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ORIGINAL RESEARCH

Countering Negotiation Power Asymmetries by Using the Adjusted Winner Algorithm

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Abstract

One promise of computational decision support is enabling better solutions in interactions and social exchange by supporting human strengths (e.g. intuitive decision-making) with formal procedures. This study investigates whether mathematical post-negotiation procedures can guide parties to an efficient negotiation result and thus overcome the shortcomings of human-only approaches in the situation of power asymmetry. The results show that (a) an increase in power by means of a rise in issue authority for one of the two parties does not lead to an increase in humans' negotiation efficiency, (b) the use of mathematical post-negotiation procedures eminently improves the overall results and (c) the powerful party is likely to benefit most from applying a neutral post-negotiation procedure. These differences highlight that power in commercial negotiations does not compensate for insufficient negotiation skills or efforts in the empowered party. On the contrary, unbalanced power decreases the likelihood of success. Despite the ability to prevail because of power, the post-negotiation procedure reveals options advantageous for both parties.

Keywords Negotiation support · Decision support · Laboratory experiments · Post-settlement · Team effectiveness

1 Introduction

This study investigates whether mathematical negotiation procedures can guide parties to an efficient negotiation result and thus overcome the shortcomings of human-only approaches in the case of power asymmetry [1, 2]. Negotiation is an interpersonal decision-making process in cases where we cannot achieve our objectives singlehandedly [3, 4]. Keeney [5] suggests that a methodical procedure

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in a utility-focused framework can help negotiators clarify their priorities. Indeed, utility-based mathematical procedures have been widely discussed by previous scholars, such as Brams [6], Brams and Taylor [7], Fang et al. [8], Gettinger et al. [9], Haffner [10], Lewicki and Litterer [11], Pruitt [12] and Roszkowska et al. [13]. Our study builds upon Coleman's [14] mathematical model of integrative, multiple issue bargaining. Notably, already Eliashberg et al. [15] and more recently Geiger [16] criticise the gap between research and real-world problems. Scholarly research with its experimental investigations rarely reflects actual bargaining issues. Meeting their call for an interaction if research and negotiation practice this study design outlines the extent to with human results can be improved. Previous research concludes that negotiators often end up with suboptimal results [17, 18] in terms of not agreeing to a Pareto-efficient solution, leading to a mutual loss of utility or profits. The reasons for this can be multifaceted (e.g. a misleading perception of the situation, decisions not matching the preferences or values of the parties, inconsistent preferences, psychological biases or inefficient strategies). However, an often occurring explanation is the allocation of bargaining power and its impact on both the negotiation process and the results [19]. In the light of Emerson's power-dependence theory and reciprocity theory, one of the thrilling topics in negotiations is power, with its consequences and antecedences Cheng et al. [20]. Power in negotiations—defined as the ability to influence the gains of both yourself and the other party—is frequently found to be an important factor [21] as quantified by the 'best alternative to negotiated agreement' or the perceived dominance of the negotiator [22, 23].

In this study, we consider as a proxy of power the concept of *issue authority* [24, 25], which quantifies the negotiating parties' ability to prevail on a certain issue. Issue authority, which refers only to the potential of each party to influence the outcome of a given issue [24], has several advantages, such as a reduction in the complexity of the negotiation task and an increase in transparency through the structuring of issues. In reality, negotiators are not informed about their efficiency/inefficiency. Within this experimental setting, the negotiators were at least informed about the structure of the negotiation problem and, therefore, knew that issue-by-issue bargaining leads to inefficiency.

Kersten et al. [26] highlight the usefulness of negotiation support systems. These either focus on improving the process or are outcome oriented. In this manner, based on the idea of improving negotiated results by means of post-negotiation procedures, we modify a formal procedure, namely the adjusted winner (AW) procedure of Brams and Taylor [7]. Our study uses the AW, which tackles the problem of the fair division of goods amongst negotiators and has been recommended for real-world negotiation challenges [27, 28]. For instance, Raith and Welzel [29] characterise the AW procedure as an algorithm that covers a broad spectrum of negotiation problems and demonstrate that it increases negotiation effectiveness by presenting an adjusted version of the Kalai-Smorodinsky bargaining solution. Notably the AW procedure is robust against the independence of irrelevant alternative assumptions limiting the Nash bargaining solution. In this vein, we use the algorithm for post-negotiations to increase profits and efficiency and combine it with the experimental setting of Gupta [24] as the basis of the negotiations.

Combining the advantages of post-negotiation strategies [30] and the AW procedure [7] may increase (mutual) negotiation success and compensate for the distortions due to power asymmetries. In real-life implementations, formal procedures provide negotiators with a solution that improves their naïve agreement. The starting point for post-settlement negotiations is an initial agreement and the goal of joint damage limitation in an accident scenario. This study's novelty arises from going beyond the accidental motivation to use a post-settlement procedure for mutual improvement through efficiency gains. One prominent source of inefficiency is human negotiators' aim of keeping their actual preferences, profits or cost structures hidden (to be protected from exploitation). Therefore, this study design facilitates a competitive human solution in the first step and considers algorithmic support in the post-settlement step. Since the human, naïve solution has been reached, a post-settlement will be accepted if (and only if) a benefit for both parties is gained. Importantly, in this study, the negotiators need to reveal their true preferences/benefits only to an algorithm, which they would not usually do to a strategically acting negotiator. The design of the experiment is that non-cooperation leads to lower outcomes, and therefore, cooperation is an advantage. This also holds for real-world scenarios, which often appear to be non-cooperative. Notably, the negotiation space is fixed due to the utility assignment in the experimental design. The task appears to be distributive, which means claiming the highest value is advantageous. However, this claim does not work out due to the allocation of issue authority. Therefore, cooperation leads to better outcomes.

With this study, we address the research question of what contribution is made by applying the post-negotiation AW procedure to overcome the adverse effects of power asymmetry in negotiations. Previous research has shown that power asymmetries usually result in inefficient negotiation outcomes (e.g. [2]. Researchers typically do not have access to real-world negotiations. Therefore, this study was aimed at evaluating the improvement provided by the AW algorithm in the context of a negotiation experiment. In particular, with this experiment, we address the research aims of learning to what degree negotiated results are influenced by asymmetrical negotiation power, whether and to what extent human agreements can be improved through formal post-negotiation procedures in the case of power asymmetries and whether a post-negotiation procedure can compensate for the effects of power asymmetries.

Hämäläinen et al. (31, p.623) argue that "in operational research the goal is to help people in problem solving but somehow we seem to have omitted the individuals, the problem owners and the OR experts, who are engaged in the process, from the picture". Therefore, the first aim, starting with a human negotiation, justifies the relevance of this study by grasping the above mentioned criticism of Eliashberg et al. [15] and Geiger [16]. Building upon human negotiation results, researchers are enabled to assess to which extend the power-asymmetries influence the human negotiation results. The second aim addresses the improvement in the level of outcomes that the parties achieve whereas the third aim considers the distribution of the outcomes amongst the parties. This distribution depends on the human result and therefore cannot be substituted by random starting points [32] or arbitrary disagreement points [12]. The remainder of the paper is organised as follows. In the next section, we explain the focus on the post-negotiation phase, then we formulate the negotiation task and provide a mathematical description of the procedures used. Then the propositions follow. In the next section we focus on our method and experiment, describing the data collection and the operationalisation of the measures. The results of our analysis are then presented. The article closes with highlighting some limitations and concluding remarks.

2 Post-Negotiation Phase

The post-negotiation phase intends to improve negotiation outcomes [33], which means the offers are restricted to those solutions that are superior to the previously negotiated agreement. In line with Kersten [34], this work considers the option of first defining an agreement and afterwards working on mutually beneficial improvements of this tentative agreement. The human negotiation phase covers the start of the negotiation process until an outcome is reached. There can be an agreement or not. The post-negotiation phase is entered when the negotiators reach an agreement that is not Pareto efficient. An agreement is Pareto efficient if no alternative makes one negotiator better off without worsening the position of the counterpart. If the post-negotiation procedure does not come to an improvement in both individual profits, the initial human solution is kept (see Fig. 1).

The literature [33] argues that a neutral third party is necessary to facilitate the improvement of agreements in a post-negotiation phase. In this negotiation setting, this is done by the formal negotiation procedure AW. The intervention's main task is to propose value-creating alternatives to the original agreement. Based on the preferences of both negotiators, superior alternatives are proposed.

Gettinger et al. [9] highlight that the post-negotiation phase differs from the initial phase. Though the negotiators can be expected to act as rationally, bounded

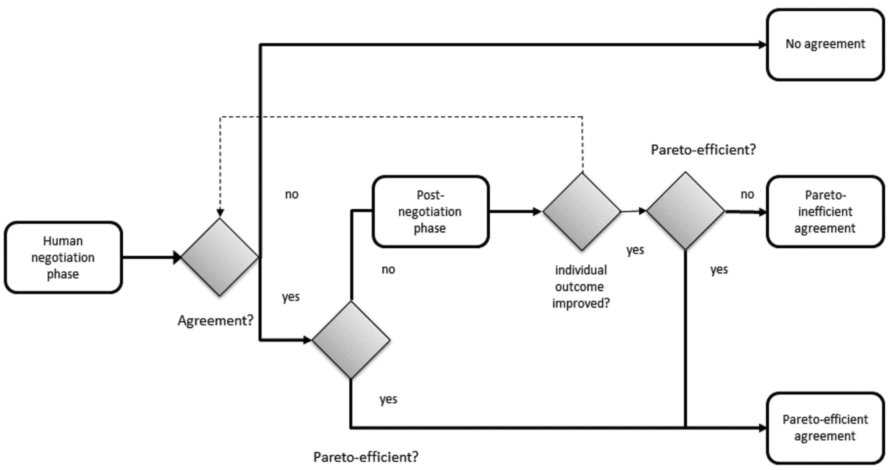

Fig. 1 Negotiation process flow chart (adapted from [9])

rationally or irrationally in the post-settlement phase as they did in the negotiation phase, the complexity of the negotiation task in the post-settlement is reduced. The restriction to consider only alternatives that are Pareto superior to the initial agreement reduces the number of possible alternatives. Second, the post-negotiation phase is more structured, as negotiators can refer to the initial agreement. In the case of formal renegotiation procedures, this is even more relevant, since negotiators can only accept or reject the improved outcome.

2.1 Negotiation Task

Our negotiation task, which describes the annual negotiations between a chocolate manufacturer (*M*) and a large retailer (*R*), is modelled in terms of the valuations of the options ($v_i^x(x \, \varepsilon \{M, R\})$) according to all issues ($i = 1, \ldots, n$). The participants negotiated the following eight issues: prices in euros (paid by the retailer, not the shelf price), advertising subsidy, shelf space, shelf maintenance, retroactive payments, sales promotions, the listing of new products and access to customer data (e.g. basket data, purchase history recorded for loyalty programmes) for each product. Asking the participants to negotiate all scenarios with the same value would be monotonous. Therefore, each scenario has different values, following the same structure. To later compare the scenarios, they were normalised using a *z*-transformation. Each issue has four options with individual values (see Fig. 2), leading to a total of 4^8 alternatives (=65,536 possible agreements in each negotiation).

2.2 Experimental Negotiation Scenario and Issue Authority

Power in negotiations, defined as the ability to influence the gains of both yourself and the other party, is frequently found to be an essential factor determining the outcome [21]. This study uses issue authority as a proxy for negotiation power over a specific issue. In their study of manufacturer-retailer negotiations, Groznik and Heese [35] provide a detailed description of decisions taken by the one or the other party. This matches the concept of issue authority. Following Coleman [14], C_i^M represents the issue authority of *M* over the i^{th} issue whilst C_i^R is the issue authority of *R* over the i^{th} issue. The issue authorities have to meet $C_i^M + C_i^R = 1$ with $0 \leq C_i^M \leq 1$ and $0 \leq C_i^R \leq 1$ [24]. In contrast to Gupta [24], issue authority is not distributed according to the negotiators' interest in this study. It is interpreted as externally assigned power.

Table 1 shows the allocation of issue authority and valuation of the options for each negotiator. The valuation of these different options represents a negotiation task with a concave efficiency frontier. As in most real negotiations [36], the counterpart's values are unknown. In the neutral scenario (E), the negotiators have equal power to decide on an issue, but the valuation for each is different. Nevertheless, the reachable maximum (i.e. a valuation of 36) is the same for both parties whilst the maximal valuation for prices is 6.5 for *M* and 2.5 for *R*. In other words, the relative importance of prices is higher for the manufacturer. By

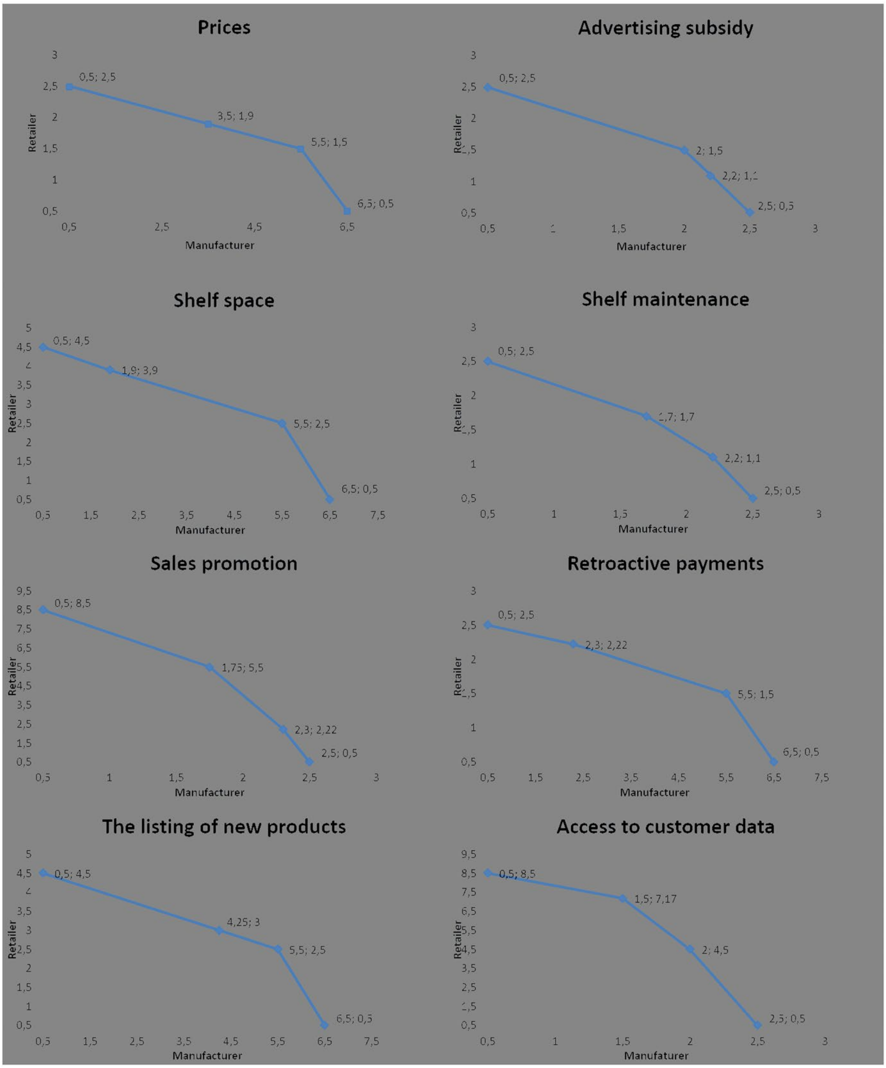

Fig. 2 Normalised valuations (payoffs) of the decisions

contrast, retroactive payments are the other way round whilst the maximum valuation and the relative importance of the advertising subsidy are the same for both parties.

The maximal output in the matched scenario is $v_Z^M = 20$ for M and $v_Z^R = 22$ for R whilst it is $v_\Gamma^M = 20$ and $v_\Gamma^R = 18$, respectively, in the mismatched scenario. As in real-world negotiations, some parties have power over specific issues. In this scenario, it is disadvantageous to insist on always wielding your own power. Negotiators should understand with careful consideration that they might leave some money on the table if they use the complete scope of the negotiation process.

Table 1 Issue authority allocation in the three scenarios and the valuation of each option

Object	Issue authority						Valuation of option							
	Scenario E		*Scenario Z*		*Scenario Γ*		*A*		*B*		*C*		*D*	
	M	*R*	*M*	*R*	*M*	*R*	*M*	*R*	*M*	*R*	*M*	*R*	*M*	*R*
Prices	0.5	0.5	1	0	0	1	0.5	2.5	3.5	1.9	5.5	1.5	6.5	0.5
Advertising subsidy	0.5	0.5	1	0	0	1	2.5	0.5	2.2	1.1	2	1.5	0.5	2.5
Shelf space	0.5	0.5	0	1	1	0	0.5	4.5	1.9	3.9	5.5	2.5	6.5	0.5
Shelf maintenance	0.5	0.5	0	1	1	0	2.5	0.5	2.2	1.1	1.7	1.7	0.5	2.5
Retroactive payments	0.5	0.5	1	0	0	1	6.5	0.5	5.5	1.5	4.16	1.72	0.5	2.5
Sales promotions	0.5	0.5	1	0	0	1	0.5	8.5	1.75	5.5	2.3	2.22	2.5	0.5
Listing of new products	0.5	0.5	0	1	1	0	0.5	4.5	4.25	3	5.5	2.5	6.5	0.5
Access to customer data	0.5	0.5	0	1	1	0	0.5	8.5	1.5	7.17	2	4.5	2.5	0.5

2.3 Post-Negotiation Procedure

As in most real negotiations [36], the counterpart's values are unknown. However, also revealing this information about preferences only indirectly is less problematic once the negotiation is completed. Therefore, several negotiation support systems contain a post-settlement phase. In this phase, they check the objective result of the negotiation to determine whether the negotiators reached a Pareto-optimal and efficient outcome [37]. Although those post-negotiations propose more valuable result strategies [30], empirical results indicate that negotiators are often reluctant to agree on entering a post-negotiation phase [9, 38].

To ensure that the potential distortion due to power asymmetries is included in the data, the basis for the post-negotiation procedure is the human negotiation result. Not every negotiator uses power to the same extent [39]. Therefore, the post-negotiation procedure starts with the human solution instead of a simulated one. With this approach, we can test the extent to which formal post-negotiation procedures can compensate for the negative consequences of power asymmetries.

From the human results of these three scenarios, we next try to improve efficiency by applying the AW procedure in two steps.

Step 1. The dyads negotiate a temporary agreement iT, such that $iT = (A, A, A, C, B, D, D, D)$. In contrast to the original procedure, the criterion of maximising the gain need not be considered. The sum of each player's temporary gains, $v_T^x = \sum v_{iT}^x$ $(x = M,R)$, determines the 'temporary winner' W and 'temporary loser' L through the condition $\frac{v_T^W}{\hat{v}_T^W} > \frac{v_T^L}{\hat{v}_T^L}$ [40]. Here, $\hat{v}$ denotes the maximum valuation.

Step 2. "For each issue i and each temporary option iT, we consider each efficient alternative option iO that gives the temporary loser a higher gain than that under the temporary option iT. We calculate the rate of substitution as

$$RS_{i:oT} := \frac{v^W_{iT} - v^W_{i_{OT}}}{v^L_{i_{OT}} - v^L_{iT}} \quad (1)$$

and then select the alternative options i_{OT*} that yield the lowest cost-gain ratio, that is, iO^*_T argmin$_O$ RS_i. If more than one option satisfies this criterion, a referee chooses $O_{i:TOT}$ from this set. Now, we determine the issues $i*$ with the lowest cost-gain ratio, that is, $iO^*_T \in \text{argmin}_O\, RS_{i:TO_T}$" [40,p315f]. If more than one option satisfies this criterion, we choose at random from this set. We calculate the players' overall utilities $v^W_{O^*_T}$ and $v^L_{O^*_T}$ by replacing only option $i{*}T$ with its efficient alternative $i * O^*_T$ if $\frac{v^W_{O^*_T}}{\hat{v}^W} > \frac{v^L_{O^*_T}}{\hat{v}^L}$. Then, we define $i * O^*_T$ as the new temporary option of issue $i*$ and repeat step 2. Otherwise, we calculate the convex combination of options $i{*}T$ and $i * O_T$ that equalises the relative gains between the winner W and loser L [40].

Our main modification of the procedure proposed by Brams and Taylor [7] is integrating the human negotiators' result as a starting partition. This procedure ensures that both parties will get at least the profits from the negotiation agreement before applying the algorithm. Thus, the post-settlement routing might support the parties in breaking the fixed-pie assumption [41]. Moreover, the proceeding encourages trust-building and honesty regarding the preference, because a party's cheating on the preference will reduce the gains of applying the post-settlement procedure. This interpretation of trust-building is technical and covers only the narrow facet of honesty [42]. However, this suggestion concurs with the disadvantage that not all starting partitions are suitable for applying the algorithm. If the human negotiators' agreement is far from the angle by sector but, in comparison to that distance, close to the Pareto edge, the algorithm does not guarantee increasing the individual outcome of both parties in addition to increasing efficiency. The approach presented herein is adaptive (because the human negotiators' temporary solutions can be altered after they become aware of the algorithm's result) and easy to communicate (because the managers only assess the algorithm's results rather than going into the details of the algorithm itself).

Here, our approach differs from previous attempts at refining the algorithm [43], Procaccia and Wang [44] to achieve post-settlement improvements with respect to fairness or envy-freeness. In a discussion of the weaknesses of decision analysis, Hämäläinen [45] makes the criticism that the effects of computer support (if used) on decision quality are not reported. Our procedure thus addresses this argument by providing decision-makers with a suggestion for improving their agreements as feedback. In particular, when power asymmetries exist, human negotiators might perceive substantial support in the vein of Hämäläinen et al. [31] if they are more concerned about asserting their powerful position than focusing on decision quality by means of Pareto efficiency.

3 Propositions

Although it is intuitive that the distribution of issue authority affects the negotiation results, both its magnitude and its direction are unclear. The above-mentioned example of manufacturers and retailers, in which the latter have gained power by means of issue authority over the past decade, demonstrates that the distribution of issue authority between parties does not match their profits [22]. Therefore, we assume that asymmetric distributions of a priori negotiation power will increase the likelihood of inefficiency. This presumption, which is in line with previous research [46–48], clarifies the need to validate our first proposition:

P_1: The allocation of issue authority determines the negotiation result.

Only if this first proposition holds for our experimental analysis of manufacturer-retailer negotiations are we able to draw conclusions about variations in issue authority in our analysis of negotiation efficiency.

Although previous research results suggest that formal negotiation procedures support the parties in achieving mutual gains [49], taking the settlement of the human negotiation as granted, the AW will provide the parties with a suitable solution if (and only if) their settlement is ‘close’ to the fair division line. If the settlement provides one party with utility higher than that of the party at the intersection of the fair division line with the Pareto edge, the AW will not generate a solution associated with mutual gains. In other cases, the extent of improvement depends on the negotiated settlements. Thus, we formulate our second proposition in a general way.

P_2: Applying the AW procedure substantially improves efficiency.

However, the negotiator generally aims to increase the individual outcome instead of focusing on the joint perspective of efficiency. Thus,

P_3: On average, applying the AW procedure substantially improves the success of individual results.

In addition to the fact that power asymmetries reduce participants’ efforts to increase the level of efficiency [50, 48], negotiators may agree on an efficient solution. However, we expect the agreed settlement to be an unequal utility distribution. Therefore,

P_4: The greater the parties’ power asymmetries, the greater is the improvement when applying the AW procedure.

The first three propositions are in line with previous research. However, evaluating these hypotheses is necessary to demonstrate (a) the validity of our experimental design, (b) the effectiveness of the manipulation, (c) the adequacy of the data obtained from our experiments and (d) the adequacy of our modified version of the AW algorithm. Evaluating the fourth hypothesis provides empirical evidence for this study’s contribution.

4 Method and Experiment

Figure 3 presents the experimental design. The participants of the face-to-face negotiations were business studies students in a negotiation class emphasising the Harvard method and multiple issue negotiations [51], with an average age of 24.52 years (range: 20–34). A proportion of 41% of the participants was male. The participants received a standard introduction to the negotiation tasks, including their role assignment. The negotiators were informed about the concavity of the efficiency curve in the negotiation task introduction. However, they knew only their own concrete utilities by means of payoffs and not the ones of their counterpart. During the negotiations, they got a feeling for their counterpart's relative priorities for each issue, but they were not allowed to ask for the numerical values. Each negotiator was enabled to access further private information about the role and products. A total of 72 negotiators completed the negotiation tasks.

The exogenous variable, power, is the capability to determine the outcome of a given issue. In the experiment, our participants faced three scenarios.

4.1 Neutral Scenario (E)

This scenario replicates the experiment by Gupta [24]. Both partners are provided with balanced power by means of authority over negotiation-relevant issues. Consequently, the manufacturer and retailer are forced to reach an agreement for all these issues. If they fail to agree on at least one, the agreements for all the other issues become invalid too.

4.2 Matched Scenario (Z)

In the matched scenario, each party has full authority over its 'natural resources'. Thus, the retailer can decide on all issues. This means that a participant with an issue authority of a retailer can dictate the agreement concerning a given issue (i.e. she or he can decide on this issue alone, and his or her counterpart has no direct bargaining power and thus must accept the offer). Summarising this scenario, retailers

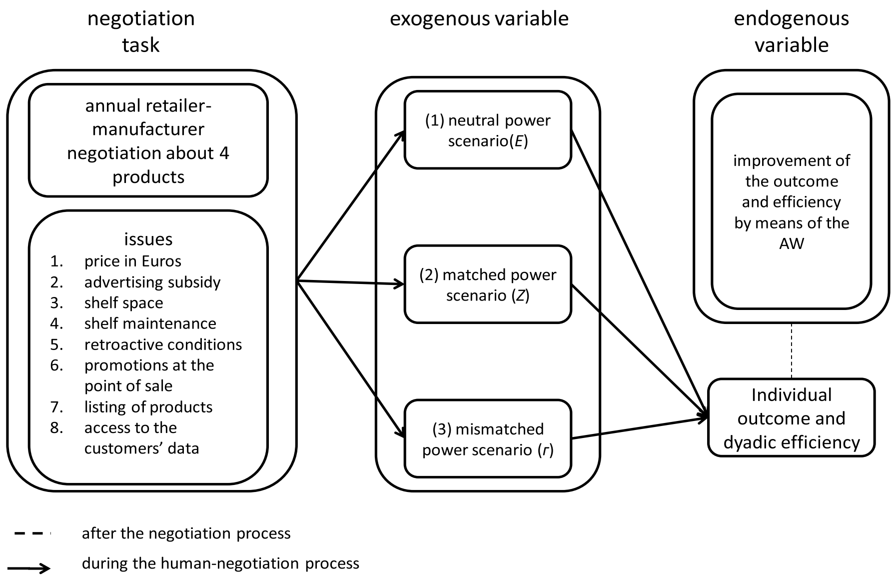

Fig. 3 Experimental design

can choose how to dispose of shelf space, improve shelf maintenance, add or remove products from their ranges and access customer data. Manufacturers, for their part, can decide on the aspects of prices, advertising subsidy, retroactive payments and sales promotions in this scenario. Hence, the negotiators can improve their situation by compensating the other party for a concession.

4.3 Mismatched Scenario (Γ)

This scenario covers the inverse authority assignment, which enables the parties to slip into the counterpart's role whilst preserving their own priorities. As in the Z scenario, the negotiators must compensate each other for any concession, but they are able to choose from their opponent's natural resources that provide the highest utility.

The dependent variable in this experiment is efficiency. Similar to Ehtamo and Hämäläinen [49], we assess efficiency as the distance of the dyadic negotiation outcome from the next possible Pareto-optimal outcome. The smaller the Euclidian distance to the nearest Pareto-optimal outcome, the more successful is the dyad.

With these three scenarios, we contribute to behavioural operations research by going beyond the identification and quantification of decision-makers' perception biases by highlighting the change in the results. Notably, the decision problem at hand in the Z and Γ scenarios and the negotiation space and power asymmetries are identical. However, by putting negotiators in their counterpart's shoes, we expect the results to change despite the negotiation task remaining identical. Following Gupta [24] and Raith [40], we provide the negotiator with a substantially simplified negotiation task compared with the real world to avoid misleading results due to information overload and the related inability to grasp the scenario's utility allocations [31, 52].

5 Results

The results of the negotiation experiment show that the negotiators were not able to reach efficient outcomes. As expected, the results of the Z and Γ scenarios are similar but clearly inefficient. By contrast, the dyads in the E scenario negotiated better and came closer to an efficient result. Because practitioners do not optimise efficiency but rather focus on their individual outcomes, we show that the improvement of the results is valid for the individual outcome too (Fig. 4). The outcome in the E scenario is significantly higher than that in Z or Γ, and the AW procedure thus ends up in a substantially higher outcome compared with the initial negotiations. In E, the dyads negotiated most successfully; however, although in the Z and Γ scenarios all the dyads were able to reach an agreement, most could not maintain the result in the E scenario.

We next evaluated how the allocations of these three issue authorities influenced negotiation success by using *t*-tests. Table 2 reports the results, showing that different issue authority allocations have a significant impact on negotiation success

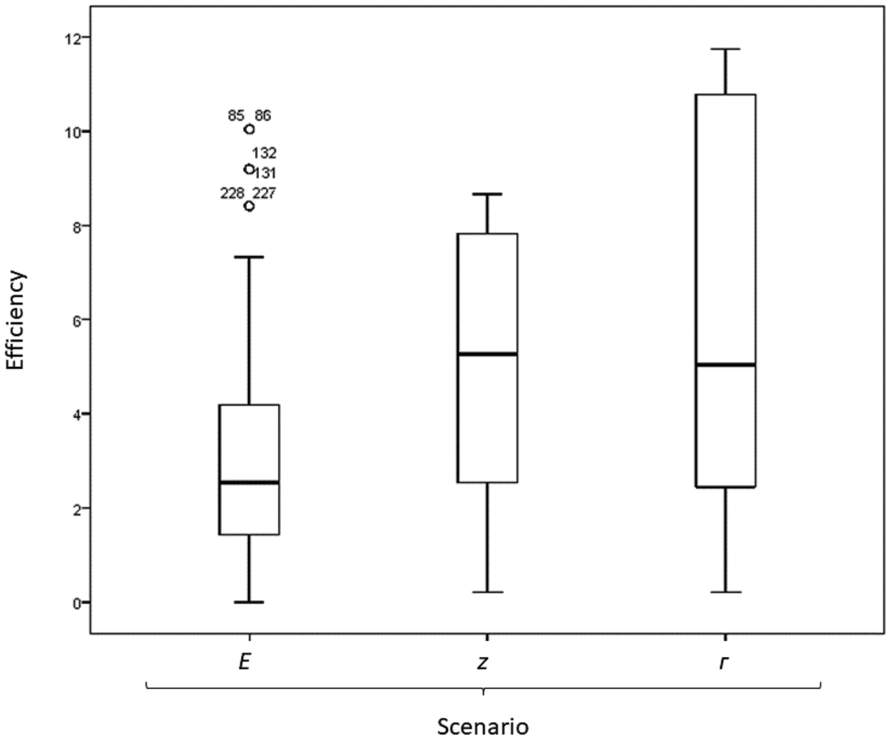

Fig. 4 Human outcomes in the different scenarios

($p<0.001$). As expected, the results of the Z and Γ scenarios are similar ($\bar{y}_Z$= 4.96 and $\bar{y}_\Gamma$ = 5.71, respectively) whilst the utility of the E scenario, with a mean of $\bar{x}_E$ = 2.98, is substantially and statistically significantly higher ($p_{E:Z}<0.001$ and $p_{E:\Gamma}<0.001$). Notably, the individual results are quite similar ($\bar{y}_E$ = 24.61, $\bar{y}_Z$ = 23.13 and $\bar{y}_\Gamma$ = 22.57, for Z, Γ and E, respectively).

Obviously, P_1 cannot be rejected. Especially in the Z and Γ scenarios, the participants were not able to achieve good results, suggesting that an increase in issue authority for one or both parties implies that the efficiency of the negotiators

Table 2 Group test for significant differences in the human solution

	Scenario	$\bar{y}_1 - \bar{y}_2$	Standard error	t	Sig.
Efficiency	*E-Z*	−1.982	0.177	−11.217	0.000
	E-Γ	−2.764	0.244	−11.343	0.000
	Z-Γ	−0.7644	0.159	−4.816	0.000
Outcome	*E-Z*	1.477	0.223	6.610	0.000
	E-Γ	2.057	0.236	8.721	0.000
	Z-Γ	0.558	0.206	2.711	0.007

Sig. ≤ 0.001

decreases. In addition, the participants were either not able to fully understand the structure of this simplified negotiation task or not able to interact with their counterparts in a manner that led to an efficient result. Taking the power of an issue in negotiation leads to issue-by-issue negotiation, which has been shown in the literature (e.g. [2] to yield to inefficiency. An additional motivation for this behaviour is that it seems more critical to gain an edge over their partners than to cooperate and maximise efficiency and joint profits.

At first glance, this result is—at least for negotiation analysts if not for practitioners—not surprising. However, in addition to the face validation of our experimental results, this finding contributes to recent discussions on problem structuring. Although the issue authority procedure forces the parties to focus on the facts and explore the utility allocations of competing agreement points systematically, the significant divergence of the human agreements between the Z and Γ scenarios implies the importance of a perceived scenario in which the parties can identify possible solution points. Although the experimental task was designed to minimise perception biases, the scenarios nevertheless affect behaviour and, more importantly, the results. Instead of improving mutual utilities systematically, we find that the parties are more likely to rely on their power to accomplish the single issues in the Z and Γ scenarios.

We judge this type of difference as more important than the statistical result itself [53, 54], because this effect is relevant for both practitioners and scholars of behavioural operations research. Whilst practitioners can recognise the importance of not relying on power, the body of scholarly knowledge has grown from two aspects. First, the context (manipulated by changing the roles whilst maintaining the structure of the decision task in our experiment) influences the perception biases themselves. Notably, the Γ scenario was the third task assigned to our negotiators. Thus, we expected them to learn best because of the learning during the experiment. Second, although the human decision-makers were not limited by industry standards, path dependencies and so on in their elaboration of possible solutions, they were still unable to agree on any efficient solutions. Thus, we must convince managers that better decisions result from adopting behavioural operations research techniques if they are willing to accept the burdens. Following the internal logic of our propositions, the parties in the Γ scenario suffering most from power asymmetries might actually have the greatest advantage in applying a post-negotiation procedure.

Further, we find that the outcome of the modified AW procedure has a significantly higher average outcome than the issue authority procedure ($p<0.001$) although the negotiated allocation does not necessarily meet the requirements of efficiency. Using the modified AW procedure thus increases success significantly ($p<0.001$). Figure 5 depicts the substantial increase in each scenario as shown by the shorter Euclidean distances to the efficient edge. Indeed, the modified AW procedure provides the parties with a substantially improved outcome and efficiency compared with the human agreement (Table 3). Hence, P_2 cannot be rejected.

Table 3 shows the differences between the human and AW solutions for outcome as well as efficiency. A negative result means the individual's outcome improved by shifting from the human to the AW solution. For efficiency, this relationship is the other way round because of the definition of the minimal Euclidean distance.

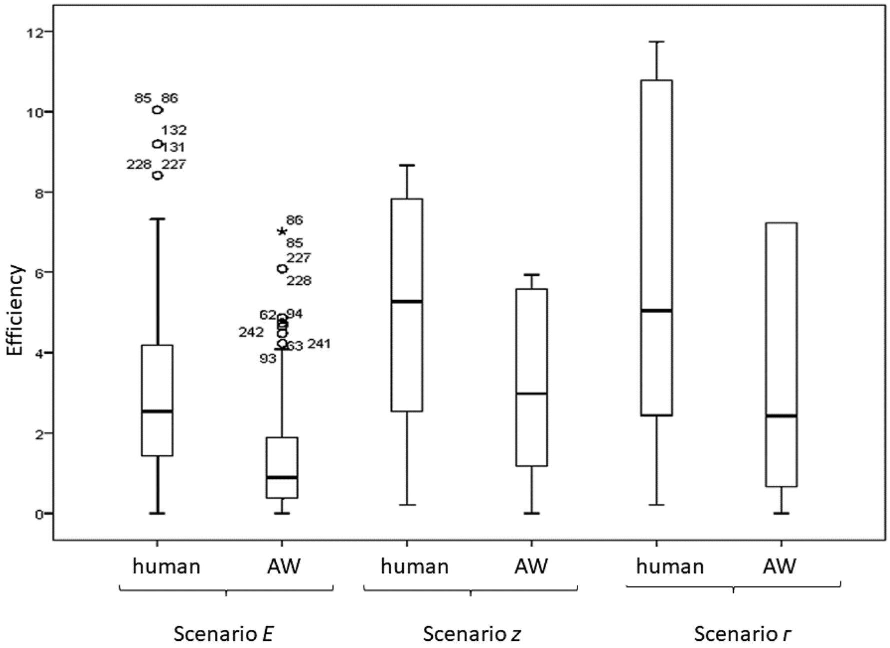

Fig. 5 Comparison of the human and AW solutions

We can conclude that applying the AW algorithm by taking the human results (which have been agreed upon by both parties) as a starting point might be a suitable step towards combining human strengths with computational decision support. In addition to the challenge of accepting a non-intuitive solution, computational decision support needs to cope with how decision-makers react to a recommended decision [55]. Notably, applying the modified AW algorithm improves the results for all human negotiators by means of their increased efficiency. However, although the algorithm provides the parties with an envy-reducing solution [40], the increase in a party's individual utility might be the strongest argument, because this directly meets the goal of the negotiators.

Table 3 Differences between the human and AW solutions

	Scenario Human–AW	$\bar{y}_1 - \bar{y}_2$	Standard error	t	Sig.
Efficiency	*E–AW E*	1.574	0.0700	22.477	0.000
	Z–AW Z	1.829	0.0582	31.441	0.000
	Γ–AW Γ	2.420	0.0855	28.295	0.000
Outcome	*E–AW E*	−1.107	0.1803	−6.138	0.000
	Z–AW Z	−0.687	0.1968	−3.492	0.001
	Γ–AW Γ	−1.168	0.1732	−6.740	0.000

Sig. ≤ 0.001

According to P_3, applying the AW procedure substantially improves the outcome of the individual results. Table 3 presents the *t*-test results for the mean differences. Notably, this proposition cannot be rejected. However, at an individual level, some dyads might benefit from the higher efficiency, but one of the two parties does not achieve an increase in individual utility. For example, Salo and Hämäläinen [56] structure the process of multi-criteria decision-making by using six partly overlapping and iterative phases, of which the generation of decision alternatives is one. Applying the AW is thus a feedback loop for our negotiators. Similarly, Bendoly et al. [57] discuss a convincing list of successful applications of such feedback loops in behavioural operations research. However, in negotiation processes, such feedback loops are seldom included.

The case of gaining greater mutual benefits from the higher utility provided by the modified AW solution is straightforward. However, the parties might still enter the negotiation process in order to explore opportunities to achieve a temporary mutually beneficial agreement. Nevertheless, as the average improvement is higher than the average loss in this one-round negotiation, a consideration of *n* rounds would show the effects over time. In real-world applications, this could easily be done by adjusting prices. However, this extension goes beyond the framework of our experiment (with the simplification of just four price levels) and is left to guide further research examining the acceptance of behavioural operations research decision support techniques and procedures by decision-makers. How likely are the negotiators to re-explore opportunities to improve their temporary agreements in the case of power asymmetries? Will a decision-maker adopt the support offered by applying operations research procedures and techniques if the decision-maker is powerful and does not need to do so?

An obvious motivation for adopting the AW procedure is the promise of an increase in the parties' individual utility. According to P_4, the dyads with the largest power asymmetries might reap the largest reward from applying a post-settlement procedure (see Table 4). Therefore, we compare the improvement from the human to the AW solution in the three scenarios. Let us imagine, in the neutral scenario, that the efficiency is $Eff_E = 3$ and, after the AW procedure, $Eff_{EAW} = 2$; we have an improvement of $\Delta E = 1$. In the matched scenario, we have $Eff_Z = 5$ and, after the AW procedure, likewise $Eff_{ZAW} = 2$, an improvement of $\Delta Z = 3$, which indicates a greater improvement in both absolute and relative terms. Using a *t*-test for paired samples, significant differences in the level of improvement are identified.

The negative results show that the AW procedure increases the efficiency more in the matched and mismatched scenarios (Z, Γ) than in the neutral scenario (E); they also show improvement in the mismatched scenario (Γ). Interestingly, when focusing on the individual outcome, there are only weakly significant ($p = 0.046$) differences in the improvement between the matched scenario (Z) and the mismatched scenario (Γ). This indicates that the improvement of the individual outcome does not differ significantly between the three scenarios. Consequently, we argue that the disadvantages in the individual outcome arising from power asymmetries in the naïve negotiation step are not compensated for by the AW algorithm.

The results presented in Table 4 partially support P_4. In terms of improving efficiency, the AW procedure is stronger if the efficiency in the human solution

Table 4 Differences in the improvement of the AW solution in the different scenarios

	Scenario Δ = (human–AW)	$\bar{y}_1 - \bar{y}_2$	Standard error	*t*	Sig.
Efficiency	Δ*E*–Δ *Z*	−0.242	0.078	−3.109	0.002
	Δ*E*–Δ *Γ*	−0.776	0.101	−7.660	0.000
	Δ*Z*–Δ *Γ*	−0.539	0.072	−7.517	0.000
Outcome	Δ*E*–Δ *Z*	−0.281	0.185	−1.521	0.129
	Δ*E*–Δ *Γ*	0.075	0.1654	0.456	0.648
	Δ*Z*–Δ *Γ*	0.353	0.176	2.002	0.046

Sig. ≤ 0.001

is lower. However, it does not balance the disadvantages of the power asymmetries, as the improvement of the individual outcome does not differ between the different power scenarios. From a practitioner's perspective, this is advantageous, because both parties are likely to improve their outcome regardless of the scenario of the prior naïve negotiation solution. Since the AW builds upon the naïve negotiation solution, it will retain the power asymmetries due to power misbalances. Therefore, the supposed advantage through power remains. This result is remarkable, because testing P_1 showed that the more powerful a party perceives its own negotiation position, the less willing it is to accept the efforts of the other and the less likely it is to 'open their books' by stating its utilities or preferences explicitly [58]. Consequently, we conclude that powerful decision-makers need to become aware of the potential that may be lost owing to their tendency to rely on their power.

5.1 Limitations

Whilst our study provides several insights, it is not without limitations. As in other studies focusing on post-negotiation settlements, there is a limitation concerning the practical application. Although post-negotiation procedures lead to valuable results [30], empirical results indicate that negotiators are often reluctant to agree on entering a post-negotiation phase [9, 38]. This could be due to a fear of losing face or harming the relationship or just because of opportunistic behaviour. Additionally, as other scholars suggest [59, 60], we have not tested the negotiators' satisfaction with the initial negotiated agreement.

The generalisability of the present study is limited by the small sample size, which emerges from the fact that only a small subset of negotiation experiments fulfil all sampling criteria to be included. However, we are confident that the sample causes no severe restrictions regarding generalisability, as, in our data set, we find very similar tendencies concerning the acceptance of the post-settlement phase as in studies with larger data sets.

6 Concluding Remarks

Given that both mathematical modelling and behavioural experiments enable researchers to provide significant contributions to behavioural decision support [57, 31, 61], this study exploited the synergies of these two research paradigms to investigate two-party negotiations. By testing the impact of power allocations amongst negotiators, we confirm the results of previous studies [49, 40] that have highlighted the need for humans to receive instrumental support in negotiations. Although the negotiation task in our experiments was simplified compared to similar real-world challenges, we proved that human negotiators fail to reach an efficient (by means of Pareto efficiency) agreement through the combination of the issue authority concept and ordered preferences based on the utility of each agreement option. The results of this study support the call by Starbuck [52] for tools to release decision-makers from information overload and help them grasp the problem situation as well as to provide them with a structured solution procedure.

This study also enhances the body of negotiation analysis knowledge by finding that power asymmetries are likely to hamper negotiation success. We took advantage of the AW algorithm by integrating human agreement as the starting solution, which increased efficiency in all of our experimental settings. Moreover, the individual utility of the solution resulting from applying the modified AW procedure is statistically significant and substantially higher than the individual utilities achieved by human interactions. Thus, the procedure proposed herein provides decision-makers with an agreement option without limiting their interactions. We also show that dyads with power asymmetries are likely to reap the greatest benefits in terms of efficiency by applying the procedure. However, the power asymmetries are not balanced with this procedure.

Hämäläinen et al. [31] argue that operations research 'is used to facilitate thinking and problem solving'. However, despite recent progress, this analytical discipline has had only a marginal impact on negotiation practice compared with production planning and supply chain optimisation. The reasons for the negligible influence of decision supporting formalisms might include the restrictive assumptions regarding the partner's behaviour in normative (game-theoretic) modelling and the failure to integrate decision-makers' human strengths in solution procedures. The approach presented herein is aimed at overcoming this obstacle in negotiation management. Although the negotiators were trained on the basis of the Harvard method, gained knowledge about multiple issue negotiations, knew the concavity of the efficiency curve in the tasks and knew their values in the matched and mismatched scenarios, many acted non-rationally. For those negotiators, it seems more critical to gain an edge over their partners than to cooperate and maximise efficiency and joint profits. Notably, the respondents emphasised using their power more than trying to reach efficiency. Also, the power differences between the parties are not equalised by the AW, but both parties benefit from increasing efficiency. Observing the decision-makers' behaviour and integrating this without loss of generality into real-world applications must be emphasised in future research projects. In addition to optimisation, future researchers must aim to address negotiators' intuitions and emotions in behavioural decision support if we want practitioners to implement these procedures in real-world applications.

Furthermore, future experiments with post-settlement reflections of the participants are needed to understand the negotiators' perception of the negotiation process and its outcome. This implies how the human negotiators react to the negotiation support, and in particular, it is interesting to assess the satisfaction with the negotiated an improved result. Notably, a post-settlement optimization provides evidence of human shortcomings and needs to be accepted and reflected considering the self-concept of the negotiator and the embedding person-situation interaction [62]. Furthermore, future research needs to exploit the relationship between issue authority and issue-by-issue negotiation. The latter are of highly practical relevance but are likely to lead to inefficient results. Finally, given the increased efficiency revealed in the presented experimental results, applying behavioural operations research to negotiation challenges might improve business success as well as societal welfare, because the most important decisions on war and peace, climate change and food supply, for instance, are the result of negotiations.

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Conflict of Interest The authors declare no competing interests.

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