00**	(0.00)	0.00*	(0.00)	−0.06	(0.04)
Lot Buyer HHI	−0.04***	(0.01)	0.01	(0.04)	−0.02	(0.05)	0.85	(2.44)
Lot # Buyers	−0.00**	(0.00)	0.02***	(0.00)	−0.00	(0.01)	0.24	(0.35)
Distance Supplier-Buyer	−0.00***	(0.00)	0.00***	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Lots won last year	0.01***	(0.00)	−0.02***	(0.00)	−0.01***	(0.00)	0.03	(0.08)
# Bidders (Potential)	−0.00***	(0.00)	−0.00*	(0.00)	−0.01***	(0.00)	0.03	(0.09)
Share SMB (Potential)	0.05***	(0.02)	0.07	(0.06)	0.11*	(0.07)	1.04	(4.02)
(Pot)Comp Distance	−0.00***	(0.00)	−0.00	(0.00)	−0.00	(0.00)	0.00	(0.00)
(Pot)Comp Lots won LY	0.00	(0.00)	0.00***	(0.00)	−0.00*	(0.00)	0.04	(0.03)
Duration of open bidding phase (minutes)			0.00***	(0.00)	0.00	(0.00)	−0.00	(0.00)
Constant	0.18***	(0.03)	−0.28**	(0.11)	−0.48**	(0.21)	47.55***	(14.94)
Firm FE	Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes	
API FE	Yes		Yes		Yes		Yes	
Regulation change	Yes		Yes		Yes		Yes	
State FE	Yes		Yes		Yes		Yes	
Observations	149019		41981		7007		6140	
R^2	0.16		0.82		0.94		0.23	
R^2 within	0.03		0.10		0.24		0.01	

Dependent variables: participation (column1), last open bid (column (2)), final price (column (3)) and relative discount when only active firms bidding lower than the estimated price (column (4)). Unit of observation: bid level (column 1 -3), auction level (column 4). Regressions include fixed effects at firm level. Standard errors are robust to heteroscedasticity and adjusted for serial correlation inside clusters. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6.2.3 Comparison

Finally, we can now compare how the different effects compare to each other by using the full sample. For this, we estimate equation 3, again for the different dependent variables as before. We report the corresponding results in table 11.

We note now that a change in the SMB status is only affecting the participation decision, but not the bidding behavior in terms of bids submitted, final prices and money left on the table. We see that participation is increased generally by the Small Business Act in 2007: SMB participate more likely in non-set-aside auctions (+2 percentage points), and further more in set aside auctions (additional +3 percentage points). The 2014 reform does not change these differences in participation significantly. Looking at the effect of the reforms on the level of last bid submitted, we see that only the 2014 reform changed the way how SMB bid: They tend to bid more aggressively in non-set-aside auctions (-12 percent), and even more in set-asides

(additional -14 percent) after the set asides become quasi-mandatory for a given lot size. A effect on final price of the reforms is only visible for set asides. While the introduction of set asides led to increased bids in the phase 2007-2014, we see again as discussed before, this effect was reverted with the 2014 reform.

Table 11: Regression on all auctions

	(1) Part.		(2) Last Op. bid		(3) Fin. price		(4) Money left on table	
	β	SE	β	SE	β	SE	β	SE
SMB	0.13***	(0.01)	−0.08	(0.05)	−0.05	(0.09)	3.11	(6.52)
SMB*SBA 2007	0.02**	(0.01)	−0.07	(0.04)	−0.06	(0.09)	−11.37*	(6.30)
SMB*SBA 2014	0.00	(0.01)	−0.12***	(0.02)	−0.02	(0.03)	1.69	(1.74)
Set-Aside Auction (SBA 2007)	0.03***	(0.01)	0.03	(0.03)	0.12***	(0.04)	−2.83	(2.03)
Set-Aside Auction (SBA 2014)	−0.00	(0.01)	−0.10***	(0.04)	−0.18***	(0.04)	5.08**	(2.22)
Framework contract	−0.02	(0.02)	−0.29***	(0.06)	0.04	(0.09)	−1.69	(5.39)
Framework contract length	0.00***	(0.00)	0.00	(0.00)	−0.00**	(0.00)	0.01	(0.01)
Engineer estimate (Log, unit)	0.04***	(0.00)	0.28***	(0.01)	0.26***	(0.01)	1.60***	(0.37)
Log(Quantity)	0.05***	(0.00)	−0.04***	(0.00)	−0.08***	(0.00)	−1.96***	(0.22)
Log(Qty)*SME	−0.02***	(0.00)	0.02***	(0.00)	0.02***	(0.00)	0.60**	(0.24)
Auctioneer experience, total	−0.00***	(0.00)	0.00	(0.00)	0.00***	(0.00)	−0.03	(0.02)
Lot Buyer HHI	−0.02***	(0.01)	0.01	(0.03)	0.03	(0.03)	1.21	(1.93)
Lot # Buyers	−0.00	(0.00)	0.02***	(0.00)	0.00	(0.00)	0.11	(0.24)
Distance Supplier-Buyer	−0.00***	(0.00)	0.00***	(0.00)	0.00	(0.00)	−0.00	(0.00)
Lots won last year	0.00***	(0.00)	−0.01***	(0.00)	−0.00***	(0.00)	0.05	(0.03)
# Bidders (Potential)	−0.00***	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)	−0.01	(0.06)
Share SMB (Potential)	0.04***	(0.01)	0.01	(0.04)	0.07	(0.05)	1.94	(2.78)
(Pot)Comp Distance	−0.00***	(0.00)	−0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)
(Pot)Comp Lots won LY	0.00*	(0.00)	0.00***	(0.00)	−0.00***	(0.00)	−0.00	(0.02)
Duration of open bidding phase (minutes)			0.00	(0.00)	0.00	(0.00)	−0.00	(0.00)
Constant	0.07***	(0.02)	−0.41***	(0.07)	−0.44***	(0.08)	34.57***	(4.91)
Firm FE	Yes		Yes		Yes		Yes	
Year FE	Yes		Yes		Yes		Yes	
API FE	Yes		Yes		Yes		Yes	
Regulation change	Yes		Yes		Yes		Yes	
State FE	Yes		Yes		Yes		Yes	
Observations	250288		70159		12635		11370	
R^2	0.19		0.86		0.95		0.23	
R^2 within	0.04		0.10		0.23		0.02	

Dependent variables: participation (column1), last open bid (column (2)), final price (column (3)) and relative discount when only active firms bidding lower than the estimated price (column (4)). Unit of observation: bid level (column 1 -3), auction level (column 4). Regressions include fixed effects at firm level. Standard errors are robust to heteroscedasticity and adjusted for serial correlation inside clusters. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

7 Summary and Discussion

In this paper, we study policies that aim to support SME in government procurement auctions. While these firms are very important for the economy, they often have higher cost than larger firms due to difficulties in financing (higher interest rates, credit rationing), regulatory burdens, big competitors or tax complexity. To give SME an advantage in procurement, governments apply different methods. Classical examples are set asides and preference margins. Another

method, used in Brazil, is the right to undercut the prospected winner after the auction, conditional on that they have not been bidding too weak during the auction.

These policies may, however, lead to inefficiencies in the tender process. For example, restricting entry to SME through set asides can reduce efficiency and revenue substantially while increasing firm participation. Using detailed data from Brazilian e-auctions for pharmaceutical drugs, we compare set asides and the right to undercut and assess their effect on the participation decisions of firms, their bidding behavior, and the final price.

Our estimation results show that the right to undercut for small firms does not have a direct impact on the final price. There is, however, a significant indirect effect through increased participation that consequently lowers prices. Set aside auctions increase participation as well. However, without non-binding rules, set asides have a direct price increasing effect. This effect only diminishes after making set aside rules clearer. Overall, we find that in 2007 set asides have a stronger effect on participation decisions than the right to undercut. In 2014, making set asides mandatory for small lots is associated with more aggressive bidding.

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A   Description of Procurement procedures in Brazil

A.1   Public Procurement in Brazil

According to the Brazilian procurement legislation, Federal Law no 8.666/93, any level of Brazilian government agency (Federal, state or municipal) must use competitive tendering as a procedure to make a purchase of a good, perform a work, or acquire a service from third parties, except in a number of cases listed by the Public Procurement Law. In the Brazilian legislation, competitive bidding is defined as the administrative procedure whereby the public administrator selects, among all application submitted for the supply of works, goods or services, which one best serves the public interest, and awards to the winner the right to supply to the government. The Brazilian government agencies may use the following forms of procurement for goods, works and services:

1. Open Competitive Bidding (a reverse first-price sealed-bid auction in which any supplier is allowed to submit a bid),

2. Pre-Qualified Bidders (a reverse first-price sealed-bid auction in which only suppliers with solid track record of providing good for the government is allowed to bid),

3. Invited Bidders (a reverse first-price sealed-bid auction in which only invited bidders are allowed to bid),

4. Open Hybrid Competitive Bidding (a reverse first-price sealed-bid auction followed by a reverse English auction in which any supplier is allowed to submit a bid), and

5. Open Electronic Competitive Bidding (an electronic reverse English auction in which any supplier is allowed to submit a bid).

The value and type of product or service determines the form of procurement to be used. In general, goods, services and works of high values must be acquired through Open Competitive Bidding, while those of lower values can be acquired through Invited Bidders. For intermediate values, one can purchase them through Pre-Qualified Bidders. Open Hybrid and Electronic

Competitive Bidding can be used for purchasing of standardized goods and services of any value.

A.2   The bidding process

1. Publishing

   (a) The Brazilian System of Price Registration (PR) is a procurement system in which one or more public agencies and entities organize a competitive tender to acquire/purchase goods, and suppliers offer goods and services at uniform prices and terms for all members of the PR. The public entities may source from the winning supplier goods and services, and may order shipments of various sizes at their own convenience and without a predetermined frequency within a period of 12 months.

   (b) The PR Managing Agency (which can be any government agency) is in charge of doing a comprehensive market survey for determining the reserve price for each object, that is, its willingness to pay for the goods/services. No matter how many agencies pool for the acquisition of a same object in a lot, the price to be paid must be the same.

   (c) The procurement transactions in the Price Registration system must rely on an Open Competitive Bidding, Open Hybrid or Electronic Competitive Bidding. Lowest price is the only award criterion allowed in PR. According to the Brazilian law, the Price Registration system should be employed when a set of off-the-shelf goods or services are to acquired by more than one agency, entity, or government programs along a year; and/or when, by the nature of the goods, it is not possible to stipulate in advance with sufficient precision the demand for them.

   (d) There are basically two types of institutions in the Brazilian System of Price Registration(PR): buyers (public entities) and suppliers.

i. The buyers in a Price Registration pool are classified as managing agency, participating agency, or free-rider. A managing agency is the public entity responsible for the procurement procedures in the PR (e.g., invitation of suppliers for competitive bidding, market survey, specification of the demanded goods and quantities, definition of the reserve price, and running the auction), and also for managing all information in the procurement transaction. A participating agency is a public entity that participates in the purchase of goods and provides to the manager their detailed demands (in terms of product specifications and estimated quantities). A free-rider, in contrast, does not participate in the procurement process, but may apply for the acquisition of goods and services at prices and terms convened between the original pool and the awarded supplier, thus joining the pool **after** the object is awarded in the auction and the PR "minutes" (the official name for the framework agreement) are signed by the original buyers and sellers.

ii. Suppliers are all companies who compete for the contracts of supply of goods and services to be awarded through a PR procedure. Any firm that meets the requirements set by the managing agency may participate in the auction and, if selected, be awarded in the PR minutes. In theory (and in fact in a few cases in practice), more than one supplier may be awarded in a same lot, in case the lowest bid is submitted by a supplier who pledges a smaller quantity than the estimated total of the lot.

be that some of the firms are just too small to participate, or have only a regional focus. whether this information can be retrieved – In the data, there is the "estimated price".

2. Submitting a sealed bid

3. Participating in the open bid phase

(a) The Decree 3.555/2000, which regulates the "pregão presencial", provides for exclusion. Art. 11 "VI - the auctioneer will proceed to open the envelopes containing

the price proposals and will classify the author of the proposal of lowest price and those who have submitted proposals in successive amounts and higher by up to ten percent , relative to the lowest price; VII - when at least three written price proposals are not verified in the conditions defined in the previous section, the auctioneer will classify the best subsequent proposals up to a maximum of three, so that their authors participate in the verbal bids, whichever prices were offered in the written proposals" (Brazil, 2000 apud Fiuza and Medeiros (2014)).

(b) In turn, Decree No. 5,450/2005, which regulates the electronic "pregão", does not contain any device that restricts the number of participants between the sealed bid and open bid phases (Fiuza and Medeiros, 2014).

4. Awarding

(a) The bidder may submit the lowest bid, but fail to submit the required documentation or have a sample rejected (among other reasons). In these cases, the auctioneer should ask the second lowest to match the first price, but the latter may refuse to do so.

(b) Normally the auctioneer is not allowed to award the item when the price is above the estimated price, unless they provide a solid justification for that.

A.3   Small Firm Policies

In 2006

Small and Micro Business Definition

- A micro firm is defined as a firm having a yearly gross revenue equal to or less than BRL 360,000.00

- A small firm is define as a firm with a gross revenue larger than BRL 360,000.00 and equal to or lower than BRL 3,600,000.00.

General Micro and Small Enterprise Law, Complementary law 123, 2006

1. In the public procurement of the Union, the States and the Municipalities, differentiated and simplified treatment may be granted to micro-enterprises and small enterprises, with a view to promoting economic and social development at the municipal and regional levels, increasing the efficiency of public policies and the incentive to technological innovation, provided that provided for and regulated in the legislation of the respective body.

2. Brazil implemented legislation favoring SMBs in public procurement at the Federal level: bid preference program for SMB.

   (a) New types of auctions are created ("restricted auctions"): Set asides auctions if the auction has a reserve price below BRL 80.000,00. Public bodies can set aside 25% of eligible lots for favored companies. *In order to comply with the provisions of art. 47 of this Supplementary Law, the public administration may carry out a bidding process intended exclusively for the participation of micro and small enterprises in hirings whose value is up to BRL 80,000.00*

      i. Subcontracting to SMB

      ii. Preference margin regime: SMBs are also favored if their bids in reverse auctions are up to 5% higher than bids by non-favored firms.

   (b) Article 44. In the biddings will be ensured, as a tiebreaker criterion, preference of hiring for micro and small companies.

      i. Paragraph 1 A tie shall mean those situations in which the proposals submitted by micro and small enterprises are equal to or up to 10% (ten percent) higher than the best-ranked proposal.

      ii. Paragraph 2 In the "pregão", the percentage interval established in paragraph 1 of this article will be up to 5% (five percent) higher than the best price.

3. Article 49. The two previous points are not applied when

(a) the criteria for differentiated and simplified treatment for micro-enterprises and small enterprises are not expressly provided for in the bidding notice;

    i. there are not a minimum of three (3) competitive suppliers classified as micro or small enterprises located locally or regionally and capable of meeting the requirements established in the instrument convening;

    ii. the bidding is waived or unenforceable, under the terms of arts. 24 and 25 of Law No. 8,666 of June 21, 1993.

(b) A preferential treatment for micro and small enterprises program: BUT firms have to register to this program.

In 2014

Complementary law 147, 2014: some change in complementary law of 2006

1. In the direct contracting of the direct and indirect, autarchic and foundational, Federal, state and municipal administrations, differentiated and simplified treatment shall be granted to micro and small enterprises with a view to promoting economic and social development in the municipal and regional cooperation, enhancing the efficiency of public policies and encouraging technological innovation.

2. Bid preference program for SMB.

(a) Restricting auctions to SMB if the value is below 80k BRL becomes binding: *In order to comply with the provisions of art. 47 of this Supplementary Law, the public administration must carry out a bidding process intended exclusively for the participation of micro and small enterprises in hirings whose value is up to BRL 80,000.00*

    i. Quotas of 25 percent for SMB become mandatory

    ii. An increased threshold in preference margin regime: *The benefits referred to in the caput of this article may justifiably establish the priority of contracting*

for micro-enterprises and small enterprises based locally or regionally, up to the limit of 10% (ten percent) of the best valid price.

(b) The two previous points are not applied when

    i. differentiated and simplified treatment for micro-enterprises and small enterprises is not advantageous for the public administration or represents damage to the whole or complex of the object to be contracted;

    ii. the bidding is waived or unenforceable, under the terms of arts. 24 and 25 of Law No. 8,666 of June 21, 1993, except for the exemptions dealt with in items I and II of art. 24 of the same Law, in which the purchase should be made preferably from micro and small companies, applying the provisions in item I of art.48.

In 2016: Complementary law 155, 2016   Small and Micro Business Definition: the threshold for the small firms has increased, but stays the same for micro firm

1. A microfirm is still defined as a firm having a yearly gross revenue equal to or less than BRL 360,000.00

2. A small firm is now defined as a firm with a gross revenue larger than BRL 360,000.00 and equal to or lower than BRL 4,800,000.00.

Besides the benefits in awarding the contracts directly to SMBs, both versions of the Small Business Act have provided for subcontracting requirements, as long as the contracting agency had specified them in the bidding notice. Unfortunately we have no access to data from the contracts whether the subcontracting has been performed, let alone the amount subcontracted, the corresponding lot, and the corresponding subcontracted firm. And we have not scraped the bidding notices, therefore we have no such data whether subcontracting had been required, and in which lots. Hence, we are not able to assess the impact of this provision.

B Descriptive statistics

Table 12: Descriptive statistics (med)

	old regime 2005-2007	1st regulation 2007-2014	2nd regulation 2014-2018
	Med	Med	Med
auction's type			
Set-Aside Auction (SBA 2007)	0.00	0.00	0.00
Duration of open bidding phase (minutes)	51.00	47.00	40.00
Lot characteristics			
Framework contract	1.00	1.00	1.00
Framework contract length	364.00	364.00	364.00
Total est. price (in 1000 BRL)	0.64	0.74	1.60
Lot quantity in 1000	1.00	1.00	2.40
Lot value above 80k BRL	0.00	0.00	0.00
Buyer characteristics			
Auctioneer experience, total	4.00	4.00	3.00
Lot Buyer HHI	1.00	1.00	1.00
Lot # Buyers	1.00	1.00	1.00
Participation			
# bids per bidder	1.00	1.00	2.00
# Bidders (Potential)	13.00	18.00	21.00
# Bidders (Sealed phase)	5.00	4.00	5.00
# Bidders (Open phase active)	2.00	2.00	3.00
# SMB (Potential)	3.00	9.00	14.00
# SMB (Sealed phase)	1.00	2.00	4.00
# SMB (Open phase active)	0.00	1.00	2.00
# SMB (winning)	0.00	1.00	1.00
Observations	825	6821	5364

C Determinants of set-aside auctions with different FE

Table 13: Comparison of regression with different drug FE

	(1) aft. 2007		(2) aft. 2014		(3) aft. 2007		(4) aft. 2014	
	β	SE	β	SE	β	SE	β	SE
Framework contract	−0.15***	(0.04)	−0.62**	(0.25)	−0.15***	(0.04)	−0.62**	(0.25)
Framework contract length	0.00	(0.00)	0.00**	(0.00)	0.00	(0.00)	0.00**	(0.00)
Total value of batch	−0.00***	(0.00)	−0.00***	(0.00)	−0.00***	(0.00)	−0.00***	(0.00)
Total est. price (in 1000 BRL)	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Lot quantity in 1000	0.00	(0.00)	−0.00**	(0.00)	0.00	(0.00)	−0.00**	(0.00)
Lot value above 80k BRL	−0.01	(0.01)	−0.32***	(0.02)	−0.01	(0.01)	−0.32***	(0.02)
SBA (2014)*above 80K	−0.34***	(0.01)			−0.34***	(0.01)		
Number of lots in batch	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)	−0.00	(0.00)
Auctioneer experience, total	−0.00***	(0.00)	−0.00***	(0.00)	−0.00***	(0.00)	−0.00***	(0.00)
# Bidders (Potential)	−0.01***	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)
# SMB (Pot.) in 150km radius area	0.03***	(0.00)	0.04***	(0.01)	0.03***	(0.00)	0.04***	(0.01)
Constant	0.47***	(0.04)	0.66***	(0.03)	0.47***	(0.04)	0.66***	(0.03)
Year FE	Yes		Yes		Yes		Yes	
API FE	Yes		Yes		No		No	
API/Form FE	No		No		Yes		Yes	
State FE	Yes		Yes		Yes		Yes	
Regulation change	Yes		No		Yes		No	
Observations	12185		5364		12184		5363	
R^2	0.25		0.20		0.25		0.20	
R^2 within	0.05		0.06		0.05		0.06	

Dependent variables: SA auctions; focus on auctions implemented after 2007 (columns (1) and (3)), auctions implemented after 2014 (columns (2) and (4)). Unit of observation: auction level. Regressions include fixed effects at the auction level. Standard errors are robust to heteroscedasticity and adjusted for serial correlation inside clusters. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$