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Simplified Bid Languages – A Remedy to Efficiency Losses in Large Spectrum Auctions

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Abstract. Combinatorial auctions have been suggested as a mean to raise efficiency in multi-item negotiations with complementarities among goods as they can be found in procurement, energy markets, transportation, and the sale of spectrum auctions. Since 2008 the Combinatorial Clock Auction (CCA), a two-stage auction format has been used in many countries. [8] tested CCA in the lab and found out that the efficiency of CCA was relatively low, since bidders tended to submit too few bids. To reduce bidders' complexity concerning evaluating lots of bundles, we simplified the bidding language without losing efficiency. Hereby, we used the knowledge of super-additivity and the fixed descending complementarity type of our value model. In lab experiments, we tested the two phases of the CCA auction, namely the Combinatorial Clock + (CC+) auction and a sealed bid version, with the simplification separately. Both formats yielded in higher efficiency and revenue than the CCA.

Keywords: Electronic markets and auctions, laboratory experiment, combinatorial auction

1 Introduction

Since 1994 more than 70 spectrum auctions were run using the simultaneous multiround auction (SMRA), an auction format which is based on [18]. In the SMRA auction several items are sold in a single auction. Bids on combinations of items are not allowed, whereas synergies in bidders' valuations cannot be expressed.

Therefore, there are many strategic problems for bidders (see also [12]), like the exposure risk. Hence and because of several other reasons, combinatorial auctions (CA) were used for spectrum auctions.

Generally, CAs are IT-based economic mechanisms, where bidders can define their own combinations of items called "packages" or "bundles" and submit bids for them. Bids on individual items are not allowed to place. So, bidders can express better their valuation, which increases economic efficiency, especially in the presence of super-additivities respectively economies of scope. Often CAs are iterative auctions, in which an auctioneer computes allocations and asks prices in each round. This would not be possible without IT-based auction platforms which solve hard computational problems in each auction round and calculate new ask prices. This is also a reason

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why CAs have been a topic in much recent Information Systems (IS) research. Examples can be found within [16], [6], and [23]. The IS literature proposed also a lot for bidder decision support, designs for new application domains, and the analysis of bidder behavior in CAs (see also [1], [3-4]) An overview about current research in IS can be found within [7].

The design of CA, however, led to a number of fundamental design problems, and many contributions during the past few years [10-11].

An important CA, the Combinatorial Clock Auction (CCA) based on [17], is a two-stage auction format with consists of primary bid rounds for price discovery and a sealed bid round The CCA was used the U.K., the Netherlands, Denmark, and Austria for the recent sale of the 2.6 GHz band.

The frequencies of the 2.6 GHz band are available for mobile services in all regions of Europe. The 2.6 GHz spectrum band includes 190 MHz which are divided into blocks of 5 MHz. It can be used to deliver wireless broadband services or mobile TV. In particular, there are two standards which will likely be used in the 2.6 GHz band, LTE and WiMAX. LTE uses paired spectrum (units of 2 blocks), while WiMAX uses unpaired spectrum (units of 1 block).

[8] compared CCA and the SMRA auction in the lab using two different value models. These models were designed similar to the practice.

In each value model, 4 bidders participated and 24 lots were sold. The small model consisted of two bands with 14 respectively 10 blocks, the large one of 4 blocks with six bands each. In total, in the small value model, the complexity for bidders was quite lower, because they needed only to calculate ca. 50 possible bundles. Contrarily, in the large value model around 2,400 value models needed to be evaluated. Because of this high complexity, the efficiency of CCA in the lab was considerably lower than that of SMRA.

In our paper, we tested the two phases of the CCA, namely the Combinatorial Clock + (CC+) auction and a sealed bid version, for the large value model separately.

We addressed the recent criticism of [12], that bidder could not submit enough bids in a value model consisting of 2,400 possible bundles by reducing bidders' complexity. We simplified the bidding language using the knowledge of super-additivity of our value model and the fixed descending complementarity type. As a consequence, the experiments that we conducted did not suffer from "too few bids" because the bidders had also a bidding tool to evaluate all the possible bundles quickly. This made it easy for them to submit their bids on all the relevant packages. We show that higher efficiency is achieved by our modifications.

This paper is organized as follows. The value model, the simplified bidding language, the payment rule and the four competing auctions are introduced in Section 2. In Section 3, the experimental design is described and the results are presented in Section 4. Finally, Section 5 concludes with a discussion.

2 Auction Design and Theory

We use in our experiments three different CA formats, CCA, CC+ and a sealed bid version. As a matter of completeness we also present the result of the SMRA, because we compare our result to those of [8], who tested SMRA and CCA.

In SMRA, all items were sold at the same time whereas each item had its own price. Bidders could not bid on bundles. If there was overdemand for an item, i.e. the demand is larger than the supply, the auctioneer increased the price for this item by a fixed increment. The auction terminated if there was no bid within one round. SMRA is a generalization of the English auction for several items, where bidders have to pay what they bid.

The CCA auction consisted of two phases, the clock phase and the sealed bid part. All items within one band had the same price, so there were 4 different (band-) prices in our value model for all blocks. The auctioneer announced the new ask price for each band in each round of the clock phase. Afterwards, bidders decided to bid on which amount of items in each band. The primary bids phase ended after there was no overdemand in any bands any more.

The sealed bid phase consisted of only one round with as many sealed bids as desired by the bidders. They were able to bid on any combination of items regardless of the bids of the first phase. A detailed description of SMRA and CCA can be found within [8].

In the following, we describe the implementation of the different formats that we actually tested in our experiments. But first, we explain the value model, the simplified bidding language and the payment rule we applied.

2.1 The Value Model

For our value model we used an economic setting which was inspired by spectrum sales as introduced at the beginning of this paper. [8] found out in lab experiments that the CCA performed poorly in this value model, since bidders had to evaluate 2,400 different possible bundles.

The model had 24 items with four bands, whereas each consisted of six items. Band A was of high value to all bidders and bands B, C, and D were less valuable. Every bidder received a base valuation for an item in each band. Base valuations are uniformly distributed: v_A was in the range of [100; 300], while v_B, v_C and v_D were in the range of [50; 200]. Furthermore, bidders had complementary valuations for bundles of items. Within a band, each block has the same value for bidders. For example A01 has the same value as A02.

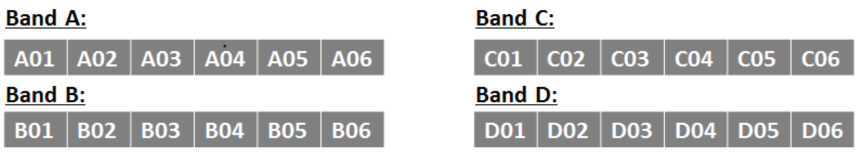


Fig. 1. The value model

In all bands, bundles of two items resulted in a bonus of 60% on top of the base valuations, bundles of three items in a bonus of 50%. More items did not add any extra bonus for this band.

The structure of the value model and the distribution of the item valuations of all bands were known by all bidders. Bidders used an artificial currency called Franc. Although the value models resemble the characteristics of spectrum sales in Europe, this was not known to the subjects in the lab (neutral framing). In figure 2 you find an example concerning the value model with the draw 200 for block A and 100 for the blocks B, C, D. The valuation per unit is the highest at 2 goods. Then, it is decreasing. However, bids could only be placed for the whole amount and not per unit.

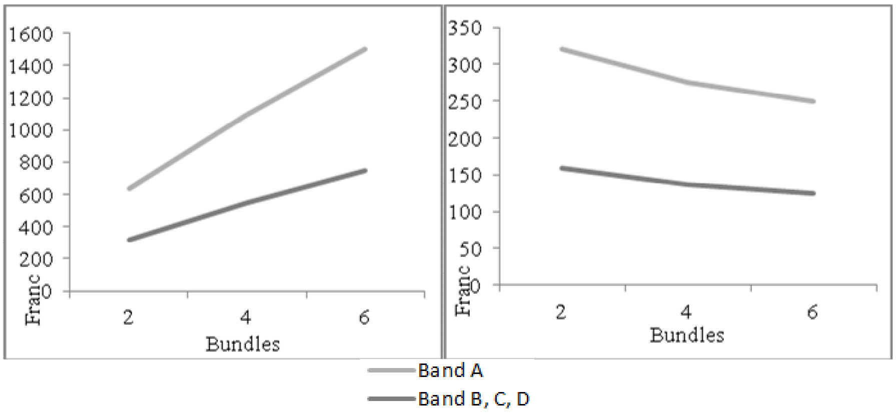


Fig. 2. The valuation structure

2.2 Simplified Bidding Language

The literature often assumes that the auctioneer has no information on synergies in the bidder valuations. This is often not the case. In spectrum auctions, bidders and auctioneers know about the main synergies in the valuations. For example, 2 blocks in 800 have high synergies and 4 blocks in 2.6 as well. Using this knowledge, we constrained the language knowing that the valuation between bands are purely additive, because there are no cross synergies respectively super-additivities between bands. However, we have to remark, that in other situation, when the value model offers e.g. cross synergies or has other properties, the bidding language should be adapted in another way.

Bidders could enter bids for 2, 4, 6 blocks (i.e., their maximum willingness to pay for a desired number of A, B, C and D) for each band, whereas each area has its own price per good which is equal for all goods. That means, altogether 12 bids can be submitted in the sealed bid auction respectively in the CC+ auction. This is a large simplification in comparison to the 2,400 bundles bidders had to evaluate in the CCA. We use an OR (additive-OR) bidding language between the bands and XOR (exclusive-OR) within a band. OR-Bid means that each bidder is willing to win any number of these disjoint bids, whereas XOR only allows winning at most one of the submitted bids. Thus, a bidder can win a maximum of 4 bids (one bid per band).

Besides, the outcome closure property is fulfilled, because simplification is not constraining. We used the ideas of [19] to restrict the space of messages available to the players. Such a simplification has the advantage that it can eliminate undesirable equilibria. However, tight simplifications, like our modification to the bidding language have to be used. Tightness removes certain equilibria that were created by eliminating profitable deviations. Some notes on this topic area given by [20].

We show, that designing the right bid language can lead to significant efficiency gains over simple SMRA or a full XOR CA, since for CAs to perform well, it is important for bidders to submit all relevant bids.

In all the auction formats, we focus on designs with linear ask prices, where each item in the auction is assigned an individual ask price, and the price of a package of items is simply the sum of the single-item prices. Such prices are easy to understand for bidders in comparison to other pricing rules like the non-linear ask prices.

2.3 The Payment Rule

The bidder-optimal core-selecting payments used within CC+ and the sealed bid auction were calculated using a quadratic program. [14] suggested a procedure to calculate bidder-Pareto-optimal payments from sealed bids right away. Over all total-payment minimizing core points, that one are selected that minimize the sum of square deviations from the VCG payments (minimal Euclidean distance). The objective is to minimize the incentive to misreport one‘s valuations.

Therefore, the core for package allocation problems has a competitive auction interpretation: an individually rational allocation is in the core if there is no group of bidders who could all do better for themselves and for the seller by raising some of their losing bids.

2.4 The CC+ Auction

[9] described the single-phase CC+, which resembles the first phase in CCA. We tested it in the lab using the simplified bidding language for our value model. With this change we supposed to achieve more robust outcomes in terms of efficiency and revenue than the two-phase CCA. CC+ can be interpreted as a practical implementation of the fictitious “Walrasian auctioneer”.

The auction consists of any number of rounds. Bidders enter (bundle) bids for 2, 4, 6 blocks in each round, whereas all bids remain active throughout the auction. OR bids allow the auctioneer to allocate one bundle to every bidder in each of the 4 different bands. In contrast, by XOR, maximum one bundle within a band can be assigned to bidders.

At the beginning of each round, the new prices of goods are announced. Based on these new prices each bidder will report the quantity how much A, B, C and D bundles they want to buy. If there is excess demand (i.e. if the combined demand of all bidders within one band exceeded the number of blocks) in at least one band, a new round starts with higher prices for the bands with excess demand. Start prices in the first round were set to 100 Franc for items in the A band and 50 Franc in the B, C, and D band. The price update is done by clock ticks for each block within a band. One clock tick in the A range is equivalent to 20 francs, in the B -, C and D range at 15 francs. Besides an activity rule is installed. According to that a bidder must submit at least one bid in each current round, to may bid again for each possible bundle in the next round. If no block is overdemanded, the auctioneer solves the winner determination problem considering all bids submitted during the auction runtime. If the computed allocation does not displace any active last iteration bidder, the auction terminates. The auctioneer selects these bids that maximize the total revenue of the auction.

[9] have shown that it is an ex-post equilibrium strategy for the bidders to submit their power set bids, which means to submit bids on all packages with a positive valuation in each round.

2.5 The Sealed Bid Auction

In the sealed bid auction, bidders enter bids for 2, 4, 6 blocks in the single round, whereas a maximum of 12 bids is possible in the whole auction. The auctioneer collects the bids and determines the revenue maximizing allocation and the prices. The same bidding language is used as within CC+, namely XOR within a band and OR between bands. During the auction, bidders do not get information about activities (bids) of other bidders.

3 Experimental Design

Our experiments are based on the MarketDesigner software framework, which we extended by an implementation of the simplified bidding language and of the two tested auction formats.

We consider 2 treatment factors, auction format and bidding language. The value model was for all formats, SMRA, CCA, CC+ and the sealed bid auction the same. For treatments 1 and 2, where the bidding language was fully expressive we used the results of [8]. For the treatments 3 and 4, which we actually tested in the lab, the simplified bidding language was used. Overall, we get four different treatments:

Table 1. Treatment structure

Treatment no.	Auction format	Bidding language	Auctions
1	SMRA	Fully expressive	16
2	CCA	Fully expressive	16
3	CC+	Simplified	16
4	Sealed bid	Simplified	16

Our Experiments (treatments 3 and 4)

Our experiments were conducted from June to July 2012 with students in computer science, mathematics, physics, and mechanical engineering at the TU München. The subjects were recruited via e-mail lists and conducted experiments in a computer lab at the TU München. Each subject participated in a single auction format in one session, but never in different ones. One session comprised all four auctions of one auction format of one wave. For the value model we drew valuations for four waves (A-D) randomly. All auctions of waves A, B, C and D were tested with the four auction formats. CC+ took on average four hours and the sealed bid auction between two and a half hours.

Subjects did not have to prepare for the experiment. All required information was given to the participants. Before each session, the environment, the auction rules and all the relevant information were explained to the participants. All the instructions were read aloud and participants had to participate in a test about the economic environment and the auction rules.

An additional tool to analyze bundle valuations and payoffs was introduced to all subjects. This tool showed a simple list of all available bundles which could be sorted by bundle size, bidder individual valuation or the payoff based on current prices. As a matter of course, last mentioned option was not available for the sealed bid format.

At the beginning of each auction all subjects received the individual draw of valuations, the distribution of valuations, and the information about the complementarity of items. With this information, subjects were asked to reason about the implications of the draw on their bidding in the upcoming auction. Each round was scheduled with 3 minutes. The time given to the subjects in each sealed bid auction was 20 minutes. The subjects could ask for more time if required.

After each session subjects were compensated financially. The total compensation resulted from a 10 Euro show up fee and the auction reward. The auction reward was calculated by a 3 Euro participation reward plus the payoff of all auction payoffs converted from Franc into Euro by a 12:1 ratio. Negative payoffs were deducted from the participation reward. Negative payoffs higher than the participation reward were ignored. Due to the different duration and auction formats, payoffs were different. Therefore, we leveled the expected payoff per participant. In CC+, we compensated two out of four and in sealed bid one out of four auctions. On average, each subject received in CC+ 70.94 EUR and in the sealed bid auction 37.69 EUR.

4 Results

First, we present efficiency and revenue of the different auction formats on an aggregate level.

4.1 Efficiency and Revenue Share

We use allocative efficiency (or simply efficiency) as a primary measure.

Given an allocation X and price set P_{pay}, let $\pi_i(X, P_{pay})$ denote the payoff of the bidder i for the allocation X and $\pi_{all}(X, P_{pay}) \coloneqq \sum_{i \in I} \pi_i(X, P_{pay})$ denote the total payoff of all bidders for an allocation at the prices P_{pay}. Further, let $\pi(X, P_{pay})$ denote the auctioneer revenue. We measure efficiency as the ratio of the total valuation of the resulting allocation X to the total valuation of an efficient allocation X^*.

$$E(X) \coloneqq \frac{\pi\,(X, P_{pay}) + \pi_{all}(X, P_{pay})}{\pi\,(X^*, P_{pay}) + \pi_{all}(X^*, P_{pay})} \in [0,1] \quad (1)$$

Because of the simplification of the bidding language 100% efficiency cannot always be achieved. To consider this fact, also the relative efficiency $E(X^*_{rel})$ is computed. Therefore, we define X^*_{rel} as the best allocation that can be achieved with the simplified bidding language.

$E(X^*_{rel})$ is calculated as

$$E(X^*_{rel}) \coloneqq \frac{\pi\,(X, P_{pay}) + \pi_{all}(X, P_{pay})}{\pi\,(X^*_{rel}, P_{pay}) + \pi_{all}(X^*_{rel}, P_{pay})} \in [0,1] \quad (2)$$

We also report the revenue distribution, which shows how the overall economic value is distributed between the auctioneer and bidders. The auctioneer revenue is measured as the ratio of the auctioneer's revenue to the total sum of valuations of an efficient allocation X^*:

$$R(X) \coloneqq \frac{\pi\,(X, P_{pay})}{\pi\,(X^*, P_{pay}) + \pi_{all}(X^*, P_{pay})} \in [0, E(X)] \subset [0,1] \quad (3)$$

Additionally, the average number of unsold items is evaluated.

Table 2. Aggregate measures of auction performance

Auction format	E(X)	$E(X^*_{rel})$	R(X)	Unsold items
CC+	97,26%	97,60%	78,96%	0
Sealed bid	97,21%	97,55%	77,28%	0
SMRA	98.51%	98,85%	81,96%	0
CCA	89.33%	89,64%	37,41%	1.25 (5.2%)

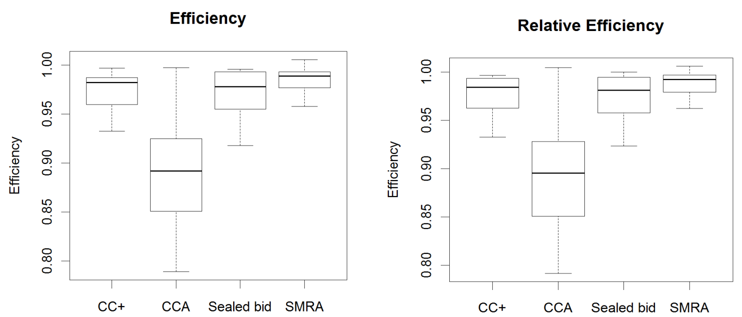


Fig. 3. Efficiency and relative efficiency

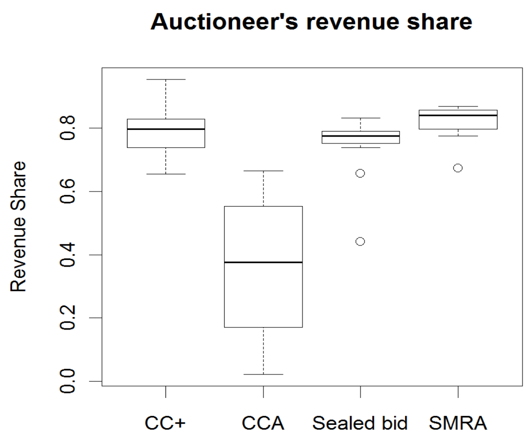


Fig. 4. Auctioneer's revenue share

Table 3. Significance tests (Wilcoxon rank sum tests) for a difference on all pairs of auction formats

Comparison	**E(X)**	**$E(X^*_{rel})$**	**R(X)**
CC+ vs. CCA	W=219 (p=0.000)	W=218 (p=0.000)	W=255 (p=0.000)
CC+ vs. Sealed bid	W=123 (p=0.867)	W=120 (p=0.777)	W=146.5 (p=0.498)
CC+ vs. SMRA	W=74 (p=0.044)	W=84.5 (p=0.105)	W=88 (p=0.138)
Sealed bid vs. CCA	W=255 (p=0.000)	W=218 (p=0.000)	W=219 (p=0.000)
Sealed bid vs. SMRA	W=74 (p=0.044)	W=84.5 (p=0.105)	W=88 (p=0.138)
CCA vs. SMRA	W=30 (p=0.000)	W=9 (p=0.000)	W=0 (p=0.000)

Support for the first three results is presented in figure 3, table 2 and 3.

Result 1: *The efficiency of SMRA, CC+ and the sealed bid format was not significantly different.*

In all the three auction formats we achieved high efficiency, on average higher than 97%. All items were sold and we did not lose social welfare by not assigning some items.

Result 2: *The efficiency of the CCA was significantly lower than that of the other auction formats.*

Bidders' choice set in the value model consisted of 2,400 different bundles, because bidders had to combine the number of items across all bands in each bundle bid. It is very difficult for human bidders to find the most valuable packages in this scale.

Result 3: *By using the simplified bidding language we do not loose efficiency.*

By restricting our bidding language we do not loose efficiency in comparison to the fully expressivity. We see, that E(X) and $E(X^*_{rel})$ are only different by ca. 0.3%.

One reason is the complementarity of the value model. Besides, the most efficient allocations consist of combinations of two, four and rarely six sized bundles. As a consequence, we simplify the language from 2,400 possible bids to at most 12 bids significantly without losing efficiency.

Result 4: *The auctioneer revenue of SMRA, CC+ and the sealed bid auction was significantly higher than that of the CCA.*

Support for result 4 and 5 can be found in figure 4 and table 2 and 3. A reason for this is that only within CCA items remained unsold. So, the auctioneer did not earn money for each block and missed revenue.

Result 5: *The auctioneer's revenue of SMRA, CC+ and the sealed bid auction was not significantly different.*

This result is remarkable, because in SMRA a different payment rule was applied as within CC+ and the sealed bid auction. Nevertheless, the revenue is in the same range.

Now, we describe bidder behavior in CC+ and the sealed bid auction at first.

4.2 Bidding Behavior in the Sealed Bid Auction

To analyze bidding behavior, we looked at bid shading. Shading is computed by the difference of bidders' valuation and the bid price for a certain bundle. Percental shading is shading divided by the valuation. In the following we categorize the bidders according to their strength.

Bidders with the highest valuation within a band are called very strong bidders, with the second highest valuation medium strong, with the third highest valuation medium weak and finally, bidders that drew the lowest valuation are named very weak.

Table 4. Average bid shading

Bidders' type	**Absolute shading**	**Percental shading**
Very strong	68,75	5,40%
Medium strong	26,09	2,40%
Medium weak	31,66	2,86%
Very weak	2,77	0,47%

Result 6: *In the sealed bid auction both the absolute and the percental bid shading of the very strong bidders is significantly higher than that of the others bidders.*

The higher the valuation was the bidder has drawn within a block; the more he shaded the bid. Bidders did not want to lose when they evaluated their situation as strong. Therefore, they placed bids above their valuation to assure their win.

Table 5. Wilcoxon tests for bid shading

	Very strong	**Medium strong**	**Medium weak**	**Very weak**
Very strong	-	W=29462 (p=0.046)	W=28483 (p=0.114)	W=30348 (p=0.001)
Medium strong	-	-	W=22113 (p=0.709)	W=23740 (p=0.223)
Medium weak	-	-	-	W=23778 (p=0.1303)
Very weak	-	-	-	-

Result 7: *In the sealed bid auction both the absolute and the percental bid shading of the medium strong and medium weak is not significantly different.*

The valuations, the medium strong and medium weak bidders drew, were sometimes not far apart. Bidders could not exactly determine their strength compared to their competitors in such situations. As a consequence, the behavior of these two kinds of bidders did not differ.

Result 8: *The weak bidder did not shade his bids.*

The weak bidder knew that he might be the one with the lowest valuation. Thus, he did not apply bid shading in order to avoid the risk to make a loss.

Support for Result 6, 7 and 8 is given in table 4 and 5. In Figure 5 we made linear interpolations of bidders' shading to get an overview of their actual activities. If a bid is not connected, bidders updated it during the auction and it was not yet active for winner determination. We see that the bid shading of different bidders is quite different.

The literature on explaining this is huge and beyond what we can describe in this context. Overall, risk aversion, regret, spite, and wrong expectations about the bids of others are the most common conjectures.

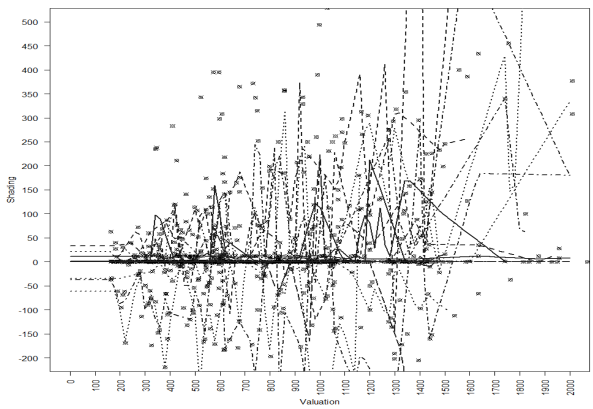


Fig. 5. Shading in the sealed bid auction

4.3 Bidding Behavior in the CC+ Auction

For the following analysis it is of interest if bidders applied their equilibrium bidding strategy for the CC+. Besides, a remark is given how bidders submitted their bids.

Result 9: *In the CC+ auction, bidders followed a powerset strategy.*

Bidders placed always their powerset bids in the CC+ auction at least in the first round. This means 48 bids, since 4 bidders participated in each auction who could submit bids on all the 12 possible bundles.

On average, CC+ consisted of 18.75 rounds and 367.75 bids have been submitted in each auction until the weakest bidder had reached his valuation and dropped out of the auction. The number of winning bidders was on average 3.8 (in 13 out of 16 auctions all four bidders won at least one bid). Support can also bid found in figure 6.

Result 10: *Bidders placed their bids on their best bundles.*

Bidders focused on their best bundle, because there was the highest valuation per unit. So, 39.51% of all bids have been for bids on 2 sized bundles, 32.27% for bids on 4 sized and finally, 28.22% on 6 sized bundles. Support can be found on figure 7. To get an impression of the scale of the submitted bids we talk, in figure 7 and 8 the numbers and not percental figures are used.

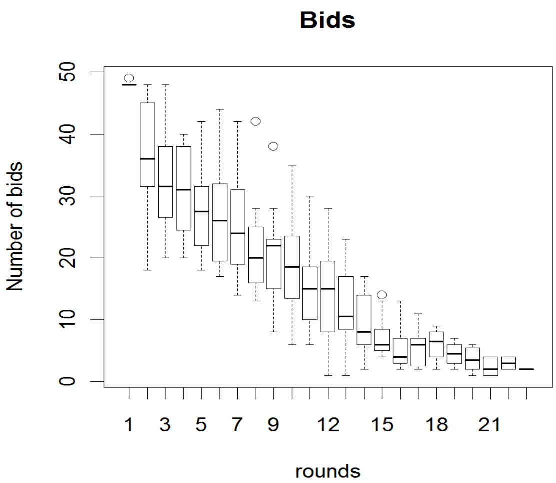
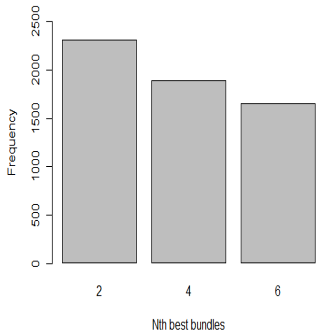


Fig. 6. Number of bids in each round



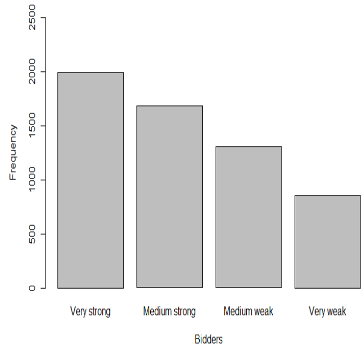


Fig. 7. Distribution of bids

Fig. 8. Bids according to bidders' strength

Result 11: *The number of bids depends on bidders' strength.*

In percentage, 34.17% of all bids submitted the very strong bidder, 28.82% the medium strong bidder, 22.36% the medium weak bidder and 14.65% the weakest bidder. If prices are too high, weak bidders cannot participate in the auction. Later in the auction, even prices for the medium weak or sometimes the medium strong bidder increased too much.

5 Conclusion

Combinatorial auctions have led to a substantial amount of research and found a number of applications in high-stakes auctions for industrial procurement, logistics, energy trading, and the sale of spectrum licenses. Thereby, communication complexity is a problem in all CAs. The question is important, how many bids must be submitted to the auctioneer to calculate an efficient allocation. Hence, we simplified the bidding language using our knowledge of the value model. Bidders only had to submit 12 bids in each round respectively in the whole sealed bid auction in comparison to evaluate all possible 2,400 bundles in the CCA. Besides, we used for CC+ and the sealed bid auction an OR bidding language between bands, which leads to the fact that bidders need to submit much less bids as with a pure XOR bidding language in CCA. Efficiency is not significantly decreased by this modification.

Single-phase auction formats where bidders can submit more than a single bid per round can have advantages and elicit more "relevant" bundle bids throughout the process. So, we tested the two phases of the CCA, the CC+ and the sealed bid auction in lab experiments, separately. We found out, that theses single-phase CAs achieved more robust outcomes and realized significantly higher efficiency and revenue than the CCA. However, there are almost no differences concerning the efficiency and revenue between the sealed bid and CC+ auction. But, the SMRA remained the most efficient auction format in our experimental setting. Nevertheless, there are many disadvantages to SMRA like the exposure problem, which says that in case of complementarities, bidders run the risk of winning only a part of a complementary collection of items in an auction without package bids. Besides, in order to maintain eligible bidders temporarily bid for packages they are not interested in which can provide less efficient outcomes. Bidders can also use signaling such as jump bidding to cooperate in SMRA. These reasons are only exemplarily, why it is not proper to use it SMRA in practice.

We argue that in addition to theoretical research, more empirical work is needed, in order to understand real-world bidder behavior. Additionally, the CCA could also be tested with the simplified bidding language and compared with the results obtained by our tested single phase auctions.

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