An experimental investigation of partnership dissolution mechanisms

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Abstract:
In this paper we examine the experimental performance of two simple dissolution mechanisms – the cake cutting mechanism (CCM) and the winner’s bid auction. We investigate the dissolution of a partnership consisting of an indivisible object which is owned in equal shares by two partners using a symmetric, independent private values framework, in which one partner buys out the other partner. Contrary to the theoretical prediction that auctions are more efficient mechanisms, our experiment provides evidence that the CCM is at least as efficient as the auction. However, the experiment reveals a trade-off between efficiency and fairness (in terms of equal payoffs). Ex ante payoff expectations for all subjects are quite the same in all treatments, but differ drastically between proposers and choosers in the CCM after the assignment of being proposer or chooser respectively.

Keywords: Mechanism design, partnership dissolution, fair division

JEL Classifications: C91, D44, D61

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1. Introduction

Imagine two partners possessing a single indivisible object in equal shares, whose partnership breaks down. Which dissolution mechanism is the “best” mechanism and should be implemented? A dissolution mechanism determines the partner who should become single owner and the compensation to be paid to the other partner.¹ The aim is the implementation of an efficient² and simple³ mechanism.

Two feasible dissolution mechanisms for a single indivisible object equally shared by two partners are the cake-cutting mechanism (CCM)⁴ and auctions. In the CCM one partner – the proposer – first proposes a price for the object and then the other partner – the chooser – decides whether he wants to buy the object or whether he wants to sell it at that price. In an auction both partners propose their bids for the object simultaneously. The partner with the higher bid obtains the object and pays the other partner out. The compensation in a two agent partnership can either be determined by a first price or by a second price rule. The winner’s bid auction (WBA) is equivalent to a first price auction without an outside seller; the loser’s bid auction (LBA) is similar to a second price auction without an outside seller. The auction is a symmetric mechanism, consisting of a simultaneous game with two identical partners facing the same strategy space. By contrast, the CCM is an asymmetric mechanism as it is composed of a sequential game with two different types of players possessing different strategy spaces. Hence, the proposer’s optimal strategy depends on the distribution of the chooser’s valuation, whereas the chooser’s optimal strategy depends only on the proposed price and his own valuation (it is therefore independent of any distributional assumptions).⁵ Obviously, the proposer’s decision is much more complicated than the chooser’s.

The purpose of this paper is to compare the performance of the CCM and the WBA experimentally using a symmetric, independent private values framework. Efficiency of allocations is one measure of performance for these two mechanisms. Theoretically under asymmetric information the CCM might lead to inefficient

¹ Thus we neglect the case of an outside buyer of the object, but rather examine dissolutions, in which it is more profitable that one of the former owners continues the partnership as exclusive owner. One might think of cases in which assets may be less valuable to a third party than to either partner.

² An efficient allocation is achieved if the partner with the higher valuation buys the object.

³ For the mechanism designer a simple mechanism requires neither knowledge of the underlying distribution of valuations nor knowledge of the utility functions of the partners (McAfee, 1992). The dissolution mechanism should be simple as the court and lawyers have no information e.g. about the risk aversion of partners. Thus, they will not implement a mechanism depending on this information.

⁴ The CCM is also known as buy and sell clauses or Texas shoot outs.

⁵ De Frutos, Kittsteiner (2006).
allocations; whereas the WBA should provide efficient allocations.\(^6\) In reality, however, the CCM is the prevalent dissolution mechanism in Anglo-Saxon corporate law (Kittsteiner, Ockenfels 2006). Its prominence is emphasized by Brooks and Spier (2004, p.2): “The importance of buy-sell agreements is now so broadly recognized that a lawyer’s failure to recommend or include them in modern joint venture agreements is considered “malpractice” among legal scholars and practitioners”. The experimental investigation of the two mechanisms should shed light on this divergence of theoretically economic and practically legal advice. Surprisingly, contrary to the theoretical prediction the experiment shows that the CCM is at least as efficient as the auction – in terms of efficiency rates as well as in terms of percentage of efficient allocations. This paper discusses several possible explanations for the surprisingly good performance in terms of efficiency of the CCM among which are risk aversion, loss aversion and ex post rationality (some kind of winner’s and loser’s regret).

Theoretically, the CCM under asymmetric information might result in inefficient allocations as in general the proposer has no incentive to submit his true valuation. In fact, he has a tendency to set a higher price than his own valuation if his valuation is below the median valuation, and to set a lower price than his own valuation if his valuation is above the median valuation. The reason for this is that in the former case he is more likely to become a seller and in the latter case he has a higher probability of being the buyer. Efficient allocations always occur if one partner’s valuation is below and the other partner’s valuation is above the median valuation. However, if both partners’ valuations are either below or above the median valuation and if the partner whose valuation is far away from the median valuation is the proposer, inefficient allocations might occur.

Fairness in terms of ex ante outcome expectations might be another measure of performance. Ex ante payoff expectations for all subjects do not differ significantly in both treatments, but diverge drastically between proposers and choosers in the CCM after the assignment of being proposer or chooser respectively. The experimental result that proposers’ profits are smaller than choosers’ profits is in line with the theoretical results.

The remaining paper is structured as follows. In section 2 we review the literature related to our experiment. Section 3 introduces the experimental design and

\(^6\) Compare McAfee (1992) who ranked WBA, LBA and CCM according to efficiency criteria and Cramton, Gibbons, Klemperer (1987) who showed for a more general formulated auction that efficient dissolution is always possible if the initial shares are not too far from the equal partnership.
procedures. The results are presented in section 4, which is followed by conclusions in section 5.

2. Related Literature
There is a broad theoretical literature dealing with partnership dissolution mechanisms. Cramton, Gibbons, Klemperer (1987) scrutinize how to allocate efficiently a single item among partners with initial share $r_i$ of the good under risk neutrality assuming symmetric independent private values. If shares are sufficiently symmetric and not too far from the equal partnership, then there exists an efficient mechanism for allocating the item that satisfies the individual rationality constraint.\footnote{This supports the Myerson, Satterthwaite (1983) result that no procedure can yield ex post efficient allocations satisfying interim individual rationality in two-player bargaining games with uncertainty and $r_1=1$ and $r_2=0$.} Cramton, Gibbons, Klemperer characterize the set of incentive-compatible interim-individually-rational dissolution mechanisms. They use an efficient bidding game in which the good is transferred to the highest bidder, and each bidder pays a total price (making a higher bid is like buying more lottery tickets in that the purchase price of losing tickets is not refunded). Advantages of the bidding game compared to a trading mechanism consist in using strategy spaces familiar in practice and shifting a great deal of the computational burden from the mechanism designer to the players. Cramton, Gibbons, Klemperer also propose a simple bidding game (k+1-price auction) in which the object is given to the higher bidder who pays an amount proportional to a convex-combination of the two bids. The WBA and the LBA are special cases of their k+1-price auction. The set of partnerships that can be dissolved efficiently using a k+1-price auction is centered around the equal-shares partnership.\footnote{This also indicates that an equal-shares partnership can always be dissolved efficiently by any k+1-price auction.}

McAfee (1992) investigates the dissolution of a partnership with simple mechanisms (WBA, LBA and CCM) under symmetric, independent private values. The CCM performs differently under asymmetric information than under full information\footnote{Asymmetric information implies that each partner only knows his own valuation for the object, whereas under full information both partners know additionally each other’s valuations.} – in the former case allocative inefficiencies might arise and agents favor to be the chooser, whereas in the latter case allocative efficiency is always reached and agents prefer being proposer. Under constant absolute risk aversion the high value bidders prefer the LBA, while low value bidders prefer the WBA. Assuming risk neutrality the WBA and the LBA produce the same expected utilities if no outside option exists.

\begin{flushright}\footnotesize\[\]\end{flushright}
However, the WBA leads even in the presence of an outside option to efficient allocations. Thus, McAfee concludes that the WBA appears to be the best way to allocate a single item, because it reaches ex post efficient allocations even in the presence of an outside option.

McAfee’s result of the chooser’s expected profit being higher than the proposer’s in an asymmetric information setting implies that nobody wants to start proposing a price. Thus, De Frutos, Kittsteiner (2006) investigate the question of who becomes proposer in the CCM. The CCM is preceded by an open, ascending-bid (English) auction that determines the assignment of the roles. If the U-shaped bidding functions are symmetric efficient dissolutions can be achieved under asymmetric information in the CCM.

Some recent theoretical studies are devoted to partnership dissolution assuming interdependent valuations of the partners. Moldovanu (2002) wrote a survey how to dissolve a partnership under interdependent valuations. Kittsteiner (2003) investigates partnerships and the double auction with interdependent valuations. Jehiel, Pauzner (2006) analyze partnership dissolutions with interdependent values in which only one partner is fully informed about the valuations. Contrary to the private value case as described by CGK extreme property-rights structure can be preferred to mixed ownership and the CCM can perform better than an auction (de Frutos and Kittsteiner, 2006). To our knowledge, our study is the first experimental investigation of partnership dissolution mechanisms. Thus, we start with the easiest case – the private, independent values framework.

We select the WBA as the auction format for the experiment due to a better theoretical and experimental performance compared to the LBA. Güth et al (2002) experimental findings show that the WBA is straightforward, easy to understand for the subjects and has a (although not significantly) better performance (in terms of efficiency). As it seems to be the more “natural” auction mechanism we choose the WBA for our experiment. Theoretically the WBA appears to be the most efficient way to allocate a single item. The CCM has a disappointing performance as it fails to reach ex post efficiency.

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10 Güth et al (2002, 2003) investigate experimentally auctions and fair division games both under first- as well as under second-price rule collecting entire bid functions. (The fair division game under first-price rule is equivalent to the winner’s bid auction in our experiment). Güth et al (2003) concentrate on learning aspects (also direction learning).
Other studies focus on aspects of fair division and social choice. In contrast to our indivisible object setting under incomplete information, Crawford (1977) considers a fixed bundle of homogeneous and perfectly divisible goods under complete information to resolve two-person bargaining disputes and concludes that the CCM is especially a good solution when agents are in an almost symmetrical position as an allocation is achieved that is nearly as equitable and efficient as any feasible allocation.

Bassi (2007) studies experimentally fair division of perfectly divisible goods under complete information about the partner’s valuation. She investigates two mechanisms: the equal division divide and choose (chooser chooses between equal division and the proposed division) and the same game with a preceding auction who becomes divider. In the experiment the equal division divide and choose mechanism leads to efficient and envy-free, but not equitable results, whereas the same mechanism with a preceding auction results in efficient, envy-free, and equitable outcomes.

Morgan (2004) investigates the division of a homogeneous object under incomplete information under fairness considerations (considering two notions of fairness: proportionality and envy freeness). Contrary to the private independent value setting from above he focuses on common values with risk neutral agents.11 His main contributions are that any pure strategy equilibrium of the CCM is unfair (as it systematically favors the choose) and that WBA and LBA also fail to achieve fair allocations.

Brams, Jones, Klamler (2006) examine the fair division of a heterogeneous, divisible good, whose parts may be valued differently by different players. The goal of each person, who are assumed to be risk averse, is to maximize the value of the minimum-size piece. For 2 players it holds that the CCM satisfies envy-freeness and Pareto-optimality, but not equitability (each person’s subjective valuation of the piece that he or she receives is the same as the other person’s subjective valuation). Thus, they propose a new procedure (surplus procedure SP) which satisfies equitability in a relative sense (proportional equitability means that after ensuring that each person receives exactly 50% of the cake, it gives each person the same proportion of the cake that remains (surplus), as he values it).12

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11 Under common values all allocations are efficient.
12 If there are three players it is not always possible to divide a cake into envy-free and equitable portions. For four and more persons there is no known minimal-cut, envy-free procedure, whereas the equitability procedure (EP) ensures an equitable and efficient division that is strategy-proof for any n.
3. Experimental Design and Procedures

The computerized experiment was conducted at the Cologne Laboratory for Economic Research in June 2006 using the programming software z-Tree (Fischbacher (2007)). Subjects were undergraduate students from the University of Cologne mostly belonging to the faculty of economics and business administration and they were recruited with ORSEE (Greiner (2004)).

We ran three sessions comprising two different treatments – the CCM and the WBA. In both treatments a single indivisible object has to be allocated among two partners. As in the WBA both partners submit their bid and in the CCM only one partner submit a price we played the CCM session twice to get an equal number of observations. Each session consists of 30 rounds and lasts about one hour. Subjects receive in session 1 (CCM) average earnings of 12.81 € (with a minimum of 9 € and a maximum of 17.10 €), in session 2 (WBA) average earnings amount to 12.60 € (with a minimum of 8.90 € and a maximum of 15.10 €) and in session 3 (CCM) (with a minimum of 8.70 € and a maximum of 16.60 €) subjects earn on average 12.64 € (including a show up fee of 2.50 €).

Each session is run with 32 subjects using stranger matching. The subjects are divided into 8 matching groups consisting of 4 subjects. Subjects know that their partners change in each round. They are told that two partners possess a “fictitious” indivisible object together and that they have to negotiate who obtains the object and which compensation the other partner receives. During the whole experiment an asymmetric information framework is used: each subject gets to know his own valuation for the object in each round, but not the valuation of his respective partners.\footnote{Instructions are given in the Appendix.}

In the CCM treatment each subject is once assigned randomly whether he will become proposer or chooser with equal probability before the experiment starts. Subjects know that they will maintain their role during the whole experiment, because we want them to face the same decision situation in all 30 rounds equivalent to the auction treatment. Then the experiment starts. In each round two partners are randomly matched. For each subject a random number is drawn from the uniformly distributed interval [0, 100] (2 decimal spaces). This number represents their own valuation for the object which is private information to the subjects. The proposer is asked to set a price for the indivisible object which is communicated to the chooser. The chooser decides whether to buy his partner’s share or to sell his own share at this price. The price the
proposer sets is the price for the whole object. Thus, the price for each share of the object is half of the announced price. Hence subjects achieve the following payoffs: if a subject is the buyer he gets $\pi_b = v_b - \frac{P}{2}$, if a subject is the seller he gets $\pi_s = \frac{P}{2}$.\textsuperscript{14}

The WBA treatment is conducted accordingly. In each round two partners are randomly matched anew. Then subjects submit their bids simultaneously after learning their own private valuation $v_i \in [0,\ldots,100]$\textsuperscript{15} for the object. The subject with the higher bid achieves the object and pays half of the winning bid to the loser. Thus, the payoffs amount to $\pi_w = v_w - \frac{b_w}{2}$ for the winning bidder and $\pi_s = \frac{b_w}{2}$ for the loser. In case the two bidders submit the same bid, a winner is randomly chosen and the payoffs of buyer and seller arise afterwards as described above. In both treatments bids (proposals respectively) were restricted to 200 to avoid obvious type errors.

In our specific independent private value design with uniformly distributed valuations in the range from 0 to 100 for risk neutral agents the equilibrium proposal in the CCM is given by $p_i^*(v_i) = \frac{v_i}{2} + 25$ and the equilibrium bid by $b_i^*(v_i) = \frac{2}{3}v_i$.

4. Experimental Results

The next subsections present the experimental results\textsuperscript{16} starting with an investigation which mechanism yields more efficient allocations, followed by an analysis of individual behavior and types and finishing with an inquiry of the subjects’ profits.

4.1 Efficiency

First, we investigate which mechanism achieves more efficient allocations. We measure efficiency in two ways – we calculate the percentage of efficient allocations which yields the frequency of efficient allocations and we use the efficiency rate which is defined as $\frac{v_i(buyer)}{\max\{v_1, v_2\}}$ yielding the degree of efficiency for each allocation. The mean efficiency rates and the percentage of efficient allocations over all rounds for our two treatments are given in Table 1. Güth et al (2002) find a very similar percentage of efficient allocations of 85.0% and an efficiency rate of 95.8% in their so called fair

\textsuperscript{14}In the following we use the subsequent abbreviations: $b$ stands for buyer, $s$ for seller, $w$ for winner.

\textsuperscript{15}These numbers are again uniformly distributed with 2 decimal spaces.

\textsuperscript{16}In the following analyses we pool the data of the two CCM sessions.
division game 1 which equals our WBA treatment.\textsuperscript{17} Table 1 shows that both the mean percentage of efficient allocations as well as the mean efficiency rate is higher in the CCM treatment than in the WBA. However, pair wise two-tailed Mann-Whitney-U tests reveal only significant differences between the treatments for percentage of efficient allocations ($p = 0.092$), but not for the efficiency rate.\textsuperscript{18}

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean percentage of efficient allocations and efficiency rates (over all rounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of efficient allocations</td>
</tr>
<tr>
<td>CCM</td>
<td>89.69%</td>
</tr>
<tr>
<td>WBA</td>
<td>85.21%</td>
</tr>
</tbody>
</table>

With regard to the reported results from above the CCM seems to generate at least as efficient allocations as the auction – in contradiction to what theory predicts and in favor of the legal advice. To get a better understanding for the underlying coherences we consider next the cases in which there should be inefficiencies in the CCM theoretically.

**Theoretical inefficient allocations**

The following conditions must hold for theoretical inefficient allocations under risk neutrality: Both partners’ valuations have to be above (below respectively) the median valuation of 50. Moreover, the proposer has to be the partner with the more extreme valuation. As described above the equilibrium proposal yields $p^\ast = \frac{v}{2} + 25$. Additionally, for the chooser’s valuation $v_c$ it must hold above the median valuation $p^\ast < v_c$ and below the median valuation $p^\ast > v_c$. The first column of Table 2 shows how often inefficient allocations occurred in the experiment and how many cases should be there theoretically given the valuations of the subjects. In only about 50% of the cases in which there should be inefficiencies, inefficiencies actually take place. As the auction should always lead to efficient allocations theoretically there is no entry. The second column summarizes the cases in which inefficient allocations occur if there

\textsuperscript{17} Note that in Güth et al. three bidders play the fair division game, whereas in our design two partners dissolve their partnership.

\textsuperscript{18} The tests use matching group averages as independent observations (CCM: 16 matching groups; Auction: 8 matching groups).
should not be any theoretically. In the CCM these cases amount to only about 5% compared to nearly 15% in the auction.

Table 2
Inefficient allocations – in theory and in the experiment

<table>
<thead>
<tr>
<th></th>
<th>Inefficient allocations if there should be inefficiencies</th>
<th>Inefficient allocations if there shouldn’t be any inefficiencies</th>
<th>Mean of inefficient allocations per session</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCM</td>
<td>56/111 = 0.5045</td>
<td>43/849 = 0.0506</td>
<td>99/960 = 0.1031</td>
</tr>
<tr>
<td>WBA</td>
<td>71/480 = 0.1480</td>
<td></td>
<td>71/480 = 0.1480</td>
</tr>
</tbody>
</table>

The high frequency of efficient allocations in situations in which there should be inefficiencies theoretically in the CCM is apparent. To understand why so many allocations in the CCM are efficient although theory predicts inefficiencies, we classify proposer’s behavior in case efficient allocations occur. Not surprisingly, the occurrence of efficient allocations is to a considerable amount driven by too hesitant proposal setting (i.e. \( p \) is set too close to the proposer’s valuation compared to \( p^* \); \( p = v \) not included) and especially the extreme case of proposers setting \( p = v \). In case theory predicts inefficiencies but actual proposals are nevertheless efficient, 40.00% of proposals are set too hesitant and furthermore 47.27% of proposals equal the valuation. This might be a first indication of risk aversion, which could be an explanation for the efficient performance of the CCM.

As in the CCM proposers should set in equilibrium their proposals in opposite directions in comparison to their valuation depending on their valuations being above or below the median valuation (\( p > v \) if \( v < 50 \) and \( p < v \) if \( v > 50 \)), we consider the cases in which proposer’s valuations are above or below their valuation separately. In total the number of theoretically inefficient allocations amounts to 111 in the CCM treatment. If the valuations are above the median valuation 44 out of 73 theoretically inefficient cases are actually inefficient (60.27%). If the valuations are below the median valuation only 12 out of 38 theoretically inefficient cases are inefficient (31.58%). It is noticeable that if both partners’ valuations are above the median valuation inefficient allocations occur nearly twice as often in case theory predicts inefficiencies than if both partner’s

\[ \text{Table A1 in the Appendix shows the results. We rounded } p^* \text{ and } p = v \text{ up to at most } +/-1. \text{ The occurrence of an efficient allocation although one proposer even proposes an excessive } p \text{ is due to a mistake of the buyer who does not buy although the price is below his own valuation. This is the only case in which the buyer does a mistake.} \]
valuations are below the median valuation. This behavior cannot be explained by constant absolute risk aversion (CARA). Besides constant relative risk aversion (CRRA) or heterogeneous risk preferences another possible explanation for this observation might be loss aversion. We will investigate possible explanations in more detail in subsection 3.2.

A probit regression (see Table 3) also shows that if both partners’ valuations are above the median valuation, this has a strong and highly significant negative impact on the efficiency of allocations in the CCM treatment. However, both partners’ valuations being below the median valuation has no significant effect. By contrast, in the WBA neither both partners’ valuations being above nor below the median valuation has a significant impact. The positive coefficients for distance of the partners’ valuations are highly significant in both treatments, but very small. Nevertheless, the coefficient for distance of valuations is nearly twice as high in the WBA as in the CCM. In the CCM the coefficient for round is positive, very small and highly significant, whereas in the WBA there is no significant round effect. Interestingly, in the first round the auction performs more efficiently than both CCM sessions – in the first round the highest efficiency rate as well as the highest percentage of efficient allocations is achieved.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Probit regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eff. allocation</td>
<td>CCM</td>
</tr>
<tr>
<td>Constant</td>
<td>0.7555062**</td>
</tr>
<tr>
<td>Distance_v</td>
<td>0.0212747**</td>
</tr>
<tr>
<td>round</td>
<td>0.0183243**</td>
</tr>
<tr>
<td>v below 50</td>
<td>-0.2395597</td>
</tr>
<tr>
<td>v above 50</td>
<td>-0.6000312**</td>
</tr>
</tbody>
</table>

** Significant at the 1% level.

In the next subsections we analyze subjects’ behavior to understand why the CCM performs in such an efficient way in contradiction to the theoretical prediction and discuss possible explanations.
4.2 Individual behavior

We examine individual behavior starting with the means of the three sessions over all rounds and all subjects given by Table 4. Note that in the CCM the proposals equal the price for the whole object which has to be actually paid whereas in the auction the price is solely determined by the winning bid. Thus the means of exclusively winning bidders are also given in brackets. In the auction the mean price is lower than in the CCM, but not significantly.20

Table 4
Mean valuations, proposals/bids and theoretical predictions

<table>
<thead>
<tr>
<th></th>
<th>Mean valuation</th>
<th>Mean proposal/bid</th>
<th>Mean theoretical proposal/bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCM</td>
<td>52.74*</td>
<td>49.72</td>
<td>51.37</td>
</tr>
<tr>
<td>Auction (only $b_w$)</td>
<td>52.50</td>
<td>35.42</td>
<td>35.00</td>
</tr>
<tr>
<td></td>
<td>(66.95)</td>
<td>(48.63)</td>
<td>(44.63)</td>
</tr>
</tbody>
</table>

* The mean is only for proposers. Mean valuation of all subjects is 52.45 in the CCM.

Mean proposal and mean bid over all rounds and subjects are very close to the theoretical predictions. Graph 1 shows scatter plots of the valuations and the corresponding proposals (respectively bids) for the CCM treatment (for the auction treatment). The pink line stands for the theoretical proposals respectively theoretical bids for each valuation. A simple linear regression21 analysis over all subjects and periods yields a quite good fit of theoretical and experimental bids for the WBA treatment. The constant amounts to 1.241 but does not differ significantly from 0 and the coefficient is 0.651 ($p<0.001$). The proposals in the CCM sessions on the contrary do not perform as well compared to the theoretical prediction. Regression analysis yields a constant of 14.839 and a coefficient of 0.661 – both highly significant. The significantly steeper slope and the smaller intercept than the theoretical prediction indicate that proposals are set too close to the valuation. However, proposer’s behavior tends to the right direction. Graph 1 shows for the CCM that if a valuation is below the median valuation of 50 proposals tend to be higher than the valuation; however, if a valuation is above the median valuation proposals tend to be lower than the valuation. In the WBA the great majority of bids lie below the valuation.

20 Two-tailed Mann Whitney U tests yield no significant differences with regard to average prices for each matching group in the CCM treatment and in the auction.

21 The bid function is estimated by $b_i = \alpha_i + \beta_i v_i$ in the auction treatment and by $p_i = \alpha_i + \beta_i v_i$ in the CCM treatment respectively.
We categorize proposals and bids according to Table 5. In the following we use rounded data (data is rounded at most +/-1). Too hesitant behavior ($p=v$ and $b=v$ are itemized as special cases) indicates proposals and bids lying between the equilibrium and the valuation of the subjects (in the WBA treatment this behavior corresponds to overbidding). Excessive proposal setting in the CCM treatment is defined by setting $p$ above $p^*$ in case $v<50$ and setting $p$ below $p^*$ in case $v>50$ and corresponds to underbidding behavior in the WBA. Wrong direction means that $p$ lies on the other side of the valuation than $p^*$. (This is a strictly dominated strategy). To investigate in the CCM whether proposal setting goes in the “right direction” we differentiate three main categories: right direction (consisting of the categories $p=p^*$, too hesitant and excessive $p$), $p=v$ as a neutral category and wrong direction. Surprisingly, if $v>50$ 66.67% of proposals are set in the right direction and only 5.52% are set in the wrong direction. However, if $v<50$ only 49.02% of proposals are set in the right and 19.43% are set in the wrong direction. The fact that less proposals are set in the right and more proposals are

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22 One extreme data point is excluded in the graph (proposal of 200).
set even in the wrong direction if \( v < 50 \) might be one reason for the higher frequency of efficient allocations below the median valuation. This behavior could be a sign of loss aversion.

### Table 5

Proposals and bids \((N=960)\)

<table>
<thead>
<tr>
<th></th>
<th>( p = p^* )</th>
<th>( p = v )</th>
<th>Too hesitant</th>
<th>Excessive ( p )</th>
<th>Wrong direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>6.25%</td>
<td>30.10%</td>
<td>24.90%</td>
<td>27.19%</td>
<td>12.08%</td>
</tr>
<tr>
<td>( v &gt; 50 )</td>
<td>6.9%</td>
<td>28.01%</td>
<td>28.01%</td>
<td>31.76%</td>
<td>5.52%</td>
</tr>
<tr>
<td>( v &lt; 50 )</td>
<td>5.52%</td>
<td>32.45%</td>
<td>21.42%</td>
<td>22.08%</td>
<td>19.43%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>( b = b^* )</th>
<th>( b = v )</th>
<th>Too hesitant</th>
<th>Excessive ( b )</th>
<th>Wrong direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>9.27%</td>
<td>10.52%</td>
<td>34.27%</td>
<td>43.02%</td>
<td>3.75%</td>
</tr>
</tbody>
</table>

We rounded \( p (b) \) in cases \( p = p^* (b = b^*) \) and \( p = v (b = v) \) up to at most \(+/-1\).

### Bids and proposals equaling the valuation

Table 5 shows that a certain fraction of subjects set \( b \) and \( p \) equal to their valuation. This is inconsistent with equilibrium behavior in the WBA as well as in the CCM. A first explanation might be risk aversion. We will discuss this in subsection 3.3.

Social choice and fair division literature emphasized that setting \( p = v \) in the CCM is the envy-free proposal, at which the proposer is indifferent between buying and selling as the proposer achieves the same utility independent of the chooser’s decision.\(^{23}\) However, this holds also for the auction treatment no matter whether the strategy \( b = v \) is the losing or winning bid. Setting \( p = v \) more frequently in the CCM sessions might be rather due to the fact that this is the only proposal for which the proposer knows for sure his payoff at the time of setting his proposal (independent from the decision of the chooser). However, although the exact payoff is still not known to subjects, submitting \( b = v \) in the WBA guaranties a minimum payoff of \( v / 2 \), so there is only positive risk.

Maybe the sequential and more complex structure of the CCM and the asymmetric strategy space tempts more subjects to choose a “save” strategy than in the symmetric and simultaneously played auction. In the WBA a subject’s bid has indeed an influence whether a subject becomes buyer or seller, but given a subject is the seller he has no influence on the price he receives (as the price is only determined by his partner’s winning bid). This is a big difference to the CCM treatment. In the CCM

\(^{23}\) Crawford (1977) highlights that an important property of the CCM is the fact that it is a way to achieve an envy free distribution. The proposer can divide in such a way that he is indifferent to his opponent’s choice and the chooser need only choose his most preferred bundle. Thus the players can insure that the outcome of the game is fair.
treatment a proposer knows for sure, that he either has to pay his proposed price or that he receives it. Concerning the price there is no uncertainty for the proposer. If a proposer is insecure if he will become buyer or seller it is risk minimizing to set $p=v$. The situation in the CCM is much more complex as the proposer has to put himself both in the situation of being buyer as well as of being seller. In the WBA subjects react “more from the buyer side” (as if they lose they get a higher price than their own losing bid).

Note that in the CCM setting $p=v$ if one’s own valuation is above the median leads to an equal distribution (if the proposer becomes buyer which is more likely for $v>50$), whereas setting $p=v$ if one’s own valuation is below the median leads to an unequal distribution (if the proposer becomes seller which is more likely for $v<50$). As there seems to be a quite constant percentage of proposals equalizing the valuations independent of valuations being below or above the median valuation in the CCM, fairness arguments cannot really capture the observed behavior.

Another explanation for the accumulated incidence of $p=v$ in the CCM might be loss aversion in combination with an endowment effect. By setting $p=v$ a subject avoids loss aversion with regard to his reference point $v/2$. If a subject in the experiment observes his valuation for the object, he knows his share is worth $v/2$. So he wants to achieve at least $v/2$ (his endowment). In the CCM the secure strategy to achieve $v/2$ is to set $p=v$. In the WBA one can set at least a slightly lower $b$, as in case the subject loses he receives the winner’s bid which must be at least slightly above his own losing bid. Note that this kind of loss aversion concerning the subject’s endowment is different from the loss aversion discussed below (which concerns strictly negative payoffs and thus can only occur below the median valuation). The loss aversion discussed concerning the endowment is independent from the valuations being below or above the median valuation and thus explains why we observe $p=v$ equally above and below the median valuation.

**Deviation from theory**

The table above only shows the frequency of a certain behavior. We are interested now in the size of the deviation from the theoretical prediction. Size of deviation is measured as percentage of deviation from the theoretical bid (proposal) in order to use a comparable measurement across treatments. A subject’s deviation from the theoretical
prediction is given by \( d = \frac{b - b^*}{b^*} \) (WBA) and \( d = \frac{p - p^*}{p^*} \) (CCM), respectively. If deviations are >0 actual behavior is above the theoretical prediction, if deviations are <0 actual behavior lies below the prediction.\(^{24}\) Absolute deviation summarizes both cases. Table 6 shows the absolute values of median deviations over all rounds and in brackets the number of occurrence. In the following we use the median due to few, but drastic outliers in the data of the auction treatment.\(^{25}\) In both treatments the median deviation is higher for behavior below the theoretical prediction. However, in the auction treatment there seems to be no significant difference between deviation below and above\(^{26}\), whereas the deviations in the CCM treatment seem to differ significantly.\(^{27}\) Compared to the CCM the median deviation in the auction treatment is more extreme in all three cases. Although bids in the WBA seem to be on average close to the theoretical prediction and a regression analysis yields a quite good fit, Graph 2 shows that there is quite a lot of variation in the data. Auction literature often documented overbidding in auction experiments which was commonly explained by risk aversion.\(^{28}\) However, in our WBA treatment there is no evidence for overbidding – neither in terms of frequency nor in terms of size. We also investigate only the winning bids in the auction treatment as these are the realized prices for the objects.\(^{29}\) The median deviation from the theoretical prediction is still more extreme in the auction treatment for winning bids than in the CCM.

\(^{24}\) Note that \( d \) can only measure the size of the deviation. It does not say anything about risk preferences of subjects. In the WBA \( d \) corresponds to over- and underbidding behavior, but it is not quite clear what it means in the CCM. The deviation only measures if a proposal is set below or above the theoretical proposal, but it does not say anything about the direction. E.g. if \( v < 50 \) and the proposer proposes \( p > p^* \) this is measured as above and if \( v > 50 \) and the proposer sets \( p > p^* \) this is also measured as above, although in the first case behavior is excessive and in the second case it is too hesitant.

\(^{25}\) E.g. one subject in the auction treatment (subject 19) overbids his theoretical \( b^* \) in one round even about 2400%.

\(^{26}\) A two-tailed Mann-Whitney U test for the independent data of the first round reveals no significant differences between above and below (for the test the absolute values of the underbids were taken).

\(^{27}\) A two-tailed Mann-Whitney U test for the data of the first round reveals highly significant differences between above and below for joint data for both CCM sessions (for the test the absolute values of the underbids were taken).

\(^{28}\) Note that unlike a first price sealed bid auction the WBA generates also for the losing bidder positive profits (the price for his share of the object).

\(^{29}\) Again a two-tailed Mann-Whitney U test reveals no significant differences between over- and underbidding in the first round.
<table>
<thead>
<tr>
<th>Table 6</th>
<th>Median deviation over- and underbidding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above</td>
</tr>
<tr>
<td>CCM</td>
<td>13.98% (N=440)</td>
</tr>
<tr>
<td>Auction</td>
<td>22.91% (N=498)</td>
</tr>
<tr>
<td>Winning bids</td>
<td>21.43% (N=297)</td>
</tr>
</tbody>
</table>

Learning

Are bids/proposals of more experienced subjects submitted closer to the theoretical prediction? Graph 2 below compares the absolute percentage of deviations among our treatments showing the median for each round. In the CCM treatment the percentage of deviation seems to decrease over time. To scrutinize whether there is some kind of learning we take the standard deviations of each round. In the CCM treatment Spearman rank correlation shows a significant correlation among round and standard deviation of percentage of deviation ($\rho = -0.591; p<0.01$). However, in the WBA there is no significant correlation among round and standard deviation. Graph 2 also shows that in the first round the absolute median deviation is over 10% higher in the CCM than in the WBA. However, in the subsequent rounds the deviation is nearly always smaller in the CCM.

Graph 2
Absolute median deviation per round

Moreover, we use a simple linear regression analysis to investigate whether bids and proposals change over time. The results are in line with the findings from above. In
the auction treatment bids seem to remain constant over time, a regression analysis with
dummies for rounds 1-10, 11-20 and 21-30 do not yield significant differences. In the
CCM treatment however, we obtain highly significant coefficients of 2.652 for the
dummy for round 11-20 and 3.961 for the dummy for round 21-30. Thus, contrary to
the bids in the auction treatment, proposals seem to increase over time in the CCM. As
in the CCM especially in the first rounds median deviation is much stronger below the
theoretical prediction than the median deviation above, this indicates some kind of
learning behavior. Furthermore, probit regression (Table 3) showed that efficiency
slightly increases only in the CCM over rounds, but for the WBA we do not achieve a
significant effect.

All in all, one might suggest that the auction is better in terms of simplicity as
subjects “do not have to learn how to bid” (in the first round with inexperienced
subjects we even obtained more efficient results in the WBA than in the CCM).

4.3 Risk Aversion

Apparently, a certain fraction of proposals and bids equals exactly the valuation
although this behavior is theoretically never optimal in the WBA and in the CCM only
optimal in case the valuation is exactly 50. Setting $p=v$ and $b=v$ might be a first
indication of risk aversion (extremely risk averse subjects set their proposals and bids
very close to their valuation). However, this behavior is observed more often in the
CCM sessions than in the auction treatment. In the CCM 17.92% of proposals equal
exactly the valuation of the proposer and moreover, only 31.25% of proposers never
used this strategy. In the auction treatment only 3.44% of bids equal exactly the
valuation and 71.88% of bidders never used this strategy.30

Table 5 also shows that $p=v$ is set more frequently in the CCM treatment than
$b=v$ in the auction for the rounded data (30.1% vs. only 10.52% in the WBA). Moreover, Table 5 shows that the prime difference between the CCM and the WBA
treatment lies in the predominance of too hesitant behavior (including $p=v$) in the CCM
compared to excessive proposal setting: in the CCM treatment in total 55% of proposals
are set too close to the corresponding valuation while excessive $p$ is observed in only
27.19% of proposals, which might indicate risk aversion. However, variation of bids is
much more balanced in the WBA than in the CCM: 44.79% of bids are set too hesitant

30 In the Appendix a table is given showing for each subject how often exactly $p=v$ ($b=v$ respectively) was
chosen. A Chi-Square test for two independent samples show highly significant differences ($p<0.001$)
between the CCM and the auction treatment for the two categories $p=v$ and $p \neq v$. 

17
(corresponding to overbidding behavior), but also 43.02% of bids are set too excessive (corresponding to underbids). This difference is quite surprising: risk aversion should be observed equally among treatments. Thus, the efficient performance of the CCM cannot be driven by risk aversion alone.

Firstly, we take a closer look on the proposal behavior in the CCM treatment for the two cases $v<50$ and $v>50$ separately. Given that the valuation is smaller than the median, theory predicts proposals being above the valuation and vice versa if the valuation is above the median valuation. Table 7 shows the mean valuations, proposals and theoretical predictions for the joint data of the CCM sessions for $v<50$ and $v>50$. For both cases Spearman rank correlations show a strong and significant correlation (two-tailed $p<0.01$) among proposals and valuations ($v<50$: $\rho = 0.608$; $v>50$: $\rho = 0.584$). Two-tailed Wilcoxon Signed Rank tests yield significant differences between valuations and proposals ($p<0.001$ for both cases).³¹

**Table 7**

<table>
<thead>
<tr>
<th>CCM</th>
<th>Mean valuation</th>
<th>Mean proposal</th>
<th>Mean theoretical proposal</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>$v&lt;50$</td>
<td>25.53</td>
<td>31.24</td>
<td>37.767</td>
<td>453</td>
</tr>
<tr>
<td>$v&gt;50$</td>
<td>77.04</td>
<td>66.23</td>
<td>63.52</td>
<td>507</td>
</tr>
</tbody>
</table>

The results indicate a systematic effect: when the proposer’s valuation is above the median valuation he submits a lower price than his valuation on average and vice versa when the proposer’s valuation is below the median valuation. This is due to the fact that in the former case a proposer is more likely to become the buyer thus trying to decrease the price he has to pay and in the latter case he is more likely to become the seller thus trying to increase the price he gets. Graph 3 illustrates the mean valuations and mean proposals per round. Obviously the mean proposal per round for valuations below the median valuation is lower than theoretically predicted and the mean proposal per round for valuations above the median valuation is higher than theoretically

³¹ Note that in this case we do not test matching group averages but we use each data point. We do so, because subjects with $v<50$ should set $p>v$ and subjects with $v>50$ should set $p<v$. Aggregating the data over matching groups would neutralize these reverse effects, but this is exactly what we want to test for. Taking only the independent data of the first period yields no significant effects except for the Wilcoxon Signed Rank test for $v>50$. 
predicted.\textsuperscript{32} Thus, although proposers tend to submit their proposals in the right direction they set their proposals yet too close to their valuation which might suggest risk aversion at first glance.

Graph 3
CCM: Mean valuation, proposal and theoretical proposal per round for \( v < 50 \)

In case \( v < 50 \) as well as in case \( v > 50 \) the mean proposals indicate proposers being too hesitant on average. However, this effect is much stronger for \( v < 50 \). In this case proposers propose 17.28\% less than they should in the CCM. In case \( v > 50 \) proposals are only 4.27\% too high compared to the theoretical proposal. For CARA utility functions there should not be differences depending on the valuation. The stronger deviation of the actual proposal from theoretical prediction if \( v < 50 \) could be explained by CRRA. Under CRRA proposers with higher valuations propose further away from their valuation and closer to the theoretical prediction. However, the Graphs below disprove CRRA as in the CCM deviation from theoretical prediction is smallest around the

\textsuperscript{32} Interestingly, for \( v < 50 \) in the first round the mean valuation is higher than the proposal, but not in the following rounds. Maybe subjects need to get used to the experiment and start rather tentatively. Likewise we observe a very cautious proposal setting in the first rounds in case \( v > 50 \) (\( p \) is even smaller than \( p' \)).
median valuation and increases the farer away the valuation is from $v_i$ and in the WBA deviation from the optimal bid even increases in the valuation.

**Graph 4**

**Absolute deviation per valuation**

CCM\(^{33}\)

[Graph showing absolute deviation per valuation for CCM]

WBA

[Graph showing absolute deviation per valuation for WBA]

After analyzing proposer behavior in the CCM treatment we focus now on auction bidding behavior. Spearman rank correlations reveal a very strong and significant correlation among bids and valuations (two-tailed $p<0.01$, $\rho = 0.832$).\(^{34}\) Two-tailed Wilcoxon Signed Rank test based on matching group averages shows significant differences between valuations and bids ($p<0.01$). The first graph in Graph 5 shows mean valuations, bids and the theoretical bid per round and the second graph shows only the winning bidders’ valuation and the winning bids (which are the realized prices for the whole object) and the theoretical prices according to the winners’

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33 One extreme data point is excluded in the CCM.

34 For the correlations we used all observations as in the CCM treatment. Taking only the independent data of the first round also yields a strong and significant correlation (two-tailed $p<0.01$, $\rho = 0.884$) as well as significant differences between valuations and bids (two-tailed Wilcoxon Signed Rank test $p<0.001$).
valuation. Bids seem to be close to their theoretical prediction on average. Table 4 also indicates that bids are on average (over all rounds and subjects) only 1.2% too high compared to the theoretical prediction. Compared to the average deviation of proposals from their theoretical prediction in the CCM this deviation is very small. Thus, on average bids in the WBA are closer to the theoretical prediction than proposals in the CCM, whereas the absolute deviation from the theoretical prediction is higher in the WBA treatment. However, risk aversion cannot be the unique explanation for the efficient performance of the CCM as subjects should be equally risk averse in both treatments.

**Graph 5**
Mean valuations, bids and theoretical bids per round

4.4 Loss aversion

It was shown in subsection 3.1 that in the CCM treatment inefficient allocations occur more frequently when both partners’ valuations are above the median, which might be explained by the fact that fewer proposals are set in the “right” and more proposals are set in the “wrong” direction if the proposer’s valuation is below the median valuation. We also showed that although proposals are set in general too hesitant compared to the theoretical prediction, deviations from theoretical proposals are on average much higher below the median valuation. A possible explanation might be loss aversion in terms of negative payoffs. If a proposer whose valuation is above the median proposes a smaller price than his valuation in the worst case he only decreases his profit when the other partner buys for that price. However, if a proposer’s valuation is below the median and he submits a too high price he might generate negative profits if the chooser does not buy.
To investigate the loss aversion argument more deeply we concentrate first on the case that a proposer’s valuation is below the median valuation. We calculate the proposal at which the payoffs of the proposer equal zero in case the chooser does not buy. This proposal is called switching point (as payoffs switch from being positive to being negative) and is given by \( s(v < v^m) = 2v \). If the theoretical proposal is above the switching point and therefore the actual proposal should also be, in only 47.62% of these cases the actual proposal is also above the switching point.

If a proposer’s valuation is above the median valuation a proposer cannot achieve a negative profit if he sets his proposals according to theory. To be able to compare proposer behavior below and above the median valuation we calculate the proposal \( s(v > v^m) = 2v - 100 \) which corresponds to the “switching point” for valuations above the median. The switching point \( s(v > v^m) \) indicates the same absolute distance on the valuation interval from \( s(v > v^m) \) to \( p \) for valuations above the median as the switching point \( s(v < v^m) \) does from \( s(v < v^m) \) to \( p \) for valuations below the median. In case proposers’ valuations are above the median valuation and if the theoretical proposal is below the switching point in 60.61% of these cases the actual proposal is also below the switching point. Thus, we conclude that below the median valuation less subjects set proposals beyond their switching point than in case valuations are above the median valuation as there is a difference of more than 10%. This might be a first indication of loss aversion. However, one has to keep in mind that loss aversion can only occur in extreme cases.

4.5 Ex post rationality

In this section we scrutinize how subjects change their behavior with regard to their experience and if subjects behave according to some kind of ex post rationality. We consider first if subjects obtained the object in the last round or not and second we take the percentage of deviation from the theoretical proposal at time \( t-1 \)

\[
d(t - 1) = \frac{p(t-1) - p^*(t-1)}{p^*(t-1)}
\]

for each subject (analogous for bids) and see in the following round whether the deviation \( d(t) \) of the subject increases or decreases compared to the reference point \( d(t-1) \). Thus, we measure if \( p \) in proportion to \( p^* \) decreased or increased respectively compared to the previous round. This proceeding follows the in auction experiments tested learning direction theory which gives
predictions about tendencies of qualitative adjustment concerning the direction of a change rather than its size.\textsuperscript{35} Table 8 shows the results. Apparently, the most often observed behavior in both treatments is an increase in deviation from theoretical proposal compared to the deviation at time $t-1$ if the subject did not obtain the object in the last round. This condition might reflect lost opportunity. However, in interpreting the results we have to be careful as in our experiment we do not give full feedback\textsuperscript{36} and moreover there is no outside seller, which implies a much more complex situation for the subjects. Contrary to an ordinary auction in our treatment the loser also receives a payoff namely the price for his share of the object. Thus it is much more complicated for the subjects to evaluate which kind of behavior would result in higher profits. The second most arising result is a decrease in $d(t)$ compared to $d(t-1)$ if a subject bought the object in the last round. This holds again for both treatments. In this condition subjects might think they could increase their profits by paying a lower price (including the risk of losing). Stated carefully in our experiment at least a certain fraction of subjects seem to react according to winner’s and loser’s regret\textsuperscript{37} as there is no reason to change the deviation from the theoretical prediction. Note that subjects seem to react according to ex post rationality does not contradict to risk aversion. $d$ and changes from $d$ in the following round do not say anything about risk preferences.

<table>
<thead>
<tr>
<th>Experience condition $t-1$</th>
<th>Not own</th>
<th>Own</th>
<th>Own</th>
<th>Not own</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes from $d(t-1)$ to $d(t)$</td>
<td>increase</td>
<td>decrease</td>
<td>increase</td>
<td>decrease</td>
</tr>
<tr>
<td>CCM</td>
<td>33.41%</td>
<td>29.42%</td>
<td>17.35%</td>
<td>19.83%</td>
</tr>
<tr>
<td>Auction *</td>
<td>31.47%</td>
<td>29.20%</td>
<td>19.40%</td>
<td>17.67%</td>
</tr>
</tbody>
</table>

* in 2.26% of the cases there is no change in deviation

\textsuperscript{35} Compare Neugebauer, Selten (2006, p. 192). See also Ockenfels, Selten (2005) and their concept of impulse balance equilibrium.

\textsuperscript{36} Additionally, in both mechanisms the agents do not get any feedback about the valuations of their partners. In the CCM the proposer knows only his own valuation as well as the price for the object and observes whether he becomes buyer or seller. We assume that proposers in the CCM might have the tendency to slightly increase the proposal in case they are sellers and to decrease their proposal in case they are buyers to increase their profits. In the WBA the losing bidder learns the bid of the winning bidder by the price he gets, thus he might suffer from lost opportunity or outpriced value. The winning bidder only knows his own valuation and his winning bid, but not the loser’s bid. Thus we assume that the winning bidders in the WBA might speculate that a slightly decrease of their bids results in an increase of their profits as long as their bid remains the winning bid.

\textsuperscript{37} “[…] the direction in which regret influences bids in a dynamic setting corresponds to Selten’s learning direction theory” Engelbrecht-Wiggans, Katok (2006, p. 2).
4.6 Profits

Now we compare the profits of the subjects between the two treatments and between the different roles in the CCM. The first two columns of Table 9 summarize the mean profits and the mean valuations of the subjects on average. It is obvious that choosers obtain much higher profits than proposers in the CCM sessions. Graph 6 even strengthens this impression as in each round of both sessions the mean profits of choosers are always higher than those of proposers.

Table 9
Mean profits per round per person

<table>
<thead>
<tr>
<th></th>
<th>Mean profit</th>
<th>Mean valuation</th>
<th>Relative profits*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCM</td>
<td>26.42 (proposer)</td>
<td>52.74 (proposer)</td>
<td>50.09% (proposer)</td>
</tr>
<tr>
<td></td>
<td>41.40 (chooser)</td>
<td>52.17 (chooser)</td>
<td>79.36% (chooser)</td>
</tr>
<tr>
<td></td>
<td>33.91 (all subjects)</td>
<td>52.45 (all subjects)</td>
<td>64.65% (all subjects)</td>
</tr>
<tr>
<td>Auction</td>
<td>33.48</td>
<td>52.50</td>
<td>63.77%</td>
</tr>
</tbody>
</table>

* Relative profits are characterized by mean profits/valuation.

Graph 6:
CCM mean profits per round

Column 3 of Table 9 shows the relative profits, namely the mean profit divided by the mean valuation. On average subjects in the CCM gain 64.65% of the mean valuation and the auction leads to a profit of 63.77%. So ex ante, before the subjects are assigned their roles in the CCM sessions, the profit expectations are quite similar across the sessions.38 But after the assignment of being proposer or chooser the profits differ a lot. On average proposers gain only 50.09% of the mean valuation in the CCM. However, choosers in the CCM achieve profits of 79.36% of the mean valuation. Thus, choosers achieve higher profits than bidders in the auction who do better than proposers.

38 Two-tailed Mann-Whitney-U tests reveal no significant differences with regard to average profits for each matching group in the CCM treatment and in the auction.
in the CCM. Profits of choosers and profits of proposers are significantly different from profits achieved in the auction (two-tailed Mann-Whitney-U tests for matching group profits reveal \( p < 0.001 \) for both cases). Thus, profits in general are quite similar between treatments, but considering the different roles in the CCM there are big payoff differences. Moreover, profits in the CCM endorse the theoretical prediction under asymmetric information. The fact that in the CCM profits of proposers and choosers differ drastically emphasizes the importance of who becomes proposer and who becomes chooser.

5. Conclusion
The main focus of this paper is to investigate the performance of the two partnership dissolution mechanisms CCM and WBA in an experiment. Contrary to the theoretical prediction for risk neutral partners that auctions are more efficient mechanisms, our experiment provides evidence that the CCM is at least as efficient as the WBA – in terms of efficiency rates as well as in terms of percentage of efficient allocations. Considering the cases in the CCM sessions in which inefficient allocations should occur theoretically, we actually observe in only 50% of these cases inefficiencies in the experiment. The CCM seems to have a better performance with regard to efficiency than theory predicts which might justify its extensive use in reality.

It was shown theoretically that the difference in performance of the two mechanisms in terms of efficiency decreases the more risk averse partners are. This is due to the conjecture that the more risk averse a proposer in the CCM is, the closer he will set his proposal to his valuation. Thus, there is less possibility that inefficiencies might occur. Risk averse bidders in the winner’s bid auction should also submit their bids closer to the valuation than in the risk neutral case. However, our experimental data does not seem to refer to risk averse behavior in the auction treatment as there is no indication that bidders bid closer to their valuation. A regression analysis shows that the data fits quite well the theoretical bidding function and there is no evidence for overbidding (overbidding does not differ significantly from underbidding and there are nearly as many bidders under- as overbidding). Moreover, risk aversion should be observed in equal measure across treatments, but in the auction treatment the percentage of bids equaling the valuation is much smaller than in the CCM. Thus, the efficient performance of the CCM in our experiment cannot be explained by risk aversion alone. In the CCM proposals are set too close to the valuation as risk aversion would imply,
but deviation from the theoretical predicted proposal is much stronger if the proposer’s valuation is below the median valuation than if it is above. Furthermore, in the experiment inefficient allocations occur more frequently if valuations of the partners are above the median valuation. This behavior might be better explained by loss aversion.

We observe in both treatments that subjects seem to react in a similar way to their experience in the previous round. The most often observed behavior across treatments is that bids and proposals increase if the partner obtained the object in the last round and that bids and proposals decrease if a subject himself received the object in the previous round. This kind of behavior indicates ex post rationality of the subjects and might be due to winner’s and loser’s regret.

The experiment provides evidence that we cannot rank the auction before the CCM in terms of efficiency. However, the experiment reveals that the CCM leads to much more unequal payoffs. Ex ante, before the subjects are assigned their roles in the CCM sessions, the profit expectations for all subjects are quite similar in the CCM and in the auction treatment. On average, subjects achieve around 64% of their valuation as profit in both treatments. But after the assignment of being proposer or chooser the profits differ significantly. Choosers in the CCM achieve significantly higher profits (about 80% of their valuation) than bidders in the auction (about 64%) whose profits are significantly higher than proposers’ profits (about 50%) in the CCM. Thus, payoff expectations differ drastically depending on the role in the CCM. The crucial point in the CCM is to clarify which partner becomes chooser. Otherwise, partners using the CCM for dissolution of their partnership run the risk of a war of attrition if no partner wants to start proposing a price for the shared object. “[…] since private parties have an insufficient incentive to make proposals ex post, it is in their interest to write contracts ex ante to encourage their use” (Brooks, Spier 2004). In our experiment subjects were assigned their roles. Future experiments should extend the investigation of the CCM by including endogenous role allocation.

39 These results endorse the theoretical prediction under asymmetric information: “For the risk neutral case with a uniform distribution of values, the chooser in the CCM does better than an agent in the WBA, who does better than the proposer in the CCM” (McAfee 1992).
References


Appendix

Written instructions (translation from German)

Welcome and thank you very much for participating in this experiment. Please read the instructions carefully. The instructions are identical for each participant. If you have any questions please raise your hand; we will come to your place. You receive 2.50 € for your participation irrespective of your decisions during the experiment. Additionally, you can earn money in this experiment. How much you earn depends on both your decisions and the decisions of other participants. All decisions and payoffs remain anonymously. During the whole experiment, starting now, communication with other participants is strictly forbidden. In case of non-compliance, we must exclude you from the experiment and all payoffs.

General Information

You and another participant possess together a “fictitious” object in equal shares. This object is indivisible. You have to negotiate who obtains the object and which compensation the other participant receives.

Payoffs

The participant obtaining the object is paid out after the negotiation a resale value for the object. Before the negotiation starts each participant gets to know his resale value for the object which can be different for both participants. The participant not obtaining the object receives from his negotiating partner a compensation having to be bargained.

Negotiation

[TREATMENT AUCTION] The negotiation proceeds as follows. You and the other participant take part in an auction in which the shared object is auctioned off between you and the other participant. You and the other bidder each submit a (freely selectable) bid for the whole object. The bidder with the higher bid wins the auction and buys for half of his bid the losing bidder’s share of the object from the losing bidder. The losing bidder sells his share of the object and receives in return half of the highest bid. This means:

- The losing bidder sells his half of the object and receives instead half of the winning bid from the other bidder:
Payoff losing bidder = \( \frac{\text{highest bid}}{2} \)

- The winning bidder *buys* half of the object, pays the losing bidder half of his bid and receives in return his own resale value:

\[
\text{Payoff winning bidder} = \text{resale value of the bidder} - \frac{\text{highest bid}}{2}
\]

- In case you and the other bidder submit the *same* bid, then a winner (=buyer) is randomly chosen and the payoffs of buyer and seller arise afterwards as described above.

[Negotiation]

[TREATMENT CCM] The negotiation proceeds as follows. One of you will become *proposer* and the other participant will become *chooser*. The proposer has to submit a (freely selectable) *proposal* for the whole object. Then the chooser decides whether he wants to sell for half of this proposal his share of the object or whether he wants to buy the proposer’s share of the object:

- If the chooser decides to *sell*, he receives instead half of the proposal from the proposer (and the proposer receives his value for the object):

\[
\text{Payoff proposer} = \text{proposer's resale value for the object} - \frac{\text{proposal}}{2}
\]

\[
\text{Payoff chooser} = \frac{\text{proposal}}{2}
\]

- If the chooser decides to *buy*, he pays the proposer half of the proposal and receives in return his own resale value for the object:

\[
\text{Payoff proposer} = \frac{\text{proposal}}{2}
\]

\[
\text{Payoff chooser} = \text{chooser's value for the object} - \frac{\text{proposal}}{2}
\]

[Procedure]

[TREATMENT Auction]

1) At the beginning of each round you are informed about your resale value for the object. Participants might typically have unequal resale values; these are drawn randomly and independently of each other from a distribution of 0 to 100 Eurocents (2 decimal places) in which each amount is equiprobable.
2) Then each negotiating partner chooses his bid for the whole object (2 decimal places are possible).

3) Afterwards it is ascertained who has the higher bid and therefore buys the other half of the object for half of his bid and who submits the lower bid and therefore sells his half of the object for half of the highest bid.

[Procedure
[TREATMENT CCM]

1) At the beginning of the experiment it will be randomly drawn with equal probability if you become proposer or chooser. You will maintain the chosen role during the whole experiment.

2) At the beginning of each round you are informed about your resale value for the object. Participants might typically have unequal resale values; these are drawn randomly and independently of each other from a distribution of 0 to 100 Eurocents (2 decimal places) in which each amount is equiprobable.

3) Then the proposer chooses a proposal for the whole object (2 decimal places are possible).

4) Afterwards the chooser will be informed about the proposal and has to decide whether he wants to sell his half of the object or whether he wants to buy the half of the proposer for half of the proposal.]

This negotiation situation is repeated altogether 30 times. Your negotiating partner as well as your resale value is again randomly drawn anew in each of the 30 rounds. At the end of the experiment you are disbursed your overall earnings over all rounds including your 2.50 €.

Are there any questions?
### Table A1
Proposer behavior if allocations are efficient although they shouldn’t be theoretically

<table>
<thead>
<tr>
<th>CCM</th>
<th>$p=p^*$</th>
<th>$p=v$</th>
<th>Too hesitant</th>
<th>Wrong direction</th>
<th>Excessive $p$</th>
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</thead>
<tbody>
<tr>
<td>All</td>
<td>0%</td>
<td>47.27%</td>
<td>40.00%</td>
<td>10.91%</td>
<td>1.82%</td>
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<tr>
<td>$v&gt;50$</td>
<td>0%</td>
<td>48.28%</td>
<td>37.93%</td>
<td>10.34%</td>
<td>3.45%</td>
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<tr>
<td>$v&lt;50$</td>
<td>0%</td>
<td>46.15%</td>
<td>42.31%</td>
<td>11.54%</td>
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### Table A2
$b=v/p=v$ (exactly) per subject

<table>
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<th>Auction subject</th>
<th>CCMs1 $p$</th>
<th>CCMs3 $p$</th>
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</tr>
<tr>
<td>Σ</td>
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N = number of rounds