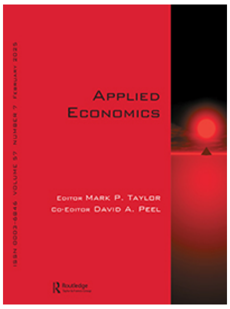

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Set-aside auctions and small businesses' participation in public procurement: an empirical analysis

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ABSTRACT
We investigate the effects of set-aside (SA) auctions supporting small business participation in public procurement, exploiting an original database of e-auctions for Russian granulated sugar (a largely homogeneous good) in the period 2011–2013. This affirmative action programme – as in many others similar and commonly adopted programmes by governments – records confounding effects. On the one hand, SA auctions attract more small business enterprises; on the other hand, SA auctions restrict the entry of possibly more cost-efficient large firms. Our findings highlight that SA auctions, on average, determine lower final prices for the procurer than non-SA (NSA) auctions do, although competition in SA auctions is not higher. We show that these findings depend on the reserve price intervals, supporting the effectiveness of SA auctions for small-scale procurement.

KEYWORDS
Procurement; auctions; SME policy; economics of regulation

JEL CLASSIFICATION
H57; D44; L53; L51

I. Introduction

Public procurement accounts for 13% of the gross domestic product (GDP) of Organisation for Economic Co-operation and Development countries (OECD 2023). Beyond the well-known aim of achieving value for money, new attention has been paid to procurement performance, from the effectiveness of the bureaucracy in charge of its implementation (Carlos Best, Hjort, and Szakonyi 2023), to the results of addressing strategic objectives such as mitigating climate change (Bafundi et al. 2023; Singh et al. 2024) and supporting innovation (Schäfer, Stephan, and Fuhrmeister 2024), employment, and social inclusion (Srhoj and Dragojević 2024).

In this study, we investigate affirmative action programmes implemented by the government to foster small business participation in public procurement and to increase the related awarding of contracts to these firms. In the U.S., the federal government explicitly recommends awarding at least 23% of its approximately 500B dollars in annual procurement contracts to small businesses (Athey, Coey, and Levin 2013). In Japan, a similar programme has been in place since 2007, with the aim of allocating 50.1% of the government's procurement expenditures to small- and medium-sized enterprises (SMEs) (Nakabayashi 2013). In Russia, an affirmative action programme was implemented in 2006, obliging each public buyer to purchase at least 15% of its annual public procurement value from small business enterprises (SBEs).

Usually, two main methods are adopted to implement these preferential programmes in public procurement[1] i) set-aside (SA) auctions, in which the public buyer restricts participation in auctions to targeted firms, and ii) bid subsidies in auctions, in which the public buyer adds a percentage discount to targeted firm bids, making these bids competitive and awarding contracts based on the adjusted bid.[2] In times of tight public budgets, the potential for these affirmative actions

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[1]Ayres and Cramton (1995) and Corns and Schotter (1999) where among the first to discuss set-aside and price preference mechanisms, respectively, as forms of affirmative action. Recent empirical and experimental studies on auctions have investigated the effectiveness of specific mechanisms (i.e. subsidy, quotas, and price preferences) and their designs in terms of procurement outcomes, as well as the related financial and societal implications (Matthäus 2020; Cho, Wooten, and Fry 2024, among others).:

[2]In particular, Mummalaneni (2023) suggested that procedures with bid subsidies may intensify competitive pressure on nontargeted bidders, who may reduce their bids relative to open procedures, leading to an overall lower procurement final price.

Supplemental data for this article can be accessed online at https://doi.org/10.1080/00036846.2025.2460745

to support SBEs increases, and efficient public procurement gains importance. However, few empirical analyses of their effects and optimum designs have been carried out.

This study aims to contribute to addressing such a gap. We empirically examine an affirmative action programme in the form of SA auctions, according to which a percentage of public procurement contracts are reserved for SBE bids. Our starting point is the consideration of the two opposing effects of an SA auction. On the one hand, in adopting this affirmative action, the public buyer might end up with a higher price because of the exclusion of more cost-efficient and larger firms. On the other hand, the public buyer may achieve a lower price determined by the larger participation and fiercer competition, given that in SA auctions, SBEs are aware that they are competing with like firms.

To empirically assess these effects, we use an original and extensive dataset of procurement auctions in Russia. This dataset has two novel and significant elements. First, it contains procurement auctions for a largely homogeneous good (i.e. granulated sugar). Such homogeneity reduces the confounding effects of unobserved quality, which can arise when estimating the effect of SA auctions for differentiated goods/services with a variety of characteristics.[3] The homogeneity of the good also enables us to exploit the price per unit of procured sugar to measure the efficiency of the auction mechanism, in which the retail price per unit on the regional market is adopted as the benchmark. Second, our dataset comprises electronic auctions (henceforth 'e-auctions') in the form of descending open auctions. The electronic format of auctions involves very low entry costs for participants, mitigating the endogeneity problem related to the firm's decision to enter the auction. Based on these unique characteristics of our dataset, we assess the effect of SA auctions. Since public buyers are free to choose between SA and not-set-aside (NSA, i.e. regular auction without entry restrictions) auctions, the type of treatment is not randomly assigned. To overcome this problem, in our empirical analysis, we adopted the inverse probability weighted regression adjustment (IPWRA) method. This method approximates the randomization of the treatment status and balances the observable covariates across SA and NSA auctions.

Our findings highlight that the competition level in SA auctions does not exceed that in NSA auctions. However, the procurement price per unit (kilo) of sugar in SA auctions is lower by 3.3% of the retail price of sugar in NSA auctions. Our findings also show that the heterogeneity in SA auction effects is driven by the reserve price. For auctions with small and medium reserve prices (i.e. 0.5–5 M RUB), compared with NSA auctions, SA auctions result in a 2.1% lower price per unit of sugar. For auctions with large reserve prices (above 5 M RUB), compared with NSA auctions, SA auctions result in a higher price per unit by 9.2%. We theoretically explain the heterogeneity in the SA auction effect, depending on the reserve price, by a bipartite structure of total cost. Namely, we show that if SBEs have smaller fixed costs than non-SBEs, while non-SBEs have lower marginal costs, then there is a quantity threshold such that SBEs have lower total costs below the threshold and higher total costs above the threshold.

Our study contributes to the empirical literature on affirmative actions in public procurement, particularly to the study of programmes by which governments aim to foster SBE participation in auctions to increase their share of public contracts. In this respect, the literature mainly deals with bid preference programmes and SA auctions. Both Marion (2007) and Krasnokutskaya and Seim (2011) studied the bid preference programme implemented in procurement auctions by the California Department of Transportation. Exploiting the variation in eligibility of bid preferences in state- and federal-funded projects, Marion (2007) showed that the winning bids in auctions with bid preferences were, on average, higher by 3.8% than in auctions in which the programme was not adopted. Developing a structural model of entry and bidding, Krasnokutskaya and Seim (2011) showed that the bid preference programme raises the average cost of procurement by 1.5%,

[3]The heterogeneity of procured goods is a shortcoming of empirical studies on the effects of SA auctions, as highlighted by Denes (1997), who used a database for dredging services. A similar issue was identified by Nakabayashi (2013), who investigated data on public construction projects, as well as by Szerman (2012) and Athey, Coey, and Levin (2013), who used data for off-the-shelf goods and timber sales.

resulting in a redistribution of 5%-12% of profit from large to small firms. Moreover, Krasnokutskaya and Seim (2011) stated that bid preference programmes have heterogeneous effects across different types of projects, leaving for future investigations the study of the effects of bid preference programmes on auctions with different reserve price values. In relation to the latter, we contribute to the literature by developing an empirical analysis in a setting of SA auctions for a homogeneous good.

Athey, Coey, and Levin (2013), investigated SA auctions for the US Forest Service timber sale programme and showed that restricting a timber sale to SBEs reduces efficiency by 17%, on average, and costs the Forest Service about 5% of its revenue. These authors designed and estimated an entry and bidding model for auctions, simulating revenue and the efficiency of bid subsidies in auctions, as opposed to SA auctions. Their simulations suggest that providing a bid subsidy to small bidders in all auctions might eliminate both inefficiency and revenue losses, while allocating the same volume of timber to SBEs through SA auctions leads to an increase in aggregate SBE profits while only slightly reducing the profits of larger firms.[4] Participation restrictions for large firms in SA auctions may well encourage small firms to enter, resulting in more aggressive competition.[5] Based on the procurement of off-the-shelf goods in Brasilia, Szerman (2012) estimated the effects of SA auctions. He showed that SA auctions are effective in increasing SBE participation and that there is no effect on prices per unit for off-the-shelf goods. On the basis of the auction of public construction projects in Japan, Nakabayashi (2013) estimated the effects of SA auctions via a three-step empirical estimation. He subsequently presented a simulation analysis showing that, if SA auctions were stopped, about 40% of SBEs would exit the procurement market. Accordingly, Nakabayashi (2013) stressed that the resulting lack of competition would increase government procurement costs by more than the cost of running SA auctions. On a large dataset of US federal procurement auctions, Cappelletti and Giuffrida (2022), showed that SA auctions lead to increased participation from targeted firms; however, they also tend to result in higher cost overruns and delays during execution, especially when SA criteria are restrictive. We contribute to this literature by exploiting a novel database on sugar procurement contracts in which the usual confounding factors are reduced. Indeed, the procurement setting we investigate is characterized by a very low entry cost and a largely homogeneous product. Our analysis provides new empirical results on reserve price ranges and competition levels, which add to the understanding of the SA auction outcomes in public procurement.

The rest of the paper is organized as follows. Section II illustrates the institutional setting to which our empirical analysis refers. Section III presents our database and descriptive statistics. Section IV illustrates the empirical strategy. Section V presents the results, and Section VI provides a robustness check. Section VII concludes the paper and discusses the policy implications of the results.

II. Institutional setting

In 2022, in the Russian Federation (RF), a total of 5.97 million SMEs employed 15.2 million people (25% of the working-age population) and contributed 32.5% to the country's GDP. In terms of size, 96% of all these SMEs were microenterprises, 3.5% were small enterprises, and only 0.29% were medium-sized firms.[6]

According to Russian law, a company is considered a microenterprise if it has up to 15 employees and its annual revenue does not exceed 120 M RUB. A company must meet all these conditions to be classified as a microenterprise. If one of the criteria exceeds the limit, the company moves to a higher category (e.g. small enterprise). A company is considered a small enterprise if it has between 16 and 100 employees or if its annual revenue is between 120 M and 800 M RUB. Both micro and small enterprises are allowed to participate in SA auctions and

[4]Note that, recalling the seminal contribution by Myerson (1981) on auction theory, these authors also indicated that the potential advantage of bid subsidies over SA auctions could turn out to be weak for different levels of bidder participation and entry costs.

[5]Chever, Saussier, and Yvrande-Billon (2017), using data on public contracts in social housing in Paris, found that that participation restrictions may stimulate competition and improve cost efficiency. By contrast, Matilla-García and Vega (2024) found that open procedures (without restrictions) in public procurement in Spain offered greater competition. However, their analysis excluded small contracts, which are less attractive for large firms and more attractive for SBEs, which are the focus of Chever, Saussier, and Yvrande-Billon (2017) and our study.

[6]Unified Register of small- and medium-sized enterprises https://rmsp.nalog.ru/index.html.

Table 1. Definition of micro and small firms in Russia.

			Revenue Limit	
Type	No. of Employees		Since 01.2015	2013 and 2014
Micro	1–15	and	RUB 120M	RUB 60M
Small	16–100	or	RUB 800M	RUB 400M

Information on revenue limits and the number of employees is from Government Decree no. 101 dated 9 February 2013 and Government Decree no. 702 dated 13 July 2015 "On limits of revenues obtained from the sale of goods (works and services) for each category of SBEs".

are defined as SBEs. In 2013 and 2014, the revenue limit was lower (see Table 1 below).

Given the importance of micro and small businesses in the Russian economy, in the past decade, the government has increasingly sought to support them via two main policies, broadly classified as follows: (i) subsidies and subsidized lending provided within dedicated federal programmes, supervised by the Ministry Economic Development, and (ii) preferential treatment in public procurement as set out in procurement legislation. The latter policy, which we focus on in this study, consists of SA awarding procedures (i.e. a mandatory quota of public procurement awarded exclusively to SBEs). This policy establishes a minimum guaranteed purchase requirement from SBEs.

Federal Procurement Law 94FL[7] (in place from 2006 to 2013, the period to which our dataset refers) contains compulsory provisions to support SBEs. Procurers should secure a minimum of 10% and a maximum of 20% of their annual purchase value via SA auction type (i.e. auctions restricted to SBE participation). The law establishes that an SA auction may have any standard procurement procedure: first-price sealed-bid auction, electronic open auction, scoring rule auction, or request for bids. Nevertheless, there is a reserve price cap for SA auctions, which is 15 M RUB (about 500,000 USD in 2011–2013). For the procurement of standardized goods such as granulated sugar, buyers can use either an electronic open auction (e-auction) or a sealed-bid auction.[8] According to 94FL, a sealed-bid auction is possible if the reserve price does not exceed 500,000 RUB (about 16,700 USD), while an e-auction can be used for tenders with any reserve price. In this study, the variation in the reserve price for an auction is crucial to estimating the heterogeneous effects of SA auctions. Because of the 500,000 RUB cap for sealed-bid auctions, we focus solely on e-auctions, describing them in detail below.

The e-auction process involves several key stages. The procurer selects an electronic platform from available options (there are five in Russia), which are accessible through a centralized procurement system: www.zakupki.gov.ru. After the platform is selected, the call for bids is announced with a specified *reserve price*, which indicates the maximum contract value. Setting the reserve price is regulated by law. For standardized goods, a buyer needs to justify setting the reserve price based on regional retail market prices or the procurement prices of similar products in the past. Firms interested in participation submit their applications. The number of firms submitting their applications is called the *Number of applicants*. The application package includes contract compliance, technical compliance, and bid security deposit. The bid security deposit varies from 0.5% to 2% of the reserve price for SA auctions and from 0.5% to 5% for NSA auctions. The buyer sets the size of the bid security deposit at the call for bids. This deposit ensures that the bidder will sign the contract if awarded, with the amount withheld as a penalty if they fail to do so. If a firm does not win the auction, it receives its deposit back.

The applications are evaluated according to the requirements, and the successful applicants proceed to the bidding phase. This is where bidders propose their bids on the online platform with the rebate from the reserve price with the lowest tick by 0.5%. The lowest bid wins if there is no further reduction within 10 minutes of this bid. The number of bidders making at least one bid is called the *Number of bidders*. Additional information is provided in the Appendix for a detailed explanation of the award process.

III. Data and descriptive statistics

We collect all procurement contracts for granulated sugar in Russia during the period 2011–2013. Namely, we make a substring search

[7]The policy objectives supporting SBEs are discussed in detail in the Appendix.

[8]An electronic open auction is a descending English auction conducted online via specialized electronic platforms. A sealed-bid auction is a first-price sealed-bid auction, in which bids are submitted in sealed envelopes and the bidder offering the lowest price wins the auction.

of the keyword 'sugar'[9] over the population of all public procurement contracts in Russia in the period 2011–2013 and create a sample of contracts in which granulated sugar is a procured item by itself or along with other procured items. This is the primary sample for our analysis. Granulated sugar is a very popular product bought by many public institutions (e.g. schools, hospitals, and prisons) at all levels of government (municipal, regional, and federal) in Russia. We focus on procurement for granulated sugar because it is a largely homogeneous product, which has a defined quality and is divisible in quantity. We obtained contract information, such as the quantity of sugar procured, the reserve price, the number of applicants and bidders, the final price, the electronic platform used, and the characteristics of the buyer. Further information is presented in Table A1 of Appendix A.

Each auction in our dataset is designed to procure sugar either by itself or as a bundle of goods (i.e. sugar, tea, cacao, grains, flour, salt, fruits, and vegetables), including sugar, all awarded together. Henceforth, we call such a basket of goods a *bundle*. Looking at the supply side of this market, we observe that it is characterized by a medium concentration: the four largest firms record 17% of the total market supply, and the remainder comprises more than 4,500 firms, mostly SBEs. Moreover, two of the four largest firms are both producers and distributors, while all SBEs are distributors.

The primary sample of granulated sugar procurement includes 40,995 contracts awarded by public procurers in Russia in the period 2011–2013. From this sample, we exclude 1,962 contracts that were awarded directly from suppliers without any type of auction (i.e. so-called single-source contracting). We further exclude auctions that record an unrealistically small or large final unit price or in which essential information on contract characteristics is missing (e.g. quantity of sugar, final unit price, number of bidders, etc.); this reduces our sample to 35,297 observations. These 35,297 observations include 17,012 e-auctions (for 7.665B RUB, corresponding to 255.5 M USD) and 18,285 sealed-bid auctions for (2.33B RUB, corresponding to 77.6 M USD). Given the strict rule on the threshold value for sealed-bid auctions (i.e. sealed-bid auctions are restricted to values no higher than 500,000 RUB), and for our purposes, we focus solely on e-auctions with much greater heterogeneity in reserve prices than sealed-bid auctions. Accordingly, our final sample consists of 17,012 observations of e-auctions.

We also consider the regional retail market price per unit of sugar, which we call the *unit retail price*. From the Federal State Statistics Service, we collect unit retail prices on a weekly basis for the period 2011–2013 for each of the 83 Russian regions. This variable enables us to control for retail market heterogeneity in prices over time and regions. For a homogeneous good, such as granulated sugar, a positive difference between the procurement final unit price and the unit retail price indicates efficiency gains from the competitive auction. Figure 1 illustrates the average dynamics (over all regions) of sugar's final unit price and unit retail price in 2011–2013. The final unit price is usually below the unit retail price, and their trends are similar.

In our empirical analysis, we consider four different auction outcomes. First, we use the *Number of applicants* and *Number of bidders* as procurement competition measures. The number of applicants is the number of all firms that submitted their applications to participate in an auction, and the number of bidders includes only those firms that passed the validation stage and submitted at least one bid. Second, we use the following two measures to characterize procurement winning winning bids and winning prices:

$$Bundle\ rebate = \frac{(bundle\ reserve\ price \\ -bundle\ winning\ bid)}{bundle\ reserve\ price} 100\%,$$

$$Scaled\ final\ unit\ price = \frac{final\ unit\ price}{unit\ retail\ price},$$

The *bundle rebate* is often used in empirical procurement literature (e.g. Coviello and Gagliarducci 2017; Coviello, Guglielmo, and Spagnolo 2018,b]). However, a high auction rebate may stem from a high reserve price, a low winning bid, or both. Because of this ambiguity in interpretation, we prioritize the final unit price as a measure of procurement effectiveness for homogeneous goods. The normalization in the *scaled final unit price* is

[9]'Caxap' in Russian.

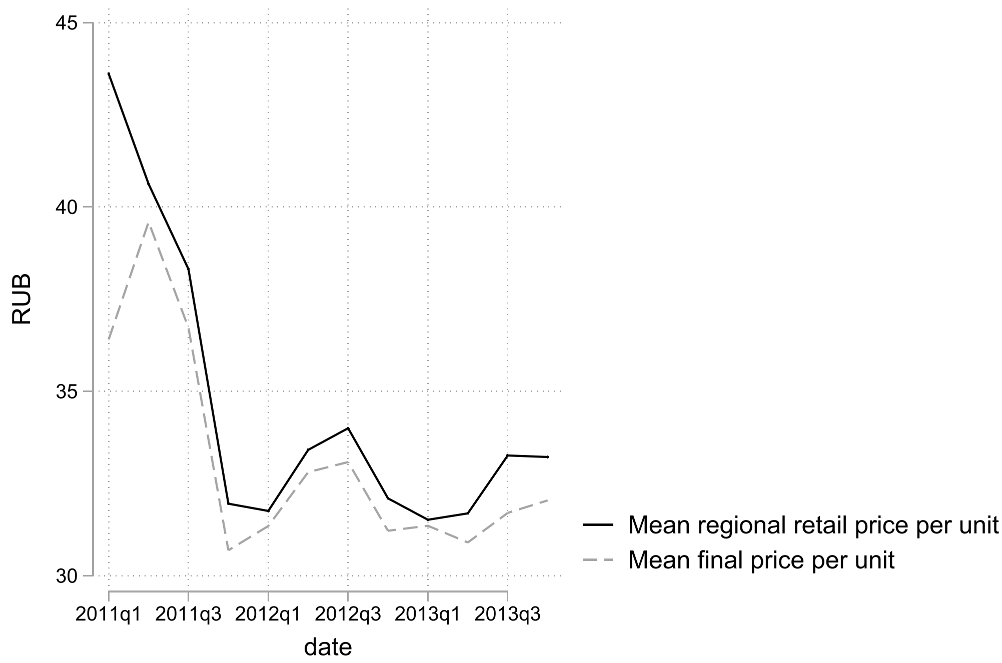

Figure 1. Mean procurement and retail unit prices for sugar in Russia, 2011–2013.

designed to consider both the seasonal nature of sugar price variation and regional heterogeneity in retail market prices. In our analysis, we use both measures of prices – bundle rebate and scaled final unit price – as procurement bundling may also mitigate the importance of the final unit price as a measure of procurement effectiveness.

Table 2 presents the descriptive statistics for our main variables of interest, broken down by SA and NSA auctions; for the latter, we also distinguish between auctions above and below the reserve threshold (below/above 15 M RUB). The average bundle rebate is higher in SA auctions (11.98%) than in NSA auctions (10.63%), with a significant difference at 1%. The scaled final unit price is lower for SA auctions (0.948) than for NSA auctions (0.966). This difference means that the final unit price in SA auctions is 1.8% lower than that in NSA auctions. In terms of competition, SA auctions attract, on average, more applicants than NSA auctions do, but there is no difference in the number of qualified bidders. There is also no difference in the reserve price of the contract. However, the quantity of sugar in the contract is greater in the NSA.

The section below presents our econometric model to investigate SA auction effects on procurement outcomes. To obtain comparable characteristics for SA and NSA auctions, we exclude e-auctions for bundles with a reserve price above the threshold of 15 M RUB.[10] However, the procurer retains a discretionary choice between SA and NSA auctions below this threshold. As explained in the institutional setting, according to Law 94FL, for auctions with a reserve price below 0.5 M RUB, procurers can choose a sealed-bid auction or an e-auction, whereas for auctions with a reserve price above 0.5 M RUB, an e-auction is the only choice. Therefore, to exclude the source of potential endogeneity regarding the procurement procedure for our main sample, we consider solely e-auctions with a reserve auction price of between 0.5 and 15 M RUB (9,036 observations). All e-auctions with a reserve price below 0.5 M RUB are used for the robustness check in Section VII.

IV. Empirical strategy

To study the role of SA auctions, we consider the following procurement outcomes: (i) *Number of*

[10]Above this threshold, Law 94FL prohibits the use of SA auctions.

Table 2. Average values for e-auction characteristics broken down by SA and NSA status and threshold.

	Set-Aside	*p*-value	Non Set-Aside	Non-Set-Aside
	Reserve Price 0.5–15 M RUB	(T-test)	Reserve Price 0.5–15 M RUB	Reserve Price > 15 M RUB
Auction outcomes				
Bundle rebate	11.98% (Obs. 1,777)	0.000	10.63% (Obs. 6,603)	4.42% (Obs. 903)
Scaled final unit price	0.948 (Obs. 1,933)	0.001	0.966 (Obs. 7,084)	1.068 (Obs. 1468)
Competition				
Number of applicants	4.37 (Obs. 1,933)	0.000	4.01 (Obs. 7,084)	2.41 (Obs. 1147)
Number of bidders	2.09 (Obs. 1,933)	0.4653	2.07 (Obs. 7,084)	1.20 (Obs. 1147)
Contract information				
Reserve price (M RUB)	2.38 (Obs. 1,933)	0.3552	2.44 (Obs. 7,084)	51.00 (Obs. 1126)
Quantity of sugar (tons)	14.38 (Obs. 1,933)	0.0000	20.17 (Obs. 7,084)	38.86 (Obs. 1468)

applicants, (ii) *Number of bidders*, (iii) *Bundle rebate*, and (iv) *Scaled final unit price*. Our model has the following specification:

$$Y_{ibrt} = \alpha SA_{ibrt} + \mathbf{A_{ibrt}}\beta + \mathbf{B_b}\gamma[+\mathbf{R_{rt}}\delta] + \varepsilon_{ibrt}, \quad (1)$$

where Y_i is auction $i's$ outcome, conducted by buyer b, who is located in region r at time t. The binary variable SA_{ibrt} is 1 for an SA auction and 0 otherwise. The vector $\mathbf{A_{ibrt}}$ of auction characteristics includes the bid security deposit (in %), the logarithm of sugar quantity, the logarithm of the reserve price, the contract duration in days, the number of products in the bundle (as a categorical variable with three levels: single products, two to eight products of different types, and more than eight products), year and quarter of contract signing, and e-platform identifier (five platforms). For the outcomes *Bundle rebate* and *Scaled final unit price*, $\mathbf{A_{ibrt}}$ also includes the binary variable if an NSA auction attracts at least one medium-sized or large firm. The vector $\mathbf{B_b}$ refers to the characteristics of the buyer: sector of economic activity (education, health, administration, defense, or other), level of subordination (federal, regional, or municipal), and the role of the buyers as an agency for centralized procurement. For the outcomes *Bundle rebate* and *Scaled final unit price*, the vector $\mathbf{R_{rt}}$ includes the regional retail unit price of sugar normalized to the average retail unit price of sugar in Russia at the week of contract signing. We call this additional control *Normalized regional retail price*. Such control for the sugar market price enables the control of the dynamic changes in market conditions in the buyer's region that are not directly induced by the procurement market. For some specifications, $\mathbf{R_{rt}}$ also contains the buyer's region fixed effect. The description of the variables and their sources is presented in Table A1 of Appendix A. To adjust for within-buyer correlations in the error terms, standard errors are clustered at the buyer level. For the main analysis, we use the sample of electronic auctions with a reserve price interval 0.5-15 M RUB. For this reserve price interval, buyers cannot vary the procurement procedure (only e-auction is allowed), and both SA and NSA auction types can be chosen at the buyer's discretion.

Our main focus in (1) is on α coefficient. The main concern with the basic ordinary least squares (OLS) estimation is the self-selection of SA auction types, which may bias the estimator for the average treatment effects of SA auctions. By regulation, public buyers can choose between SA and NSA types when the reserve price is below 15 M RUB. In other words, the auction type (i.e. SA or NSA) is not randomly assigned and depends on observable and unobservable confounders. To address this issue empirically, we use the inverse probability weighted regression adjustment (IPWRA) method, which approximates the randomization of the treatment assignment on observable characteristics and balances observable covariates across SA and NSA auctions. Notably, IPWRA can be seen as a generalization of standard propensity score matching ([Wooldridge 2010; Cerulli 2015]). The method includes the following stages.

First, we estimate selection to treatment using a probit model in which the SA auction indicator SA_{ibrt} is the dependent variable, and the control variables are the same auction and buyer characteristics that we use for the competition outcomes – Number of applicants and Number of bidders:

$$\mathbf{P}(SA_{ibrt} = 1) = \Phi(\mathbf{A_{ibrt}}\theta + \mathbf{B_b}\lambda). \quad (2)$$

After estimating regression (2), we predict the treatment status for all observations – an auction of being the SA type. Finally, we assign the inverse probability of treatment $w^{SA} = 1/p$ for treated units ($SA_{ibrt} = 1$) and the inverse probability of not being treated $w^{NSA}(x) = 1/1 - p$ for control units ($SA_{ibrt} = 0$). We reestimate the regression (1) using these new weights in the last stage.

V. Estimation results

We present the results in three steps. The first step presents the average effects of SA auctions on procurement outcomes. Here, we consider two measures of auction competition (*Number of applicants* and *Number of bidders*), and two measures of auction prices (*Bundle rebate* and *Scaled final unit price*). The second step presents the analysis of the heterogeneity of SA auction effects by reserve price range. The third step analyses the role of bundling in the SA auction effect.

Average effect of SA auctions

We apply the strategy described in Section IV to the sample of e-auctions with a reserve price of between 0.5-15 M RUB. IPWRA requires that, after reweighing, the treatment and control groups should be balanced based on the observable characteristics used as controls in Equation (2). For each of the variables, Table A2 of Appendix A shows the mean and 95% confidence intervals. It is noteworthy that when we use the full sample, the bid security deposit and some other variables are not balanced, suggesting that SA and NSA may differ even after the reweighting. Therefore, controlling for these unbalanced variables in (1) is necessary. However, when we restrict to the subsample of bid security deposit being at most 2%, the balance is reached.[11] Therefore, we present all our results for the full sample and the subsample for the bid security deposit $\leq 2\%$, giving a preference for the interpretation of the latter in case of discrepancy.

Panel A of Table 3 presents the results for the full sample and Panel B for the subsample for the bid security deposit $\leq 2\%$. The negative coefficient of SA auction in Columns 1–4 of both panels shows that the level of competition in the SA auctions does not exceed that for NSA. Columns 2 and 4 control for regional heterogeneity in competition via regional fixed effects, while Columns 1 and 3 do not. Panel B shows that the number of firms that applied for the auction (Column 2) and the number of firms that made at least one bid (Column 4) are smaller in the SA auctions by 0.35 and 0.29 units, respectively. This result is in line with the explanation that SA auctions do not attract more firms because of restrictions on competition.

Columns 5–8 of Table 3 show the results for *Bundle rebate* and *Scaled final unit price* as the dependent variables. Recall that these regressions include two additional control variables – normalized regional retail price and a binary indicator for medium- or large-sized firms participating in the NSA auction. Columns 6 and 8 include the regional fixed effects, while Columns 5 and 7 do not. Both Panels A and B show that the *Bundle rebate* in SA auctions is not smaller than that in NSA auctions (Columns 5–6). Moreover, Columns 7–8 consistently show that the *Scaled final unit price* is significantly lower in SA auctions. For the most flexible model (Column 8, Panel B), the SA auctions, on average, demonstrate a lower price per kilo by 3.3%.[12] Overall, the analysis of procurement outcomes suggests that despite SA auctions not having higher competition, SA auctions may result in lower prices for standardized goods.

[11]The reduced bid security deposit in SA auctions alleviates the financial burden on SBEs, incentivizing them to apply. This is an additional reason to compare SA and NSA auctions only when the bid security deposit.$\leq 2\%$.

[12]Hereafter, in the model in which the *Scaled final unit price* is the dependent variable, the interpretation of the coefficient for SA auction is a difference in the price of SA auctions compared to NSA auctions, expressed as a percentage of the regional retail price.

Table 3. Effects of SA auctions on procurement outcomes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Number of Applicants		Number of Bidders		Bundle Rebate		Scaled Final Unit Price	
Panel A: Full sample								
SA auction	−0.20**	−0.087	−0.12***	−0.15***	1.44***	0.95**	−0.047***	−0.041***
	(0.10)	(0.097)	(0.037)	(0.043)	(0.40)	(0.47)	(0.0072)	(0.0072)
Observations	9,017	9,017	9,017	9,017	8,380	8,380	9,017	9,017
R-squared	0.240	0.533	0.219	0.364	0.142	0.255	0.250	0.353
Region FE	N	Y	N	Y	N	Y	N	Y
Panel B: Bid security deposit ≤ 2%								
SA auction	0.18	−0.35***	−0.16***	−0.29***	0.047	0.38	−0.021***	−0.033***
	(0.11)	(0.10)	(0.044)	(0.049)	(0.46)	(0.54)	(0.0073)	(0.0077)
Observations	4,542	4,542	4,542	4,542	4,207	4,207	4,542	4,542
R-squared	0.293	0.621	0.246	0.385	0.159	0.272	0.248	0.373
Region FE	N	Y	N	Y	N	Y	N	Y

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$ The table shows the estimation results of (1) using IPWRA with weights derived from (2). Panel A includes all e-auctions with a reserve price of 0.5-15M RUB. Panel B includes the subsample from Panel A for NSA auctions with the bid security $\leq 2\%$. The controls are the bid security deposit, the logarithm of sugar quantity, the logarithm of the reserve price, contract duration, number of products in the bundle, year and quarter of contract signing, e-platform identifier, sector of economic activity, level of subordination (federal, regional, or municipal), and an indicator for centralized procurement. For Columns 5–8, the retail regional normalized price per kilo and an indicator of non-SBE participation in NSA are additional controls. Odd columns do not include the regional FE for 1, while even columns do. Standard errors in parentheses are clustered at the buyer level. The full output is in Table B1 of Appendix B for the full sample and in Table B2 of Appendix B for the bid security deposit subsample.

Heterogeneous effect by reserve price

In the empirical literature on public procurement auctions, the reserve price is usually adopted as a proxy for the awarded contract size, and is used to control for scale and related effects ([Porter and Douglas Zona 1993; Hong and Shum 2002; Jofre-Bonet and Pesendorfer 2003; Krasnokutskaya and Seim 2011; Bajari, Houghton, and Tadelis 2014; Coviello et al. 2018]). The reserve price may determine SBE participation per se. The reserve price may proxy the procurement scale for standardized goods. Therefore, the economy of scale may complement the effects of SA auctions on procurement prices. To address this heterogeneous effect, we divide our sample of auctions into two subsamples by the reserve price threshold of 5 M RUB, ,[13] namely:

- Small and medium reserve price interval: 0.5-5 M RUB (17,000–167,000 USD);
- Large reserve price interval: 5-15 M RUB (167,000–500,000 USD).

For these subsamples, we apply the empirical approach introduced in Section IV without regional fixed effects, as the sample size for the large reserve

Table 4. Effects of SA auctions on procurement outcomes by the reserve price intervals.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Number of Applicants		Number of Bidders		Bundle Rebate		Scaled Final Unit Price	
Reserve price	0.5–5	5–15	0.5–5	5–15	0.5–5	5–15	0.5–5	5–15
Panel A: Full sample								
SA auction	−0.0029	−1.09***	−0.12***	−0.46***	2.08***	−13.8***	−0.043***	0.030
	(0.11)	(0.32)	(0.042)	(0.12)	(0.42)	(1.44)	(0.0075)	(0.027)
Observations	7,891	1,126	7,891	1,126	7,351	1,029	7,891	1,126
R-squared	0.250	0.488	0.222	0.437	0.164	0.512	0.254	0.477
Panel B: Bid security deposit ≤ 2%								
SA auction	0.38***	−1.40***	−0.16***	−0.87***	0.60	−13.8***	−0.021***	0.092***
	(0.12)	(0.48)	(0.045)	(0.23)	(0.45)	(2.24)	(0.0075)	(0.030)
Observations	4,081	461	4,081	461	3,787	420	4,081	461
R-squared	0.296	0.715	0.251	0.554	0.165	0.795	0.244	0.658

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$ The table shows the estimation results of (1) using IPWRA with weights derived from (2). Panel A includes all e-auctions with a reserve price of 0.5-5M RUB for odd columns and 5-15M RUB for even columns. Panel B includes the subsample from Panel A for NSA auctions with the bid security $\leq 2\%$. The controls are similar to Table 3. Because of the multicollinearity problem for even columns, all regressions do not include the regional FE. Standard errors in parentheses are clustered at the buyer level.

[13]In the robustness check of Section VII, we show the robustness of the results for the alternative thresholds.

price interval is quite limited. Table 4 shows the results for all procurement outcomes. Odd columns use subsample 0.5-5 M RUB, and even columns use subsample 5-15 M RUB. Panel B shows the subsample for the bid security deposit $\leq 2\%$. The results from Columns 1–4 consistently show that the level of competition in SA auctions does not exceed that in NSA auctions for both reserve price intervals. However, the SA effect on procurement prices depends on prices. For the reserve price of 0.5-5 M RUB, Columns 5 and 7 (Panel B) show that SA auctions have at least the same rebate, and prices per kilo are around 2.1% lower than those in the NSA auctions. However, for the reserve price of 5-15 M RUB, Columns 6 and 8 (Panel B) show that SA auctions have lower rebates by around 13.8% points and higher prices per kilo by 9.2%. Overall, the results suggest that the procurement scale determines the effect of SA auctions on procurement prices.

As Section VI explains, differences in fixed and marginal costs between SBEs and non-SBEs firms rationalize the reversal of the SA auction effect, depending on the procurement scale. For auctions of low value, the efficiency of small firms in fixed costs gives them a competitive advantage. However, for auctions of large value, large firms' marginal cost efficiency gives them a comparative advantage because of the economy of scale.

Bundling

In this section, we discuss the role of bundling in the effects of SA auctions. Bundling can affect the fixed cost of assembling different products together. Moreover, the price per kilo of sugar as a dependent variable may lose its value when the share of sugar in the bundle is minor. For this, we divide our sample into single-product procurement (i.e. sugar only) and bundles and apply the approach from Section IV.

Table 5 shows the results with division by single (odd columns) and bundle (even columns) auctions and on the subsample for the bid security deposit $\leq 2\%$ (Panel B). Considering the number of bidders (Columns 3–4), both the single-product and bundled auctions show that SA auctions do not have higher competition. However, in single-product auctions, the rebate in SA auctions is higher (Column 5), while in bundled auctions, the price per kilo is lower in auctions (Column 8). The absence of a significant difference in prices per kilo for single-product auctions may indicate that the efficiency of SA auctions may arise from the lower fixed costs of bundling, while SA auctions may not demonstrate efficiency in single-product auctions irrespective of the procurement scale. Therefore, in what follows, we analyze the interaction of bundling and procurement scale on our main outcome – price per kilo. Figure 2 shows the results for the full sample (Panel A) and the subsample for the bid security deposit $\leq 2\%$ (Panel B) by single and bundled auctions for quartiles of sugar quantity.[14]

Panel B shows that SA auctions result in lower prices in single-product auctions only when the procurement scale is low (quartile 1). For bundled auctions, SA actions have lower prices when the procurement is of a low or medium scale (quartiles 1–3). Overall, the analysis of bundling suggests that SA auctions may have lower prices in both single- and bundled auctions but only up to a certain level of the procurement scale.

VI. Discussion

In this section, we discuss the potential mechanism behind the empirical association between SA auctions and procurement outcomes highlighted in our setting. We found that SA auctions record lower competition because of the entry restrictions included in the design of the affirmative action itself. Nevertheless, if the reserve price (or the amount of procured product) is below a certain threshold, the SA auctions end up with lower unit prices. By contrast, if the reserve price is above the threshold, the SA auctions have higher prices and lower auction rebates. This suggests that despite the restriction of competition, SA auctions may lead to lower final prices if the auctions are not too large. We rationalize this result by a simple bipartite total cost structure for a firm i, which can be of one of two types j – small firm ($j = SBE$) or nonsmall firm ($j = NSBE$).

[14]For single-product auctions, we have less than 10 observations with a reserve price above 5 M RUB, which would correspond to more than 150 tons of sugar. Therefore, we do not divide by the reserve price but by the quartiles of sugar quantity.

Table 5. Effects of SA auctions on procurement outcomes for single-product auctions and bundles.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Number of Applicants		Number of Bidders		Bundle Rebate		Scaled Final Unit Price	
No. of products	Single	Bundle	Single	Bundle	Single	Bundle	Single	Bundle
Panel A: Full sample								
SA auction	−1.03***	0.013	−0.37***	−0.0059	2.15***	0.80	−0.00099	−0.055***
Observations	2,910	6,108	2,910	6,108	2,840	5,541	2,910	6,108
R-squared	0.516	0.211	0.510	0.145	0.476	0.110	0.530	0.249
Panel B: Bid security deposit $\leq$ 2%								
SA auction	−1.08***	0.42***	−0.75***	−0.035	2.35**	−0.36	−0.00096	−0.024***
	(0.34)	(0.12)	(0.15)	(0.044)	(1.04)	(0.53)	(0.019)	(0.0084)
Observations	959	3,583	959	3,583	925	3,282	959	3,583
R-squared	0.684	0.250	0.562	0.146	0.537	0.165	0.484	0.258

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$ The table shows the estimation results of (1) using IPWRA with weights derived from (2). Panel A includes all e-auctions procuring single products for odd columns and bundles for even columns. Panel B includes the subsample from Panel A for NSA auctions with the bid security $\leq 2\%$. The controls are similar to Table 3. Because of the multicollinearity problem for odd columns, all regressions do not include regional FE. Standard errors in parentheses are clustered at the buyer level.

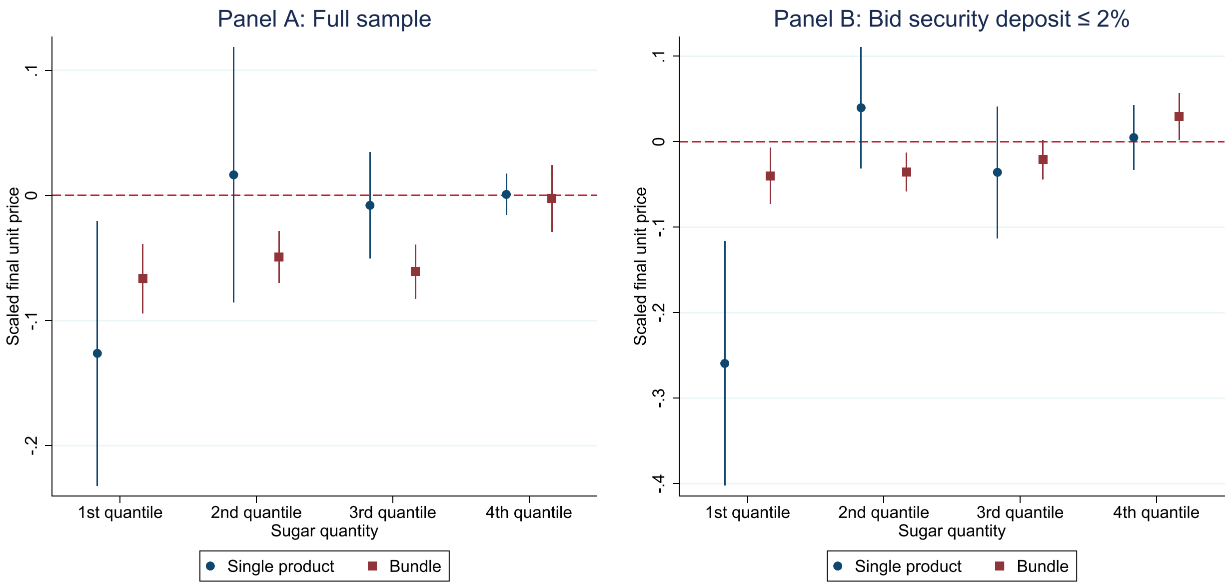

Figure 2. The effect of SA auctions on scaled final unit price by quantity quantiles and bundling. The figure shows the effect of SA auctions for the full sample (Panel A) and subsample for Bid security deposit $\leq 2\%$ (Panel B). We further split each of these samples by single-product and bundled auctions. For each subsample, we calculate the quartiles of procured sugar quantities. Points on the graph show the coefficient α interacted with the quantity quartiles from IPWRA regression (1) with reweighting from (2). Lines are 95% confidence intervals with errors clustered at the buyer level.

Therefore, we assume the following form of total cost function, TC, to supply q units:

$$TC_i^j(q) = F_i^j + c_i^j q \quad , \qquad (3)$$

where F_i^j is the fixed cost of firm i to management participation in the auction, which has the continuous cumulative distribution function $F^j(x)$; and c_i^j is the marginal cost of providing an additional unit of sugar, which has the continuous cumulative distribution function $G^j(x)$. It is reasonable to assume that $F^{SBE}(x) \geq F^{NSBE}(x)$; that is, the fixed costs of NSBEs (first order) stochastically dominate the fixed costs of SBEs. This may be true because the bid preparation processes in small firms are simpler, given the simplified management structure. Nevertheless, the marginal costs of SBEs stochastically dominate the marginal costs of NSBEs; that is, $G^{SBE}(x) \leq G^{NSBE}(x)$, as larger firms are more effective in production, so their marginal costs are lower. As Figure 3 shows, this type of total cost structure would imply that there is

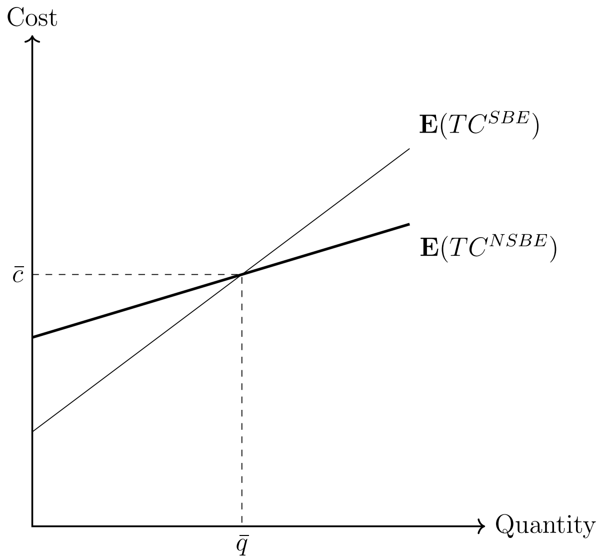

Figure 3. Expected total cost structure for SBEs and non-SBEs firms.

a threshold quantity $\bar{q}$ such that for auctions purchasing less than $\bar{q}$ units, the expected total cost $\mathbf{E}(TC^{SBE})$ of small firms participating in the SA auction is smaller than the expected total cost $\mathbf{E}(TC^{NSBE})$ of nonsmall firms participating in the NSA auction. Because of the stochastic dominance properties of fixed and marginal costs, such a single-crossing property between SBEs and NSBEs holds for any percentile of total costs.

Let n be the number of bidders in an auction in which all bidders have the same type. Since the auctions we consider in this study are reverse English auctions, the winning bid is the second-lowest total cost.[15] This yields the distribution of the winning bid $b_{1,j}^{(n)}(q) \sim F_{Beta(2,n-1)}(F_{TC^j(q)}(x))$, where outer is the Beta distribution and inner is the distribution of the total cost for a firm of type j that has to supply q units. As $F_{Beta(2,n-1)}$ is an increasing function, and because of the single-crossing property of the total costs, as shown in Figure 3, there exists a threshold $\tilde{q}$ such that $\mathbf{E}(b_{1,SBE}^{(n)}(q)) < \mathbf{E}(b_{1,NSBE}^{(n)}(q))$ for all $q < \tilde{q}$, and $\mathbf{E}(b_{1,SBE}^{(n)}(q)) > \mathbf{E}(b_{1,NSBE}^{(n)}(q))$ for all $q > \tilde{q}$. This threshold $\tilde{q}$ resumes what was shown in our empirical analysis about the size of the reserve price and the effects of SA auctions.

VII. Robustness checks

This section presents the robustness checks. The first check deals with the unobserved confounders that may affect our causal interpretation of the results. In our main analysis, we have selected the sample of analysis such that neither the reserve price nor the bid security deposit could create incentives for discretion,[16] so they can be seen as relatively exogenous. Nevertheless, the SA auction type is still endogenous. While IPWRA balances the observed auction characteristics, it does not solve the problem of unobserved confounders. We use the heteroscedasticity of error components in (1) to build the heteroscedasticity-based instruments. Therefore, we consider all regressors from (1) except for SA auction type as exogenous and apply the approach from Lewbel (2012). Panel A of Table B3 of Appendix B shows the results for the full sample and Panel B shows those for the subsample with the bid security deposit $\leq 2\%$. The overall results are in line with the main findings. While the number of bidders is lower in SA auctions, they demonstrate higher bundle rebates by 2.84% points and lower unit prices by 2.9%.[17]

The second check considers the alternative thresholds for analysing the heterogeneous effects of SA

[15]This is under the assumption that bidders reduce price gradually without jumps, and the reserve price is not binding.
[16]For example, in the selected subsample, buyers can only use the descending e-auction as a procurement procedure.
[17]The F-statistics of the first stage is above the commonly used threshold of 10.

auctions by reserve price. We also consider two other reserve price intervals: 0.1–4.5 M RUB and 4.5–14.5 M RUB. For these new ranges, we apply IPWRA using (1) with probability weights from (2). Table B4 in Appendix B shows that the results are robust to the interval change. The number of bidders in SA auctions for both reserve price intervals does not exceed the number in the NSA auction. Nevertheless, the SA auctions demonstrate price efficiency (regarding bundle rebate and unit price) in low reserve price intervals, while NSA auctions are more efficient when the reserve price is high.

The final robustness check considers the heterogeneous effects of SA auctions by reserve price in continuous form. We extend Equation (1) by the interaction term of the SA auction with the logarithm of the reserve price. That is, we consider

$$Y_{ibrt} = \alpha_1 SA_{ibrt} + \alpha_2 SA_{ibrt} \times Ln(Res.Prc_{ibrt}) + \mathbf{A_{ibrt}}\beta + \mathbf{B_b}\gamma + \varepsilon_{ibrt}, \tag{4}$$

where other controls are identical to (1). We apply IPWRA using (4) with probability weights from (2). Table B5 of Appendix B confirms our conclusion for the heterogeneous effects of SA auctions by reserve price. Namely, the coefficient α_2 for the interaction term is significant and negative for the number of bidders and the bundle rebate, and it is significant and positive for the scaled final unit price. This suggests that a rise in the reserve price decreases competition and rebates and increases the price per unit for SA auctions. This suggests that there is a threshold for the procurement scale such that above this threshold, the SA auctions are less effective compared to the NSA auctions, as Figure 3 demonstrates.

VIII. Conclusion and policy implications

This study empirically investigates the effects of affirmative action in the form of SA auctions for SBEs in Russia. Specifically, with this preferential policy, the government aims to encourage the participation of SBEs in procurement tenders and to increase their share of public contracts. We run our analysis on a large and original database consisting of the population of public procurement auctions for granulated sugar in Russia in the period 2011–2013.

In an empirical auction setting in which supplier entry costs are minimized (through an electronic auction format, e-auction) and the quality of the procured item is not an issue (i.e. granulated sugar, a largely homogeneous good), we estimate the difference in outcomes from SA auctions compared with NSA auctions, focusing on both competition and the final purchase price. To measure competition, we use the *Number of applicants* and the *Number of bidders* in auctions. The homogeneity of the good enables us to use *price per unit* as a measure of the auction outcome; we also consider *bundle rebate* and *bundle size* for further analysis.

By adopting the IPWRA approach, we show that, on average, competition in SA auctions does not exceed that in NSA auctions. However, SA auctions result in lower procurement prices per unit and higher auction rebates. The analysis of the effect's heterogeneity implies that SA auctions result in lower procurement prices only up to a specific procurement scale threshold. We rationalize this result with a bipartite total cost structure of firms, in which SBEs have lower fixed participation costs, while non-SBEs have lower margin costs of production.

To suggest policy improvements for SA auctions in sectors other than granulated sugar, one should start from the consideration that the range of reserve prices in which the SA format leads to lower awarding prices can be affected by the features of the goods/services to be procured and by their related market regulations. In this light, our investigation suggests that procurers should carry out a preliminary and detailed study before implementing affirmative action. In particular, this study should instruct the design of SA auctions by highlighting elements such as market size and market concentration (with a focus on the number of local SBEs), effective and potential competition, and any form of barriers to entry, as well as the characteristics of goods/services to be awarded and their relevant regulations.

Finally, as information and firms' experience can also play a significant role when entering SA auctions, procurement regulators should consider training policies aimed at incentivizing SBEs' participation in procurement, specifically in combination with preferential policies, such as SA auctions.

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Disclosure statement

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