COMBINATORIAL AUCTIONS IN PUBLIC PROCUREMENT: EXPERIENCES FROM SWEDEN

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Abstract

It is quite common that procuring authorities practice multi contract tender when buying for example, public transportation, cleaning services, resurfacing of roads, etc. Traditionally, single bidding is applied. Alternatively and recently introduced in Sweden, are tenders in which bidders are allowed to submit bids on combinations or packages of contracts in addition to their stand-alone bids. Combinatorial procurement auctions are increasingly being employed in both the private and public sectors as an alternative to simultaneous single contract auctions. The advantage with this mechanism is that it enables suppliers to express synergies across bundles of public contracts. This mitigates the exposure problem and also has the potential to both lower the price paid by the procuring authority and enhance efficiency. This paper provides some illustrative cases of recently performed procurements in Sweden in which package bidding has been applied.

1. Introduction

The procedure most commonly employed within public procurement, when a procuring agency divides a larger tender into smaller independent lots (contracts henceforth), is that bidders submit sealed separate bids (in the following referred to as single bids) on the contracts that they wish to be awarded, without any possibility to condition the prices in their bids on the outcome of other contracts. In other words, the tender will consist of as many smaller and independent partial tenders as there are contracts. The supplier who has offered the lowest individual price (or the economically most advantageous simple bid) on contract A is awarded that contract, the supplier who has submitted the best bid on contracts B is awarded that contract, and so on.

The strongest incentive for a purchaser to divide a tender into smaller contracts, with parallel bidding on each part, is that few suppliers – or sometimes none of them – would have the capacity to fulfil the whole contract if it was tendered in its entirety. Dividing the contract

into lots can thereby increase the competition from small and medium-sized suppliers with limited capacity. This is advantageous for both the supplier and the procurer as long as the supplier's costs for undertaking one or more of the parts of the procurement are independent of how many contracts they are awarded, that is to say, if the supplier's unit price per lot is nearly constant up to a certain volume.[1] If all the suppliers can be assumed to have a cost structure wherein the average cost per contract does not depend on how many contracts the supplier is awarded, but instead only varies among suppliers, then the individual suppliers' strategy sets are the same as if the tender had only concerned a single contract.

It is perhaps more realistic to assume that in simultaneously bidding on several contracts, a supplier's cost for fulfilling a specific part of the tender depends on the *number* and *volume* of the contrats awarded. In such a situation, a supplier choosing to bid on several parts of the tender faces more complex strategies than in cases where the costs of different parts are independent of each other. It now becomes decisive how, and to what extent, the supplier has an opportunity in the bidding process to convey that their costs, and consequently their prices offered, depend on how much of the tender that they are awarded. The complexity of the tender is increasing in the number of contracts auctioned in one and the same tender.

The obvious problem with an unconditional (non-linked) bidding process and evaluation of bids is that it makes it difficult for suppliers to 1) convey economies of scale, that is to say, discounted unit-prices if the supplier is guaranteed a certain volume in the procurement, and 2) convey that their capacity is limited in the event that they are awarded a too great volume. The purchaser therefore risks not being able to take advantage of possible lower prices from a supplier who may have economies of scale in the production process. Furthermore, the purchaser can miss out on competitive bids from smaller suppliers because they limit their bidding to a few single bids out of consideration of the risk of being awarded too many contracts.

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[1] One can, however, claim that a procuring agency has a marginal extra administrative cost for managing each contracted supplier. The more parts that a procurement auction has the greater the likelihood that several suppliers will be contracted. A reasonable balance here ought to be to contract more suppliers as long as the marginal reduction of the procurement costs for an additional supplier is greater than the marginal extra administrative cost for an additional supplier. A precondition for being able to weigh such alternatives is, of course, that the purchaser has an idea of the extra administrative cost of contracting an additional supplier.

If, on the other hand, the procuring entity in a tender comprising several contracts were to give the bidders the possibility – via the bidding itself – to communicate to the buyer
what the price-picture looks like for different volumes or numbers of contracts, then this ought to increase the likelihood that the purchaser can take advantage of any economies of scale among the suppliers. There are several alternative ways to design a bidding process for tendering multiple contracts in order to reduce the suppliers' uncertainty as to what they can expect to be awarded at different prices.[2] The perhaps most effective method for tenders of multiple contracts, both in terms of minimizing costs and maximizing efficiency, is combinatorial bidding.

In a combinatorial tender, the bidders have – if they so desire – the possibility, alongside placing stand-alone bids on individual contracts, to submit combinatorial bids. Roughly speaking one can distinguish between two types of combinatorial bids. One type offers some sort of discount if the bidder is guaranteed certain contracts, guaranteed a given minimum number of contracts, or is guaranteed a minimum contract value. At bid can be formulated as a package bid, that is to say, the bidder submits a price for a bundle of contracts where the package price only applies on the condition that the bidder is awarded all the contracts in the bundle. The bid can also be formulated as a vector of prices for different contracts, where the prices only apply on the condition that the bidder is awarded a minimum contract value or a minimum number of contracts from those included in the price vector.

The other type of combinatorial bid expresses that the supplier has a limited capacity, or additional costs for engaging to fulfil more that a certain number of contracts. A combinatorial bid conveying limited capacity can be formulated in such a way that the bidder submits stand-alone bids on a number of contracts, but in an addendum states

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[2] One method is to hold the tenders for the various contracts sequentially, that is to say, one after another in time. First you hold the bidding and bid evaluation for contract A. The results of the tender of contract A are announced before the bids for contract B must be submitted. This procedure is repeated for contract B and its result is announced before bids must be submitted for contract C, and so on. Suppliers would hence be aware of any awarded contracts in previous partial tenders before a new one is started, and can attempt to plan their bids around whether they have previously been accorded contracts. This method can, however, lead to the entire tender taking too long to carry out. In addition, a supplier with economy of scale advantages will still face the uncertainty of future awarded contracts during the period $t+1$ while bidding on ancontract during period t.

that they are only prepared to accept contracts up to a given maximum contract value, or up to a given maximum physical volume, such as for example, a maximum number of m^2 in a tender of several cleaning contracts. The bidder can also submit stand-alone bids on several of the contracts, but in an addendum stipulate negative discounts, that is to say, if they are awarded more than a certain number of contracts then all bids should be raised by x percent for each additional contract awarded.

Combinatorial procurement auctions are difficult to implement, mainly for two reasons: (1) the computational complexity to determine the winner(s) and (2) the strategic complexity for bidders. However, progress in combinatorial algorithms and computer-processing capacity the last years has increased the use of the mechanism in industrial procurement, mainly in transportation.

Unlike single-item auctions, multiple item environments still lack theoretical guidelines for making general predictions concerning revenue ranking and efficiency ranking of various types of combinatorial auctions. Krishna and Rosenthal (1996) show in a sealed-bid second-price auction, with two objects and a single global bidder, that a simultaneous auction outperforms the combinatorial auction when synergies are present. The reason is that the global bidder engages in "overbidding", that is, the bidder is bidding above his value, facing the possibility of a loss *ex post*.[3] When it comes to the first-price multiple unit auction, there is to our knowledge, no similar proof derived showing that a simultaneous first-price auction outperforms a first-price combinatorial auction. Also, the number of empirical and experimental studies, comparing the outcome from the two auction formats, are very few. If any, there is a weak support that the first-price combinatorial mechanism generates at least as the same low cost as the simultaneous format does [e.g. Epstein *et al*. (2004), Lunander and Nilsson, (2004), Cantillon and Pesendorfer, (2006), Lunander and Lundberg (2009)].

A number of studies on combinatorial bidding focuses on the inherent winner determination problem and how to express combined bids (e.g. De Vries and Vohra, 2003; Sheffi, 2004; Cramton et al., 2006; Abrache et al., 2007). Also, there is quite a large literature analysing the strategic implications of combinatorial bidding and

[3] 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 a bidder with multi-unit demand has, for some intervals of values, an incentive to submit bids above her valuation. Testing their prediction in an experiment, they find that subjects exhibit no reluctance to overbidding.

how to design combinatorial bidding. A number studies consider the the Vickrey-Clarke-Groves (VCG) mechanism, e.g., Krishna and Rosentahl (1996), Holzman and Monderer (2004), Yokoo *et al.* (2004), Ausubel and Milgrom (2006), Chew and Serizawa (2007).[4]

In this paper we will describe the design, the implementation and the outcome from a number of combinatorial first-price public procurement auctions of various services carried out in Sweden during the period 2003-2010. Given the data from these tenders, the questions we raise are

- to what extent do bidders use the option to express capacity constraints
- if contracts are allocated more to packages bids rather than to stand-alone bids.
- to what extent does the option to submit packages bids in a tender effect the bidder's stand-alone bids in the same tender.
- how large is the observed difference in cost when contracts are allocated to the lowest bids, excluding the packages bids, vis-a-vis including all bids.
- to what extent does combinatorial bids effect the distribution of awarded contracts among winning bidders compared to the distribution of contracts when packages bids are excluded.

Clearly, the lack of theoretical predictions as to the bidding behaviour in combinatorial auctions as well as the lack of data from the contra factual, that is, data from corresponding tenders without the option to submit combinatorial bids, limits the analyse of the data from the case studies.[5] Nevertheless, the observed outcome provides us with information as to how bidders respond to the option to submit conditional bids. The aim of the paper is rather to contribute with stylized facts than to thoroughly assess the effects of allowing for combinatorial bids in public procurement. However, our results may be of value not only of value to policy makers and practitioners, but also to those involved in research on combinatorial auctions.

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[4] For a criticism on the practical usefulness of the VCG mechanism, see Rothkopf (2007)

[5] Lunander and Lundberg (2009) compare bidding behavior in first-price procurement auctions of multiple contracts with and without the option to submit combinatorial bids using data from the procurement of cleaning services with same set of bidding firms. They find that firms inflate their stand alone bids in the former auction compared to their corresponding bids in the latter auction.

The cases we describe illustrate different ways to design bidding rules within a first-price combinatorial procurement auction. For every case described in the study, we provide a vector of identical statistics on the observed outcome. In addition, we briefly comment upon some individual characteristics of each tender.

The paper is organized as follows. In Section two we illustrate, by means of some numerical examples, a number of practical strategic design problem inherent in a first-price combinatorial procurement auction. In section three we describe the background, the design and report the outcome from the procurement of different types of public contracts. Section four provides the conclusions.

2. Some strategic considerations in designing combinatorial procurement auctions

One motive for bidding on packages of contract is that it enables the bidders to express synergies across bundles, which mitigates the exposure problem, helping them to be more competitive in the bidding process. This in turn may lower the procurer's cost and enhance efficiency. Package bidding can also be motivated from a marketing strategy. A bidder's stand-alone bids will compete with her package, giving her an incentive to raise the former to favor the later, even in the absence of synergies. For that reason, the effect on the procurer's cost of allowing for package bidding is likely to depend on the bidders' motives behind their packages bids.
Also, from the procurer's point of view, allowing bidders to bid on packages entails a strategic problem in terms of designing the bidding rules. We illustrate some of the strategic implications with an example with two bidders and four contracts. To make sure that there will no "dead-lock" when allocating the contracts, a bidder has to place a stand-alone bid for every contract included in one or several package bids.

Figure 1. Package bids without accompanying stand-alone bids.

Bidder 1			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A		ABC	100
B			
C			
D			

Bidder 2			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A		BCD	150
B			
C			
D			

The four contracts in figure 1 are due to a dead-lock. Contract A cannot be given to bidder A unless she is awarded contracts B and C. Contract D cannot be allocated to bidder B unless he also is awarded contracts B and C. Hence, the lack of stand-alone bids in a combinatorial auction may lead to an unsolved allocation of contracts. Now, if a stand-alone bid is required for every contract that is part of any bundle of contracts, then the winning bids can be determined.

Figure 2. Package bids with accompanying stand-alone bids

Bidder 1			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	30	ABC	100
B	30		
C	60		
D	30		

Bidder 2			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	50	BCD	150
B	80		
C	30		
D	50		

Given the stand-alone bids in figure 2 for both bidders, the cost minimizing allocation of contracts is to award contracts {A,B,D} to bidder 1 and contract {C} to bidder 2.
Figure 2 illustrates that bidder 1's stand-alone bids for contracts {A,B}, together with bidder 2's stand-alone bid for contract {C}, prevent bidder 1's own package bid {(ABC)} from being a winning bid. Given the compulsion of placing stand-alone bids on those contract making up a package, bidder 1 had been better off if the sum of his stand-alone bids on contracts {A,B} had been $10+\varepsilon$ higher than the sum submitted, *c.p.* In that case bidder 1 had been awarded all four contracts (see figure 3). The example in figure 3 illustrates that, even though the procurer demands stand-alone bids in order to avoid a dead-lock allocation, the bidders can still "opt out" by submitting extremely high stand-alone bids.

Figure 3. Inflating stand-alone increases the competitiveness of own package bid

Bidder 1			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	35	ABC	100
B	36		
C	60		
D	30		

Bidder 2			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	50	BCD	150
B	80		
C	30		
D	50		

In the eyes of the procurer, the compulsory presence of stand-alone bids is a remedy for potential dead-lock problems, but from the bidder's perspective, excessively high stand-alone bids will almost have the same effect as refraining from submitting stand-alone bids. Either he is awarded the package or nothing.[6] The level of the raised stand-alone bids will be decisive in determining which package bid is the winning bid.

Figure 4. Inflating stand-alone increases the competitiveness of own package bid

Bidder 1			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	∞	ABC	100
B	∞		
C	∞		
D	∞		

Bidder 2			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	∞	BCD	150
B	∞		
C	∞		
D	∞		

If we assume an environment with a global bidder, who submits bids on every contract, and a local bidder, submitting bids for a subset of contracts, then the global bidder may engage in "predatory bidding". That is, if the global bidder expects that the local bidder will leave one or several contracts without a bid, then the global bidder can insure that he gets all the contracts, and not only those left without bids from the local bidder, by placing one package bid for all contracts, combined with high stand-alone bids. Figure 5 illustrates.

Figure 5. Predatory package bids

Global bidder			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	1000	ABCD	1000
B	1000		
C	1000		
D	1000		

Local bidder			
Stand-alone bids		Package bids	
Contract	Bid	Contract	Bid
A	40	AB	115
B	40	BC	135
C	60	AC	95
D			

[6] Of course, in contrast to the situation with no submission of stand-alone bids at all, the bidder may now lose on his package bid but instead be contracted on a single bid at a very high cost for the procurer.

Imposing a rule of a compulsory stand-alone bid for every contract being part of a package bid solves the dead-lock problem, but it does not stop global bidders to try to shut out local bidders from the competition. If a global bidder for some reason is interested in driving local bidders out of the market by trying to winning all or almost all contracts in the tender, one strategy would be to submit extremely high single bids combined with package bids with a large discount, say 80-90%. The strategy effectively prevents the supplier's package bids from being outperformed by its own stand-alone bids in combination with the bids from other suppliers.

There are several ways to deal with this problem. If the procurer has prior information which of the contracts the local bidders are likely to refrain bidding for, then these contracts can be procured in a separate tender. Having no knowledge on the expected distribution of bids for various contracts, the procurer may set a limit as to the maximum number of contracts allowed to be in a package bid. Another way is to limit the size of the maximum discount allowed in a package bids. A bidder who is about to bid aggressively by means of a package bid also has to submit relatively low stand-alone on those contracts making up the package. As a result, the competitiveness of the stand-alone bids of others is strengthened.
However, the potential drawback with restriction either on the maximum number of contracts allowed in a package bids or on the maximum package discount, is that the procurer may not be able to fully exploit potentially substantial synergies in large package bids.

3. Case studies on combinatorial public procurement

Although there is a rather large literature on combinatorial auctions, the number of empirical studies on combinatorial procurement auctions is relatively limited. The reason is that this type of auction mechanism is scarcely applied in public procurement today, albeit increasingly used in industrial procurement (see Bichler *et al*. (2009) for a review of some previous empirical studies). Therefore, very little is empirically investigated to what extent bidders use the option to submit bids on packages, the size of the packages and the size of the discounts. Also, it is an empirical question whether observed packages bids are likely to be motivated by synergies rather than by marketing strategies.

In this chapter we will briefly describe the procurement of five different public services (road resurfacing, elderly care, cleaning services, bus services and domestic flights) carried out in Sweden over the period 2003 to 2010. The tenders were all first-price sealed-

bid combinatorial auctions where bidders had the option to submit bids on bundles of contracts as well as the option to declare limited capacity. In all tenders bidders were required to submit a stand-alone bid for every contract being part of a package bid. The bidders were, with some minor exceptions, free to bid on any bundle of contracts. In some of the tenders the procurer imposed a constraint upon the maximum number of contracts allowed to be in a package bid, or a constraint upon the maximum size of the offered discount in a package bid. Finally, the awarding of contracts were in some of the tenders based on the lowest price only, whereas in other tenders the procurer adjusted for differences in other aspects than price using a scoring rule where bidders received a negative or a positive discount on their bids.

In order to measure and compare the distribution of awarded contracts among the bidders across the studied cases, we construct an index indicating the concentration of contracts among bidders. The index can take any value in the interval *[0,1]*. The distribution index is defined as

$$Index = \sqrt{\frac{\sum_{i=1}^{N}\left(W_i - \frac{C}{N}\right)^2}{\left(C - \frac{C}{N}\right)^2 + (N-1)\left(\frac{C}{N}\right)^2}} = \sqrt{\frac{\left[\sum_{i=1}^{N}\left(W_i - \frac{C}{N}\right)^2\right] \times N}{C^2(N-1)}}$$

(1)

where N is the number of bidders, W_i is the number of contracts allocated to bidder i and C is the total number of contracts in the tender.

If $W_{i,i\neq j} = C$, that is, one bidder is awarded all contracts in the tender, the index takes the value one. If $W_i = \frac{C}{N}$, that is, every bidder is awarded the average share of contracts, the index takes the value zero. Also, holding the number of contracts constant and increasing the number of non-awarded bidders increases the index.

Another way to define the distribution index is to replace the number of contracts (C) with the procurer's total payments to the winning bidders. This would capture the heterogeneity in the sizes across contracts and more appropriately measure the value awarded to winning bidders. However, this implies that the index will be determined by the value of the winning bids, that is, endogenously

determined. For that reason, the comparison of the awarded distribution in the studied cases is based on the number of contracts rather than the payments to winning bidders.

3.1. Procurement of Road Resurfacing

Asphalt resurfacing in Sweden is characterized by a relatively high degree of homogeneity with different suppliers offering similar quality and performance. Most suppliers operate over the whole of Sweden and submit tenders for contracts in all regions. Contracts are mostly awarded on the basis of price alone. Suppliers do, however, differ significantly in their capacity to produce and lay asphalt and this can vary according to their current workload. Asphalt resurfacing has a high fixed cost and a relatively low marginal cost – the marginal cost being the cost to produce and lay an additional square meter. This is because the laying of asphalt requires the intensive use of expensive machinery and to manufacture asphalt, it is often necessary to set up a mobile plant close to the working site, unless the supplier has a stationary plant nearby or can buy asphalt from a competitor. At any time, it is likely that there will be a size of contract which is most desirable for each supplier, best exploiting their spare capacity and enabling them to bid their most competitive price. In this situation there is a tendency for collusion between suppliers which, in their eyes, can be 'legitimized' by the fact that it should lead to a reduction in total cost. The inherent problem when suppliers coordinate their bidding behavior is, of course, that they take advantage of the situation to offer prices which are higher than they need be.

In order to try to lower the incentives for collusions the Swedish Road Administration (*SRA*) in year 2002 decided to allow suppliers to submit combinatorial bids when bidding for asphalt resurfacing contracts. The data collected for this study are from the yearly tenders of asphalt resurfacing 2005-2010 of various regions located in the middle of Sweden.

The combinatorial procurement auctions for 2005-2010 were conducted with almost the same design and, except for 2005, with almost the same number of contracts and the same number of bidders. However, the total value of the tenders varied substantially across the years. In all six tenders, the SRA allowed bidders to submit bids on any combination of contracts, but the agency imposed a constraint upon the bidder as to the maximum number of contracts allowed to have in a package bid. As can bee seen in table 1, this upper limit varied across the years. Also, the SRA imposed an upper value on the maximum size of the offered discount in any package bid. For the years 2005-2007 this limit was set to 20% and for the years 2008-2010 it sunk to 10%.

Table 1 summarizes the outcome of the six tenders. The number of observed package bids is, with one exception, higher than observed stand-alone bids across the years. However, no firm used the option to declare a limit on their capacity. In all six cases, bidders were successful in using package bids to get business. For every year, more than 70% of the contracts were awarded to package bids. Also, bidders who were awarded contracts by means of package bids, at the same time seemed to have submitted very competitive stand-alone bids on the individual contracts making up the package. In fact, in two of the cases, 2007 and 2010, the bidders who won contracts by means of one or several package bids, also had submitted the lowest stand-alone price on the individual contracts making up the package.

Table 1. Observed outcome from the procurement of road resurfacing

	2005	**2006**	**2007**	**2008**	**2009**	**2010**
Number of separate contracts	17	8	8	9	7	9
Maximum number of contracts allowed in a package bids	5	4	8	3	3	5
Number of bidders	8	8	6	5	6	6
Number of stand-alone bids	103	48	43	33	33	35
Number of package bids	104	46	63	43	16	43
Bidders indicating constrained capacity	0	0	0	0	0	0
Share of total contracts won by package bids	71%	75%	88%	78%	71%	89%
Winner of contract through package bid also submitted lowest stand-alone bid	50%	83%	100%	43%	80%	100%
Distribution index (lowest single bids only)	0.30	0.42	0.6	0.63	0.56	0.54
Distribution index (all bids)	0.27	0.42	0.6	0.70	0.68	0.54
(a) Minimized total cost based only on best single bids (€×1000)	8 463	4 869	10 368	22 999	12 869	18 154
(b) Minimized total cost based on winning bids (€×1000)	8 286	4 735	10 218	22 326	12 737	17 764
Observed discount [(a)-(b)] (€×1000)	177 (2,1%)	134 (2,8%)	150 (1,4%)	673 (2,9%)	131 (1,0%)	390 (2,1%)

The observation that a large share of the bidders, who have won their contracts with package bids, also have submitted lower stand-alone bids than those bidder who have refrained from bidding on packages, suggests that bidders do not inflate their stand-alone bids substantially. As a consequence, we cannot rule out that the observed discount in the winning allocation of contracts, compared to an

allocation based on lowest single bids only, reflects a real reduction in procurer's cost. The distribution index shows the impact of the package bids had a relatively little effect upon the concentration of contracts among the bidders.

3.2 Public procurement of cleaning services

In 2006 the Swedish Social Insurance Agency procured cleaning services for all of its local offices in Sweden using a combinatorial bidding process. In total 42 separate contracts, of which some of them comprised several offices, were auctioned out. The total area to be cleaned was 450 000 m^2. Besides submitting a single bid on any of the 42 contracts, bidding firms were given the opportunity to submit package bids on any bundle of these contracts. There was no limit to how many bundles the suppliers could specify. In addition to their single bids and package bids suppliers could also express capacity constraints by specify the maximum amount of cleaning area they could manage in total in terms of m^2.
Also, bidding firms could place so-called price lists. In a price list the firm specified individual prices for the contracts listed. These individual prices were conditioned upon the firm being awarded at least a certain number of the contracts listed in the price list, or awarded contracts worth a minimum amount

Table 2. Observed outcome from the procurement of cleaning services

Number of separate contracts	42
Number of bidders	22
Number of single bids	207
Number of package bids	82
Bidders indicating constrained capacity	0
Share of total contracts won by package bids	100%
Winner of contract through package bid also submitted lowest stand-alone bid	75%
Distribution index (lowest single bids only)	0.75
Distribution index (winning allocation)	1.0
(a) Minimized total cost based only on best single bids (€×1000)	3 766
(b) Minimized total cost based on winning bids (€×1000)	3 578
Observed discount [(a)-(b)] (€×1000)	188 (5.0%)

Contracts were awarded according to the principle of most economically advantageous bids. Qualitative criteria were in addition

to price considered when bids were evaluated and contracts assigned winners. The scoring rule stipulated an absolute deduction per square meter depending of the quality the bid reflected. The bidder submitting the lowest net bid was then awarded the contract.
In order to understand whether the motives behind package bids are likely to be driven by synergies rather than by strategic marketing, we investigate the relationship between the stand alone bids (bid/m2) and size of the relevant contracts in terms of square meter to be cleaned.

Figure 6. Standard alone bids (€/m2) and the size of contract

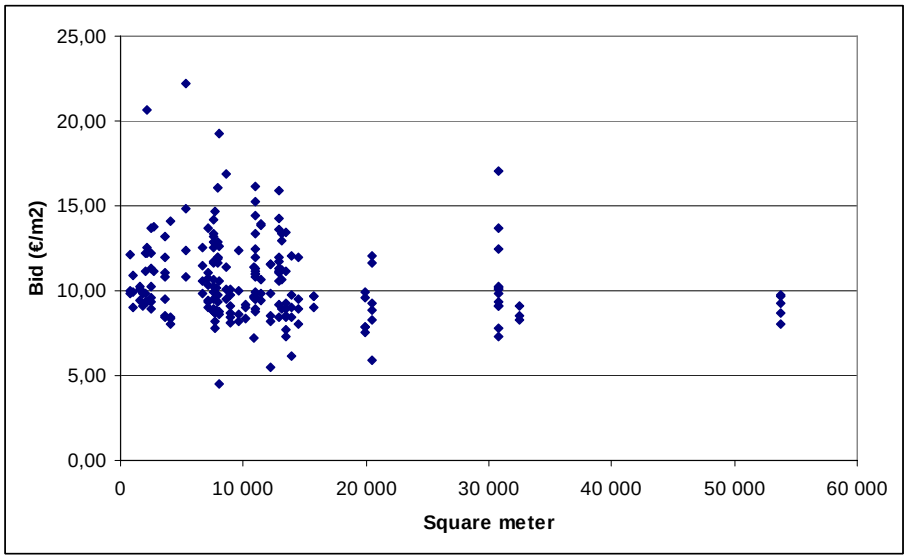


Figure 6 shows a scatter plot of all stand alone bids, where each bid is divided with the contract size, in terms of number of square meter. The data indicates that the bid price per square meter tends to decrease as the size of the contract in terms of square meter increases, which is compatible with the view that firms face synergies in the number of contracts won.
As displayed in table 2, 22 firms submitted in total 207 single bids. Eleven of these firms also submitted in total 70 package bids. Two firms placed each a package bid comprising all 42 contracts, where one of them was a winning. It is noteworthy that the same firm also has placed the lowest single bids on 35 of the 42 contracts. Given that 50% of the firms only submitted single bids and no package bids, the high “lowest-single bid” ratio of the winning firm, indicates that the firms placed highly competitive stand-alone bids. Somewhat surprisingly, a third of the bidders only submitted single bids on one or two contracts each, even though they had the option to bid on

more contracts than they were able to fulfil, by specifying a maximum total capacity.

3.3 Public procurement of elderly care

The Swedish government has, in the last ten years, encouraged its municipalities to contract out their elderly care services. Private firms compete for contracts in a tendering process and the suppliers offering the best price and quality combination are awarded contracts. The motives for contracting the elderly care are both to improve the quality of the services and to lower the cost. In most cases a municipality's procurement of elderly care comprises two types of contract; operation of nursing home (residental care) contracts and home care service contracts. In general, the size of a contract is determined by the number of elderly to be taken care of. Although it is quite common that municipalities offer multiple set of contracts in one and the same procurement combinatorial bidding is seldom applied (see Bergman, Lundberg and Spagnolo, 2010). However, one of the municipalities in northern Sweden has applied combinatorial bidding.

In this case study we briefly describe the design and outcome of the procurement auction covering elderly care in the city of Östersund in northern Sweden carried out in November 2008. Sealed bidding was applied and it was designed as a combinatorial auction, where eight separate contracts were available. Four of them concerned nursing homes (compromising 26, 13, 6, and 9 apartments respectively) and four concerned home care service contracts. Suppliers were given the option to submit bids on packages of contracts, as well as single bids for individual contracts. Two of the nursing homes were excluded from the combinatorial bidding. Bids on the six remaining lots had to be non-trivial. Stand-alone bids for all lots in a combination had to be submitted. Also, the municipality had according to its own calculations estimated the maximum scale effect to five percent. The maximum allowed difference between the single bid and the stand-alone bid in a combination was therefore set to five percent. Bidders could express capacity constraints in two ways; by making the bid contingent on either the maximum number of contracts a firm could handle or the minimum number of contracts demanded for a combination to be valid. The contract period was four years with an option for a prolongation period of three years.

The evaluation of the bids consisted of two phases, a qualification phase and a bid evaluation phase. In order to ensure that the necessary quality requirements were met, only suppliers who met

specified pre-qualification criteria were qualified to the evaluation phase. Contracts were then awarded according to the lowest bid principle. The bidder offering the best combination of single bids or single bids and combination bids was awarded the contracts.

Table 3. Observed outcome from the procurement of elderly care

Number of separate contracts	8
Number of bidders	7
Number of single bids	49
Number of package bids	121
Bidders indicating constrained capacity	0
Share of total contracts won by package bids	62%
Winner of contract through package bid also submitted lowest stand-alone bid	60%
Distribution index (lowest single bids only)	0.23
Distribution index	0.36
(a) Minimized total cost based only on best single bids (€×1000, yearly basis)	6 249
(b) Minimized total cost based on winning bids (€×1000, yearly basis))	6 102
Observed discount [(a)-(b)] (€×1000)	148 (2,4%)

As shown in table 3, seven firms participated in the tender, where one of the firms was the municipality's in-house production unit. Four of the firms submitted in total 121 package bids, where 113 of these bids were placed by two firms. One firm only submitted one single bid, although the option was given to bid on more contracts and at the same time declare a limited capacity. The dispersion of contracted firms was relative high. Eight contracts were split among four firms, where two of them got three contracts each.

3.4 Public procurement of bus transportation

Sweden's local and regional bus services have been procured on a competitive basis since the late 1980s. In each province the buyer is an administrative body, owned by the local governments within the province and the elected regional assembly. The buyer makes a detailed description of the way in which the services are to be operated, including precise time tables. The buyer also controls the ticket price and the operator hands all ticket revenue over to the buyer, alternatively this revenue is deducted from the payment made to the operator. The contracts that are available are therefore gross

cost contracts, with no revenue risk for the operator. Operators provide vehicles, garages, maintenance depots, drivers and facilities for drivers. The buyer also specifies norms for bus quality, including environmental standards, and minimum requirements for drivers, including such things as the use of standardized uniforms. Finally, the operator has to present a plan for the quality control of the activities to be undertaken. In most regions contracts are awarded to bidders with the lowest price. The supply of bus services to the public sector in Sweden is characterized by a high degree of homogeneity between operators in terms of the service quality and high fixed costs for operators due to large investments in capital (buses). It is therefore likely that at any time there will be, for each operator, a package of services which closely matches their spare capacity and enables them to bid very competitively. Here, we describe three cases of public procurement of regional bus services, in 2003 in Region Värmland and Region Skåne and in 2004 in Region Skåne. In all three cases the bus services being procured concerned buses operating between two regional nodes although there was a significant variation in the number of trips per day between the nodes.

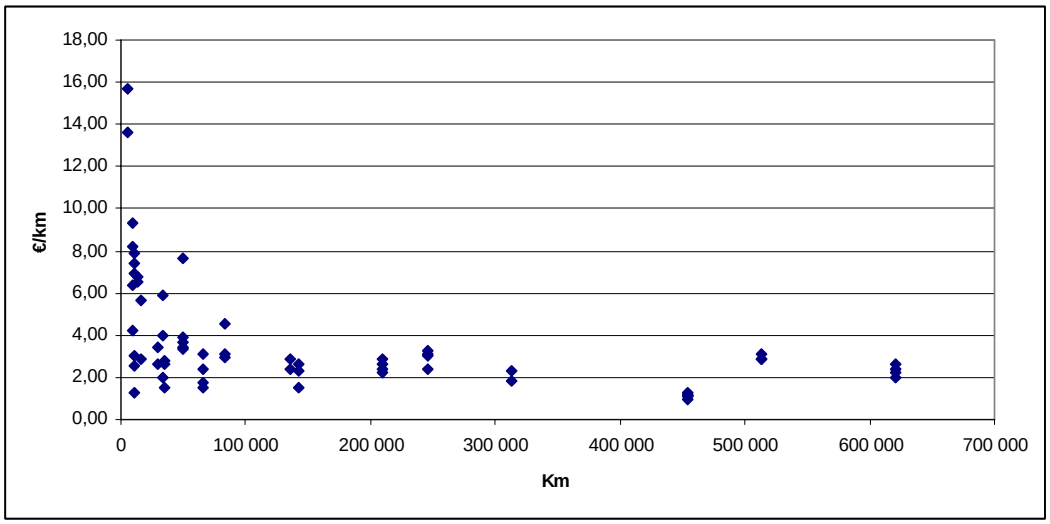
The design of the tendering process was quite similar across the three cases, although the number of routes and the estimated average cost per route differed somewhat. Operators had the option to submit bids on any package of routes and also to declare the maximum overall volume they were willing to accept. In region Värmland (2004) operators declared their capacity limit in terms of kilometers. In region Skåne (2003 and 2004) operators declared their capacity in terms of buses. The evaluation of the overall process in Region Skåne (2004) deviated from the other two cases in two aspects. First, before evaluating the bids, the bidder adjusted each operator's bid for differences in observed quality based on pre-announced scoring rules. Secondly, after having received the bids, the buyer revealed information to operators about the ranking of their individual bids and gave each operator the opportunity to lower their bids. The option to lower bids in a "second round" was not publicly announced

Table 4. Observed outcome from the procurement of bus transportation.

	2003		2004
	Värmland	**Skåne**	**Skåne**
Number of separate contracts	34	6	12
Number of bidders	22	8	6
Number of single bids	97	29	54
Number of package bids	105	26	28
Bidders indicating constrained capacity	0	0	0
Share of total contracts won by package bids	32%	83%	75%
Winner of contract through package bid also submitted lowest stand-alone bid	n.a	100%	75%
Distribution index (lowest single bids only)	0.29	0,55	0.34
Distribution index (all bids)	0.32	0.55	0.41
(a) Minimized total cost based only on best single bids (€×1000)	21 950	3 490	17 900
(b) Minimized total cost based on winning bids (€×1000)	21 380	3 320	17 600
Observed discount [(a)-(b)] (€×1000)	570 (2.6%)	170 (4.95)	300 (1.7%)

As can be seen in table 4, the tender in region Värmland was significantly larger than the other two tenders in terms of number of contracts, number of bidders and the total value of the contracts. However, the relatively low number of contracts won by package bids in the same region, suggests highly competitive stand-alone bids. Looking only at the stand-alone bids, we observe that the submitted average price per kilometre is decreasing in contract size, indicating the presence of synergies in the number of kilometres won.

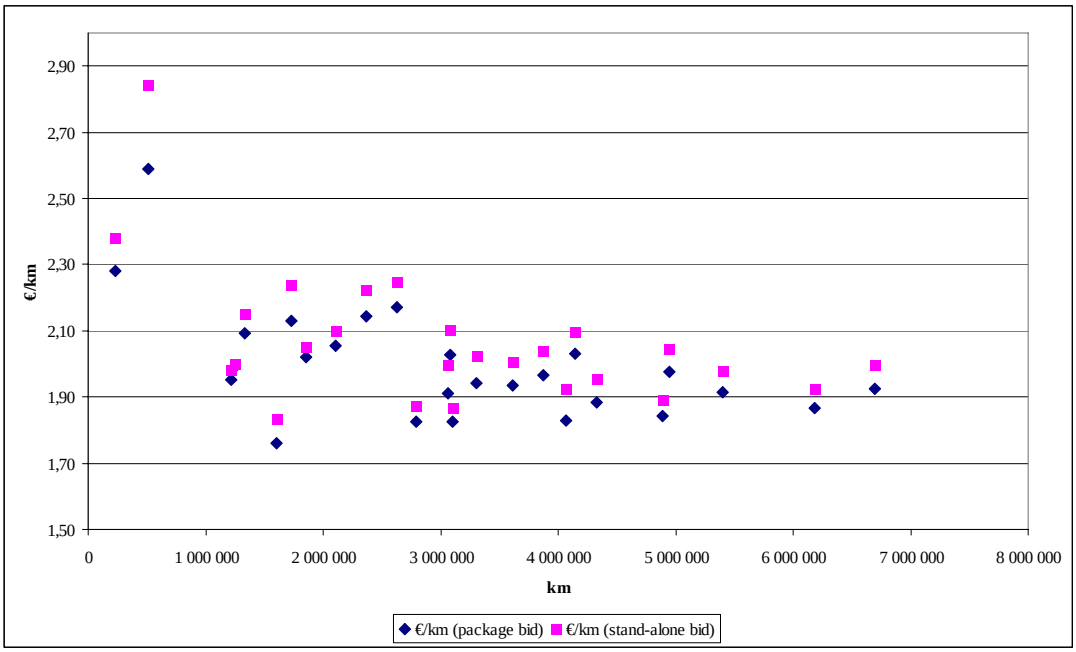
*Figure 11. Stand-alone bids (€/km) and the size of contracts**



* Contract size over 700 000 km not included. For a complete scatterplot ,see Appendix.

In addition, we also plot the bids submitted by one of the bidding firms, which placed stand-alone bids on almost every contract and also about a forth of the total package bids. The diamonds in the scatter illustrate the submitted price per km for packages of various sizes. Each square, located above every diamond for any given volume, represents the sum of the stand-alone bids – in terms of price per km - for those contracts making up the corresponding package bid. The scatter plot suggest that the firm exhibits larger and larger synergies as the volume increases, but the size of the discount of the packages bids remains constant as the package bids include large and larger volumes.

Figure 12. Discount size and volume



3.5 Public procurement of domestic flights

The Swedish National Public Transport Agency (NPTA) is responsible for the procurement of the long distance public transport system in Sweden. Motivated by transport policy, the agency's objective is to secure a socio-economically efficient and long-term transport supply for the entire country. This includes the procurement of domestic flight routes from Stockholm Airport (Arlanda) to a number of smaller airports, mainly located in the northern part of Sweden. Normally, this bidding process takes place every third or every fifth year. In general, each of these airports constitutes a single contract in the tendering process. The NPTA imposes a number of restrictions on the services that the operators have to take into account when formulating their bids. The agency sets the minimum number of flights per day and a minimum number of seats per year between a specific airport and Arlanda. Restrictions are also put upon the types of aircraft to be used. Finally, and perhaps most importantly, a winning operator does not determine the passenger rates. The ticket prices for every destination are regulated by the NPTA during the contract period. When auctioning the contracts for the period 2004 to 2007, the agency decided to give the operators the option to make combinatorial bids (bids for packages of contracts). Given their high investment in aircraft, it was assumed that operators would gain significant economies of scale by winning multiple contracts and that this would be reflected in their bids. Also, since the different

contracts could, in many respects, be viewed as very close substitutes, the overall volume of business won would be much more important than which contracts were won. It was thought that providing operators with the opportunity to make capacity-constrained bids would help operators to win an optimum volume.

The number of contracts to be allocated (number of airports to be served) to the bidders was ten. However, the NPTA decided, prior to bidding, in addition to the ten single-airport contracts, to let seven of these airports form three different pre-defined multi-airport contracts (see table 1). The multi-airport contracts were created to form efficient routings and operators were allowed to use intermediate landings on the way to and from Stockholm to fulfil these contracts. Bidders had the option to submit bids on any package of contracts. Bidders could also declare the maximum number of airports they were willing to serve in case they were awarded too many contracts. Before evaluating the bids, the agency adjusted each operators bids for differences in observed quality according to a pre-defined scoring system which was advised to bidders at the start of the process.

Table 5. Observed outcome from the procurement of domestic flights

Number of separate contracts	6
Number of bidders	8
Number of single bids	14
Number of package bids	6
Bidders indicating constrained capacity	0
Share of total contracts won by package bids	50%
Winner of contract through package bid also submitted lowest stand-alone bid	100%
Distribution index (lowest single bids only)	0,55
Distribution index (all bids)	0,55
(a) Minimized total cost based only on best single bids (€×1000)	6 079
(b) Minimized total cost based on winning bids (€×1000)	6 059
Observed discount [(a)-(b)] (€×1000)	20
	(0.3)

Table 5 indicates that the option to submit combinatorial bids had a marginal impact upon the outcome. In fact, four of the eight bidding firms submitted only one bid, although they had the option to bid for more contracts and declare the maximum number of airports they were willing to serve in case they were awarded too many contracts.

A possible explanation not to condition the bids upon the number of contracts won, could be that the contracts were not considered as substitutes in the eyes of some bidders. Three of the contracts were awarded a bidder through a package bid, but the same bidder also placed the lowest stand-alone bids on these contracts, leaving the distribution index unchanged.

4. Discussion and Conclusions

Traditionally in Sweden and in most other countries with formalized public procurement procedures, goods and services are purchased based on standard auction formats as the single item or multi item first-price sealed bid auction. Within the multi item setting, allowing for package bidding is an opportunity that could induce bidders to better express scale opportunities and express combination of contracts that better match their capacity constraints. In Sweden there are some interesting examples of procurement auctions where the combinatorial first-price sealed bid auction has been practiced. In this paper we have provided stylized facts obtained from combinatorial auctions of road resurfacing, internal regular cleaning services, elderly care, bus transportation, and domestic flights. The number of contracts and the number of bidders vary across the auctions. The number of contracts auctioned in one and the same tender ranges from six (bus routes) to 42 (cleaning services). The minimum number of bidders is four (road resurfacing) and 22 (cleaning services). The presentation has showed that in all five types of auctions, the bidders have in one way or the other been allowed to express capacity constraints. Few of the bidders have however practiced this opportunity. Common for all procurements is that the package bids had to be followed by a single bid for each contract in the package. The package bids had to be non-trivial meaning that they had to be lower than the single bids. A vast majority of the contracts were allocated based on package bids. This was the case in all but two procurements. The overall impression is that the package bids come out as very competitive compared to all the submitted single bids. Further, the firms that have won set of contracts based on their package bids, have also submitted very competitive single bids on the same set of contracts. In almost every of the presented cases, more than 60% of the contracts allocated through packages bids, should have been awarded to the same set of firms if we exclude the package bids when determining the winning bids.

The total number of single bids submitted varies between 22 and 254 while the same figures for the number of combinations submitted are

5 and 121, respectively. A linear approxiamtion of the correlation between the number of contracts auctioned and the degree of competition indicate a larger interest for tenders where more contracts are auctioned out (see figure A2 in the appendix).

For each of the tenders we have calculated a distribution index. The index is used to illustrate the degree of concentration of won contracts among the bidders. Based on figure A3 (appendix) we find that the more contracts included in one and the same tender the higher is the concentration index. Also, the distribution index based on all bids varies between 0.27 and 1 and the observed mean is 0.54. If the combination bids are excluded and the index is only based on the single bids the index decreases to 0.48. Looking at the difference between the minimized total cost based on the best single bids and the minimized total cost based on actual winning bids across all tenders, we see that the average discount is 2.4 percent (std dev 1,35).

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Appendix

Figure A1. Procurement of road resurfacing - standard alone bids (€/km) and the size of contract

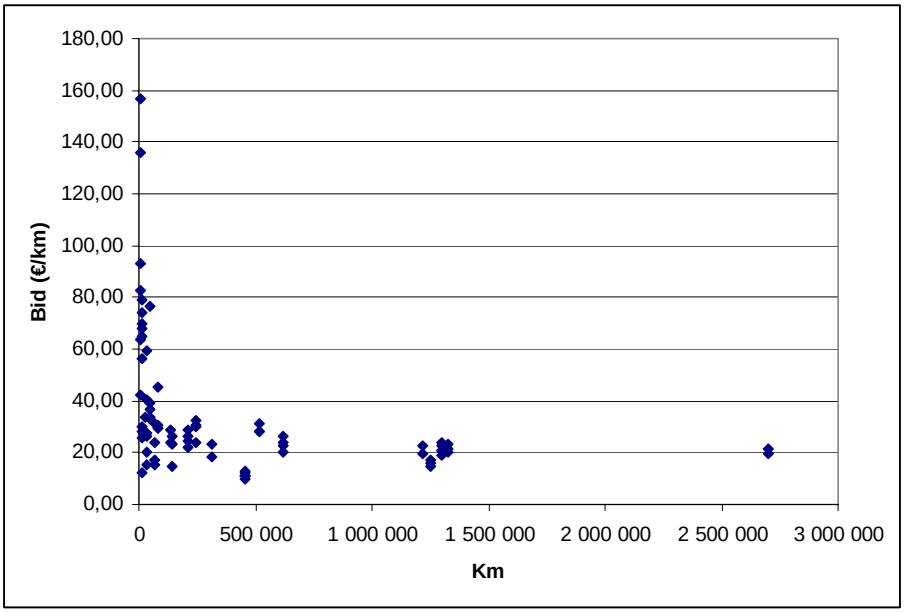

Figure A2. Correlation between the number of bidders and number of contracts auctioned, comparison over auctions.

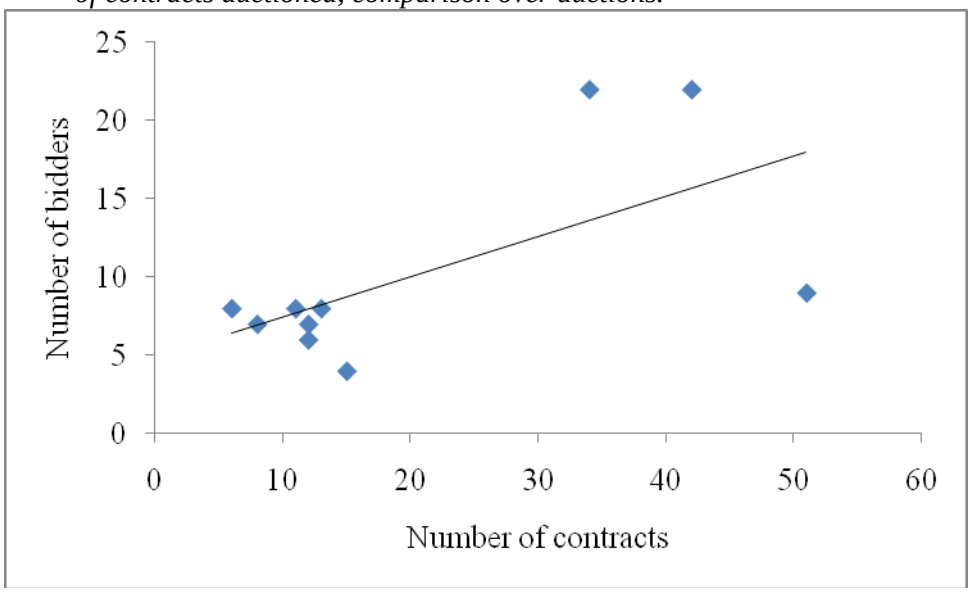

Figure A3. Correlation between the number of bidders and the concentration index (expression 1).