



HAL
open science

How robust is the equal split? Transferable utility and three-person bargaining in the laboratory

Noemí Navarro, Róbert F. Veszteg

► To cite this version:

Noemí Navarro, Róbert F. Veszteg. How robust is the equal split? Transferable utility and three-person bargaining in the laboratory. *Journal of Economic Inequality*, 2025, <10.1007/s10888-025-09694-5>. <hal-05240606>

HAL Id: hal-05240606

<https://hal.science/hal-05240606v1>

Submitted on 4 Sep 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY 4.0 - Attribution - International License



How robust is the equal split? Transferable utility and three-person bargaining in the laboratory

Noemí Navarro¹ · Róbert F. Veszteg²

Received: 29 June 2025 / Accepted: 8 July 2025
© The Author(s) 2025

Abstract

This paper investigates the robustness of equal-split outcomes in unstructured bargaining environments, expanding on classic two-person settings to include payoff transfers and multi-party bargaining. Drawing from experimental data, we find that equal splits persist as a focal solution in two-person bargaining with payoff transfers, even when some potential efficiency gains are left unexploited, likely due to limitations in participants' cognitive and strategic sophistication. In three-person settings (without payoff transfers), while agreements align closely with equality, they tend to do so only as long as efficiency and stability criteria are met. Our results suggest that bargaining parties prioritize equality when efficient solutions are complicated to find, but prioritize efficiency when efficient solutions are easily accessible. Also, in multilateral bargaining, coalitional stability becomes a primary concern, whereas it remains a softer constraint in simpler, bilateral negotiations.

Keywords Bilateral bargaining · Multilateral bargaining · Experiments · Nash bargaining solution · Equal-split solution · Individual rationality

JEL Classification Primary C78 · C91 · D63

1 Introduction

Bargaining is everywhere. We bargain with (prospective) employers, with editors, with our partners, and most of the time we do it in an unstructured (or complex) environment. While markets constitute strong institutions, bargaining is considered weak as its outcome depends heavily on individual preferences (Friedman and Sunder 1994).

In regard to bargaining outcomes, the literature has accumulated overwhelming evidence from the experimental laboratory in favor of equal splits (Roth 1995). They seem to dominate in unstructured symmetric environments (Nydegger and Owen 1974; Roth and Malouf 1979, 1982; Roth and Murnighan 1982; Roth et al. 1981), but also act as a strong focal point

✉ Róbert F. Veszteg
rveszteg@waseda.jp

Noemí Navarro
navarro.prada@gmail.com

¹ Université de Rennes, CNRS, CREM - UMR 6211 F-35000 Rennes, France

² Waseda University, School of Political Science and Economics, 1-6-1 Nishiwaseda, Shinjuku-ku, 169-8050 Tokyo, Japan

in asymmetric settings by making bargaining agreements “under-responsive” to changes in disagreement outcomes (Anbarci and Feltovich 2013, 2018). Even in structured environments – like in alternating-offer bargaining games and their simplest variant, the ultimatum game –, the equal split plays an important role in explaining the observed outcomes (Güth et al. 1982; Binmore et al. 1985; Güth and Kocher 2014; Binmore 2014).

Although bargaining outcomes might not always coincide with the textbook equal-split solution, which makes sure that parties earn equal levels of utility, observations tend to be much more equal than most alternative theoretical solutions to bargaining would predict.¹ Depending on the bargaining environment, the best-performing theoretical solution is an equal-split solution *with a twist*, like the egalitarian solution which creates an equal split for earnings above the disagreement payoffs (Kalai 1977), or the deal-me-out solution which delivers an individually rational outcome as close as possible to the equal split (Binmore et al. 1989, 1991).²

In this paper, we test the robustness of the equal split in situations that allow for (utility) transfers, and in situations that involve three bargaining parties. Both constitute natural generalizations to the standard unstructured bilateral bargaining setting that has been studied in the literature (e.g., Navarro and Veszteg 2020). They add new layers of complexity to the otherwise unstructured bargaining problem that, in principle, might disrupt the focality of the equal-split solution.³ Transfers offer an opportunity to extend the set of bargaining possibilities by allocating the physical units of the good that is being bargained about to the party who can derive the most payoff (utility that is) of it and then share that larger payoff with the other party. This, however, not only requires a higher level of rationality or sophistication, but could also lead to imbalance in final payoffs favoring the party who extended the set of bargaining possibilities. Trilateral bargaining requires more strategic sophistication as well, because an additional coalition-formation agreement is necessary before bargaining can take place. The availability of multiple coalitions with potentially different sets of bargaining possibilities not only might complicate the bargaining problem, but it also might make differences among bargaining parties more visible and, with that, reduce the attractiveness of equal split as the final agreement.

For this project, we rely on an experimental design that we have used for years to study bargaining in an unconstrained setting. The first instance in which we have used this design was when we tested the empirical validity of seven of the most frequently used axioms in the literature on the axiomatic approach to bargaining theory (Navarro and Veszteg 2020). We found that, although (strong) efficiency, symmetry, independence of irrelevant alternatives and individual monotonicity are supported by the data, the axioms of scale invariance and midpoint domination are not. Also individual rationality is supported by the data in treatments where the disagreement payoffs are not asymmetric. Asymmetric disagreement payoffs, however, produce a large heterogeneity in agreements, many of which give lower payoffs to

¹ The long list of alternative solutions includes the Nash bargaining solution, the Kalai-Smorodinsky solution for the axiomatic approach (Thomson 2010, 2022), and outcomes that correspond to Nash and subgame-perfect equilibria of various strategic models (Binmore et al. 1992). Section 4 provides further details on the solutions which are best suited to organize the data from the unstructured bargaining environment that our experimental design implements.

² The individual rationality of a bargaining outcome means that bargaining parties earn at least as much with the bargaining agreement as they would in the case of a disagreement.

³ In unstructured bargaining experiments, the experimenter only fixes the time frame, the disagreement payoffs and the payoffs for each of the possible agreements. We believe that such a design is inherently more realistic than a structured one with additional strict rules and protocols imposed, and it helps researchers understand the bargaining process (including the hows and the whys). Refer to Karagözöğlü (2019) for further discussion.

parties than they would have enjoyed without reaching an agreement. The set of four axioms that pass the test together suggest that the solution to the bilateral bargaining problem has to be *sort of equal*.⁴ Indeed, based on proximity measures (the Euclidean distance and relative frequency), it is the equal-split solution and deal-me-out that are best able to rationalize the gathered data.

Equality seems to have a strong attraction power as an ideal of fairness in bargaining, but obviously bargaining parties will only be able to equate their splits (be it in physical units, utility, or expected gain) when they have enough information to do so. Observations from the experimental laboratory based on a slightly modified design reveal that the equal split (in utilities, as defined in theory) acts as a strong focal point in bargaining whenever utilities are observable and it is not in conflict with efficiency or individual rationality (Navarro and Veszteg 2025). Insufficient information distorts the agreements towards alternative equal splits in observables. Agreements tend to avoid waste, as parties settle on the efficient distribution that lies the closest to the equal split. And again, individual rationality might disrupt bargaining agreements, when in conflict with the equal split, without offering an alternative focal point.

Navarro and Veszteg (2025) conclude that the bargaining problem is “solved” in two steps. First, parties agree on some sort of equal split whenever that is in the “compatibility zone”, that is non-wasteful and individually rational. Second, if that is not the case, hard constraints (e.g. feasibility constraints imposed by nature and other outside forces) solve the problem by offering corner solutions, while soft constraints (e.g. individual rationality which might be ignored by parties) offer much less guidance leading to overall murky results. Note that this two-step process is in line with the above-mentioned idea of equal split *with a twist*, very much in the spirit of the deal-me-out solution.

In other settings, however, soft constraints have been reported to significantly disrupt the dominance of equal splits in favor of other theoretical solutions (like the Nash bargaining solution). For example, Takeuchi et al. (2022) introduced a production stage before bargaining that took on the role of a priming device and/or a solution-selection device in a problem that has no obvious unique solution. They observe that the form of the production function has a statistically significant and sizable impact on the distribution of bargaining outcomes.⁵

Our results can be summarized as follows. In (two-person) bargaining problems where payoff transfers are allowed, we do not find evidence of a reduction of payoff equality in exchange for efficiency gains. The equal split acts as a strong focal point, even when such a split implies for one of the bargaining parties a lower payoff than in case of disagreement. We do observe that bargaining parties fail to fully exploit the gains from specialization, as they tend agree on divisions of the physical good that are Pareto inefficient. We conjecture that the possible lack of efficiency is due to cognitive and strategic unsophistication. In contrast, three-person bargaining problems where no payoff transfers are allowed tend to lead to agreements that are Pareto efficient. Also, participants in our study seem to settle on three-party agreements that prevent deviations to two-party agreements (or to total disagreement). In summary, the most popular agreements in our data stay as close to the equal split as Pareto

⁴ Three of the solutions concepts included in the Navarro and Veszteg (2020) study satisfy the axioms supported by the data: the equal-split solution, the egalitarian solution, and deal-me-out. Three other of the considered solution concepts are in conflict with the data for satisfying a rejected axiom and/or not satisfying an accepted one: the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, and the proportional solution (where proportionality is with respect to the disagreement payoffs).

⁵ The main finding by Takeuchi et al. (2022) is that when surplus is created in an additive way the bargaining outcome is more likely to be in line with the Nash bargaining solution. Similarly, when surplus is created in a proportional way, bargaining outcomes are more often proportional as well.

efficiency and stability permit. Although a minority, also the observed two-party agreements align with this pattern. Note, however, that in the bilateral bargaining problems studied by Navarro and Veszteg (2025), participants considered Pareto efficiency a harder constraint than stability while staying as close to equality as possible.⁶

Our findings highlight that, when confronted with the dilemma of equality against efficiency, bargaining parties choose efficiency over equality as long as they possess the sophistication required to find the efficient agreement. When efficient agreements are easy to identify, and when given the choice, bargaining parties stay as close to equality as possible, with efficiency acting as a hard constraint. Furthermore, in more populous or multilateral bargaining settings, stability enters into the bargaining process as a hard constraint (i.e., difficult to ignore), while it seems to be a soft constraint (i.e., easy to ignore) in two-party bargaining settings.⁷

The experimental literature on unstructured bargaining dates back to the 70s with seminal works including (Nydegger and Owen 1974) and Roth and Malouf (1979). Although it was unduly ignored for over four decades due to the dominance of ultimatum-bargaining studies (since Güth et al. 1982), it has experienced a revival recently with a dramatic increase in contributions reviewed by Karagözoğlu (2019). Many of these studies have documented the focality of the equal split in unconstrained (and arguably more natural) bargaining environments in which parties are free to decide how to share a pie of a given size (e.g., Nydegger and Owen 1974, Roth and Malouf 1979, Anbarci and Feltovich 2013, Anbarci and Feltovich 2018, Navarro and Veszteg 2020).

To the best of our knowledge, we are among the first to explore the robustness of the equal split by adding new layers of complexity to the bargaining problem to be solved in the experimental laboratory. We enrich the environment in two other possible ways: either by allowing for payoff transfers or by involving more than just two parties in bargaining. Our results show how additional complexity drives participants to react to the new challenges and how *adjusted* notions of equality emerge. These notions of equality are notably more complex than a simple equal split. Equal split, however, only loses part of its attraction power: bargaining agreements stay close to equality while dealing with the added complexities (and satisfying the new constraints that those impose).⁸

This paper is structured as follows. We present the experimental design in Section 2, and the experimental procedures in Section 3. The theory guiding our analysis is briefly summarized in Section 4. Our main results are in Section 5, while some further results can be found in Section 6. Section 7 concludes.

⁶ Navarro and Veszteg (2025) have found that individual rationality, which is a coalitional constraint, was ignored in a significant proportion of agreements when in conflict with equality, while the capacity constraint was respected in almost all agreements. For that reason, we refer to efficiency as a hard constraint on the equal split (i.e., difficult or impossible to avoid) for participants in the experimental laboratory, and to the coalitional constraint as a soft constraint on the equal split (i.e., easier or possible to avoid).

⁷ Galeotti et al. (2019) designed an experiment based on unconstrained two-party bargaining over menus of two or three contracts, where each contract specified payoffs to each of the two bargaining parties. All the menus contained a contract with an equal split, but in some of the proposed menus the equal split was Pareto dominated by at least another contract in the menu. The experimental results show that the frequency of agreements with equal splits decreases dramatically when those menus are offered to participants. In light of these observations, one might be tempted to conclude that participants tend to prefer efficiency over equality. We, however, believe that Galeotti et al. (2019) simply did not offer enough choice options to participants for such a strong conclusion to be deduced.

⁸ In contrast, in Takeuchi et al. (2022) participants departed from egalitarian or equal split solutions in favor of the Nash bargaining solution or the proportional bargaining solution, depending on the production technology used prior to the bargaining stage.

2 Experimental design

Our experimental design relies on the one introduced by Navarro and Veszteg (2020, 2025). This essentially means that we use some *meaningful context* (that of imaginary farms) to create a rich bargaining environment that resembles real-world conflicts. We also believe that the behavioral patterns that we report based on our experimental design constitute relevant findings even in the absence of the related theoretical discussion. For instance, while the interpretation of our empirical results is in light of the axiomatic approach to bargaining theory, the reader might have doubts regarding the empirical validity of certain popular assumptions (like the use of expected utility theory). Should that be the case, the three interconnected layers (hens, eggs, money) meshed into our bargaining problems still allow for studying empirical regularities in bargaining behavior.

Each participant in our experiment was told to imagine that they owned an imaginary farm. Bargaining then happened in pairs about the distribution of a fixed number of fictitious goods (hens) across the farms. The same amount of those goods (hens), however, could produce different amounts of monetary gains (by selling eggs on a fictitious market) due to exogenously given and fixed circumstances (farm characteristics).

Essentially, our experimental participants bargained over probabilities to gain a certain fixed monetary prize. We made the probability of winning proportional to the number of eggs produced on one's farm, so that the number of eggs produced can be interpreted as utility levels (based on expected-utility theory). By doing so, and by relying on so-called binary lotteries (with only two possible monetary payoffs), we keep our experimental design close to the theoretical model of Nash bargaining in which bargaining happens in utilities, and also to earlier experimental work (von Neumann and Morgenstern 1944; Roth and Malouf 1979, 1982; Malouf and Roth 1981; Roth and Murnighan 1982).⁹

Each participant was requested to participate in 12 bargaining problems in randomly assigned groups. The 12 bargaining problems differed in some exogenously imposed circumstances and were implemented in the same order in all our experimental sessions. For that reason, we shall refer to them as *bargaining rounds*. One of them was selected randomly for payment at the end of the experiment. At the beginning of each round, participants were randomly assigned to a farm (a role). Farms potentially differed in terms of technology (the number of eggs laid by each hen), storage capacity (how many eggs can be collected and stored safely), the amount of money the owner could earn when successfully completing an order of 300 eggs, and the number of hens allocated in case of disagreement.

In each round, each bargaining party received an order for 300 eggs in exchange for a certain fixed amount of money. The number of eggs produced clearly depended on the farm characteristics and the number of hens, that is the bargaining outcome. Should a participant produce the requested 300 eggs, she would earn for sure (with 100% probability) the specified amount of money in the round. Producing that much, however, was not always possible as hens were laying different number of eggs on different farms and farms also had an egg-storage capacity. In that case, participants could still earn the same specified amount of money, but not for sure. The probability of earning the fixed

⁹ Based on expected-utility theory, and without loss of generality, we normalize bargaining parties' utility by setting $u(\text{prize}) = 1$ and $u(\text{no prize}) = 0$. With that, the utility for each unit of the *physical* good under negotiation can be computed as $u(\text{hens}) = \Pr(\text{earn the prize}|\text{hens}) \cdot u(\text{prize}) + \Pr(\text{don't earn the prize}|\text{hens}) \cdot u(\text{no prize})$. This, in our experimental design, simplifies to $u(\text{hens}) = \Pr(\text{earn the prize}|\text{hens}) = \frac{1}{\text{order}} \cdot (\text{eggs per hen} \cdot \text{hens}) = \frac{\text{eggs}}{\text{order}}$.

monetary prize was computed as $(\text{number of eggs produced})/300$, or in more detail as $\frac{1}{300} \cdot \min\{(\text{eggs per hen}) \cdot (\text{hens}); \text{storage capacity}\}$.

Participants could bargain with each other through a simple computer interface that allowed for sending and receiving text messages and also numerical proposals indicating the suggested split of available resources (hens). Farm characteristics, the ordered amounts, and monetary prizes were public knowledge. Proposals could be rejected, accepted, and even withdrawn (when left pending by the bargaining partner) at any time. If bargaining broke down or parties did not want to engage in it at all, participants were allowed to quit the bargaining process and obtained a predetermined number of hens. Due to this special feature, disagreement payoffs and outside options coincide in our experimental design.¹⁰ Each bargaining round (i.e., bargaining problem) lasted for at most 5 minutes. Participants had the option to quit bargaining early and get their disagreement payoff.

Our two treatments, one with utility transfers and another with trilateral bargaining, were based on the above-detailed experimental design with the following modification.

2.1 Transferable utility

In the transferable-utility (TU) treatment, egg transfers could take place after the production stage.¹¹ Each bargaining problem involved two parties challenged to consider the allocation of 150 hens. Proposals and agreements had to specify not only a feasible distribution of hens, but also whether any eggs were to be moved from one farm to the other before payoffs (i.e., the probability of earning the monetary prize) were determined. Recall that, based on the assumptions we make, hens are to be interpreted as physical units, and the number of eggs is considered as utility levels in the corresponding theoretical model. A complete list of the 12 bargaining problems implemented in the TU treatment is included in Table 1.

The benchmark for our TU treatment is based on an identical design except that the possibility of (egg) transfers is removed. Data from that benchmark treatment (together with some other treatments targeting the effect of asymmetric information) are analyzed by Navarro and Veszteg (2025). They use the label FULL_U as a short name, but here for simplicity, we shall call it the non-transferable-utility (NTU) treatment.

2.2 Three-person bargaining

In the three-person (3P) bargaining treatment, participants were randomly assigned to groups of three. Bargaining happened through the same protocol and platform as in the other treatment. Participants could decide about how to distribute 300 hens among the three of them. For such an agreement in the grand coalition unanimity was required. It was also possible to exclude one group member from the negotiation and form a group of two, but in that case

¹⁰ Refer to Appendix D for sample screens and detailed experimental instructions. On the one hand, our experimental design is very much unconstrained and offers a lot of freedom to bargaining parties. On the other, it has been carefully constructed to align with the rather complex theoretical model of cooperative bargaining. The experimental instructions offer the simplest explanation of what exactly was happening in our experimental sessions in the laboratory.

¹¹ Note that the hard constraint of egg storage was imposed on production, but not on transfers. For that reason, the experimental instructions talked about *eggs produced* (before possible transfers) and *eggs delivered* (after possible transfers). To keep our discussion simpler, we use the more natural *eggs produced* expression here, unless we wish to emphasize some differences between the before-transfer and after-transfer situations.

Table 1 Bargaining problems implemented in the TU and 3P treatments

		TU		3P		
		Farm 1	Farm 2	Farm 1	Farm 2	Farm 3
round 1	monetary prize	15	60	15	15	15
	eggs per hen	1	1	1	1	1
	egg storage capacity	300	300	300	300	300
	outside option (hens)	30	30	30	30	30
round 2	monetary prize	60	15	60	60	60
	eggs per hen	1	2	2	1	1
	egg storage capacity	300	300	300	300	300
	outside option (hens)	30	30	30	30	30
round 3	monetary prize	60	15	60	60	60
	eggs per hen	1	2	1	1	1
	egg storage capacity	75	300	300	300	300
	outside option (hens)	30	30	90	30	30
round 4	monetary prize	60	15	60	60	60
	eggs per hen	2	1	2	1	1
	egg storage capacity	300	300	300	300	300
	outside option (hens)	90	30	90	30	30
round 5	monetary prize	60	15	60	60	60
	eggs per hen	1	2	2	1	1
	egg storage capacity	300	300	300	300	300
	outside option (hens)	90	30	30	90	30
round 6	monetary prize	15	60	60	60	60
	eggs per hen	2	1	1	1	1
	egg storage capacity	150	300	70	300	300
	outside option (hens)	30	30	30	30	30
round 7	monetary prize	60	15	15	15	15
	eggs per hen	2	1	2	1	1
	egg storage capacity	210	300	70	300	300
	outside option (hens)	90	30	30	30	30
round 8	monetary prize	60	15	60	60	60
	eggs per hen	1	2	2	1	1
	egg storage capacity	45	300	300	70	300
	outside option (hens)	30	90	30	30	30
round 9	monetary prize	15	60	15	15	15
	eggs per hen	1	2	1	1	1
	egg storage capacity	105	300	70	300	300
	outside option (hens)	90	30	30	90	30
round 10	monetary prize	60	15	15	15	15
	eggs per hen	2	1	2	1	1
	egg storage capacity	90	300	70	300	300
	outside option (hens)	30	90	30	90	30

Table 1 continued

		TU		3P		
		Farm 1	Farm 2	Farm 1	Farm 2	Farm 3
round 11	monetary prize	15	60	15	15	15
	eggs per hen	1	1	2	1	1
	egg storage capacity	300	300	300	70	300
	outside option (hens)	90	30	90	30	30
round 12	monetary prize	60	15	15	15	15
	eggs per hen	1	1	2	1	1
	egg storage capacity	75	300	300	70	300
	outside option (hens)	30	30	30	30	90

Note: Monetary prizes are listed in euro (as used in the experimental sessions)

only 150 were available for distribution between the two farms. Unlike in the TU treatment, transfers were not allowed.

The benchmark for our 3P treatment is treatment FULL_E used by Navarro and Veszteg (2025).¹² For simplicity, here we shall refer to it as 2P.

3 Experimental procedures

Our experimental sessions took place at LEEP, Paris 1 University (Paris, France) between November 15, 2022 and December 8, 2022.¹³ Participants were recruited through ORSEE (Greiner 2015). Both the main experiment and the post-experimental questionnaire were implemented with zTree (Fischbacher 2007). Participants interacted anonymously in randomly matched groups and played 12 rounds of bargaining, one of which was chosen randomly by the computer for payment at the end of the session and participants were paid their gains in cash. Our observations stem from a sample of volunteer participants who received monetary performance-dependent compensation for participation.¹⁴ We used stranger matching, so each round of bargaining occurred with new randomly and anonymously assigned partners. Upon arrival, the participants were randomly assigned to a booth with a computer terminal and could only interact with each other through zTree. Participants read the instructions individually, then played the bargaining games and answered the ques-

¹² To make sense of the treatment codes used by Navarro and Veszteg (2025), we note that they refer to full or hidden information, and symmetric or asymmetric monetary prizes. Here we study bargaining under full information, as assumed by most theoretical models of bargaining. Regarding monetary prizes, while asymmetry creates a richer design, it could overcomplicate the three-person treatment by requiring too many permutations of the parameter values to be included. For that reason, we kept monetary prizes equal across the bargaining parties.

¹³ The Parisian Experimental Economics Laboratory (LEEP) implemented all the experimental sessions on our behalf using the software code, instructions, and questionnaire that we had prepared. For the complete list of sessions, refer to Table B.17 in the appendix.

¹⁴ For further details on participant characteristics, refer to Table B.18 in the appendix.

tions of a survey at the end of the session before privately receiving their earnings in cash.¹⁵ The experimental sessions lasted for about 90 minutes. Participants were paid privately in cash at the end of each experimental session. 80 volunteers participated in the TU treatment, and 123 volunteers participated in the 3P treatment. The average earning was 35.4 euro in the TU treatment and 34.7 euro in the 3P treatment, including a 10 euro show-up fee.

At the beginning of each round, participants were informed about the characteristics of their own farm and also of those of the opponent(s). In order to keep the effect of the changing farm characteristics under control, the computer screen contained a profit simulator that allowed participants to check (privately, and at any time during the round) their own payoffs and their opponents' for any hypothetical agreement.

4 Theoretical predictions

This section summarizes the main theoretical predictions based on our experimental design. The detailed exposition of the models, including the basic theoretical model of Nash bargaining for two players, can be found in Appendix A. We consider payoff transfers and three-person bargaining separately. Bargaining with the possibility of payoff transfers fits into the model of transferable-utility games (TU games), while three-person bargaining fits into the model of Nash bargaining under coalitional constraints.

4.1 Two-person TU-games

The implications of allowing for utility transfers in our experimental design are twofold. First, cooperative game theory assumes that players reaching an agreement together (typically called a *coalition*) are rational and clever enough to produce the highest possible aggregate utility. We call this assumption *coalitional rationality*, but this assumption can also be regarded as a strong notion of efficiency. In our experimental design, coalitional rationality requires hens to be assigned to the more productive farm up to its capacity.¹⁶

Second, the most popular and well-known bargaining solutions are all defined through very simple mathematical expressions with some of them yielding the same outcome in terms of payoff distribution. Recall that the predicted bargaining outcomes are embedded in what are called theoretical bargaining *solutions*. Also note that in our experimental design payoffs are proxied by the number of eggs produced, as the probability of obtaining the monetary prize is proportional to that.

In the analysis that follows, we consider, together with the equal split, where both parties obtain exactly the same payoff or utility, (i) the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, and the egalitarian solution, all yielding an equal difference

¹⁵ The English translation of the instructions used, including a screenshot of the user interface, are to be found in Appendix D. The zTree files, the collected data, and the code for the statistical analysis are available from the authors upon request. An unfortunate bug in the zTree code for treatments NTU and 2P reported by Navarro and Veszteg (2025) affected some numbers in the summary tables displayed after bargaining. Those entries did not reflect the capacity constraints. It happened in about 1% of all bargaining interactions and its average size was of 0.1 percentage points. All tables (including the simulation tables) worked correctly during the decision-making stage, and we have not received inquiries during the experimental sessions regarding the round summaries displayed a posteriori.

¹⁶ Coalitional rationality yields a clear prediction in all rounds except 1 and 11 because in those rounds productivities are equal and capacity constraints are not binding. Table A.8 in Appendix A shows the distribution of hens according to coalitional rationality and the resulting total or *ideal* amount of eggs (denoted by M).

in payoffs with respect to disagreement payoffs, and (ii) the deal-me-out solution, yielding the payoff pair closest to the equal split restricted to both parties obtaining at least their disagreement payoff.¹⁷

4.2 Three-person bargaining

Recall that in our 3P treatment bargaining parties are not allowed to make transfers. Hence, the three-person games considered here are not transferable utility games. The implications of increasing the number of parties involved in the bargaining problem are again twofold. It affects the possible bargaining outcomes or agreements (embedded in theoretical solutions) and also group rationality.

Regarding the bargaining outcomes, two types of additional constraints restrict the (standard) theoretical predictions.¹⁸ First, parties in a three-person bargaining problem may also exclude someone and form two-party coalitions, apart from the possibilities of forming the grand coalition and of simply walking away from bargaining with the number of hens at disagreement. Second, capacity constraints are binding in terms of eggs produced (and therefore in the probability of obtaining the monetary prize), which was not the case in our two-player transferable-utility bargaining problems (as transfers happened after the production stage).

Regarding the coalitional or group rationality, theory predicts that the final agreement gives the highest possible payoffs to all parties involved. In other words, participants are expected to reach a three-party agreement if by doing so the possible payoffs are globally higher than in two-party agreements (with one party staying alone) and than in total disagreement (with all three parties alone). In our experimental design, a three-party agreement allowed participants to distribute 300 hens, which was more than the 150 hens permitted for a two-party agreement plus the highest possible hens at disagreement (90). Also, 300 hens was also higher than the sum of hens at disagreement for the three participants in all rounds. In conclusion, coalitional rationality in our experiment implies three-party agreements.¹⁹

When it comes to distributing payoffs among the members of the grand coalition, we require the agreement to be “deviation-proof” with respect to all possible sub-coalitions.²⁰ More precisely, we follow (Dutta and Ray 1989, 1991) and consider that sub-coalitions would block an agreement whenever *all* members of the coalition *strictly* gain from the deviation.

¹⁷ Table A.9 in Appendix A shows the eggs delivered (e_i for each $i = 1, 2$) according to the Nash, the Kalai-Smorodinsky, or the egalitarian solutions (for simplicity, we use the common “egalitarian” label in the table), to the equal-split, and to the deal-me-out solutions for all the two-person bargaining problems with transfers included in our experimental design.

¹⁸ We consider the extension of all the standard solutions mentioned above to three-party agreements: the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, and the egalitarian solution, together with the equal split. Table A.10 in Appendix A shows the distribution of hens according to the Nash bargaining solution depending on whether the grand coalition or any of the two player-coalition forms. In the latter case, the player not participating in the coalition is assumed to obtain the number of hens at disagreement. If there is disagreement, each party obtains the disagreement number of hens. Similarly, Tables A.11, A.12, and A.13 in Appendix A show the predicted agreements according to the Kalai-Smorodinsky bargaining solution, the egalitarian solution, and the equal split, respectively.

¹⁹ We refer to three-party agreements as forming the grand coalition, an expression we borrow from cooperative game theory. In the benchmark treatment, only two-party agreements are allowed. Recall that reaching a two-party agreement (a grand coalition) in the benchmark treatment allows participants to distribute 150 hens, which is higher than the sum of the hens at disagreement in all rounds (being at most 120).

²⁰ Recall that the deal-me-out solution for the two-player case proposes the closest payoff pair to the equal split solution that yields at least the disagreement payoff to each party. Recall that the disagreement payoff is what a deviating sub-coalition with one member (a singleton) would obtain. For that reason, the constrained versions of the solutions that we present here can be interpreted as a generalization of the deal-me-out solution.

Intuitively, the solutions with such coalitional constraints (i.e., constrained solutions, in short) work as follows in our experimental design. We first distribute hens according to each of the proposed theoretical solutions in each of the possible coalitions (with one, two, or three members) and check whether any (sub)coalition would block by unanimity (based on strict gains). If that is the case, we choose the closest payoff vector to the solution outcome that prevents that deviation.²¹

Regarding the effect of capacity constraints, it turns out that the egalitarian and equal-split solutions are not Pareto efficient.²² To avoid wasteful agreements, participants could consider the *lexicographic* versions of the standard solutions (found in the literature). To give the reader an intuition of how these adapted solutions work, let us consider the lexicographic egalitarian solution for the grand coalition.²³ Starting from the egalitarian solution, we check whether we can improve some farm's situations without harming any of the others. If that is the case, we do so by following the egalitarian rule (i.e., equal difference in payoffs from disagreement). Hence, in the egalitarian solution, for instance, in round 6 all farms produce 70 eggs (with eggs wasted), whereas in the lexicographic egalitarian solution Farm 1 produces 70 eggs, while Farm 2 and Farm 3 produce 115 eggs each (no eggs wasted). The same reasoning applies when computing the lexicographic equal split solution, with the difference of using the equal split rule when some farms can improve without harming others.²⁴

5 Results

5.1 Bargaining with payoff transfers

The possibility of (utility) transfers enlarges the bargaining set if parties are able to exploit comparative advantages. In our experimental design, with egg transfers happening after the

²¹ Note that the outcomes of the constrained versions of the Nash and the Kalai-Smorodinsky solutions coincide with their unconstrained versions in our experimental design (with the sole exception of the Kalai-Smorodinsky solution in round 10). The constrained egalitarian solution and the constrained equal split solution do not yield a unique distribution in terms of hens in our bargaining problems: there exist multiple distributions (i.e., agreements) that are at an equal and minimal distance from the egalitarian solution and the equal split solution, respectively. This is the reason why they are excluded from our analysis which, for simplicity, is based on theoretical solutions yielding a unique prediction.

²² To see that, consider round 6. In the egalitarian solution, Farm 1 cannot have a difference in egg production (with respect to the disagreement value) larger than 40, that is the difference between 70 (capacity constraint) and 30 (disagreement). For the other two farms to obtain a difference in egg production exactly equal to 40, the egalitarian solution would prescribe an allocation of 40 hens to the other two farms as well above their disagreement values. This means that Farms 2 and 3 should obtain 70 hens (and a production of 70 eggs) each, and that the remaining 160 hens should be attributed to Farm 1, obtaining 70 eggs as well. This distribution is not Pareto efficient because we can improve at least one party's situation without harming any other's, but it is *weakly* Pareto efficient because we cannot improve *all parties' situation simultaneously*. This is a feature of *monotonic* solutions (for further details, refer to Thomson 2022). Note that the Nash bargaining solution is not monotonic and always yields a Pareto efficient solution.

²³ We rely on Thomson (2022) in the intuitive explanation above.

²⁴ There exists a lexicographic version of the Kalai-Smorodinsky bargaining solution as well, but it does not yield a different prediction in terms of hens than the standard solution in our experimental design - all its theoretical predictions yield a production of eggs below the farms' storage capacity. Tables A.14 and A.15 in Appendix A show the distribution of hens that is obtained by the lexicographic egalitarian solution and by the lexicographic equal-split solution, respectively. These lexicographic versions differ from the standard solutions in rounds 6 to 12 except for the coalition configurations where the farm with the lowest storage capacity is left out. The outcome of the constrained lexicographic egalitarian solution coincides with the outcome of the lexicographic egalitarian solution in our experimental design. Table A.16 in Appendix A shows the distribution of hens predicted by the constrained lexicographic equal-split solution.

Table 2 Equalizing splits in observed agreements (as a % of all agreements, treatments NTU and TU)

	NTU		TU
equal hens	29.67	≥ 0.02	21.78
equal eggs	26.09	$= 0.25$	30.03
equal expected prize	0.51	$= 0.07$	1.98
obs.	391		303

Note: Comparison signs between the reported numbers correspond to two-tailed statistical tests for the equality of proportions. Numbers as subindices indicate the corresponding p -values

production stage and not being limited by capacity constraints, parties could expand the bargaining set, that is the total number of eggs produced, by allocating hens to the farm with better technology (i.e., 2 eggs per hen, instead of 1) up to its storage capacity. Transfers then allowed for any desired distribution of eggs.

Result 1 *The proportion of agreements with equal payoffs does not depend on whether payoff transfers are possible (TU: 30%) or not (NTU: 26%).*

When it comes to final agreements, transfers do reduce the number of outcomes with equal number of physical units (hens), as parties try to widen the bargaining set through “specialization”, but the number of agreements that equalize payoffs (hens) remains the same in the TU treatments as in the NTU treatment (Table 2).²⁵

5.2 Three-person bargaining

When bargaining involves more than two parties, agreements emerge from a much richer space as they might involve coalitions of different sizes. Our experimental design gave strong incentives to participants to form the grand coalition (including three farms), as 300 physical units (hens) were available to be distributed among three farms, while only 150 in case of agreements with two only. Even in the rounds where at least one party could obtain 90 hens at disagreement, the availability of 300 physical units allowed to improve all three parties payoffs from any two-party agreement.²⁶

Result 2 *The proportion of agreements with equal payoffs is much smaller with three parties (3P: 18%) than with only two parties (2P: 36%) involved in bargaining.*

We have observed much fewer equalizing splits of any kind in the 3P treatment than in the comparable 2P treatment (Table 3). When it comes to agreements with equal eggs, which correspond to the theoretical equal-split solution, their frequency is halved, merely reach 18%. In next subsection we search for alternative focal points in three-person bargaining.

²⁵ In principle, bargaining parties could have tried to equalize the expected monetary gains, too, but that has only happened in 0.5% to 2% of the cases without statistically significant differences between the NTU and TU treatments.

²⁶ Just like in our other experimental treatments, disagreements led to an even smaller aggregate number of hens across farms.

Table 3 Equalizing splits in observed agreements (as a % of all grand-coalition agreements, treatments 2P and 3P)

	2P		3P
equal hens	31.68	>0.02	23.89
equal eggs	36.14	>0.00	18.15
equal expected prize	36.14	>0.00	18.15
observations	404		314

Note: Comparison signs between the reported numbers correspond to two-tailed statistical tests for the equality of proportions. Numbers as subindices are the corresponding p -values

6 Alternative focal points and coalitional rationality

6.1 Alternative focal points in bargaining with payoff transfers

Regarding the theoretical predictions (summarized in Appendix A), it is the equal-split solution that best organizes the data among the most popular single-valued solutions that we consider.²⁷ Recall that all theoretical solution concepts assume full efficiency. For that reason, our discussion on the predictive success of theoretical solutions focuses on fully efficient proposals and agreements.

Overall, the theoretical solution of equal split remains focal (upper half of Table 4). Even if we require full precision from theoretical predictions, nearly one quarter of all observed agreements is such that parties managed to allocate the physical units to achieve full efficiency and then distributed payoffs equally. Only around 40% of the agreements gives more payoffs than the disagreement payoffs to both parties (while achieving full efficiency). This suggests that people are willing to disregard individual rationality in favor of a more equal outcome. If DMO lags behind the equal-split solution is for the same reason: parties do not necessarily have to be dealt out for bargaining to succeed.²⁸

For a graphical summary of all observed agreements, including those that are not fully efficient, refer to the histograms in Fig. C.1 in the appendix. Regarding the distribution of fully efficient agreements in terms of how equal they are, we find that the median (but also the mean) difference between proposed payoffs (i.e., eggs) is the same no matter whether we look at individually rational agreements or those that violate individual rationality.²⁹

To check whether equal splits are intended (and targeted as) solution to the bargaining problem or whether they arise as a compromise from the two-party negotiation, we take a

²⁷ Note that predictions by the egalitarian solution coincide with the ones by the Nash bargaining solution, and by the Kalai-Smorodinsky bargaining solution in all the bargaining problems included in our two-party TU experimental design. Those predictions also coincide with the ones that the Shapley value and the nucleolus (two popular solutions concepts defined for general TU games involving more than two bargaining parties) would predict for our experimental design. Individual rationality refers to both parties in the agreements and, for that reason, coincides in our design for two bargaining parties with the solution concept known as the *core* in general TU games.

²⁸ According to two-sample tests of proportions, the equal-split solution is significantly more frequent than the egalitarian solution and at least as frequent as DMO (p -value = 0.02) independently of the error permitted in the categorization (Table 4).

²⁹ The median difference in payoffs is 20 for individually rational agreements, and it is 0 for those that are not. The nonparametric equality-of-medians test and the two-sample Wilcoxon rank-sum (Mann-Whitney) test both suggest that there are no significant differences, with p -values of 0.90 and 0.83, respectively. As for the mean difference in payoffs, it is of 51 eggs for individually rational agreements, and it is 72 for those that are not. The two-sample t test with unequal variances suggests no significant difference either (p -value = 0.23). These numbers are based on categorizations with 0 errors in predictions.

Table 4 Theoretical solutions as proportions (%) of observed / proposed agreements (treatments TU and NTU)

	NBS	KSS	egalitarian	equal split	DMO
% of observed TU agreements					
		7.9		24.8	17.2
		[5.1 - 11.6]		[20.0 - 30.0]	[13.1 - 21.9]
obs.		303		303	303
% of proposed TU agreements					
		1.4		4.9	3.3
		[1.0 - 1.9]		[4.2 - 5.8]	[2.7 - 4.0]
obs.		3179		3179	3179
% of observed NTU agreements					
	34.8	8.2	13.8	23.5	22.0
	[30.1 - 39.7]	[5.7 - 11.4]	[10.5 - 17.6]	[19.4 - 28.1]	[18.0 - 26.4]
obs.	391	391	391	391	391

Note: Observed agreements are categorized based on theoretical point predictions. 95% confidence intervals between parentheses below the point estimates. NBS = Nash bargaining solution, KSS = Kalai-Smorodinsky solution, DMO = deal-me-out solution. The Nash bargaining solution, the Kalai-Smorodinsky solution, the Shapley value and the nucleolus all coincide with the egalitarian solution in the TU treatment

look at all proposed deals as well. The numbers in the middle section of Table 4 show a very similar picture to the one described above based on observed mutually-accepted agreements. Equal-split proposals outnumber all the other solutions that predict a single outcome.³⁰ This result also holds even if we allow for some error in the categorization. Table C.19 in the appendix shows similar numbers when deviations of 2.5 or 5 eggs (or hens) are permitted with respect to the theoretical predictions.

Regarding the benchmark NTU treatment, the most frequent agreement in there is the Nash bargaining solution followed by the equal split solution (see the bottom section of Table 4).³¹ The proportion of equal splits is the same in both treatments TU and NTU (p -value = 0.71). We have not yet found an explanation for the large difference in the proportion of agreements coinciding with the Nash bargaining solution between the two treatments.

6.2 Alternative focal points in three-person bargaining

In Section 4 we have briefly introduced the solution concepts that we use here to organize our observations (details can be found in Appendix A). Namely, we use the predictions by the solution concepts considered in the two-party bargaining, which are the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, the egalitarian solution, and the equal-split solution. Due to the possibility that participants in our experiment might have been considering efficiency and/or coalitional (strategic) constraints while bargaining, we have included three additional theoretical solutions in the analysis. We refer to them as the lexicographic egalitarian solution, the lexicographic equal-split solution and the constrained lexicographic equal-split solution. Refer to Section 4 and Appendix A for details.

³⁰ Due to the much larger number of observations when proposals are considered, all the above-reported point estimates are significantly different from each other at all usual significance levels (p -value = 0.00).

³¹ According to two-sample tests of proportion, the proportion of Nash bargaining solutions is statistically significantly larger than the proportion of any other solutions in the NTU treatment (p -value = 0.00).

Recall that theoretical solutions concepts for our bargaining problems would all predict the grand coalition to form. That is why we first look at agreements that involve the grand coalition (top panel in Table 5).³² The constrained lexicographic equal-split solution, closely followed by the lexicographic equal split, is the most frequently observed prediction out of all the solution concepts considered in this paper, with about one third of three-party agreements coinciding with its prediction. The equal-split solution performs significantly worse.³³

The lexicographic equal-split solution predicts equal gains for all parties whenever such a division is Pareto efficient. That is, in those cases the two solutions coincide. When the equal split is not Pareto efficient, like in rounds 6 to 12 of our experimental design, the lexicographic equal-split solution predicts an outcome that lies closest to the equal split among all Pareto-efficient outcomes.³⁴ In other words, in rounds 6 to 12 at least one party has a storage capacity that is low enough to create a dilemma between efficiency and equality. The equal-split solution predicts that bargaining parties stick to the equal split, renouncing Pareto efficiency. The lexicographic equal split and the constrained lexicographic equal split predict that bargaining parties stick to Pareto efficiency and get as close as possible to the equal split. The two latter solutions differ in the way they deal with another dilemma: if parties are free to disagree, that is to form two-party agreements or three-party agreements, the constrained lexicographic equal split satisfies the coalitional constraint (see Section 4), while the lexicographic equal split ignores it.

In summary, there are two dilemmas to be considered in our three-party bargaining problems. Participants need to solve the dilemma between equality and efficiency, as well as the dilemma between equality and coalitional stability. Our data suggest that the first dilemma is solved in favor of efficiency (while staying as close to equality as possible) with the lexicographic and the constrained lexicographic equal-split solutions outperforming all the others. The second dilemma is solved in favor of stability (while staying as close to equality as possible and respecting the efficiency constraint).

It is surprising that the equal split not only loses part of its power of attraction, but it is outperformed by the constrained lexicographic equal-split solution when three parties are involved in the bargaining problem and the corresponding agreement. It turns out that this is not an artifact of the bargaining process itself. Parties' intentions (or one might even claim, their fairness ideals) are best reflected by the long list of proposals made during the bargaining process. A remarkable 94% of all proposals sent was targeting the grand coalition in our experiment and almost 10% of them were in line with the constrained lexicographic

³² Note that the theoretical solutions to the cooperative bargainings model might predict the same distribution of payoffs for certain bargaining problems. For that reason, the percentages reported in the rows of Table 5 do not add up to 100.

³³ Two-sample tests of proportions corroborate the above statements, as reported p -values are 0.00 for all binary comparisons with the constrained lexicographic equal-split solution, except for the lexicographic equal-split solution, which lead to a p -value of 0.87.

³⁴ More precisely, in rounds 6 to 12, where one party has a very low storage capacity, the equal split would prescribe some egg production to be lost (or some hens not distributed) in order to make all parties receive the same payoff. From such an equal-split division, there is a possible improvement in the sense of Pareto where the other bargaining party (in a two-party agreement) or the other two bargaining parties (in the three-party agreement) can improve upon without hurting the party whose delivered production is at its upper limit. In the case of three-party agreements, the two remaining agents gain equally (following the equal split rule) unless their storage capacity is reached. In our experimental design, at most one party has a storage capacity creating this type of dilemma between efficiency and equality in each possible agreement.

Table 5 Theoretical solutions as proportions (%) of observed / proposed agreements (treatments 2P and 3P)

	NBS	KSS	egalitarian	equal split	lexico. egalitarian	lexico. equal split	constr. lexico. equal split	DMO
% of observed 3P agreements in grand coalition								
	18.5	10.2	8.0	18.2	16.6	32.2	32.5	-
	[14.3 - 23.2]	[7.1 - 14.1]	[5.2 - 11.5]	[14.0 - 22.9]	[12.6 - 21.1]	[27.0 - 37.6]	[27.3 - 38.0]	-
obs.	314	314	314	314	314	314	314	-
% of observed 3P agreements in coalitions of 2								
	57.1	36.5	25.4	38.1	50.8	66.7	52.4	-
	[44.0 - 69.5]	[24.7 - 49.6]	[15.3 - 37.9]	[26.1 - 51.2]	[37.9 - 63.6]	[53.7 - 78.0]	[39.4 - 65.1]	-
obs.	63	63	63	63	63	63	63	-
% of proposed 3P agreements in grand coalition								
	7.9	6.0	4.3	7.6	5.6	9.3	9.4	-
	[7.2 - 8.7]	[5.3 - 6.7]	[3.7 - 4.9]	[6.9 - 8.4]	[5.0 - 6.3]	[8.5 - 10.2]	[8.6 - 10.3]	-
obs.	4546	4546	4546	4546	4546	4546	4546	-
% of observed 2P agreements in grand coalition								
	35.6	12.6	18.1	32.9	28.7	46.3	44.3	31.4
	[31.0 - 40.5]	[9.8 - 16.5]	[14.4 - 22.2]	[28.4 - 37.7]	[24.3 - 33.3]	[41.3 - 51.3]	[39.4 - 49.3]	[26.9 - 36.2]
obs.	404	404	404	404	404	404	404	404

Note: Observed / proposed agreements are categorized based on theoretical point predictions. 95% confidence intervals between parentheses below the point estimates. NBS = Nash bargaining solution, KSS = Kalai-Smorodinsky solution, DMO = deal-me-out solution, lexico. = lexicographic, constr. lexico. = constrained lexicographic. DMO is only defined for two-person bargaining problems. Rows do not add up to 100, as solutions might coincide for some bargaining problems.

equal-split solution. That is a significantly larger proportion than of any other solution concept considered (third panel from the top in Table 5).³⁵

We have also analyzed two-party agreements, even though they were much less frequent than three-party agreements (second panel from the top in Table 5). For two-party agreements, the lexicographic egalitarian solution seems to weakly outperform the other solutions considered.³⁶ The lexicographic egalitarian solution solves the dilemma between efficiency and equality as explained above for the lexicographic equal split. The difference here is that parties apply the notion of equality in terms of differences with respect to gains at disagreement (instead of equality in terms of payoffs). The lexicographic egalitarian solution is by definition stable (or individually rational), hence it satisfies the coalitional constraints. Briefly stated, by looking at two-party agreements we obtain a similar conclusion as before: bargaining parties solve the dilemmas in favor of efficiency and stability (while staying as close to equality as possible).³⁷

When comparing our results with the benchmark from Navarro and Veszteg (2025), where bargaining only involved two parties, we observe that the lexicographic equal-split was the most frequent solution there (bottom panel in Table 5).³⁸ This indicates that, in the 2P treatment, stability concerns were not as important as in our 3P treatment. We note also that equal split is observed more frequently than deal-me-out, another indication that stability was ignored in favor of equality by participants in the 2P treatment. Put it differently, in more populous bargaining problems, stability concerns have an effect on equality. A similar difference, although in a weak form, shows up when we check the proportion of individually rational agreements depending on whether the agreement involves the grand coalition or only two parties. The constraint of individual rationality was respected in 86% of the cases when the grand coalition reached an agreement, but in only 76% of the cases, when it was a two-person coalition. The two-sample test of proportions gives a p -value of 0.05 for this comparison.

Just like for the TU treatments, we have checked and confirmed the robustness of our conclusions by allowing for some errors in the categorization of observed agreements. Refer to Table C.20 in the appendix for details.

Another way to quantify the focality of the theoretical solutions is by considering their predictive power relative to each other (Table 6).³⁹ When a three-person agreement is predicted only by one solution concept, it is by the equal split in 44% of the cases. In this case, however, the NBS stays close behind. When two or more solution concepts coincide, the

³⁵ The two-sample tests of proportions show statistically significant differences (p -value < 0.01) between the constrained lexicographic equal-split and the other solutions, except for lexicographic equal split (p -value = 0.91).

³⁶ Two-sample tests of proportions show that the lexicographic egalitarian performs significantly better than the egalitarian solution (p -value = 0.00), and as well as NBS (p -value = 0.47), KSS (p -value = 0.07), the equal split (p -value = 0.15), the lexicographic equal split (p -value = 0.07), and the constrained lexicographic equal split (p -value = 0.86).

³⁷ We conjecture that, in a two-party agreement, it is easier for the party with a higher disagreement payoff to obtain a deal that is strictly better (as in the lexicographic egalitarian solution) instead of just indifferent (as in the constrained lexicographic equal-split) than in a three-party agreement. For this reason, the lexicographic egalitarian solution is more frequently consistent with the observed two-party agreements than the constrained lexicographic equal split.

³⁸ The two-sample tests of proportions show statistically significant differences (p -value < 0.02) between the lexicographic equal-split and the other solutions, except for NBS (p -value = 0.83) and the constrained lexicographic equal split (p -value = 0.78).

³⁹ Note that rows in Table 6 add up to 100 times the number of predictors, as the same observed agreement might be rationalized by multiple theoretical solutions.

Table 6 Predictive power of theoretical solutions (as a % of all agreements, 3P treatment)

	number of predictors	NBS	KSS	egalitarian	equal split	lexico. egalitarian	lexico. equal split	constr. lexico. equal split	obs.
% of observed agreements with grand coalition									
	0	-	-	-	-	-	-	-	196
	1	33	11	0	44	0	0	11	9
	2	22	22	3	0	3	75	75	32
	3	0	0	0	100	0	100	100	26
	4	89	0	0	11	100	100	100	27
	7	100	100	100	100	100	100	100	24
	obs.	-	-	-	-	-	-	-	314
% of observed agreements with coalitions of 2									
	0	-	-	-	-	-	-	-	16
	1	0	0	0	25	0	75	0	4
	2	40	40	0	60	0	60	0	10
	3	0	0	0	100	0	100	100	1
	4	100	0	0	0	100	100	100	13
	5	100	100	0	0	100	100	100	3
	7	100	100	100	100	100	100	100	16
	obs.	-	-	-	-	-	-	-	63

Note: The number of predictors is the number of theoretical solution concepts considered (0-7) that rationalize a certain set of observed agreements. All numbers are to be interpreted as % except for the number of observations (in absolute terms). NBS = Nash bargaining solution, KSS = Kalai-Smorodinsky solution, DMO = deal-me-out solution, lexico. = lexicographic, constr. lexico. = constrained lexicographic. Rows add up to 100 times the number of predictors, as the same agreement might be rationalized by multiple solutions

lexicographic equal split and the constrained lexicographic equal split perform at least as well as any other solution concept. When it comes to two-person coalitions, it is again the lexicographic equal split that excels. In other words, these numbers add to the robustness of our conclusions reached earlier.

6.3 Coalitional rationality in transferable utility bargaining

The possibility of (utility) transfers enlarges the bargaining set if parties are able to exploit comparative advantages. In our experimental design, with egg transfers happening after the production stage and not being limited by capacity constraints, parties could expand the bargaining set, that is the total number of eggs produced, by allocating hens to the farm with better technology (i.e., 2 eggs per hen, instead of 1) up to its storage capacity.⁴⁰ Transfers then allowed for any desired distribution of eggs.

Result 3 *Relative efficiency is slightly larger when payoff transfers are allowed (TU: 89%) than when they are not (NTU: 85%).*

On average, bargaining agreements included transfers of 53 eggs in one way or another. This number was 66 in bargaining problems between farms with different production technology, and 60 in cases with both technology and storage capacity being different between farms. We not only observe that transfers happened, but also that they increased the overall efficiency of the final agreements. Considering the aggregate probability of winning the monetary prize, as in the end parties bargained about how to distribute winning probabilities between themselves, the TU treatment produced a statistically significantly higher number for the bargaining pair with 72% than the NTU treatment with 67% (p -value = 0.00, two-sample t -test with unequal variances). In terms of relative efficiency, that is the achieved aggregate payoff by the bargaining pair as a percentage of the maximum possible payoff, the TU treatment increased it to 89% from the 85% in the NTU treatment (p -value = 0.00, two-sample t -test with unequal variances). Albeit their statistical significance, the efficiency gains due to transfers are rather small and parties fail to reach the theoretical upper limit.

In summary, participants in our transferable utility design obtained efficiency gains by specialization while distributing equally the number of produced eggs. We conjecture that participants did not fully exploit the efficiency gains (by complete specialization) due to a lack of sophistication: 9 out of the 12 rounds allowed for an efficiency gain of 33% from an equal split of hens. Interestingly enough, the proportion of equal split agreements is significantly larger (43.6%) among fully efficient deals than among inefficient ones (12.1%).

6.4 Coalitional rationality in three-person bargaining

When bargaining involves more than two parties, agreements emerge from a much richer space as they might involve coalitions of different sizes. Our experimental design gave strong incentives to participants to form the grand coalition (including three farms), as 300 physical units (hens) were available to be distributed among three farms, while only 150 in case of agreements with two only. Even in the rounds where at least one party could obtain 90 hens

⁴⁰ The above-described allocation rule leads to the total or ideal amount of eggs that we denoted by M in Appendix A.

Table 7 Observed coalitions (as a % of all observations, treatments 2P and 3P)

coalition size	2P		3P
1	15.83	<0.00	23.37
2 or 3	84.17	>0.00	76.63
2	84.17		12.80
3	-		63.82
grand observations	84.17	>0.00	63.82
	404		377

Note: Comparison signs between the reported numbers correspond to two-tailed statistical tests for the equality of proportions. Numbers as subindices indicate the corresponding *p*-values

at disagreement, the availability of 300 physical units allowed to improve all three parties payoffs from any two-party agreement.⁴¹

Result 4 *The grand coalition is less likely to form with three parties (3P: 64%) than with only two parties (2P: 84%) involved in bargaining.*

In spite of the strong incentives in our bargaining problems in favor of the grand coalition, reaching an agreement among three parties turned out to be significantly more difficult (64%) than reaching one when there were only two parties (84%) around (Table 7). Even reaching any sort of agreement was more challenging in more populous problems. Bargaining broke down more frequently in problems with three bargainers (23%) than with two (16%).

Although the proportion of agreements involving the grand coalition varies from round to round, with round 8 having the lowest (46%) and round 5 the highest (78%), we have not been able to identify any pattern.⁴² Regarding two-person coalitions, it is in round 8 where their proportion is the highest (24%) and in round 1 (2%) where it is the lowest. Yet again, there are no clear patterns arising.⁴³

7 Conclusions

Our experimental results show that there can be much more to bargaining than simply sharing the joint profits in equal ways.

In some settings, bargaining parties might be able to expand the bargaining set and increase those joint profits by considering comparative advantages in an initial *production stage* before they need to agree on how to distribute them in the final *distribution stage*. Our TU treatment created such an environment by instructing participants to allocate physical units (*production*) and specifying payoff transfers (*distribution*). Although participants failed to achieve full

⁴¹ Just like in our other experimental treatments, disagreements led to an even smaller aggregate number of hens across farms.

⁴² Both ANOVA and the Kruskal-Wallis equality-of-populations rank test are unable to reject the null hypothesis when looking at grand coalitions arising across rounds. The *p*-value is 0.14 in both tests.

⁴³ Both Pearson χ^2 and the Kruskal-Wallis equality-of-populations rank test are unable to reject the null hypothesis when looking at the formed coalition sizes (3, 2, or 1) across rounds. The *p*-values are 0.11 and 0.18, respectively.

efficiency in production, they did rely on payoff transfers to redistribute the proceedings. That happened, more often than not, in line with the equal split solution, just like in many other bilateral bargaining settings reported in the literature.

In some other settings, bargaining might involve three (instead of two) parties requiring them to consider not only different distributions of payoffs across all of them, but also possibly different number of parties being involved in the final agreement. Our 3P treatment challenged participants to consider such a *coalition-formation problem* and *payoff-distribution problem* simultaneously. Surprisingly enough, while participants aimed at forming the grand coalition in an overwhelming majority of all cases, the equal split had much weaker power of attraction with three than with two bargaining parties.

In two-person bargaining situations with payoff transfers, participants tend to favor equal splits, even if this results in less efficient outcomes, potentially due to limited cognitive and strategic sophistication. In contrast, three-person bargaining without payoff transfers generally leads to Pareto-efficient and stable agreements, with most participants favoring outcomes that balance equality with efficiency. This suggests that in simpler bargaining situations, efficiency is pursued as long as it does not demand too much sophistication. However, in multilateral settings, stability becomes a critical factor alongside efficiency, unlike in two-person scenarios where it remains a softer constraint.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10888-025-09694-5>.

Acknowledgements Navarro acknowledges financial support from the Institut des Sciences Humaines et Sociales (InSHS) CNRS through the “Soutien à la mobilité internationale 2022” program. She is grateful for the hospitality received from the School of Political Science and Economics and the Office of International Relations at Waseda University. Financial support from Grants-in-Aid for Scientific Research 20K01553 from MEXT and JSPS have made our experimental sessions possible. We are grateful to LEEP (Laboratoire d’Economie Expérimentale de Paris) in Paris 1 (Paris Pantheon-Sorbonne), and especially to Maxim Frolov (Paris School of Economics) for his help and assistance. Comments and suggestions from the editors and an anonymous reviewer on earlier versions have helped us to significantly improve our manuscript.

Author Contributions N.N. and R.F.V. contributed equally to formulating the research questions and designing the laboratory experiment for collecting data. R.F.V. wrote the zTree code for the experimental sessions. The authors wrote and reviewed the manuscript together, although the theoretical analysis was mostly completed by N.N., and the statistical analysis was mostly done by R.F.V.

Data Availability The experimental data collected for and analyzed in this research article are publicly available with the help of the following identifier: [10.17605/OSF.IO/8UAE9](https://doi.org/10.17605/OSF.IO/8UAE9)

Declarations

Competing Interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Anbarci, N., Feltovich, N.: How sensitive are bargaining outcomes to changes in disagreement payoffs? Experiment. Econ. **16**, 560–596 (2013)
- Anbarci, N., Feltovich, N.: How fully do people exploit their bargaining position? The effects of bargaining institution and the 50–50 norm. J. Econ. Behav. Organiz. **145**, 320–334 (2018)
- Binmore, K.: Bargaining and fairness. Proceed. National Acad. Sci. United States of America **111**(3), 10785–10788 (2014)
- Binmore, K., Morgan, P., Shaked, A., Sutton, J.: Do people exploit their bargaining power? An experimental study. Games. Econ. Behav. **3**, 295–322 (1991)
- Binmore, K., Osborne, M.J., Rubinstein, A.: Noncooperative models of bargaining. In: Aumann, R.J., Hart, S. (eds.) Handbook for Game Theory with Economic Applications, North-Holland Amsterdam: **1**, 179–225, (1992)
- Binmore, K., Shaked, A., Sutton, J.: Testing noncooperative bargaining theory: A preliminary study. American Econ. Rev. **75**, 1178–80 (1985)
- Binmore, K., Shaked, A., Sutton, J.: The outside option experiment. The Quart. J. Econ. **104**, 753–770 (1989)
- Chun, Y., Peters, H.J.M.: The lexicographic egalitarian solution. Cahiers du CERO **30**, 149–156 (1988)
- Chun, Y., Peters, H.J.M.: Lexicographic monotone path solutions. O.R. Spektrum **11**, 43–47 (1989)
- Dutta, B., Ray, D.: A concept of egalitarianism under participation constraints. Econometrica **57**(3), 615–635 (1989)
- Dutta, B., Ray, D.: Constrained egalitarian allocations. Games. Econ. Behav. **3**, 403–422 (1991)
- Fischbacher, U.: z-Tree: Zurich toolbox for ready-made economic experiments. Experiment. Econ. **10**, 171–178 (2007)
- Friedman, D., Sunder, S.: Experimental methods: A primer for economists. Cambridge University Press, Cambridge (1994)
- Galeotti, F., Montero, M., M., Poulsen, A.: Efficiency versus equality in bargaining. J. European Econ. Ass. **17**(6), 1941–1970 (2019)
- Greiner, B.: Subject pool recruitment procedures: organizing experiments with ORSEE. J. Econ. Sci. Ass. **1**, 114–125 (2015)
- Güth, W., Schmittberger, R., Schwarze, B.: An experimental analysis of ultimatum bargaining. J. Econ. Behav. Organiz. **3**, 367–388 (1982)
- Güth, W., Kocher, M.G.: More than thirty years of ultimatum bargaining experiments: Motives, variations, and a survey of the recent literature. J. Econ. Behav. Organiz. **108**, 396–409 (2014)
- Imai, H.: Individual monotonicity and lexicographic maximin solution. Econometrica **51**, 389–401 (1983)
- Kalai, E.: Proportional solutions to bargaining situations: Interpersonal utility comparisons. Econometrica **45**(7), 1623–1630 (1977)
- Kalai, E., Smorodinsky, M.: Other solutions to Nash’s bargaining problem. Econometrica **43**, 513–518 (1975)
- Karagözoğlu, E.: On “going unstructured” in bargaining experiments. In: Laslier, J.F., Moulin, H., Sanver, M., Zwicker, W. (eds.) The future of economic design. Springer, Studies in Economic Design (2019)
- Malouf, M.W.K., Roth, A.E.: Disagreement in bargaining: an experimental study. J. Conflict. Resol. **25**, 329–348 (1981)
- Myerson, R.B.: Game theory: Analysis of conflict. Harvard University Press (1991)
- Nash, J.: The bargaining problem. Econometrica **18**(2), 155–162 (1950)
- Navarro, N., Veszteg, R.F.: On the empirical validity of axioms in unstructured bargaining. Games. Econ. Behav. **121**, 117–145 (2020)
- Navarro, N., Veszteg, R.F.: On welfarism and scale invariance: What do bargainers bargain about? J. Econ. Behav. Organiz., forthcoming (2025)
- von Neumann, J., Morgenstern, O.: Theory of games and economic behavior, 1st ed., 1947 2nd ed., 1953 3rd ed., 2020 60th Anniversary Commemorative ed., Princeton University Press (1944)
- Nydegger, R.V., Owen, G.: Two-person bargaining: An experimental test of the Nash axioms. Int. J. Game Theory **3**, 239–249 (1974)
- Peters, H.J.M., Tijs, S.H.: Individually monotonic bargaining solutions for n -person bargaining games. Method. Operation. Res. **51**, 377–384 (1984)
- Roth, A.E.: Axiomatic models of bargaining. Springer-Verlag, Berlin Heidelberg (1979)
- Roth, A.E.: Bargaining experiments. In: Kagel, J.H., Roth, A.E. (eds.) The handbook of experimental economics. Princeton University Press (1995)
- Roth, A.E., Malouf, M.W.K.: Game-theoretic models and the role of information in bargaining. Psych. Rev. **86**, 574–94 (1979)
- Roth, A.E., Malouf, M.W.K.: Scale changes and shared information in bargaining: An experimental study. Math. Soc. Sci. **3**, 157–177 (1982)

- Roth, A.E., Malouf, M.W.K., Murnighan, J.K.: Sociological versus strategic factors in bargaining. *J. Econ. Behav. Organiz.* **2**, 153–177 (1981)
- Roth, A.E., Murnighan, J.K.: The role of information in bargaining: An experimental study. *Econometrica* **50**, 1123–1142 (1982)
- Takeuchi, A., Veszteg, R.F., Kamijo, Y., Funaki, Y.: Bargaining over a jointly produced pie: The effect of the production function on bargaining outcomes. *Games. Econ. Behav.* **134**, 169–198 (2022)
- Thomson, W.: Bargaining and the theory of cooperative games: John Nash and beyond. Introduction. In: Thomson, W. (ed.) *Bargaining and the theory of cooperative games: John Nash and beyond*. MA, Edward Elgar Publishing Ltd, Camberly, Northampton (2010)
- Thomson, W.: On the axiomatic theory of bargaining: a survey of recent results. *Rev. Econ. Design* **26**, 491–542 (2022)

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.