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## On welfarism and scale invariance: What do bargainers bargain about?

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### ABSTRACT

We experimentally test welfarism and scale invariance, two prominent simplifying assumptions that are often used to characterize bargaining solutions in theoretical models. Our study relies on a context-rich bargaining environment and varies the parameters of the bargaining problem along with the information that bargaining parties have about each other. Under the auxiliary assumption of selfishness, it aims at understanding whether bargaining is guided by abstract utilities as assumed by the classic version of cooperative bargaining theory or rather by comparisons in observables (e.g., money) as often assumed by behavioral models of decision-making. The experimental results show that welfarism and scale invariance are supported when the relevant information is only privately known. In general, bargaining outcomes are robust to rescaling that only affects the anchoring points of the utility scale (welfarism), but not to rescaling that affects the units on the utility scale (scale invariance). Overall, our experimental data deliver scarce empirical support to classic theoretical bargaining solutions based on abstract utility units.

### 1. Introduction

For they are so much in line with the workhorse theoretical model and the assumptions on which neoclassical economics is built, welfarism and scale invariance are often overlooked as innocuous properties imposed on solutions for the bargaining problem. They have been present since the early attempts at creating a theoretical model that would explain and even predict bargaining agreements (von Neumann and Morgenstern (1944), Nash (1950), for a review see Thomson (1994)). Indeed, the starting point of the typical bargaining model is to assume that bargaining parties, as any other decision-maker in neoclassical microeconomics, have preferences over (the consequences of) all possible agreements and that those preferences can be represented by means of a utility function.

Think about some of the bargaining situations that you face in your everyday life. For example, maybe you wish to organize some out-of-work activities with your coworkers, such as a soccer game. For that to happen, you will need to find an agreement regarding the frequency (weekly, once a month, only once), the location (paid or not, indoor or outdoor), the individual payment shares for the equipment, etc. Although each of these elements are well defined in some physical units, they could imply different commuting times, different levels of enjoyment, and different levels of monetary burden on each of the parties involved. Or imagine that you are hiring someone to design a new website for your business. You will need to reach an agreement regarding the website's features (general aesthetic, whether to allow for features like client accounts and online orders or not) and the price (by the hour worked or as a package deal, including the specified list of provided services for a fixed price). In both examples, bargaining and the final

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agreement are very likely to happen in terms of observable features and well-defined physical units. In contrast, the agreements that are acceptable to you and the other parties will depend on how each of you evaluate the combination of items that those agreements entail. They are going to depend on individual preferences.

In cooperative bargaining theory, the result of bargaining (the bargaining outcome) is determined by a rule (a bargaining solution) that is acceptable to both parties. Such a rule usually depends on the bargainers' preferences and it describes the bargaining outcome in terms of utilities obtained by the bargainers. As utilities are assumed to be common knowledge and well-behaved functions, the bargaining problem can then conveniently be reduced to an interaction in terms of utilities. Put differently, theory solves the bargaining problem in utilities, and offers the same solution to all bargaining problems that are identical when formulated in utilities. This (hidden) assumption behind the model of bargaining is referred to as (simple) welfarism (Roemer, 1990) or the welfarist axiom (de Clippel, 2015).

When it comes to applied and empirical work, however, relying on the utility representation of preferences is not without problems. On the one hand, utility functions are not uniquely defined. On the other hand, utility functions are not directly observable or even measurable. In the absence of reliable estimates for them, simplifying assumptions are needed to give empirical relevance to the theoretical model. In a sense, scale invariance is a natural property to pair up with welfarism, as it compensates for the shortcomings of the model.<sup>1</sup>

The axiom of scale invariance was presented as a natural property of a bargaining solution in the original propositions by Nash (1950) and Kalai and Smorodinsky (1975). Intuitively, this property requires that as long as the set of feasible agreements is unaltered, the bargaining agreement should not be affected by changes in the utility representation provided those are affine mathematical transformations.<sup>2</sup> For instance, a specific attitude to risk "fixes" the shape of the utility function, and scale invariance in turn makes sure that changes in scale are irrelevant to the bargaining outcome. In this case, not only bargaining could then happen in observables (e.g., natural units of the good, monetary units, expected gains), but those observables serve as reliable proxies for the decision-makers utilities. Thus, scale invariance circumvents two important problems: the theoretical indeterminacy of utility representation and the empirical unobservability of utilities. All this, however, comes at a high price. Paired with the welfarist axiom, scale invariance imposes too much structure and makes the bargaining solution irresponsive to changes in the bargaining environment that many people would consider as relevant and would want to adjust the bargaining solution accordingly.

Nash's cooperative bargaining model has received strong criticism from inside neoclassical theory for relying on the assumptions of welfarism (Roemer, 1988, 1990) and scale invariance (Rubinstein et al., 1992). In contrast, behavioral economics seems to have accepted the welfarist axiom and the simplifying assumption of scale invariance.<sup>3</sup> Although it has criticized the neoclassical model for imposing the axiom of selfishness, behavioral economics ended up incorporating insights from psychology into the neoclassical model without changing its very basic "maxU" structure. That is, the decision-maker of behavioral economics is still represented by a utility function — to be maximized. Its main argument merely emphasizes that utility functions might incorporate elements other than personal gains. This approach is in line with the neoclassical model in that the utility representation of the underlying preferences is all one needs to know about the decision-maker in order to describe her behavior.<sup>4</sup>

Using the experimental approach, our goal in this paper is to test welfarism and to better understand the limits of scale invariance as a simplifying assumption in a welfarist, selfish model of bargaining. Put differently, we wish to understand whether bargaining is guided by utilities as assumed by the classic version of cooperative bargaining theory or possibly by comparisons in observables (e.g., money) as often assumed by behavioral models of decision-making. In terms of the correct application of theory – in particular, the correct use of scale invariance as an assumption – it makes a difference whether the solution is invariant to changes in utility scales, or to changes in monetary scales, or to changes in the physical units the good is measured in, or to changes in all the aforementioned.

Our experimental design relies on binary lottery games introduced by Malouf, Murningham, and Roth in a series of experiments (Roth and Malouf, 1979, 1982; Malouf and Roth, 1981; Roth and Murnighan, 1982). Each bargainer faces a binary lottery with only two possible outcomes: a monetary prize with the probability given by the bargaining agreement, or nothing with the remaining probability. Bargaining determines the distribution of lottery tickets. According to the expected utility theory (von Neumann and Morgenstern, 1944), the bargainer's utility from any agreement equals the induced (or implied) probability of obtaining the prize

<sup>1</sup> The cooperative theory of bargaining assumes that all we need to know to solve the bargaining problem (and predict its outcome) are the bargainers' utility functions which represent their preferences over the set of feasible outcomes and the disagreement outcome. Essentially, this is welfarism. Recall, however, that the utility representation of preferences is not unique. Now if the solution to the model depends on which utility representation is used to describe the underlying bargaining problem, we have vacuous predictions. Imposing scale invariance circumvents this trouble by making the solution immune to (at least certain) changes in the utility representation.

<sup>2</sup> An affine transformation of a von-Neumann–Morgenstern utility function represents the same preferences. As long as preferences admit a von-Neumann–Morgenstern utility representation and remain unaltered, scale invariance guarantees that the bargaining agreement is immune to affine changes in the utility representation.

<sup>3</sup> For example, following Nash's original approach, Anbarci and Feltovich (2013) and Birkeland and Tungodden (2014) incorporate social preferences into the Nash product and define the bargaining solution as its maximum point.

<sup>4</sup> Although she might care about fellow citizens and have exotic preferences, the decision-maker of behavioral economics is still represented by a utility function – to be maximized (for models of social preferences, refer to Fehr and Schmidt (1999), Bolton and Ockenfels (2000), Charness and Rabin (2002)). The roots of the above-described approach to human behavior are deep enough to have withstood the forces of the so-called behavioral critique which promised a more realistic model of human decision-making. Note that, by "generalizing" the decision-makers' utility function through incorporating sufficiently many variables in it, one might even rule out the possibility of a conflict of interest. When bargaining parties' interests are totally in line with each other, bargaining agreements can be reached by unanimity. In other words, incorporating social preferences into the model risks "solving" the bargaining challenge by simply eliminating it.

in such an agreement.<sup>5</sup> We adopt this basic design element and propose a context-rich bargaining environment following the design by Navarro and Veszteg (2020).<sup>6</sup> Participants are owners of imaginary farms where hens produce eggs to cater a received order. The number of eggs delivered then determines the probability of obtaining a monetary prize. We vary the bargaining parties' outside options, their farm's productivity and storage capacity, and the monetary prizes. We also make use of different informational treatments ranging from full information, where bargainers know each other's characteristics, to hidden information, where bargainers know only their own characteristics and the outside options.

Under the auxiliary assumption of selfishness and expected utility, scale invariance paired with welfarism requires that neither monetary prizes (the extremes of the utility scale) nor the probability with which they are realized (the units of the utility scale) have an effect on the bargaining outcome. Although they are tightly related, for clarity in the presentation of our results, we are going to refer to the irresponsiveness of bargaining outcomes to changes in monetary prizes as welfarism, and to the irresponsiveness of bargaining outcomes to changes in probability scales as scale invariance.<sup>7</sup>

Our experimental results show that monetary prizes – that identify the extremes of the theoretical utility scales – do not have a significant effect on bargaining agreements (even when they constitute public information). On the other hand, hen productivity – that indirectly specifies the units on the utility scale – has a significant (and negative) effect on agreements when known by both bargaining parties. Farmers with more productive hens tend to obtain a smaller number of hens.

In clear contrast to earlier findings (Roth and Malouf, 1982), we find that bargaining parties are not guided by expected monetary gains.<sup>8</sup> Besides the effect of the variables directly linked to welfarism and scale invariance, we find that outside options and storage capacity act as constraints imposing upper and lower limits on the bargaining outcome, respectively. Agreements are more frequent (and vary much less) when the equal split (with respect to hens or with respect to the probability of obtaining the monetary prize) does not enter into conflict with any of the constraints. When in conflict, about half of the bargaining pairs ignored individual rationality and settled for agreements where one of the bargainers obtained less than their outside option. This contrasts the effect of the storage capacity constraint, which is externally imposed and was nearly always respected by bargainers. That agreements almost always respect capacity constraints while individual rationality is often violated suggests that bargainers have preferences for efficiency. Recall that ignoring the hard constraint of storage capacity implies that some eggs are lost. Ignoring the soft constraint of individual rationality simply leads to a different distribution of the available resources. These results are in line with previous experimental findings: the trade-off between efficiency and equality (Galeotti et al., 2019), and the focality of equal split when in conflict with individual rationality (Anbarci and Feltovich, 2018).

## 2. Related literature

Compared to the early works by Nydegger and Owen (1974) and Roth and co-authors, who were the first to test scale invariance in the experimental laboratory, we also test welfarism. That is a fundamental assumption behind cooperative models, related to the formulation of bargaining in terms of utilities, with scale invariance being its natural companion property. In other words, we try to find a proxy for utility among the myriad of layers or dimensions typically found in real-world bargaining situations.

Our research is closely related to those early, and nearly forgotten papers. The first volume of the Handbook of Experimental Economics (Kagel and Roth, 1995) only dedicates two pages to the above-mentioned experiments on unstructured bargaining before turning to structural models and experiments (based on sequential bargainings) that have dominated the literature since the early '80s. The early papers were “focal point” experiments looking at bargaining agreements and started an *unfinished drama* between “game theory purists” and “social norm purists” (Roth, 1995, pp. 254–256). In our paper, we also look at agreements and test the focality of the equal split agreement, but we do so with the help of a much richer experimental design that incorporates more layers of complexity in the bargaining problem and is able to create – in multiple ways – more unequal environments than the earlier designs. For the exact same reason, we are able to simultaneously test more possible theoretical solutions (and axioms).<sup>9</sup> Also, we do not believe that all that *drama* must exist between “game theory purists” and “social norm purists”. On the one hand, it is enough to look at a different kind of theory: cooperative game theory. On the other, there is no need to abandon the assumption of self-regarding preferences even if we wish to incorporate fairness considerations in the theoretical model. Cooperative bargaining theory does exactly that when proposing a certain solution to the problem, instead of writing the problem in a way (e.g., by resorting to the idea of social preferences) that eliminates part of the conflict among bargaining parties right at the beginning.

Our experimental results contribute to some sort of an *experimental* Nash program. While the so-called Nash program in game theory aims at bridging the gap between the cooperative approach and the non-cooperative approach, its empirical version aims at

<sup>5</sup> The use of binary lotteries is motivated by Nash's original description of the bargaining model in terms of “anticipations” (Nash, 1950) and also by the subsequent theoretical work exploring the model (e.g., Roemer (1988, 1990), Rubinstein et al. (1992)). Also note that it is implicitly assumed here that bargainers strictly prefer more money to less, i.e., bargainers' preferences are not satiated in money. This is in line with the standard assumptions on money as a reward used in the experimental laboratory (Smith, 1982).

<sup>6</sup> The context used is only to facilitate comprehension of an otherwise rather complex laboratory environment by experimental participants.

<sup>7</sup> The alternative would be to refer to both robustness properties as scale invariance and consider welfarism as a “hidden axiom” of the bargaining model written in terms of utilities.

<sup>8</sup> We wish to mention that the experimental results summarized by Büyükboyacı (2007), although statistically underpowered, also support welfarism. Her design is based on non-monetary rewards (chocolate bars and cans of tuna) and does not aim at investigating scale invariance.

<sup>9</sup> Even if we focus on the research questions that we share with the early literature, we find that the experimental results might differ. For instance, in contrast to Roth and Malouf (1979), we do not find that bargaining agreements aim at equating expected monetary gains.

validating theory at its different stages through observing human decision-making in the experimental laboratory.<sup>10</sup> Among the many contributions to this experimental Nash program, we find research that tests the empirical validity of a certain solution, research that tests the empirical validity of well-known properties or axioms, and research that compares different strategic characterizations (i.e., game forms) leading to the same solution. In the first two cases, the interaction among participants in the laboratory is typically unstructured, while in the third case, it is typically structured (based on the game forms to be tested). The experimental Nash program is more than fifty years old, and it has experienced a dramatic increase in the number of contributions during the last decade. The list of early works looking for empirical evidence in support of the Nash bargaining solution and some of its properties in unstructured environments include Nydegger and Owen (1974), Roth and Malouf (1979, 1982), Roth and Murnighan (1982), and Roth et al. (1981), to name a few. The recent stream of the literature – with Anbarci and Feltovitch (2013, 2018), Banerjee (2020), Navarro and Veszteg (2020), and Takeuchi et al. (2022) – constitutes a fresh attempt at testing empirically the properties of bargaining outcomes in unstructured environments.<sup>11</sup> This recent stream also aims at testing the Nash program directly. For instance, Navarro and Veszteg (2011) and Chessa et al. (2023) have taken two strategic characterizations (or game forms) that yield the Shapley value as a theoretical equilibrium to the experimental laboratory.

### 3. Experimental design

Participants in our experiment were requested to bargain in pairs about how to distribute a fixed number of fictitious goods (150 hens) between themselves. The same amount of those goods, however, could produce different amounts of monetary gains (eggs sold on a fictitious market) due to exogenously given and fixed circumstances (farm characteristics). Our experimental design relies on expected utility-theory to make sure that bargaining happens in utilities. The way to achieve that is to make parties bargain over probabilities to gain a certain fixed monetary prize, with probabilities that are proportional to the number of eggs produced on one's farm (von Neumann and Morgenstern, 1944; Roth and Malouf, 1979, 1982; Malouf and Roth, 1981), (Roth and Murnighan, 1982). The three interconnected layers (hens, eggs, money) meshed into our bargaining problems, together with a *meaningful context* of imaginary farms, create a rich environment that resembles real-world conflicts.

Each participant was requested to consider 12 bargaining problems together with a randomly assigned partner. 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 the specified amount of money in the round. Producing that much, however, was not always possible. In that case, participants could still earn the same specified amount of money, but not for sure. The probability of earning the fixed monetary prize was computed as (number of eggs produced)/300, or in more detail as  $\frac{1}{300} \cdot \min\{(\text{eggs per hen}) \cdot (\text{hens}); \text{storage capacity}\}$ .

Our experimental sessions fall into one of three categories depending on the amount of information bargaining parties had about the characteristics of the partner's farm and whether the monetary prizes that participants could earn were equal or not. We shall refer to these categories as treatments.

- In the FULL-E treatment, participants were informed about the characteristics of their partner's farm, and monetary prizes were equal between bargaining parties (although varied from round to round).
- In the FULL-U treatment, participants were informed about the characteristics of their partner's farm, and monetary prizes were unequal between bargaining parties (and varied from round to round).
- In the HIDDEN-U treatment, participants were not informed about the characteristics of their partner's farm, but they did receive information about the partner's outside option. Monetary prizes were unequal between bargaining parties (and varied from round to round).

Recall that the typical cooperative model of bargaining allows for asymmetries between the decision-makers, but assumes full information. One of the problems of welfarism (i.e., simplifying the bargaining interaction as one in terms of utilities) is that utility functions in real-world bargaining situations are not known by participants (or observable by the experimenter).<sup>12</sup> In the example described earlier, where bargaining takes place between you and a professional website designer, if you do not know your counterpart's personally, it is not possible for you to know their preferences over time, effort, and money. They hopefully know

<sup>10</sup> The cooperative or axiomatic approach in game theory consists of (i) defining a solution and (ii) identifying the set of characteristics that are jointly and uniquely satisfied by the previously defined solution (axiomatic characterization). The non-cooperative or strategic characterization of a solution implies constructing a non-cooperative game that yields the proposed solution as the equilibrium outcome.

<sup>11</sup> Refer to Karagözoğlu (2019) for an exhaustive review of the revival of unstructured bargaining in the experimental laboratory.

<sup>12</sup> The assumption of common knowledge of utility functions is shared by all games of complete information, as Nash's bargaining model is: "participants have full knowledge of each others' tastes and preferences" (Nash, 1950, p. 155).

**Table 1**  
Bargaining round characteristics.

		unequal		equal				unequal		equal		
		Farm 1	Farm 2	Farm 1	Farm 2			Farm 1	Farm 2	Farm 1	Farm 2	
round 1	monetary prize	15	60	15	15	round 7	monetary prize	60	15	15	15	
	eggs per hen	1	1	1	1		eggs per hen	2	1	2	1	1
	egg storage capacity	300	300	300	300		egg storage capacity	210	300	210	300	300
	outside option (hens)	30	30	30	30		outside option (hens)	90	30	90	30	30
round 2	monetary prize	60	15	60	60	round 8	monetary prize	60	15	60	60	
	eggs per hen	1	2	1	2		eggs per hen	1	2	1	2	
	egg storage capacity	300	300	300	300		egg storage capacity	45	300	45	300	
	outside option (hens)	30	30	30	30		outside option (hens)	30	90	30	90	
round 3	monetary prize	60	15	60	60	round 9	monetary prize	15	60	15	15	
	eggs per hen	1	2	1	2		eggs per hen	1	2	1	2	
	egg storage capacity	75	300	75	300		egg storage capacity	105	300	105	300	
	outside option (hens)	30	30	30	30		outside option (hens)	90	30	90	30	
round 4	monetary prize	60	15	60	60	round 10	monetary prize	60	15	15	15	
	eggs per hen	2	1	2	1		eggs per hen	2	1	2	1	
	egg storage capacity	300	300	300	300		egg storage capacity	90	300	90	300	
	outside option (hens)	90	30	90	30		outside option (hens)	30	90	30	90	
round 5	monetary prize	60	15	60	60	round 11	monetary prize	15	60	15	15	
	eggs per hen	1	2	1	2		eggs per hen	1	1	1	1	
	egg storage capacity	300	300	300	300		egg storage capacity	300	300	300	300	
	outside option (hens)	90	30	90	30		outside option (hens)	90	30	90	30	
round 6	monetary prize	15	60	60	60	round 12	monetary prize	60	15	15	15	
	eggs per hen	2	1	2	1		eggs per hen	1	1	1	1	
	egg storage capacity	150	300	150	300		egg storage capacity	75	300	75	300	
	outside option (hens)	30	30	30	30		outside option (hens)	30	30	30	30	

what they prefer but they would probably not know what a utility scale is or how to express their preferences on one. Therefore, if we want to use a theory of bargaining – embedded into the different solutions proposed by the axiomatic approach – to organize the data, we need to know which layer of the real-life bargaining situation is guiding bargainers’ choices, and whether that layer is observable by both bargaining parties or not.<sup>13</sup>

Table 1 lists the values for all the relevant farm characteristics across the 12 bargaining rounds included in our experimental design. The order of the 12 bargaining rounds is fixed in our experimental design. Note, however, that order does not follow any specific pattern. The bargaining problems are not changing in their complexity throughout the sequence, nor they involve more or less asymmetries in any particular way.

Although our aim of testing welfarism and especially scale invariance implies that different bargaining problems (i.e., bargaining rounds) are to be construed as different treatments, and the characteristics of those problems as treatment variables, our strategy of testing welfarism also requires information to be treated as a treatment variable. Fixing the order of bargaining problems is a compromise which we have carefully considered. Note that it increases the experimental control for comparisons across informational treatments, although it does come at the cost of possible order effects across bargaining rounds.

### 3.1. Welfarism and scale invariance

Each bargaining pair in our experimental design is bound to consider how to distribute some goods (imaginary hens), while the cooperative model of bargaining assumes that bargaining parties are guided by utilities that are all that is needed to define the entire problem of bargaining. This is the so-called welfarist approach discussed in the introduction. Although there does not exist a universal scale for measuring utility, our experimental design allows for a simple and straightforward utility representation based on selfishness and von-Neumann–Morgenstern expected utility theory.

Recall that each bargainer faces a binary lottery according to which they can earn a fixed monetary prize with a probability that is proportional to the number of physical units (i.e., imaginary hens) that they obtain or receive nothing. In their famous theorem, von Neumann and Morgenstern showed that if the decision-maker’s preferences over lotteries satisfy a specific list of axioms then (i) for each lottery, no matter how complex, we can find a binary lottery between the best possible outcome and the worst possible outcome that makes the decision-maker indifferent, and (ii) the probability of obtaining the best outcome in those binary lotteries (over the worst and the best outcome) is a utility scale representing preferences over those binary lotteries.<sup>14</sup>

<sup>13</sup> For simplicity and due to budget constraints, our design only incorporates one HIDDEN treatment. Theoretically and even empirically it should not matter for the bargaining outcomes whether monetary prizes are symmetric or not. We have decided to implement the HIDDEN-U treatment, and not a HIDDEN-E treatment. The reason behind that choice is that if, for whatever behavioral reason and/or due to parties revealing their private information through chat messages to their bargaining partner, monetary prizes affect the bargaining outcomes, they should have a stronger impact when they are unequal across decision-makers (than when they are equal).

In our experimental design, each possible distribution of hens between the two bargaining parties induces a binary lottery over two outcomes: a monetary prize with probability  $p$ , and obtaining nothing with the remaining probability  $(1 - p)$ . If experimental participants prefer obtaining the prize to not obtaining it irrespectively of whether the participant they are matched to is obtaining it or not, then the utility of the lottery (prize,  $p$ ; no prize,  $1 - p$ ) is simply the probability  $p$ . Formally,

$$u(\text{prize}, p; \text{no prize}, 1 - p) = p.$$

Note that the above utility representation incorporates a normalization. Given that obtaining the prize with certainty corresponds to a probability of 1, we have that  $u(\text{prize}, 1; \text{no prize}, 0) = u(\text{prize}) = 1$ . Similarly, as the probability of not obtaining the prize with certainty is 0,  $u(\text{prize}, 0; \text{no prize}, 1) = u(\text{no prize}) = 0$ .

It is well known that preferences of the von-Neumann–Morgenstern type can be represented by any other utility function,  $v$ , as far as this other utility function is an increasing affine transformation of  $u$  defined above. In particular, we recover the more intuitive expression of

$$v(\text{prize}, p; \text{no prize}, 1 - p) = p \cdot v(\text{prize}) + (1 - p) \cdot v(\text{no prize}),$$

where  $v(\text{prize})$  and  $v(\text{no prize})$  are the utility of obtaining the prize with certainty and the utility of not obtaining the prize with certainty, respectively.<sup>15</sup> Note that the utility scale under certainty is not unique either (any monotone increasing transformation of a utility function is also a utility function representing the same preferences), which makes this second specification for a utility function dependent on the utility scale under certainty. Note that any function yielding  $v(\text{prize}) > v(\text{no prize})$  is a utility scale that represents preferences under certainty. On the contrary, the probability of the best possible outcome is a commonly observable and comparable utility scale.

Based on the above, the utility of owning  $h$  hens in our experimental design is simply the probability  $p_h$  that makes the decision-maker indifferent between having  $h$  hens on her farm and a lottery that pays the monetary prize with probability  $p_h$  (and pays nothing with probability  $1 - p_h$ ):  $h \sim (\text{prize}, p_h; \text{no prize}, 1 - p_h)$ . Furthermore, as each farmer in the experiment receives an order of 300 eggs and has a storage capacity of  $c$  eggs, the probability of winning the prize when one owns  $h$  hens on a farm where each hen lays  $\gamma$  eggs is  $\gamma \cdot h/300$ , provided the number of eggs can be stored, that is  $\gamma h \leq c$ . This then leads to  $u(h) = p_h = \frac{\min\{\gamma h, c\}}{300}$ .

This simple result indicates that we have several possible proxies for utility functions in our experimental design. Notably, (i) the probability of obtaining the prize (which is a function of the number of eggs), and (ii) the expected prize (i.e., the probability of obtaining the prize multiplied by the prize).

Assume now that the bargaining outcome is theoretically embedded in a solution concept (that depends on utilities). If that solution concept is scale invariant, doubling the number of eggs each hen lays or increasing the amount of the prize should have no effect on the (observed) bargaining outcome. If, on the contrary, the bargaining outcome is not scale invariant, we would expect bargainers to reach agreements that aim at reducing differences in utility, due to the focality of equal split in previous experiments. When that is the case and bargainers in our experiment are using probability as their proxy for utility, then the farmer with more productive hens should obtain a smaller number of hens when all other characteristics remain constant. Alternatively, if bargainers in our experiment are using the expected prize as their proxy for utility, then the farmer obtaining a higher prize should obtain a smaller number of hens when all other characteristics remain constant.

Before closing this section, a comment is in order. Even if preferences are not of the von-Neumann–Morgestern type, our design is still coherent whenever bargainers' preferences satisfy monotonicity with respect to (first-order) stochastic dominance (Machina and Schmeidler, 1992, p.754).<sup>16</sup> Extending the intuition behind the use of binary lotteries to induce preferences in early experiments on bargaining (e.g., Roth and Malouf (1979)), Hossain and Okui (2013) show that binary scoring rules can be used as long as decision-makers prefer maximizing the larger of two possible rewards. They underline that, while this still assumes probabilistic sophistication, “[m]any non-expected utility theories, such as the ones suggested by Machina (1982) or the rank-dependent expected utility theory of Quiggin (1982) satisfy this property”. Hossain and Okui (2013) also present experimental results supporting the theoretical claims (in contrast to reports by Selten et al. (1999)). In these cases, however, the test implemented by our experimental design is to be interpreted as a test of monotonicity with respect to stochastic dominance (in a bargaining setting) rather than a test of welfarism.

#### 4. Experimental procedures

Our experimental sessions involved 242 participants (61% female, 41% students, with an average age of 32.9) and took place at LEEP, Paris 1 University (Paris, France) between December 6, 2021 and February 15, 2022, and between January 23 and 25, 2023.<sup>17</sup> The 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 pairs and played 12

<sup>14</sup> The proposed list of axioms are completeness, transitivity, continuity, and substitution or independence. A concise description of this famous theorem can be found in Kreps (1988). In particular, refer to the proof of Lemma (5.6) on pages 46 to 48.

<sup>15</sup> Indeed, it is easy to check that  $v = au + b$ , where  $a = v(\text{prize}) - v(\text{no prize})$  and  $b = v(\text{no prize})$ .

<sup>16</sup> We thank an anonymous referee for pointing out the generality of our experimental design in this direction.

<sup>17</sup> 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.7 in the appendix.

rounds of bargaining. Our observations stem from a sample of volunteer participants who received monetary performance-dependent compensation for participation.<sup>18</sup> We used stranger matching, so each round of bargaining occurred with a new randomly and anonymously assigned partner. 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 questions of a survey at the end of the session before privately receiving their earnings in cash.<sup>19</sup> The experimental sessions lasted for about 90 min. Participants were paid privately in cash at the end of each experimental session. The average earning was 25.5 euros, including a 10 euro show-up fee.

At the beginning of each round, participants were informed about the characteristics of their own farm and, in the full-information treatments, also of those of the opponent. 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 earnings and their opponent's for any hypothetical agreement. In the hidden-information treatment the simulation table only showed results based on the information available to the decision-maker.

## 5. Results

Overall, bargaining pairs across the three treatments and 12 rounds in our experiment reached an agreement in 82% of the cases, with 96% of those agreements being efficient. Most of the agreements were individually rational (80%) and symmetric, when applicable (83% in period 1, FULL-E). The proportion of agreements seems to be lower in the FULL-U treatment than in the other two treatments, but the differences are not statistically significant.<sup>20</sup> In any case, round number 7 was the one with the lowest frequency of agreement both in FULL-E and HIDDEN-U, while it has the second lowest frequency of agreements in the FULL-U treatment. Round 7 is also the round with lowest frequency of agreements when we consider all treatments together. In addition, it is worth noting that round 7 is the only round where all agreements are efficient independently of the treatment. These results are in line with results reported by Navarro and Veszteg (2020) for the Paris subsample, where participants had more difficulties reaching an agreement in rounds with more asymmetry between the two parties. Differences in outside options, especially when paired with differences in productivity and/or in capacity constraints, can create challenging bargaining situations in which an equal split would not yield an individually rational agreement (to one of the bargaining parties).<sup>21</sup>

Individual rationality shows large variations across rounds or bargaining situations, but the proportion of agreements and their symmetry are much more stable. Except for the unexpectedly low proportion (48%) of agreements in round 1 in treatment FULL-U, these results are consistent with findings reported by Navarro and Veszteg (2020).<sup>22</sup>

Regarding the fixed order of bargaining rounds, the regression results presented in the appendix (numerical columns 1, 3, and 5 in Table B.10) suggest that no systematic bias is present in our data. Agreements are not significantly more or less likely to arise for certain specific combinations of the characteristics of the bargaining problem. Time (proxied by the round number) does show up as a statistically significant regressor, hinting towards some slight positive learning trend that makes agreements more likely to happen. Note, however, that the effect size of the time regressor is very small, with odds ratios close to 1.

The very same logistic regressions results indicate that we are unable to offer a general explanation for why exactly bargaining failed in the 18% of all cases except for a possible weak time trend. Recall that participants' final earnings were determined by a random draw (from the sequence of 12 rounds) at the very end of each experimental session. That feature of the experimental design aims at reducing potential income effects that could have also induced some order effect. Even if we look at the two possible ways of not reaching an agreement (running out of time, and abandoning the negotiation early), the regression results (numerical columns 2, 4, and 6 in Table B.10) are unable to identify a significant and systematic pattern.

### 5.1. Welfarism and scale invariance

Welfarism implies that the monetary prize should have no effect on the agreement (expressed in number of hens), while the theoretical property of scale invariance implies invariance with respect to the egg-productivity technology. To test these, we regress the observed efficient agreements on the characteristics of the bargaining situation, separately so for the two informational

<sup>18</sup> For further details on participant characteristics, refer to Table B.8 in the appendix.

<sup>19</sup> The English translation of the instructions used, including some screenshots 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 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.

<sup>20</sup> The two-sample tests of proportions all result in a  $p$ -value above 0.10. The only exception is the comparison of the proportion of agreements reached in the FULL-E and FULL-U treatments, where the  $p$ -value is 0.06.

<sup>21</sup> Simultaneous asymmetries in several characteristics can also act in opposite ways and even reduce the complexity of the bargaining problem. For example, our round 10 is equally unbalanced in terms of outside options and technologies as round 7, and even more in terms of capacity constraints. Those constraints however – with the more productive farm being severely limited in storage – make claims of more than 45 hens by farm 1 practically meaningless (i.e., with no impact on the final outcome) in round 10, while in round 7 such claims by farm 1 would lead to strictly more beneficial outcomes. Not only that, individual rationality would require at least exactly 90 hens for farm 1 in round 7, while merely 30 would suffice in round 10 (which actually produced more agreements, and more individually rational agreements than round 7).

<sup>22</sup> The detailed frequency of agreements, their efficiency, individual rationality and symmetry by round and treatment can be found in Tables B.9 and B.11.

**Table 2**

The effect of farm characteristics on the bargaining outcome.

	(HIDDEN-U) hens difference	(FULL-U & FULL-E) hens difference
eggs per chicken difference	-2.982 (2.111)	-11.80** (2.761)
monetary prize difference	-0.0524 (0.0703)	-0.0144 (0.0404)
outside option difference	0.562*** (0.0914)	0.517*** (0.0626)
capacity difference	0.0286 (0.0399)	0.0363 (0.0214)
constant	-2.129 (6.470)	-7.667 (3.765)
observations	377	760
adjusted $R^2$	0.413	0.347
log likelihood	-1841.5	-3809.4
F statistic	213.1	146.5
model degrees of freedom	4	4
residual degrees of freedom	7	11

OLS estimates. Dependent variable: number of hens assigned to Farm 1 minus number of hens assigned to Farm 2 in efficient agreements. Standard errors 2-way clustered around experimental sessions and bargaining rounds shown in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

treatments. Those round characteristics are eggs per hen, monetary prizes, outside options, and storage capacities. Given that bargaining happened in pairs, we identify each efficient agreement with the number of hens that the owner of Farm 1 receives in addition to what the owner of Farms 2 gets. This difference in hens (for the owner of Farm 1) is positive when she receives more than her bargaining partner, it is negative when she receives less, and its 0 value indicates an equal split of hens. All the regressors are expressed as similar differences in the characteristics between the two farms. Estimation results are shown in [Table 2](#).

Our analysis is based on efficient agreements not only because all theoretical solutions to the cooperative bargaining problem assume efficiency, but also because 96% of all the agreements in our dataset satisfy this property.<sup>23</sup>

In the hidden information treatment, only the (difference in the) number of hens that parties could obtain in case of disagreement has a statistically significant effect on the agreement. With an  $\eta^2$  of 0.26, it has a large effect size in the expected direction: a larger outside option (as compared to the opponent's) results in relatively more hens obtained. Given that outside options were the only commonly-known parameters in the treatment, these results are hardly surprising. In the full-information treatments, the difference in outside options retains its importance (with  $\eta^2$  of 0.19), but also another regressors become statistically significant. Technology differences in the number of eggs each hen lays has a medium-sized negative impact (with  $\eta^2$  of 0.07). The negative impact of eggs per hen suggests that bargaining parties tend to rebalance the asymmetry in farm characteristics by assigning less hens to the relatively more productive farm. In other words, they tend to equilibrate the number of eggs obtained through the bargaining agreement.

Interestingly, differences in monetary prizes have no statistically significant impact on agreements (and the absolute value of the coefficient estimates is very close to zero). In other words, bargaining parties do not try to counterbalance that type of asymmetry by equating expected monetary gains. The following result states the implication of these findings for the general and abstract theoretical axiom of scale invariance.

**Result 1.** *Welfarism is supported by the experimental data, while scale invariance only enjoys partial empirical support.*

- *Bargaining agreements are invariant to changes in the extreme points of the utility scale.*
- *Bargaining agreements are not invariant to changes in the utility units when those changes are commonly known.*

Our main result suggests that bargaining happens in observables. When a reliable proxy for personal utility is available and observable (like eggs in our full-information treatments), bargaining parties are undoubtedly guided by it, exactly as the theoretical model of cooperative bargaining suggests. Although altering the maximum point of the scale does not impact agreements, changing the units on the scale does. In other words, the bargaining solution does not satisfy the axiom of scale invariance in general.

### 5.1.1. Robustness test

As linear regressions impose quite some structure on the observed agreements, the above finding might be driven by the untested features of the statistical model. The carefully chosen 3 informational treatments and the 12 bargaining problems in our experimental design, however, offer a straightforward way to robustness tests.

<sup>23</sup> As some readers might wish to consider all observed agreements, we have performed the statistical analysis presented in the main text including inefficient agreements as well. All of our results are robust to this change. Refer to [Appendix C](#) for details.

**Table 3**  
Comparing (efficient) agreements between the FULL-E and FULL-U treatments (across rounds).

round(s)	all	1	2	3	4	5	6	7	8	9	10	11	12
Kruskal–Wallis equality-of-populations rank test													
degrees of freedom	1	1	1	1	1	1	1	1	1	1	1	1	1
$\chi^2$ statistic	0.001	2.562	0.003	0.105	0.157	0.143	3.228	1.505	1.265	0.014	0.003	2.429	1.378
<i>p</i> -value	0.972	0.109	0.956	0.746	0.692	0.706	0.072	0.220	0.261	0.906	0.957	0.119	0.240
Two-sample Kolmogorov–Smirnov test for equality of distribution functions													
<i>D</i> statistic	0.028	0.268	0.113	0.063	0.124	0.073	0.243	0.194	0.236	0.099	0.097	0.152	0.178
<i>p</i> -value	0.998	0.348	0.992	1	0.974	1	0.270	0.668	0.301	0.998	0.998	0.825	0.609

**Table 4**  
Comparing (efficient) agreements between rounds (across informational treatments).

	HIDDEN-U	FULL-U	FULL-E
rounds 1 vs 2*			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	0.006	0.777	4.810
<i>p</i> -value	0.940	0.378	0.028
Kolmogorov–Smirnov test for equality of distribution functions			
<i>D</i> statistic	0.147	0.216	0.468
<i>p</i> -value	0.931	0.621	0.003
rounds 4 vs 5			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	1.995	10.87	15.98
<i>p</i> -value	0.158	0.001	0.000
Kolmogorov–Smirnov test for equality of distribution functions			
<i>D</i> statistic	0.207	0.467	0.507
<i>p</i> -value	0.564	0.003	0.001
rounds 3 vs 12			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	4.909	0.608	0.429
<i>p</i> -value	0.0267	0.435	0.512
Kolmogorov–Smirnov test for equality of distribution functions			
<i>D</i> statistic	0.186	0.0964	0.109
<i>p</i> -value	0.576	0.998	0.987

Comparing the observed distribution of efficient agreements across rounds based on observations for bargaining owning Farm 1, except for round 2 (\*) where the owner of Farm 2 is considered.

We first double check welfarism, the impact of monetary prizes (i.e., maximum points on the utility scale), by comparing the distributions of the observed efficient agreements between treatments FULL-E and FULL-U. Our (pairwise) comparisons of the distribution of agreements are based on non-parametric tests: the Kruskal–Wallis equality of populations rank test and the two-sample Kolmogorov–Smirnov test. Detailed results are shown in Table 3. No matter whether bargaining rounds are compared in isolation between the two treatments or the 12 together at once, changes in the monetary prizes do not have statistically significant impact on the bargaining outcome. The *p*-values are all larger than 0.10, except for the Kruskal–Wallis test in round 6. Even in that particular case, the resulting *p*-value of 0.07 does not give us enough confidence to reject the null hypothesis (i.e., invariance with respect to the extreme point of the scale).

Our second robustness check involves comparing the observed distribution of agreements between some particular bargaining rounds (in the same informational treatment). When rounds 1 and 2, 4 and 5, and 3 and 12 are compared to each other, we directly test the impact of technology (i.e., eggs per hen), as bargaining rounds in those pairs are identical to each other in terms of all the other characteristics. The estimation results in Table 4 confirm that changes in the utility scale units may have a significant impact on the bargaining outcome when those changes are common knowledge.<sup>24</sup> In other words, scale invariance with respect to changes in the units of the utility scale is not a universal property, although it might hold in a specific collection of bargaining situations.

<sup>24</sup> Both applied tests suggest that to be the case in FULL-E (rounds 1 vs 2, and rounds 4 vs 5) and in FULL-U (rounds 4 vs 5).

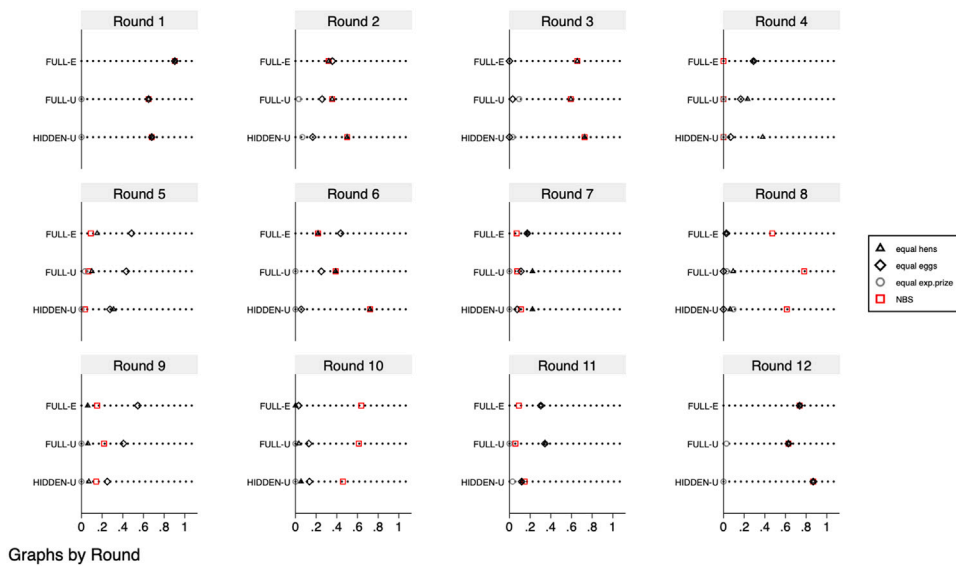


Fig. 1. Type of observed agreements (as a proportion of efficient agreements across rounds).

Table 5

Type of observed agreements (as a percentage of all efficient agreements).

	HIDDEN-U	FULL-U	FULL-E	Total
equal hens	40.05	30.46	32.13	34.21
equal eggs	22.55	27.76	35.99	28.85
equal expected prize	1.86	1.89	35.99	13.54

### 5.2. Equal splits

By rejecting scale invariance as a universal property, we reject prominent and popular theoretical solutions to the bargaining problem, like the Nash bargaining solution and the Kalai–Smorodinsky bargaining solution. Our data suggest that bargaining outcomes tend to equate utilities between the bargaining parties in the spirit of the so-called equal-split solution.

The graphs in Fig. 1 show that the Nash bargaining solution (NBS) is only able to outperform the equal-split type solutions in rounds 8 and 10 that were very particular for reasons discussed below. Solutions based on equalizing the number of hens between bargaining parties are only relevant when technology and egg production constitute hidden information. In full-information treatments many rounds are dominated by agreements equalizing the number of eggs (i.e., utility). Just as suggested by our earlier analysis, monetary prizes fail to offer any guidance to agreements. Overall, however, the explanatory power of equal splits is moderate at best.

Table 5 shows a summary for the relevance of equal split in bargaining. Recall that the considered three equal splits are not mutually exclusive as in certain bargaining situations (rounds) they coincide. Overall, the numbers underline the importance of equal split as a strong focal point in bargaining.

Nevertheless, we must take a closer look at the bargaining problems to be able to make the picture less murky. The histograms in Fig. 2 for the hidden information treatment, and Fig. 3 for the full information treatments offer a graphical summary for those closer looks.

Each histogram depicts the distribution of hens that owners of Farm 1 got in the observed efficient agreements. The efficiency of those agreements implies that the same histograms represent Farm 2, as well, when we look at them from right to left. The dashed vertical lines represent the number of hens allocated to Farm 1 at disagreement (left dashed line) and the number of hens allocated to Farm 1 when the owner of Farm 2 obtains exactly her number of hens at disagreement (right dashed line). In other words, agreements between those dashed lines satisfy individual rationality. The solid vertical lines mark the number of hens allocated to Farm 1 so that the warehouse is at full capacity (right solid line) and the number of hens to Farm 1 when Farm 2 warehouse is at full capacity (left solid line). Agreements between the solid lines satisfy capacity constraints.

The shaded gray area is the combination of the two constraints: individual rationality and the capacity constraint. We shall refer to that area as the *compatibility zone*. Finally, the agreement that would yield an equal number of hens is marked with a diamond, the one that would yield an equal number of (delivered) eggs is marked with a circle, and the agreement that would yield an equal expected monetary prize is marked with a triangle. The vertical location of these marks carries no meaning, it simply aims at avoiding overlaps.

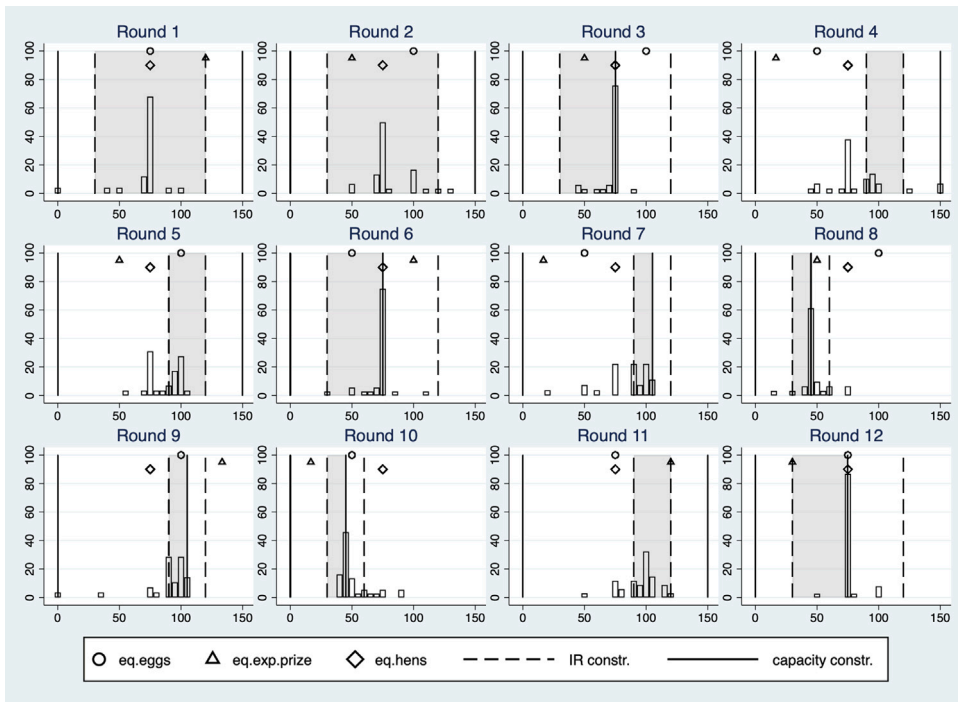


Fig. 2. Distribution of observed efficient agreement in the hidden-information treatments (across rounds).

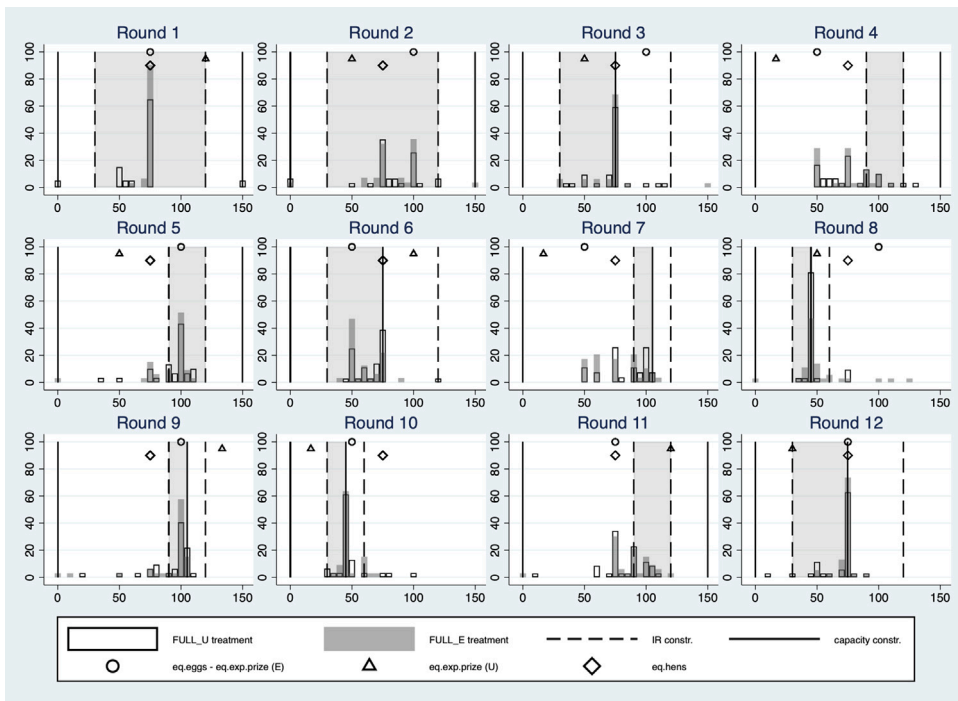


Fig. 3. Distribution of observed efficient agreement in the full-information treatments (across rounds).

Regarding the hidden-information treatment (Fig. 2), the first observation is that the equal split in *hens* is a strong focal point whenever it satisfies both the individual-rationality constraint and the capacity constraint. This is the case in rounds 1, 2, 3, 6, and 12. In rounds 8 and 10, the equal split in *hens* makes at least one of the two bargainers lose some eggs due to small storage

capacity (i.e., capacity constraint is binding). For those two rounds, the bargaining party with the lower egg-storage capacity tends to obtain the number of hens for an egg production at full capacity. In other words, the equal split gets minimally distorted to avoid a wasteful (inefficient) agreement. In the rest of bargaining rounds (4, 5, 7, 9, and 11), the equal split in hens is not individually rational. The distribution of the resulting agreements is murkier. On the one hand, many bargaining pairs still agree on an equal distribution of hens (specially in rounds 4 and 5, but also in round 7) ignoring the individual-rationality constraint. But on the other hand, many pairs make sure that the final distribution of hens that is individually rational (especially in round 11). Overall, we do not see an alternative focal point emerging. This finding is in line with previous results reported by Navarro and Veszteg (2020) where half of the bargaining pairs would ignore the individual-rationality constraint when that is in conflict with equality.

In the (symmetric and asymmetric) full-information treatments (Fig. 3), agreements with an equal number of *delivered eggs* is a strong focal point whenever it satisfies both the individual-rationality constraint and the capacity constraint. This is the case in rounds 1, 2, 5, 6, 9, and 12.<sup>25</sup> In rounds 3, 8, and 10 the equal split in eggs would be in conflict with the capacity constraints and would make at least one bargaining party waste some eggs. Just like in the hidden-information treatment, agreements tend to avoid such wasteful (inefficient) allocations. In the rest of the rounds (4, 7, and 11), an equal split in eggs is not individually rational. These rounds are again murkier. Some bargaining pairs agreed on an equal distribution of hens, some on an equal distribution of delivered eggs. Other pairs decided on a distribution of hens that was individually rational. As was the case in the hidden-information treatment, no alternative focal point seems to emerge.

Note that eggs and the resulting probabilities of earning the promised monetary prize, in our experimental design, offer a utility representation for bargainers' preferences over hens (i.e., the physical units that bargaining is directly about). Hence, the equal split in eggs corresponds to the theoretical equal split (in utilities). The following result summarizes the above findings about bargaining outcomes.

**Result 2.** *The equal split in utilities acts as a strong focal point in bargaining whenever utilities are observable and when it is not in conflict with efficiency or individual rationality.*

- *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.*
- *Individual rationality might disrupt bargaining agreements, when in conflict with the equal split, without offering an alternative focal point.*

The second bullet point in Result 2 resembles the so-called deal-me-out solution, but the resemblance is merely superficial. Deal-me-out is typically defined as an agreement that gets as close to the equal split as the individual-rationality constraints permit. It does treat those constraints as hard constraints. What we find in our experimental data (and summarize in the third bullet point) is that, individual rationality is a rather soft constraint that many people are willing to violate when in conflict with equity. At the same time, we must agree that hard constraints (like our exogenously imposed capacity constraints) do not alter bargainers' typical aim, the equal split. They merely turn the original optimization problem of minimizing differences in parties' final utility level into a constrained problem. Simply put, bargaining starts at an equal split that then might get distorted by the constraints imposed by the bargaining environment.

To gather further empirical support for the above claim, we have regressed the bargaining outcomes (expressed as differences in the number of hens or eggs received) on the characteristics of the bargaining situation. As opposed to the models summarized in Table 2, this time the individual-rationality constraint and the capacity constraint appear among the regressors in interaction with a dummy variable that is equal to 1 when any of the equal-split solutions (in hens, eggs, or expected monetary prize) is in conflict with the respective constraint.

The regression results shown in Table 6 confirm the statistically significant impact of changes in the utility scale units on the bargaining outcome when those are commonly known, and that changes in the extremes of the scale are irrelevant. Given that the 12 rounds of our experimental design do not cover all possible combinations of the variables that define our bargaining problems, some interaction terms had to be dropped from the estimation. Nevertheless, the results are fairly clear. Outside options distort the equal split whenever such a solution is not individually rational. Lower outside options result in a smaller bargaining outcome (in hens or eggs), higher outside options in a larger one. Storage-capacity constraints play a similar role, whenever they are low and restrictive enough (45 or 75).

## 6. Discussion

In clear contrast to earlier findings (Roth and Malouf, 1982), we find that bargaining parties are not guided by expected monetary gains. They rather use the probability of obtaining the monetary prize, a theoretical proxy for personal utility levels, for interpersonal comparisons and solving the bargaining problem.

One possible explanation for that is that participants are simply (and directly) aiming at the best probability of obtaining the prize. Note that this does not immediately imply that preferences over binary lotteries are in line with expected-utility theory. It

<sup>25</sup> Rounds 2 and 6 seem murkier than the others in this group, with both equal split in hens and equal split in delivered eggs emerging as competing focal points. We do not have a clear explanation for this. It could be a result of differing monetary prizes in the asymmetric treatment and bargaining parties trying to move towards equal expected gains, but without reaching them. It might as well be due to some order effects.

**Table 6**  
The effect of equity-vs-individual-rationality conflict on the bargaining outcome.

	(HIDDEN-U) hens difference	(FULL-U & FULL-E) hens difference	eggs difference
eggs per chicken difference	-7.348 (3.619)	-17.03*** (2.764)	50.09*** (4.125)
monetary prize difference	-0.0693 (0.0951)	-0.00630 (0.0402)	0.0187 (0.0594)
outside option hens (me) = 30 × equality vs IR conflict = 1	-36.41** (9.292)	-32.67*** (3.031)	-51.71*** (4.850)
outside option hens (me) = 90 × equality vs IR conflict = 1	30.27* (11.68)	21.39*** (1.973)	27.13*** (2.601)
egg storage capacity (me) = 45 × equality vs capacity conflict = 1	-23.31* (8.186)	-31.02*** (6.155)	-45.23*** (9.108)
egg storage capacity (me) = 75 × equality vs capacity conflict = 0	6.648 (9.358)	-5.479* (2.188)	-5.681 (2.722)
egg storage capacity (me) = 75 × equality vs capacity conflict = 1	-10.02 (9.138)	-18.52** (4.463)	-29.21** (6.728)
egg storage capacity (me)=105 × equality vs capacity conflict = 1	-12.32 (10.48)	-2.295 (3.843)	1.334 (6.056)
egg storage capacity (me)=150 × equality vs capacity conflict = 1	0.139 (12.25)	-3.670 (2.757)	-6.922 (3.741)
egg storage capacity (me)=210 × equality vs capacity conflict = 0	-0.580 (2.782)	9.629*** (1.348)	16.70*** (2.159)
constant	-0.633 (8.787)	-3.563* (1.212)	-3.899* (1.622)
observations	377	760	760
adjusted R <sup>2</sup>	0.429	0.365	0.607
log likelihood	-1833.1	-3795.9	-4058.4
F statistic	.	91.00	216.9
model degrees of freedom	6	10	10
residual degrees of freedom	7	11	11

OLS estimates. Dependent variable: number of hens assigned to Farm 1 minus number of hens assigned to Farm 2 in efficient agreements. Standard errors 2-way clustered around experimental sessions and bargaining rounds shown in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

could be that the underlying utility function is increasing in probability but not in a linear way. Another possible explanation is that participants do not consider the physical units (hens) or the probabilities of obtaining a monetary prize (induced by owning more or less of those physical units) as a mechanism for achieving compensations between the bargaining parties when monetary prizes are unequal. That is, when each individual faces an independent binary lottery with possibly different monetary rewards, equating expected gains requires thinking and operating on a scale that is two levels of abstraction apart from physical units. In contrast, compensating for differences in productivity requires a move that is only one level of abstraction apart. A third possible explanation is that even though individual preferences do satisfy the welfarist axiom (as the monetary prize has no effect on agreement) and probabilities are a good proxy for utility, the agreement is still not scale invariant because when bargainers' utility scales are known, interpersonal comparisons of utility can be meaningful and easy to make. Intuitively, for scale invariance to hold the comparison of bargainers' utility scales should be impossible or meaningless. As noted by [Luce and Raiffa \(1957\)](#), pp. 130–131, the assumption of scale invariance does not allow for interpersonal comparisons of utility.

Yet another explanation for why bargaining agreements depend on hen productivity but not on monetary prizes could be the combination of *reference-dependent preferences*, *naive accounting*, and *fairness considerations*, as explained by [Kahneman et al. \(1986\)](#) in the context of market-transaction-related decisions by firms. Participants in our study might evaluate each bargaining agreement in terms of gains or losses with respect to a reference point that could be the equal split in hens, in eggs, in probability of obtaining the monetary prize, or in expected monetary gain. As mentioned above, using the probability of obtaining the monetary prize as the layer for reference instead of the expected monetary gain might simply be the result of naive accounting. Alternatively, as participants were assigned monetary prizes randomly (not depending on the results of a real-effort task), it is possible that they considered it unfair to use those monetary prizes as an argument (alone or embedded into expected monetary prize computations) to obtain more hens during the bargaining process.

Finally, let us also mention that we have also analyzed the chat messages that participants sent to each other, and they seem to be in line with the interpretation of our statistical results based on agreements detailed above. Recall that our experimental design made two channels available for bargaining. Besides the principal channel of numerical messages where the final agreement had to take place, bargaining parties were allowed to exchange text messages in a chat box. We have simply counted how often each of the characteristics of the bargaining problem (in any context) is mentioned by any of the bargaining parties. It turns out that monetary prizes are mentioned less frequently than productivity in treatments HIDDEN-U and FULL-E. Although they gain similar

importance to the other round characteristics in treatment FULL-U, as our analysis has shown above, monetary prizes do not seem to have an impact on the bargaining outcome.<sup>26</sup>

## 7. Conclusions

We have implemented an experimental design based on binary lottery games (following (Roth and Malouf, 1979, 1982; Roth and Murnighan, 1982)) in an unstructured, intuitive environment. Our participants bargained over the distribution of a fixed number of objects (hens) that yield different stakes and different chances of obtaining those stakes. We compared two information environments, with full and hidden information related to the bargaining environment.<sup>27</sup> Across the 12 bargaining rounds included in our design, we kept changing the impact of two feasibility constraints: individual rationality (obtaining more than at disagreement) and efficiency (no waste of production).

In principle, both monetary prizes (or stakes) and productivity have a rescaling effect that – according to welfarism and the theoretical property of scale invariance, respectively – should not affect the bargaining agreements in terms of divisions of hens. Surprisingly, only the effect of productivity on bargaining outcomes turns out to be significant. In other words, although the probability of obtaining the higher stake – which is directly proportional to the number of eggs produced – is a good proxy for utility, the bargaining agreements are sensitive to unit changes on the probability scale caused by changes in productivity. This could be indicating that the utility of the object to be distributed is not linear in the induced probabilities. It could also be the case that the observable used as a proxy for utility allowed for easy interpersonal comparisons, as it was the same for both bargainers. Alternatively, we conjecture that bargainers might find it computationally more difficult to use different distributions of hens to compensate for higher monetary prizes than for higher productivity. They might have also found it unfair to use monetary prizes as an argument during discussions.

Finally, we wish to offer a slightly different interpretation for our findings. One might argue that utilities are not only unobservable, but are completely out of the experimenter's control (e.g., Büyükböyaci (2007)). If that is the case, our experimental design only tests the welfarist axiom by comparing bargaining outcomes across situations with different monetary prizes. In sharp contrast to the early findings (e.g., Yaari and M. (1984), Roth and Malouf (1982)), we find empirical support for welfarism (similarly to Büyükböyaci (2007)). Moreover, our experimental findings are in line with the bargaining solution based on de Clippel (2015)'s reformulation of Nash's model. de Clippel (2015) builds on Rubinstein et al. (1992) whose new symmetry axiom leads to bargaining agreements with *equal probability in elementary problems* (EPEP). Elementary problems are bargaining conflicts in which bargaining happens over probabilities (i.e., lotteries) of obtaining one of three possible outcomes: the null bundle, a bundle in which one bargaining party gains a monetary prize, a bundle in which the other does. de Clippel (2015) assumes selfish decision-makers, therefore only the marginals of the considered lotteries matter to each of the bargainers. Note that our experimental design implements such elementary problems in each round even if it allows for both bargainers to obtain a monetary prize as long as the disagreement outcome is considered the null bundle.<sup>28</sup> The main finding is that “EPEP and [...] welfarism appear as unavoidable consequences of the straightforward reformulation of Nash's axioms in a natural economic environment with probabilities” (de Clippel 2015, p.628). Recall that our experimental results deliver empirical support to welfarism by showing that agreements are robust to changing differences in monetary prizes between the two bargaining parties. They also suggest that equal probabilities act as a strong focal point. In spite of these findings, however, a word of caution is in order: our experiment was not designed to test the axioms, that make welfarism redundant, proposed by de Clippel (2015).<sup>29</sup>

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgments

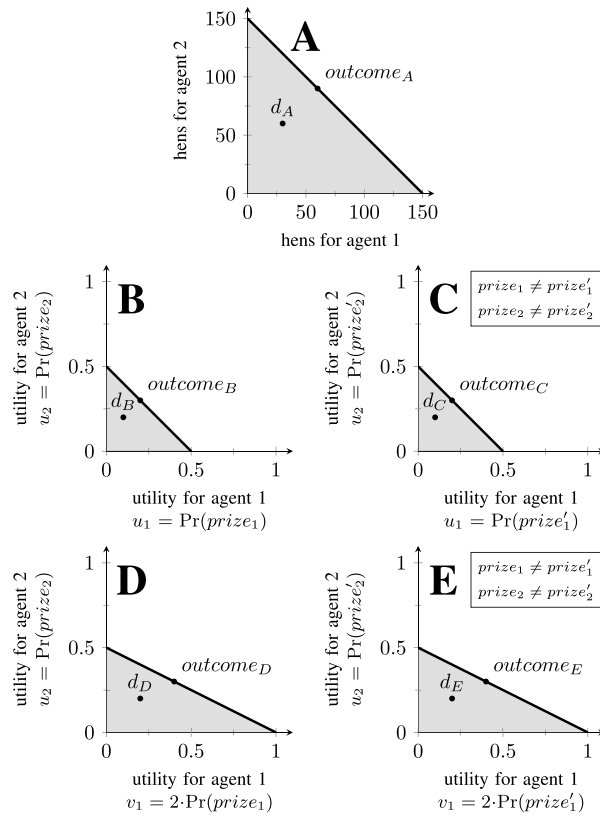
Navarro acknowledges financial support from the Institut des Sciences Humaines et Sociales (InSHS) CNRS through the “Soutien à la mobilité internationale 2022” program. She is grateful for the hospitality received from the School of Political Science and Economics and the Office of International Relations 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'Économie 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, Lata Gangadharan and Emin Karagözoğlu, and two anonymous reviewers on earlier versions have helped us to significantly improve our manuscript.

<sup>26</sup> Refer to Appendix B.1 for further details.

<sup>27</sup> Note that our primary goal with changes in the amount of information that bargaining parties had about each other was to further explore the axioms of welfarism and scale invariance. For that reason, we focused entirely on the cooperative, axiomatic approach to bargaining. Unlike others (e.g., Harsanyi and Selten (1972), Camerer et al. (2019)), we did not develop any non-cooperative game-theoretic equilibrium predictions to test with the data collected in the experimental laboratory.

<sup>28</sup> Note that our experimental design also satisfies the four assumptions that set de Clippel (2015)'s model apart from Roemer (1988)'s.

<sup>29</sup> In particular, the IIA axiom by de Clippel (2015) imposes conditions on the bargaining solution in case the set of goods shrinks, but in our experimental design the total number of hens is constant over all bargaining rounds.



**Fig. A.4.** Welfarism and scale invariance in our experimental design. Graph A represents a bargaining problem over 150 hens with a disagreement outcome at  $d_A$  and a possible solution at  $outcome_A$ . Graphs B to E represent the same bargaining problem through different utility representations (different anchoring points and utility scales) as described in the text. Welfarism is present as the bargaining sets and disagreement points are identical across graphs B and C (also D and E), even though the monetary prizes used to anchor the utility representation differ. Scale invariance is satisfied by the illustrated solutions as  $outcome_B$  and  $outcome_D$  refer to the same distribution of hens ( $outcome_A$ ), except that agent 1 obtains twice as large utility in  $outcome_D$  than in  $outcome_B$ , because her utility is measured through  $v_1 = 2 \cdot u_1$  there. Similar relationship exists between the illustrations in graphs C and E.

## Appendix A. Welfarism and scale invariance

See Fig. A.4.

## Appendix B. Further statistical results

See Tables B.7–B.11.

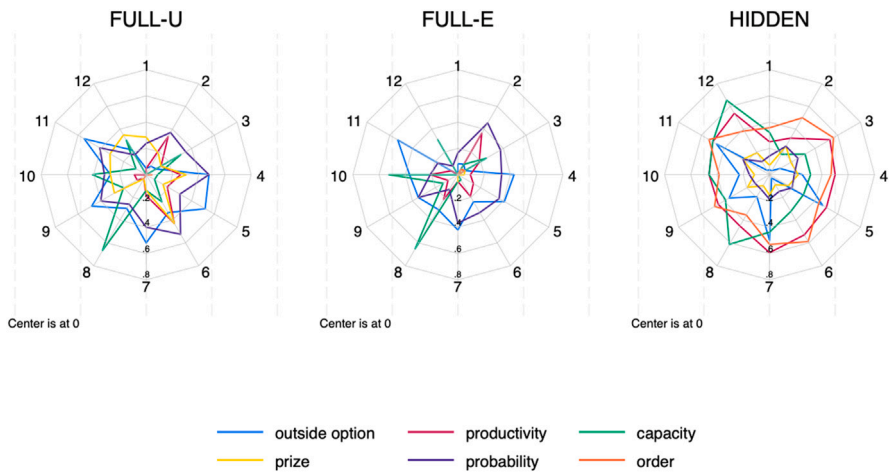
### B.1. Chat messages

Our experimental design made two channels available for bargaining. Besides the principal channel of numerical messages where the final agreement had to take place, bargaining parties were allowed to exchange text messages in a chat box. In the HIDDEN-U treatment 75% of the bargaining couples exchanges at least one pair of messages, and on average they did send 8.1 message entries to each other. In the full-information treatments, these numbers drop to 48% and 6.2 messages in FULL-E, and 58% and 7.3 messages in FULL-U. In summary, and quite naturally, less publicly available information and more asymmetry in the bargaining situation triggers more communication between the parties.

Regarding the contents of the chat messages, we have simply counted how often each of the characteristics of the bargaining problem (in any context) is mentioned by any of the bargaining parties. Obviously, some characteristics are texted about more than some others depending the bargaining situation. The radar diagrams in Fig. B.5 confirm these claims and show that monetary prizes are mentioned less frequently than productivity in treatments HIDDEN-U and FULL-E. Although they gain similar importance to the other round characteristics in treatment FULL-U, as our analysis has shown above, monetary prizes do not seem to have an impact on the bargaining outcome.

**Table B.7**  
Experimental sessions.

zTree code	number of participants in			
	HIDDEN-U	FULL-U	FULL-E	all
211206_1313		6		6
211208_1342		12		12
211208_1644		14		14
211216_0901		8		8
211216_1303		12		12
211216_1546			10	10
220106_0846			6	6
220106_1020		10		10
220106_1705			10	10
220107_1151			10	10
220107_1420			10	10
220107_1611			12	12
220113_0945	6			6
220113_1237	6			6
220120_1029	10			10
220120_1344	8			8
220120_1719	12			12
220214_1232	14			14
220215_1044	14			14
230123_1152	10			10
230123_1718		20		20
230125_1321			22	22
all	80	82	80	242



**Fig. B.5.** The frequency of situation characteristics as chat-message topics by treatments and rounds.

**Table B.8**  
Participant characteristics.

	mean	std. dev.	25%	50%	75%	95%	min.	max.
all treatments								
age	32.9	12.4	23	28	42	57	18	70
female	0.61	0.49	0	1	1	1	0	1
student	0.41	0.49	0	0	1	1	0	1
risk attitude	5.90	2.13	5	6	7	9	0	10
hens/owns	0.14	0.35	0	0	0	1	0	1
hens/visited farm	0.12	0.32	0	0	0	1	0	1
hens/plays related game	0.05	0.22	0	0	0	0	0	1
observations	242							
treatment HIDDEN-U								
age	29.8	10.8	22	28	31.5	54	18	68
female	0.62	0.49	0	1	1	1	0	1
student	0.50	0.50	0	0.50	1	1	0	1
risk attitude	5.86	2.04	4.50	6	7	9	1	10
hens/owns	0.087	0.28	0	0	0	1	0	1
hens/visited farm	0.10	0.30	0	0	0	1	0	1
hens/plays related game	0.050	0.22	0	0	0	0.50	0	1
observations	80							
treatment FULL-U								
age	35.5	12.6	25	33	45	59	19	63
female	0.61	0.49	0	1	1	1	0	1
student	0.29	0.46	0	0	1	1	0	1
risk attitude	5.82	2.07	4	6	8	9	0	10
hens/owns	0.15	0.36	0	0	0	1	0	1
hens/visited farm	0.13	0.34	0	0	0	1	0	1
hens/plays related game	0.024	0.16	0	0	0	0	0	1
observations	82							
treatment FULL-E								
age	33.1	13.2	22	26.5	45	59	18	70
female	0.59	0.50	0	1	1	1	0	1
student	0.44	0.50	0	0	1	1	0	1
risk attitude	6.01	2.30	5	6	7	10	1	10
hens/owns	0.19	0.39	0	0	0	1	0	1
hens/visited farm	0.11	0.32	0	0	0	1	0	1
hens/plays related game	0.075	0.27	0	0	0	1	0	1
observations	80							

Self-reported *risk attitude* measured on a scale from 0 (not at all willing to take risks) to 10 (very willing to take risks) by answering the general risk question "How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?" (Dohmen et al., 2011). *Visited farm* is 1 if a visit happened in the past 12 months. *Plays related game* is 1 if played a computer game or board game related to chicken in the past 12 months.

**Table B.9**  
Proportion (%) of agreements reached and their efficiency by round and treatment.

round	agreements reached				efficiency			
	HIDDEN-U	FULL-U	FULL-E	all	HIDDEN-U	FULL-U	FULL-E	all
1	80.0	53.7	90.0	74.4	78.1	90.9	86.1	84.4
2	80.0	85.4	77.5	81.0	93.8	88.6	90.3	90.8
3	85.0	80.5	85.0	83.5	97.1	97.0	94.1	96.0
4	72.5	78.0	77.5	76.0	100.0	93.8	100.0	97.8
5	75.0	75.6	87.5	79.3	96.7	96.8	94.3	95.8
6	92.5	87.8	80.0	86.8	97.3	100.0	100.0	99.0
7	67.5	65.9	72.5	68.6	100.0	100.0	100.0	100.0
8	85.0	90.2	95.0	90.1	91.2	86.5	94.7	90.8
9	75.0	80.5	82.5	79.3	93.3	97.0	100.0	96.9
10	92.5	82.9	85.0	86.8	100.0	91.2	97.1	96.2
11	87.5	85.4	82.5	85.1	97.1	100.0	100.0	99.0
12	95.0	87.8	95.0	92.6	100.0	97.2	100.0	99.1
all	82.3	79.5	84.2	82.0	95.4	94.9	96.3	95.5

**Table B.10**  
The effect of problem characteristics on the success of bargaining by treatment.

	(HIDDEN-U)		(FULL-U)		(FULL-E)	
	agreement	quit	agreement	quit	agreement	quit
eggs per chicken difference	1.030 (0.0992)	1.152 (0.114)	0.842 (0.154)	0.702*** (0.00247)	0.772** (0.0613)	0.967 (0.0445)
monetary prize difference	0.997 (0.00413)	0.999 (0.0104)	1.002 (0.00349)	1.000 (0.00488)	1 (5.09e-17)	1 (2.25e-09)
outside option difference	0.989 (0.00739)	1.006 (0.00383)	0.996 (0.00297)	0.999 (0.00518)	0.993 (0.00452)	1.002 (0.00993)
capacity difference	1.001 (0.00127)	0.999 (0.00432)	1.000 (0.00138)	0.997 (0.00241)	1.000 (0.00215)	1.000 (0.00436)
time	1.088* (0.0396)	1.052 (0.0380)	1.106* (0.0564)	0.856* (0.0582)	1.054* (0.0267)	1.082 (0.0787)
observations	480	85	492	101	480	76
pseudo $R^2$	0.036	0.024	0.027	0.053	0.020	0.012
log likelihood	-216.1	-55.41	-243.1	-36.74	-205.5	-47.54
Chi2	222.8	47.40	10.60	132.0	23.27	2.721
model degrees of freedom	5	5	5	5	4	4
p-value	3.75e-46	4.70e-09	0.0600	8.95e-27	0.000112	0.606

Exponentiated coefficients from logit estimates. Dependent variables: agreement (1 if an agreement is reached) or quit (1 if the failure of reaching an agreement is due to a party quitting). Standard errors 2-way clustered around experimental sessions and bargaining rounds shown in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Table B.11**  
Proportion (%) of individually rational and symmetric agreements (among all agreements).

round	individual rationality				symmetry (in hens)			
	HIDDEN-U	FULL-U	FULL-E	all	HIDDEN-U	FULL-U	FULL-E	all
1	93.8	86.4	94.4	92.2	62.5	83.3	63.6	71.1
2	93.8	91.4	93.5	92.9	50.0	32.3	34.3	38.8
3	100.0	100.0	97.1	99.0	70.6	61.8	57.6	63.4
4	31.0	31.3	29.0	30.4	37.9	29.0	21.9	29.3
5	56.7	80.6	71.4	69.8	30.0	14.3	9.7	17.7
6	100.0	100.0	100.0	100.0	70.3	21.9	38.9	44.8
7	63.0	51.9	44.8	53.0	22.2	17.2	22.2	20.5
8	85.3	86.5	78.9	83.5	5.9	2.6	8.1	5.5
9	76.7	75.8	78.8	77.1	6.7	6.1	6.1	6.3
10	83.8	88.2	94.1	88.6	5.4	0.0	2.9	2.9
11	80.0	45.7	57.6	61.2	11.4	30.3	34.3	25.2
12	100.0	97.2	100.0	99.1	86.8	73.7	63.9	75.0
all	81.8	78.5	79.2	79.8	39.2	31.7	29.7	33.5

## Appendix C. Statistical results including all agreements

The statistical analysis in the main text focuses on efficient agreements that represent 96% of all agreements in our data. The fundamental reason for that is that all theoretical cooperative bargaining solutions are efficient. Taking inefficient outcomes into consideration while testing theory could potentially bias the conclusions that we reach regarding the other axioms. We do understand, however, that some readers might wish to consider our data detached from such theoretical structures. This appendix reproduces all the tables from the main text without excluding inefficient agreement from the analysis. Overall, none of the results discussed in the main text changes substantially when following this approach (see [Tables C.12–C.16](#)).

**Table C.12**  
The effect of farm characteristics on the bargaining outcome.

	(HIDDEN-U) hens difference	(FULL-U & FULL-E) hens difference
eggs per chicken difference	-3.211 (2.025)	-11.73*** (2.433)
monetary prize difference	-0.0492 (0.0682)	-0.0155 (0.0312)
outside option difference	0.549*** (0.0860)	0.507*** (0.0570)
capacity difference	0.0318 (0.0361)	0.0356 (0.0196)
constant	-1.305 (5.782)	-7.104 (3.360)
observations	395	795
adjusted R <sup>2</sup>	0.409	0.338
log likelihood	-1924.9	-3987.6
F statistic	259.1	190.5
model degrees of freedom	4	4
residual degrees of freedom	7	11

OLS estimates. Dependent variable: number of hens assigned to Farm 1 minus number of hens assigned to Farm 2 in agreements. Standard errors 2-way clustered around experimental sessions and bargaining rounds shown in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

**Table C.13**  
Comparing agreements between the FULL-E and FULL-U treatments (across rounds).

round(s)	all	1	2	3	4	5	6	7	8	9	10	11	12
Kruskal–Wallis equality-of-populations rank test													
degrees of freedom	1	1	1	1	1	1	1	1	1	1	1	1	1
$\chi^2$ statistic	0.045	1.431	0.099	0.201	0.193	0.328	3.228	1.505	1.536	0.000	0.242	2.429	1.922
p-value	0.833	0.232	0.752	0.654	0.660	0.567	0.072	0.220	0.215	0.994	0.623	0.119	0.166
Two-sample Kolmogorov–Smirnov test for equality of distribution functions													
D statistic	0.033	0.225	0.141	0.062	0.134	0.092	0.243	0.194	0.233	0.091	0.088	0.152	0.199
p-value	0.981	0.495	0.899	1	0.940	0.999	0.270	0.668	0.259	0.999	1.000	0.825	0.458

**Table C.14**  
Comparing agreements between rounds (across informational treatments).

	HIDDEN-U	FULL-U	FULL-E
rounds 1 vs 2*			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	0.218	0.907	2.051
p-value	0.640	0.341	0.152
Kolmogorov–Smirnov test for equality of distribution functions			
D statistic	0.094	0.208	0.377
p-value	0.999	0.604	0.018
rounds 4 vs 5			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	2.370	11.48	13.83
p-value	0.124	0.001	0.000
Kolmogorov–Smirnov test for equality of distribution functions			
D statistic	0.220	0.464	0.471
p-value	0.476	0.002	0.001
rounds 3 vs 12			
Kruskal–Wallis equality-of-populations rank test			
degrees of freedom	1	1	1
$\chi^2$ statistic	4.859	1.008	0.591
p-value	0.028	0.315	0.442
Kolmogorov–Smirnov test for equality of distribution functions			
D statistic	0.180	0.099	0.098
p-value	0.609	0.996	0.996

Comparing the observed distribution of agreements across rounds based on observations for bargaining owning Farm 1, except for round 2 (\*) where the owner of Farm 2 is considered.

Table C.15

The effect of equity-vs-individual-rationality conflict on the bargaining outcome.

	(HIDDEN-U)	(FULL-U & FULL-E)	
	hens difference	hens difference	eggs difference
eggs per chicken difference	-7.739 (3.387)	-15.08*** (2.517)	51.97*** (3.705)
monetary prize difference	-0.0665 (0.0940)	-0.00369 (0.0226)	0.0241 (0.0525)
outside option hens (me) = 30 × equality vs IR conflict = 1	-36.11** (8.467)	-35.67*** (2.577)	-55.75*** (4.607)
outside option hens (me) = 90 × equality vs IR conflict = 1	30.57* (10.81)	19.89*** (1.884)	24.87*** (2.505)
egg storage capacity (me) = 45 × equality vs capacity conflict = 1	-20.76* (7.104)	-24.56** (6.145)	-35.57** (9.024)
egg storage capacity (me) = 75 × equality vs capacity conflict = 0	6.555 (8.544)	-6.746** (2.157)	-7.717* (2.799)
egg storage capacity (me) = 75 × equality vs capacity conflict = 1	-10.17 (8.292)	-16.38** (4.251)	-26.37** (6.707)
egg storage capacity (me)=105 × equality vs capacity conflict = 1	-13.87 (10.31)	0.296 (3.565)	4.417 (5.745)
egg storage capacity (me)=150 × equality vs capacity conflict = 1	1.357 (10.16)	-6.898* (2.681)	-10.71* (3.801)
egg storage capacity (me)=210 × equality vs capacity conflict = 0	-0.580 (2.515)	7.784*** (1.590)	14.93*** (2.404)
constant	-0.666 (7.575)	-2.227* (0.959)	-1.864 (1.431)
observations	395	795	795
adjusted $R^2$	0.423	0.352	0.594
log likelihood	-1917.1	-3975.9	-4255.1
$F$ statistic	.	208.3	581.4
model degrees of freedom	6	10	10
residual degrees of freedom	7	11	11

OLS estimates. Dependent variable: number of hens assigned to Farm 1 minus number of hens assigned to Farm 2 in agreements. Standard errors 2-way clustered around experimental sessions and bargaining rounds shown in parentheses.

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Table C.16

Type of observed agreements (as a percentage of all agreements).

	HIDDEN-U	FULL-U	FULL-E	Total
equal hens	39.24	29.67	31.68	33.53
equal eggs	22.28	27.11	35.15	28.24
equal expected prize	1.78	2.05	35.15	13.19

## Appendix D. Experimental instructions

### D.1. Instructions used in the HIDDEN-U treatment

#### Welcome to our experiment, thank you for your participation!

You are about to participate in an experiment, which will help us to study decision-making and economic behavior. In this experiment, we will first ask you to read the instructions that explain the rules. Then you will be asked to make a series of decisions that will allow you to earn money. Your earnings beyond the 10 euro show-up fee will depend on the decisions you made and the decisions of others.

We will pay you at the end of the experiment in cash. Your identity, decisions and earnings will be kept strictly anonymous and confidential.

It is important that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loud, etc., you will be asked to leave and you will forfeit your earnings.

## Instructions

### The general environment

This experiment consists of 12 rounds and interaction will take place in randomly formed pairs. You are going to face similar decision-making scenarios in each round.

The computer will randomly assign you a partner in each round. You and your partner are asked to imagine that you each own a chicken farm. Your goal is to sell imaginary eggs to the experimenter produced by imaginary hens on your imaginary farm.

In each round you will receive an order consisting of a specific number of delivered eggs. If you are able to produce and sell, or, in other words, deliver the ordered number of eggs, you will surely earn an amount of money, for example 30 euros, that will also be specified in the order. You will see, however, that delivering the ordered number of eggs is not always possible. If you deliver less eggs than ordered, you can still earn the amount of money, but it is not for sure. The larger the difference between the ordered number of eggs and the number of eggs that you deliver, the smaller the probability of earning the amount of money is going to be. In other words, if you deliver the ordered amount, your chance of earning the amount of money is 100%. If you deliver no eggs at all, your chance of earning the amount of money is 0%. Each egg that you deliver is going to proportionally increase your chances of earning the amount of money. The computer is going to use the following formula to compute your chances of earning the amount of money.

$$\begin{aligned} \text{Probability of earning the amount of money} &= \\ &= (\text{number of eggs delivered}) / (\text{number of eggs ordered}) \end{aligned}$$

The number of eggs that you deliver in each round is going to depend on the number of hens you have on your farm, on the number of eggs each hen lays and on the storage capacity of your warehouse.

At the end of the experiment, the computer will randomly choose one of the 12 rounds and you will be paid only for your winnings during the chosen round. This rule ensures that each round is equally important to your final monetary earnings and that you will pay attention to each round.

At the beginning of each round, the computer will randomly assign a farm with some particular characteristics (number of eggs each hen lays and the storage capacity of the warehouse) to you and to your partner. Note that your farm might have different characteristics from those of your partner. At the beginning of each round, you will be informed about the characteristics of your farm. You will only receive information about your farm, and your partner will only receive information about his or her farm.

You and your partner will receive an order at the beginning of each round. Each order specifies the number of eggs required and the amount of money that can be earned in that round. Please note that the order you and your partner receive may be different. They may specify different quantities of eggs and/or different amounts of money. You will not only receive information about your order, but also about your partner's order.

Your decision task in each round is to reach an agreement with your partner on how to allocate 150 hens between your farm and your partner's farm. You are going to have at most 5 min in each round to reach an agreement.

If you are unable to reach an agreement, you and also your partner are going to be assigned a certain fixed number of hens. Note that the number of hens that your partner gets, if you do not reach an agreement, may be different from the number of hens that you get. Also, these numbers may change from round to round. At the beginning of each round, you will be informed about these numbers.

### The details of your task

Let us imagine, for example, that each hen on your farm lays 2 eggs. If you produce an amount of eggs that exceeds the storage capacity of your warehouse, the excess over the storage capacity is damaged and cannot be sold and delivered. Imagine that this storage capacity is equal to 100 eggs. Let us further imagine that you have received an order for 300 eggs for an amount of money of 20 euros.

Under these circumstances, if you had 45 hens, they would lay  $2 * 45 = 90$  eggs. Since this does not exceed the storage capacity of your warehouse, which is 100 eggs, you can deliver your 90 eggs. However, the amount you will be able to deliver, which is 90 eggs, is less than the quantity ordered, which is 300 eggs. Your chances of earning the promised amount of 20 euros will be  $90/300 = 30\%$ .

If you had 110 hens, however, they would lay  $2 * 110 = 220$  eggs. Since this number of eggs exceeds the storage capacity of your warehouse, which is 100 eggs, you can only sell 100 eggs. Your chances of earning the promised 20 Euro will in this case be  $100/300 = 33\%$ , during this round. Please note that all eggs in excess of the storage capacity of your warehouse are damaged and cannot be delivered, they are all wasted.

### The details of the computer screen

The picture below shows an example of the computer screen that you and your partner will see in each round of this experiment. The two tables on the top specify the orders and the characteristics of your farm and your partner's.

These characteristics are eggs per hen, storage capacity of your warehouse, and the number of hens you get in case you do not reach an agreement. Remember that the orders and the farm characteristics may change from round to round. In addition, please note that the information about the order your partner received is not displayed. Your partner will have the same information on his or her screen: he or she will see the characteristics of his or her farm, but he or she will not see any information about the order you received.

The screenshot shows a web-based interface for an experiment. At the top, it displays 'Tour 1 de 12' and 'Temps restant [sec] 204'. The main area is divided into several sections:

- VOTRE BASSE COUR:** A table showing parameters for your own farm: commande (300), argent promis (15), oeufs par poule (1), capacité de stockage des oeufs (300), and nombre de poules sans accord (30).
- BASSE COUR DE VOTRE PARTENAIRE:** A table showing parameters for your partner's farm, with some values obscured by asterisks (\*\*\*) for privacy.
- Input Section:** Two purple input fields for 'Poules pour vous' and 'Poules pour votre partenaire', with a 'VÉRIFIER' button below them.
- Table:** A table showing the current state of the experiment:
 

	poules	oeufs	oeufs vendus	probabilité
vous	0	0	0	0.00
votre partenaire	0	***	***	***
- Buttons:** 'VÉRIFIER', 'ENVOYER', 'QUITTER', 'ANNULER', 'RE-JETER', and 'ACCEPTER'.
- Chat Box:** A large purple area on the left for communication.

Remember that in each round you have 150 hens to assign between the two farms. If you would like to check the consequences of a specific split in terms of the number of eggs you would produce, the number of eggs you would deliver, and the probabilities of earning your amount of money, you can use the purple cells that appear in the center of the screen right above the CHECK button. Simply enter two numbers in the purple cells, click on the CHECK button and the numbers of the table on the right will automatically be updated. Note that this information is private. Your partner will not be informed about the splits that you check this way.

If you would like to send a proposal to your partner, enter two numbers in the purple cells above the SEND PROPOSAL button and click on the button. Your partner will immediately see your proposal on her screen and can decide whether to accept it or reject it. Your proposal will also appear in a table on your screen and you may cancel it as long as your partner has not yet accepted or rejected it. Proposals can be sent without any restriction at any moment in time, but remember that you have a limit of 5 min to reach an agreement.

If your partner sends you a proposal, it will immediately appear in the table at the bottom of the screen. If you would like to accept or reject it, select it first and then click on the button of your choice.

Note that the round ends as soon as a proposal has been accepted or if you run out of time (the remaining time is displayed in seconds in the upper right corner of your screen). You can also abandon the screen (and the round) without any agreement before the time is over by clicking on the QUIT WITHOUT AGREEMENT button.

You are allowed to chat with your partner during the experiment. The left part of the screen is a chat box. You can type freely in the long purple cell at the bottom of this box and send your message by hitting ENTER on the keyboard. Please do not reveal your identity (your name, your e-mail address or phone number) while chatting.

## D.2. Instructions used in the FULL treatments

### Welcome to our experiment, thank you for your participation!

You are about to participate in an experiment, which will help us to study decision-making and economic behavior. In this experiment, we will first ask you to read the instructions that explain the rules. Then you will be asked to make a series of decisions that will allow you to earn money. Your earnings beyond the 10 euro show-up fee will depend on the decisions you made and the decisions of others.

We will pay you at the end of the experiment in cash. Your identity, decisions and earnings will be kept strictly anonymous and confidential.

It is important that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loud, etc., you will be asked to leave and you will forfeit your earnings.

## Instructions

### The general environment

This experiment consists of 12 rounds and interaction will take place in randomly formed pairs. You are going to face similar decision-making scenarios in each round.

The computer will randomly assign you a partner in each round. You and your partner are asked to imagine that you each own a chicken farm. Your goal is to sell imaginary eggs to the experimenter produced by imaginary hens on your imaginary farm.

In each round you will receive an order consisting of a specific number of delivered eggs. If you are able to produce and sell, or, in other words, deliver the ordered number of eggs, you will surely earn an amount of money, for example 30 euros, that will also be specified in the order. You will see, however, that delivering the ordered number of eggs is not always possible. If you deliver less eggs than ordered, you can still earn the amount of money, but it is not for sure. The larger the difference between the ordered number of eggs and the number of eggs that you deliver, the smaller the probability of earning the amount of money is going to be. In other words, if you deliver the ordered amount, your chance of earning the amount of money is 100%. If you deliver no eggs at all, your chance of earning the amount of money is 0%. Each egg that you deliver is going to proportionally increase your chances of earning the amount of money. The computer is going to use the following formula to compute your chances of earning the amount of money.

$$\begin{aligned} \text{Probability of earning the amount of money} &= \\ &= (\text{number of eggs delivered}) / (\text{number of eggs ordered}) \end{aligned}$$

The number of eggs that you deliver in each round is going to depend on the number of hens you have on your farm, on the number of eggs each hen lays and on the storage capacity of your warehouse.

At the end of the experiment, the computer will randomly choose one of the 12 rounds and you will be paid only for your winnings during the chosen round. This rule ensures that each round is equally important to your final monetary earnings and that you will pay attention to each round.

At the beginning of each round, the computer will randomly assign a farm with some particular characteristics (number of eggs each hen lays and the storage capacity of the warehouse) to you and to your partner. Note that your farm might have different characteristics from those of your partner. At the beginning of each round, you will be informed about the characteristics both of your farm and your opponent's.

You and your partner will receive an order at the beginning of each round. Each order specifies the number of eggs required and the amount of money that can be earned in that round. Please note that the order you and your partner receive may be different. They may specify different quantities of eggs and/or different amounts of money. You will not only receive information about your order, but also about your partner's order.

Your decision task in each round is to reach an agreement with your partner on how to allocate 150 hens between your farm and your partner's farm. You are going to have at most 5 min in each round to reach an agreement.

If you are unable to reach an agreement, you and also your partner are going to be assigned a certain fixed number of hens. Note that the number of hens that your partner gets, if you do not reach an agreement, may be different from the number of hens that you get. Also, these numbers may change from round to round. At the beginning of each round, you will be informed about these numbers.

### The details of your task

Let us imagine, for example, that each hen on your farm lays 2 eggs. If you produce an amount of eggs that exceeds the storage capacity of your warehouse, the excess over the storage capacity is damaged and cannot be sold and delivered. Imagine that this storage capacity is equal to 100 eggs. Let us further imagine that you have received an order for 300 eggs for an amount of money of 20 euros.

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### The details of the computer screen

The picture below shows an example of the computer screen that you and your partner will see in each round of this experiment. The two tables on the top specify the orders and the characteristics of your farm and your partner's.

These characteristics are eggs per hen, storage capacity of your warehouse, and the number of hens you get in case you do not reach an agreement. Remember that the orders and the farm characteristics may change from round to round, and that your partner is going to see the same information as you do on her screen.

Remember that in each round you have 150 hens to assign between the two farms. If you would like to check the consequences of a specific split in terms of the number of eggs you would produce, the number of eggs you would deliver, and the probabilities of earning the amount of money, you can use the purple cells that appear in the center of the screen right above the CHECK button. Simply enter two numbers in the purple cells, click on the CHECK button and the numbers of the table on the right will automatically be updated. Note that this information is private. Your partner will not be informed about the splits that you check this way.

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If your partner sends you a proposal, it will immediately appear in the table at the bottom of the screen. If you would like to accept or reject it, select it first and then click on the button of your choice.

Note that the round ends as soon as a proposal has been accepted or if you run out of time (the remaining time is displayed in seconds in the upper right corner of your screen). You can also abandon the screen (and the round) without any agreement before the time is over by clicking on the QUIT WITHOUT AGREEMENT button.

You are allowed to chat with your partner during the experiment. The left part of the screen is a chat box. You can type freely in the long purple cell at the bottom of this box and send your message by hitting ENTER on the keyboard. Please do not reveal your identity (your name, your e-mail address or phone number) while chatting.

### Data availability

Data will be made available on request.

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