BIDS AND COSTS IN COMBINATORIAL AND NONCOMBINATORIAL PROCUREMENT AUCTIONS—EVIDENCE FROM PROCUREMENT OF PUBLIC CLEANING CONTRACTS

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Combinatorial procurement auctions enable suppliers to pass their potential cost synergies on to the procuring entity and may therefore lead to lower costs and enhance efficiency. However, bidders might find it profitable to inflate their stand-alone bids in order to favor their package bids. Using data from standard and combinatorial procurement auctions, we find that bids on individual contracts in simultaneous standard auctions without the option to submit package bids are significantly lower than the corresponding stand-alone bids in combinatorial auctions. Further, no significant difference in procurer’s cost as explained by auction format is found. (JEL D44, H57, L15)

I. INTRODUCTION

Auctions in which bidders are allowed to submit bids on combinations (or packages) of contracts have received substantial attention in recent years, in both practice and theory (Abrache et al. 2007; Cantillon and Pesendorfer 2006; Cramton, Shoham, and Steinberg 2006; De Vries and Vohra 2003; Epstein et al. 2004; Sheffi 2004). Combinatorial procurement auctions are increasingly being employed in both the private and public sector as an alternative to simultaneous auctions of individual contracts. The mechanism enables suppliers to express synergies across bundles of contracts, which mitigates the exposure problem (Pekeć and Rothkopf 2003) and putatively has the potential to both lower the procurer’s cost and enhance efficiency.

However, combinatorial auctions are very complex. Beside the inherent potential computational problem in determining the winner in a combinatorial auction (Nisan 2006), the auction mechanism is also strategically very complicated. When first-price combinatorial procurement auctions are practiced, bidders generally place both stand-alone bids on single contracts and bids on various packages of contracts. This implies that a bidder’s stand-alone bids also will be competing with his combination bids. Hence, bidders might find it profitable to inflate their stand-alone bids, or refrain from submitting any, in order to increase the probability of winning with their combination bids. Therefore, an observed difference between the sum of a bidder’s stand-alone bids on a particular set of contracts and her combination bid for the same set of contracts does not necessarily reflect the size of the underlying cost synergy.

In this paper we empirically study bidding behavior in first-price public procurement auctions of single and multiple contracts, where bidders in some of the multicontract auctions also had the option to submit bids on combinations of contracts. In the combinatorial auctions studied, suppliers were free to bid for any combination of contracts but there had to be a submitted stand-alone bid for every contract being

ABBREVIATIONS
EU: European Union
OECD: Organization for Economic Cooperation and Development
SEK: Swedish Kroner

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part of any combination.\footnote{One reason for restricting bidders to place stand-alone bids on those contracts included in one or several combination bids, is to avoid a dead-lock problem, that is, overlapping winning bids, when determining the winner(s).} The data analyzed in the paper are collected from both combinatorial procurement auctions and from multi-contract auctions. In the latter auctions, bidders have submitted bids simultaneously on single contracts, where the evaluation of the bids on a specific contract has been done independently of the bids on any other contract. Data are also collected from procurement auctions where only a single contract has been auctioned out.\footnote{2. The noncombinatorial auctions are henceforth labeled standard auctions.} The same set of bidders is found in the combinatorial and in the standard auctions. As such we can compare the behavior of the bidders for different auction rules: package bidding allowed and not allowed, and evaluate the extent to which the package bid discount really reflects a cost reduction for the procuring entity. The procurement auctions studied consist of internal regular cleaning contracts. We argue that cost synergies across contracts are the motivation for the observed combination bids.

In the presence of synergies across items or contracts, the effect upon revenues or cost when allowing bidders to submit combination bids has been assessed in a number of experimental studies (see Chernomaz and Levin 2011, for a list of some previous experiments). However, few studies have provided equilibrium bidding strategies in environments of heterogeneous multiple items. In Krishna and Rosenthal (1996), it is shown that the simultaneous sealed-bid second-price auction with two objects and a single global bidder outperforms a corresponding combinatorial auction when synergies are present. The reason for this is that the global bidder engages in “overbidding,” that is, bids above her value, facing the possibility of a loss ex post. A similar result is found in Kagel and Levin (2005), in which they derive and analyze bidding behavior in a sealed-bid uniform price auction when synergies are present. They find that bidders with multiunit demand have, for some intervals of values, an incentive to submit bids above their valuation. Chernomaz and Levin (2011) analyze a simple bidding environment in a first-price sealed bid model where a single item is auctioned off in each of two markets. In every market there is a bidder with unit demand (local bidder) who bids against a single bidder demanding one unit in each market (global bidder). Two auction rules are analyzed: a separate auction rule and a combinatorial auction rule. Under the separate auction rule, the outcome in the first market is determined independently from the outcome in the second market (simultaneous single-item auctions). Under the combinatorial auction rule, the global bidder is allowed to submit a package bid for both items. The outcome in each market is then determined by considering all the bids in both markets. Under the separate auction rule, Chernomaz and Levin prove that the global bidder, when facing synergies, is more aggressive than the local bidders are. Their result is in line with the results obtained in the literature on asymmetric auctions, where bidders’ valuations are drawn from different probability distributions, that is, one distribution first-order stochastically dominates another distribution. Maskin and Riley (2000) show that in a first-price auction, the equilibrium bid distribution of the “strong” bidder (the global bidder) stochastically dominates that of the “weak” bidder (the local bidder).\footnote{3. See also Bernheim and Whinston (1986) who provide equilibrium allocations in first-price menu auctions of multiple objects, assuming that bidders have complete information.}

Chernomaz and Levin also show that the combinatorial auction rule generates lower revenues to the seller than does the separate auction, regardless of the level of synergies. The reason is a pervasive threshold problem. Local bidders have to coordinate their single bids in order to outbid the combination bid from the global bidder (the threshold value), which gives rise to a free riding problem as either of their bids could be the one to push their sum above the threshold value necessary to beat the combination bid. Therefore, the local bidders are expected to bid less aggressively in a combinatorial auction than they do in two separate auctions. In other words, there is a trade-off as the combinatorial procurement auction may solve the exposure problem (lowering the offered prices from global bidders), it also introduces a free riding behavior (less aggressive bids from local bidders). The experimental results obtained by Chernomax and Levin indicate that the theory qualitatively is consistent with the observed behavior: the stronger the synergies, the better performance of the combinatorial auction in terms of efficiency; the seller’s revenue is higher under separate auctions than under the combinatorial auctions, irrespective of the size of the induced synergies.
It should be pointed out, that even in the absence of any cost synergies there are still incentives for a bidder to submit a combination bid which is lower than the sum of the stand-alone bids for corresponding contracts. Referring to the literature on multiproduct monopoly pricing (e.g., McAffee, McMillan, and Whinston 1989), Cantillon and Pesendorfer (2007) show that a combination bid in a first-price auction can be profitable for the same reason that the multiproduct monopolist finds price discrimination profitable. In their model with one unit auctioned out in two markets, Chernomaz and Levin (2011) derive a unique equilibrium where the global bidder submits only a combination bid for the two items, even though stand-alone bids are allowed. The cost of submitting stand-alone bids outweighs their benefit. However, this result probably hinges on the fact that the values of the global bidder in their model are perfectly positive correlated across the two markets. Under the assumption that combination bids are motivated by strategic pricing rather than by the presence of (strong) synergies Chernomaz and Levin (2011) show that the expected efficiency is higher if the items are auctioned off in two separate auctions. As the synergies reach a significant level, an auction allowing for combination bids will eventually outperform the separate auctions in terms of efficiency.

Given the presence of cost synergies in a multicontract auction environment there seems to be few reasons—if any—to believe that the stand-alone bids in a first-price combinatorial procurement auction on a set of individual contracts are identical to the bids submitted on the same set of contracts in a first-price auction without the option to bid on packages. Because of aggressive bidding on individual contracts in the simultaneous format and to inflated stand-alone bids in the combinatorial format, the bids on single items are likely to be higher in the combinatorial format than in the noncombinatorial format. Therefore, the observed package discounts are likely to overstate the real cost savings of allowing for combinatorial bids in a multicontract environment. Here, we empirically explore this idea by comparing observed bidding behavior in procurement auctions—single-contract auctions as well as simultaneous auctions (standard auctions)—with that in combinatorial procurement auctions (combinatorial auctions).

Two major questions are addressed empirically in the paper. The first question is whether there is a difference or not between the stand-alone bids on individual contracts in combinatorial auctions and the bids submitted in standard auctions. The second question concerns the cost; is there an observable difference in procurement cost across the auction formats? In order to analyze the two questions, three hypotheses are evaluated. The first hypothesis is that the stand-alone bids in combinatorial auctions do not reflect the contrafactual case, that is, they are higher than the bids on individual contracts in standard auctions. In the second test, which is carried out to shed some light on the second question concerning the cost, we test the hypothesis that the bid level in a standard auction decreases as the number of contracts increases. Given the a priori assumption that firms face synergies in the number of square meters to be cleaned, we expect lower bids on individual contracts as the number of contracts auctioned out in a standard auction increases, ceteris paribus. The idea is that the potential for cost synergies across contracts is increasing in the number of contracts auctioned out in one and the same procurement. The third test evaluates differences in procurement cost across auction formats. Making use of the winning bids in both combinatorial and standard auctions, we test the null hypothesis that both auction formats generate identical procurement costs.

Our empirical study is based on a dataset consisting of single bids in standard auctions (single and multiple contracts) and stand-alone bids and package bids in combinatorial auctions. The bids originate from public procurement of an identical service, internal regular cleaning service contracts, with an identical set of bidding firms in both the standard and combinatorial auctions. Hence, the data include information about bids submitted in both combinatorial and standard auctions, allowing us to assess the true cost savings putatively realized by applying package bidding. To our knowledge, this study is the first to compare observed bidding behavior in procurement auctions both with and without the option to submit package bids, contingent upon firm identity.

The main findings are that, when controlling for firm identity and other characteristics: (1) the stand-alone bids in the combinatorial auctions are significantly higher than the bids in standard auctions; (2) the bid level in standard auctions decreases as the number of contracts auctioned in one and the same procurement increases; (3) we do not find any significant difference in
winning bids that can be attributed to differences in the format of auctions of multiple contracts.

The paper is organized as follows. In Section II, we very briefly describe different types of combinatorial public procurement auctions that we are aware of having been applied in Sweden in recent years. Section II also includes a description of the design of three specific combinatorial auctions and the standard auctions from which our data originate. The full dataset, empirical analysis, and results are presented in Section III. Section IV concludes the paper. Additional figures and tables are presented in the Appendix.

II. PUBLIC PROCUREMENT AUCTIONS IN SWEDEN

Since the enforcement of the European (EU) procurement directives in Sweden in 1994, public procurement auctions have been held on a regular basis and, as in most Organisation for Economic Cooperation and Development (OECD) countries, the contracts awarded in them account for a substantial part of the national economy (about 15% of the gross national product). Public procurement auctions in Sweden are regulated by legislation (following the EU directives) stipulating that bids must be sealed, and the contract(s) awarded either to the bidder who submits the lowest bid, or (when criteria other than price are also important) to the bidder who is considered to have submitted the most economically advantageous bid (or tender). Irrespective of the award criteria, the winning bidder is paid in accordance with her bid.

The procurement auctions may be either single-contract auctions or involve multiple contracts. In the latter case, the auctions are simultaneous and traditionally separate bids are placed on the different contracts auctioned in one and the same procurement. The opportunity to submit bids on public contracts is announced by a “call for tenders” and the announcement is accompanied by detailed descriptions of the services to be performed and the conditions to be stipulated in the contracts.

In Sweden, combinatorial auctions have been used relatively scarcely in public procurement auctions of multiple contracts, but there is a growing interest in the mechanism. Examples are found in the procurement of bus routes, road resurfacing, elderly care, and internal regular cleaning services. The generally applied mechanism has been a first-price procurement auction with an option to bid on packages of contracts. In most of these auctions the contracts have been more or less substitutes. The design of the combinatorial auctions has varied in terms of the restrictions imposed on bidding. In general, to avoid dead-lock problems, bidders have been obliged to submit a stand-alone bid for every contract that makes up a package bid.

A. Auctions of Cleaning Services

The empirical analysis in this paper is based on data from sealed bid public procurement auctions of internal regular cleaning services in Sweden. The auctions had the character of first-price sealed bid auctions and were organized either as single-contract or simultaneous multicontract auctions. Bids were placed on individual contracts, where each contract referred to a specific object to be cleaned: a school or an office. Hence, the size of an individual contract—in terms of number of square meters—is exogenously given by the size of the particular school or office to be cleaned. In all auctions, one shot simultaneous sealed bidding was applied. No contracts within a procurement auction were auctioned out sequentially. The combinatorial auctions were first-price sealed bid auctions held in 2005, 2006, and 2007. The standard auction data originate from auctions held in the periods 1992–1998 and 2006–2007. We regard the different procurements as independent over time and over geographical position. A bidding firm could not make their bids in one auction contingent on the outcome in another auction.

We have identified the same set of bidding firms in all sub-samples considered here. This enables us to compare the bidding behavior of the same firms, submitting all types of bids, across auction mechanisms, and thus robustly compare bidding behavior in auctions with different designs (combinatorial vs. non-combinatorial), including one or several contracts (single-contract vs. multicontract auctions). Before describing the full dataset, the design of the three combinatorial auctions is briefly reviewed.
B. Combinatorial Auctions

One of the combinatorial procurement auctions was held in 2005 and another in 2006 (designated auctions A and B, respectively). In both of these cases the procuring entity was a local government. Auctions A and B were for nine and seven separate contracts, with total areas to be cleaned of 105,000 and 400,000 m², respectively. The premises to be cleaned were either public offices or public schools. In both auctions bidders were free to submit bids on any bundle of contracts, and bidders had to submit a stand-alone bid for every contract included in a package bid. In Auction A, a bidding firm could, in addition to the various bids, declare the maximum area in terms of square meters it could accept being contracted for if it was awarded too many contracts. In Auction B, a firm could express its capacity constraint by stating the maximum contract sum it could be awarded. In Auction A, 14 firms participated. Almost every firm placed a stand-alone bid on each of the nine contracts. Six firms submitted package bids of various sizes, from a two-contract bundle up to a nine-contract bundle. The total number of package bids was 54, of which 35 were submitted by a single firm. The discounts in the package bids ranged from 2% to 9%. No firm declared a constraint on the maximum number of square meters it could clean. All the winning bids were stand-alone bids. In Auction B, there were six bidders, and the maximum number of contracts allowed in a package bid was three. All the bidding firms, except one, placed stand-alone bids on each of the seven contracts, and four of the six participating firms submitted 104 package bids in total. The discount in these package bids ranged from 2% to 6%. Again, no bidder placed a bid declaring a constrained capacity. Two firms were each allocated three contracts and one firm was awarded one contract. As shown in Figures A1 and A2 in the Appendix, for both types of bids the offered price declined with increases in the number of square meters to be cleaned.

The third combinatorial procurement auction examined (designated Auction C) was organized by the Swedish Social Insurance Agency in 2007. This is a national agency with local representation throughout the country. The number of separate contracts offered was 42 and they concerned regular cleaning services in all of the agency’s local offices in Sweden. Each contract was to clean one or more offices in the same geographical area, and the total area to be cleaned was about 440,000 m². Unlike combinatorial auctions A and B, both of which were local government auctions, combinatorial Auction C was a nationwide auction. The number of bidders in this auction was 22. Three firms submitted only stand-alone bids on each of the 42 contracts. Eight firms submitted a total of 69 package bids. Two of these firms also submitted, among several other package bids, a package bid on all 42 contracts. One of the nationwide firms was awarded all 42 contracts through one package bid. Again, the stand-alone bids and package bids declined with increases in contract size, suggesting the presence of synergies. Hence, as shown in Figure A3 in the Appendix, the offered price per square meter decreased with increases in volume for both the stand-alone and package bids. Stand-alone bids and winning bids from auctions A, B, and C are included in the data in order to analyze the presence of synergies and cost differences attributable to differences in auction format.

As indicated by the scatter-plots in Figures A1–A3 (and later in this paper also statistically tested), the bidders’ offered price is decreasing in the number of square meters to be cleaned. Hence, there are reasons to believe that the package bids are motivated by significant cost synergies. In personal contacts with some of the bidding firms, we have been told that there are cost advantages of winning larger contracts. A larger contract means more personnel but at a diminishing ratio. Also, the branch suffers from relatively high frequency of sick leave. The nature of the work makes people get back and shoulder pain. Because the cleaning contracts are very close substitutes, firms with more employees can more easily replace those who are on sick leave than firms with fewer employees. At least for larger firms, the flexibility to move personnel from one contract to another contract is increasing in the number of contracts.

III. EMPIRICAL ANALYSIS

A. The Data and the Standard Auctions

As outlined above, the bids used to compare the stand-alone and winning bids from the combinatorial auctions originate from single and multi-contract public procurement auctions of cleaning services, organized by local governments and government authorities. We refer to these bids as single bids. The data were acquired
from two surveys. The first covers the time period 1992–1998 and includes 362 contracts. The second covers 2006 and 2007 and includes 30 contracts. We also use solely the winning bids in this dataset to compare the difference in procurement costs across the auction formats. Descriptive statistics are found in Table 1.

The bid level dataset consists of bids from cleaning firms that participated in auctions with both formats, that is, they submitted single bids in standard auctions and at least one package bid in a combinatorial auction. Bids from firms that only participated in one type of auction are excluded from this analysis. In total, 12 firms satisfied the criteria for including their bids. In all, the dataset includes 1,182 bids submitted on 450 sealed-bid internal regular cleaning service contracts auctioned in 96 procurement auctions. The winning bid data comprise winning bids on the 450 contracts. The contracts were fixed price contracts for cleaning public premises that were either schools or offices. The dataset is based on submitted bids—a matter of open public record—requested from the procuring entities, which have also provided us with the documentation related to the calls for tenders. The majority of the bids (80%) in the dataset have been collected from standard auctions of single contracts or standard auctions of multiple contracts.

Descriptive statistics for the annual bids in Swedish kroner (SEK) per square meter to be cleaned (at the 1994 price level) together with contract, auction, and bidding environment characteristics, can be found in Table 1, and correlations among these variables in Table A1 in the Appendix.

As displayed in Table 1, the average bid was 10% higher in the standard auction format than the average stand-alone bid in the combinatorial format. Decomposing the data for the two types of premises, we see that there is
The average contract specified 5,735.35 m² to be cleaned, and a majority of the premises were schools (68%). Approximately five contracts were auctioned, on average, in the same procurement. The degree of competition in these auctions was fairly high; the average number of bidders was about seven with a slightly lower degree of competition in the combinatorial auctions (5.7) compared to the standard auctions (7.0).

In order to get a rough picture of whether the distribution of bids— all bids as well as only the winnings bids—is different across the two formats, the distributions of the bids are compared in a $t$ test. As can be seen from Table 2, the $t$ test rejects the hypothesis of equal mean values across the two auction formats, no matter the type of bids used in the test. Without considering the explanatory power of covariates, the tests indicate no difference between the winning bids generated in the combinatorial format and the corresponding bids generated in a standard auction of multiple contracts.

### TABLE 2

$t$ Test of Mean Values (SEK/m²)

<table>
<thead>
<tr>
<th>Auction format</th>
<th>All bids</th>
<th></th>
<th>Winning bids</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>$n$</td>
<td>Mean</td>
</tr>
<tr>
<td>Combinatorial auctions</td>
<td>88.95</td>
<td>17.97</td>
<td>195</td>
<td>99.99</td>
</tr>
<tr>
<td>Standard auctions</td>
<td>102.47</td>
<td>45.51</td>
<td>972</td>
<td>104.44</td>
</tr>
<tr>
<td>Test ($t$ value)</td>
<td>4.08</td>
<td>—</td>
<td>—</td>
<td>0.37</td>
</tr>
</tbody>
</table>

In the first test, the data from the standard auctions together with the stand-alone bids from the combinatorial auctions are used to assess whether the stand-alone bids submitted in the combinatorial auctions are identical to bids on individual contracts in standard auctions. For reasons mentioned in the introduction, we conjecture that the stand-alone bids in the combinatorial format are likely to be higher than those submitted in standard auctions. In our second test we only make use of the data from standard auctions. The purpose is to investigate if the bid level, in terms of submitted price per square meter to be cleaned, is affected by the number of contracts auctioned in the same tender process. Assuming that the bidders’ costs are asymmetrically distributed, we expect to find lower bids when the number of contracts in a tender is increased because of aggressive bidding on individual contracts. Finally, using only the winning bids in the dataset, the third test analyzes whether the procurement cost differs across auction format.

### B. Empirical Setting and Results

To analyze the extent to which package discounts in combinatorial bids reflect a true cost reduction for the procuring entity, we make use of different samples of our dataset in the three tests: (Test I) stand-alone bids from combinatorial auctions versus bids from single and multicontract standard auctions; (Test II) bids from single-contract standard auctions versus bids from multicontracts standard auctions; (Test III) winning bids from combinatorial auctions versus winning bids from standard auctions.

Test of Bidding Behavior and of Procurement Cost. Bidding behavior is empirically tested here using the annual bids per square meter at the 1994 price level (SEK) as the dependent variable (logarithmically transformed because the annual bid per square meter is a unitary measure). A dummy variable, $FORMAT$, is used in two of the tests to control for the type of auction—standard or combinatorial—the bids originate from. The logarithm of the number of contracts in each auction is captured by the variable $CONTRACT$, the size of each contract is defined as the logarithm of the number of square meters.
meters to be cleaned, $SQM$. A dummy variable for the type of premises takes the value one if the premises is a school ($SCHOOL$) and zero otherwise. The degree of competition ($COMP$) is measured as the logarithm of the observed number of bidders in each auction. By including dummy variables for the six most frequently bidding firms we control for bidder identity ($FIRM_j$, where $j = A, \ldots, F$). These six firms operate on a national or regional basis. Smaller, essentially locally operating firms constitute the reference category. Including a dummy variable for each of the smaller firms is not meaningful. They constitute individually a small part of the sample and are therefore more interesting as a firm category. We do however, in addition to this, control for cluster where firm identity for all firms defines the cluster. This approach follows the one used by Hyytinen, Lundberg, and Toivanen (2007).

In addition, as the auctions took place in different areas of Sweden, differences in cost structure and preferences are accounted for by controlling for unemployment rate ($UNEMP$), population density ($DENSITY$), and the proportion of seats in the local council assigned to the left wing ($LEFT$). These variables are also expressed as logarithmic values. Cleaning services are personnel-intensive and thus their costs are mainly driven by wages, which are expected to be lower when the unemployment rate is high, but higher in more densely populated areas. Political preferences have in previous studies proved to affect the outcome of public procurement auctions in Sweden (Hyytinen, Lundberg, and Toivanen 2007) and are therefore included. In order to control for the fact that our data originates from two time periods with minor changes in the procurement regulation, a dummy variable ($TIME$), taking the value one if the procurement was carried out before year 2000 and zero otherwise, is included. The regression equation applied in the first test and in the third test (Test I and Test III) is

$$y_i = \alpha_i + \beta_1 FORMAT_i + \beta_2 CONTRACTS_i + \beta_3 SQM_i + \beta_4 COMP_i + \beta_5 SCHOOL_i + \sum_{j=A}^{F} FIRM_{ij} + \beta_7 UNEMP_i + \beta_8 DENS_i + \beta_9 LEFT_i + \beta_10 TIME_i + \varepsilon_i.$$ \hspace{1cm} (1)

Equations (1) and (2) are solved by ordinary least square regression with White-correction for heteroscedasticity.

**Results.** The regression results from all tests are presented in Table 3. The main result of the first test, Test I, is that we can reject the hypothesis of identical (stand-alone) bids submitted within both auction formats. The significantly higher stand-alone bids are probably attributable both to inflated stand-alone bids in the combinatorial format and to increased aggressive bidding in the standard auctions as the number of contracts increases. The estimate of the first variable, $FORMAT$, indicates that the stand-alone bids are inflated whereas the estimate of the second variable, $CONTRACTS$, shows a lowered bid level as the tenders are enlarged in terms of number of contracts. These findings are robust for controlling for firm identity clusters (see Table A2 in the Appendix).$^9$

Our second test, Test II, rejects the hypothesis that bids are unaffected by the total number of contracts that are auctioned out in a specific

9. A similar comparison of the stand-alone bids from the combinatorial auctions with the bids from auctions of single contracts, that is, excluding any potential effect of multicontract bidding behavior in the standard auction from the analysis, confirms the finding of inflated stand-alone bids.
tender. The negative estimate of the variable \textit{CONTRACTS} suggests that the bidding firms bid more aggressively as the number of contracts in a specific tender increases. Finally, Test III does not support that either of the two auction formats should be superior to the other in terms of cost per square meter on the contract level. Hence, our data do not provide significant evidence that the use of a combinatorial auction lowers procurement costs. This might be because of the fact that the observed discounts in the package bids are offset by the inflated standalone bids and to lowered bids in the standard auctions as the number of contracts increases.

The tests suggest that increased competition (\textit{COMP}) to some extent leads to lower bids. This result is in accordance with previous findings based on an extended set of the data used in this study.\footnote{Lundberg (2005) finds bids to decrease with increases in the number of bidders in an empirical study in which all bids, from which the data in this study are a sub-sample, generated in standard auctions, are used.} In addition, the results show that the size of the contracts, in terms of square meters to be cleaned, has a significant negative impact on the bids per square meter, indicating the presence of economies of scale. The coefficient for the number of square meters to be cleaned per contract is also negative and significant.

The results also indicate that scale effects are present not only in terms of the number of contracts, but also within contracts, and that schools are more expensive to clean than offices, most likely because of differences in needs and quality demands. The outcome of the three tests for the firm identity coefficients varies, but the impression is that larger firms generally submit lower bids than local firms. Another finding is that the bidding environment affects, to some extent, the size of the bids. The coefficients for the population density in the area, and the proportion of seats in the local council held by the leftwing, does not support that either of the two auction formats should be superior to the other in terms of cost per square meter on the contract level. Hence, our data do not provide significant evidence that the use of a combinatorial auction lowers procurement costs. This might be because of the fact that the observed discounts in the package bids are offset by the inflated standalone bids and to lowered bids in the standard auctions as the number of contracts increases.

\begin{table}[h]
\centering
\begin{tabular}{lccc}
\hline
\textbf{Variable} & \textbf{Test I} & \textbf{Test II} & \textbf{Test III} \\
\hline
Format & $-0.19$ (–3.82) & $-0.04$ (–4.61) & $-0.10$ (–7.78) \\
Number of contracts & $-0.04$ (–4.61) & $-0.004$ (–7.57) & $-0.06$ (–3.42) \\
Square meter & $-0.10$ (–7.78) & $-0.10$ (–7.12) & $-0.11$ (–7.00) \\
Competition & $-0.04$ (–1.69) & $-0.08$ (–2.49) & $-0.11$ (–1.43) \\
School & 0.25 (8.51) & 0.23 (6.34) & 0.36 (4.63) \\
FIRM A & $-0.11$ (–3.09) & $-0.10$ (–1.97) & $-0.16$ (–2.28) \\
FIRM B & $-0.09$ (–2.28) & $-0.06$ (–1.17) & $-0.00$ (0.22) \\
FIRM C & $-0.26$ (–3.92) & $-0.32$ (–3.71) & $-0.41$ (5.87) \\
FIRM D & $-0.07$ (–2.01) & $-0.08$ (–1.54) & $-0.24$ (2.07) \\
FIRM E & $-0.06$ (–1.47) & $-0.07$ (–1.30) & $-0.01$ (–0.57) \\
FIRM F & $-0.19$ (–3.28) & $-0.20$ (–2.85) & $-0.20$ (–2.85) \\
Unemployment rate & $-0.07$ (–1.38) & $-0.11$ (–1.58) & $-0.16$ (–2.28) \\
Population density & 0.02 (2.06) & 0.02 (1.88) & $-0.41$ (5.87) \\
Leftwing & $-0.18$ (–3.07) & $-0.23$ (–3.52) & $-0.24$ (2.07) \\
Time & 0.04 (0.53) & 0.11 (1.31) & $-0.20$ (–2.85) \\
Constant & 5.26 (35.39) & 6.32 (25.88) & 5.16 (26.07) \\
\hline
\end{tabular}
\caption{Estimation Results ($t$-Ratio in Parentheses)}
\end{table}

Note: VIF = variance inflation factor.
positive coefficients are found. Clearly (and not surprisingly) therefore, the number of square meters to be cleaned is a very strong predictor of the total bid. The estimation results can be found in Table A3.

IV. SUMMARY AND CONCLUSIONS

The simultaneous first-price procurement auction is normally used in the public sector when multiple contracts are auctioned out. In contrast to that mechanism, a first-price combinatorial auction enables suppliers to express the presumably nonlinear nature of their production cost, that is, economies or diseconomies of scale, without being exposed to the risk of winning too few or too many contracts. The option to submit bids on bundles of contracts or to express constraints on available capacity, when multiple contracts are auctioned out, has the potential to increase competition from both small and larger suppliers and thus increase efficiency and reduce procurement cost. However, there are a number of issues related to combinatorial procurement auctions that need to be further analyzed before one firmly can assess the value of the mechanism.

In this paper, we have empirically investigated two related aspects of first-price combinatorial procurement auctions. The first question raised is to what extent the bids on individual contracts in a combinatorial auction—the stand-alone bids—differ from the bids on individual contracts in auctions with no option to place bids on packages of contracts. Referring to the present theoretical guidance concerning first-price sealed bid combinatorial auction—albeit not precisely modeling the bidding environment of the auctions from which we have collected the data—we predict the stand-alone bids to be higher than the bids on individual contracts in standard auctions for two reasons. Firstly, in order to favor a package bid in a combinatorial auction, bidders inflate their stand-alone bids on those contracts making up the package bid. Secondly, given synergies across contracts, bidders submit a lower bid on each individual contract in a multicontract noncombination auction than they do in a single-contract auction. The second question raised is whether the procurement cost in a combinatorial auction format is different from that in a standard auction format.

Based on data from Swedish procurement auctions of cleaning services, we find that the stand-alone bids in combinatorial auctions are higher than the bids from tenders where only one single contract has been auctioned out. When multiple contracts are auctioned out in the same procurement auction, with no option to submit bids on packages, bidders tend to bid lower on individual contracts than they do in a single-contract environment. Hence, the observed difference between the stand-alone bids in the combinatorial auction and the bids in the standard auction seems to be because of both inflated stand-alone bids in the former auction and to aggressive bidding in the latter auction. Our empirical analysis does not unambiguously support that a combinatorial procurement auction generates a lower procurement cost per square meter on the contract level than does the standard auction.

This study points out that one needs to be careful when interpreting the size of the package discounts in first-price combinatorial auctions. Based on our data we conclude that the observed stand-alone bids in the combinatorial format do not reflect the contrafactual, that is, bids submitted in a similar auction with no option to bid on packages. Even if package bids are motivated by synergies, and thus have the potential to lower the procurer’s cost, the observed package discount overstates the actual cost reduction of a combinatorial auction.

Further, the contracts studied here can be considered as substitutes rather than complements. Therefore, a firm’s cost synergies are likely to be stronger in the size of the individual contracts (number of square meters) rather than in the number of contracts the firm is awarded. The potential advantages of using a combinatorial auction when contracts are substitutes will likely depend on the sizes of the contracts. If the individual contracts are sufficiently large, the firm may capture significant cost synergies already through their single bids. In such a case, the use of a combinatorial auction format may not be as beneficial as it would be if the number of contracts is large but the contracts are of smaller sizes. In our dataset, the average contract auctioned out within the combinatorial format is almost four times larger than the average size of the contracts within the standard auctions. This difference in contract sizes, together with other observed heterogeneity, could possibly explain why we in this study find no significant differences in winning bids across formats.
FIGURE A1
Stand-Alone and Package Bids/m² in Auction A (SEK)

FIGURE A2
Stand-Alone and Package Bids/m² in Auction B (SEK)

FIGURE A3
Stand-Alone and Package Bids/m² in Auction C (SEK)
### TABLE A1
**Correlation Matrix**

<table>
<thead>
<tr>
<th></th>
<th>Contract</th>
<th>Competition</th>
<th>Format</th>
<th>Square Meter</th>
<th>School</th>
<th>Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract</td>
<td>1.00</td>
<td>-0.09</td>
<td>-0.27</td>
<td>-0.07</td>
<td>-0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Competition</td>
<td>-0.09</td>
<td>1.00</td>
<td>0.12</td>
<td>-0.04</td>
<td>-0.05</td>
<td>-0.12</td>
</tr>
<tr>
<td>Format</td>
<td>-0.27</td>
<td>0.12</td>
<td>1.00</td>
<td>-0.49</td>
<td>0.42</td>
<td>-0.42</td>
</tr>
<tr>
<td>Square meter</td>
<td>-0.07</td>
<td>-0.04</td>
<td>-0.49</td>
<td>1.00</td>
<td>-0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>School</td>
<td>-0.28</td>
<td>-0.05</td>
<td>0.42</td>
<td>-0.02</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Office</td>
<td>0.28</td>
<td>-0.12</td>
<td>-0.42</td>
<td>0.02</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

### TABLE A2
**Estimation Results—Standard Errors Adjusted for 12 Clusters in Firm Identity (t-Ratio in Parentheses)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test I</th>
<th>Test II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format</td>
<td>-0.21 (-8.98)</td>
<td>-0.04 (-4.20)</td>
</tr>
<tr>
<td>Number of contracts</td>
<td>-0.04 (-4.89)</td>
<td>-0.04 (-6.27)</td>
</tr>
<tr>
<td>Square meter</td>
<td>-0.10 (-7.28)</td>
<td>-0.07 (-1.15)</td>
</tr>
<tr>
<td>Competition</td>
<td>-0.03 (-6.73)</td>
<td>-0.07 (-1.15)</td>
</tr>
<tr>
<td>School</td>
<td>0.24 (5.73)</td>
<td>0.23 (5.28)</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>-0.04 (-0.52)</td>
<td>-0.08 (-1.10)</td>
</tr>
<tr>
<td>Population density</td>
<td>0.02 (1.46)</td>
<td>0.02 (1.73)</td>
</tr>
<tr>
<td>Leftwing</td>
<td>-0.15 (-2.90)</td>
<td>-0.16 (-2.35)</td>
</tr>
<tr>
<td>Time</td>
<td>0.01 (0.23)</td>
<td>0.07 (0.95)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.96 (16.07)</td>
<td>5.92 (16.54)</td>
</tr>
<tr>
<td>(N)</td>
<td>1,182</td>
<td>972</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.14</td>
<td>0.12</td>
</tr>
<tr>
<td>(F(9, 11)/F(8, 11))</td>
<td>5,107.57</td>
<td>953.24</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>3.60</td>
<td>2.27</td>
</tr>
</tbody>
</table>

**Note:** VIF = variance inflation factor.

### TABLE A3
**Estimation Results—Dependent Variable “Total Bid,” Annual Price in SEK (t-Ratio in Parentheses)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test I</th>
<th>Test II</th>
<th>Test III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format</td>
<td>-0.19 (-3.83)</td>
<td>-0.18 (-1.90)</td>
<td></td>
</tr>
<tr>
<td>Number of contracts</td>
<td>-0.04 (-4.61)</td>
<td>-0.04 (-3.52)</td>
<td>-0.06 (-3.05)</td>
</tr>
<tr>
<td>Square meter</td>
<td>0.90 (73.23)</td>
<td>0.91 (64.77)</td>
<td>0.89 (54.51)</td>
</tr>
<tr>
<td>Competition</td>
<td>-0.04 (-1.69)</td>
<td>-0.07 (-2.27)</td>
<td>-0.11 (-3.95)</td>
</tr>
<tr>
<td>School</td>
<td>0.25 (8.51)</td>
<td>0.24 (6.47)</td>
<td>0.36 (7.47)</td>
</tr>
<tr>
<td>FIRM A</td>
<td>-0.11 (-3.09)</td>
<td>-0.12 (-2.39)</td>
<td></td>
</tr>
<tr>
<td>FIRM B</td>
<td>-0.09 (-2.28)</td>
<td>-0.07 (-1.22)</td>
<td></td>
</tr>
<tr>
<td>FIRM C</td>
<td>-0.26 (-3.98)</td>
<td>-0.35 (-4.10)</td>
<td></td>
</tr>
<tr>
<td>FIRM D</td>
<td>-0.07 (-2.01)</td>
<td>-0.10 (-1.97)</td>
<td></td>
</tr>
<tr>
<td>FIRM E</td>
<td>-0.06 (-1.47)</td>
<td>-0.10 (-1.74)</td>
<td></td>
</tr>
<tr>
<td>FIRM F</td>
<td>-0.19 (-3.28)</td>
<td>-0.22 (-3.05)</td>
<td></td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>-0.08 (-1.38)</td>
<td>-0.12 (-1.75)</td>
<td>-0.16 (-1.77)</td>
</tr>
<tr>
<td>Population density</td>
<td>0.02 (2.06)</td>
<td>0.02 (2.13)</td>
<td>0.00 (0.28)</td>
</tr>
<tr>
<td>Leftwing</td>
<td>-0.18 (-3.07)</td>
<td>-0.20 (-3.06)</td>
<td>-0.41 (-4.87)</td>
</tr>
<tr>
<td>Time</td>
<td>0.04 (0.53)</td>
<td>0.11 (1.34)</td>
<td>0.24 (2.13)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.25 (35.39)</td>
<td>6.22 (24.57)</td>
<td>5.43 (21.26)</td>
</tr>
<tr>
<td>(N)</td>
<td>1,182</td>
<td>972</td>
<td>450</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.94</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td>(F(15, 1166), F(14, 957), F(9, 440))</td>
<td>934.52</td>
<td>443.26</td>
<td>611.73</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>3.16</td>
<td>2.52</td>
<td>2.08</td>
</tr>
</tbody>
</table>

**Note:** VIF = variance inflation factor.
REFERENCES


