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On the empirical validity of axioms in unstructured bargaining

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We report experimental results and test axiomatic models of unstructured bargaining by checking the empirical relevance of the underlying axioms. Our data support strong efficiency, symmetry, independence of irrelevant alternatives and monotonicity, and reject scale invariance. Individual rationality and midpoint domination are violated by a significant fraction of agreements that implement equal division in highly unequal circumstances. Two well-known bargaining solutions that satisfy the confirmed properties explain the observed agreements reasonably well. The most frequent agreements in our sample are the ones suggested by the equal-division solution. In terms of the average Euclidean distance, the theoretical solution that best explains the data is the deal-me-out solution (Sutton, 1986; Binmore et al., 1989, 1991). Popular solutions that satisfy scale invariance, individual rationality, and midpoint domination, as the well-known Nash or Kalai-Smorodinsky bargaining solutions, perform poorly in the laboratory.

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1. Introduction

Bargaining is ubiquitous and being good at bargaining is often considered the key to success in life. We bargain with prospective and current employers, with sellers and service providers, with editors, and even with our partners. Most of the time bargaining occurs in an unstructured (or complex) environment without pre-specified fixed rules.

Game theorists have been interested in bargaining problems since the early years (von Neumann and Morgenstern, 1944; Nash, 1950; Rubinstein, 1982). As economics has embraced the game-theoretical approach to analyzing human interaction, abstract models of bargaining have appeared embedded in more general models of industrial organization (e.g., in models of vertical integration, Church and Ware, 2000: ch. 22), labor economics and macroeconomics (e.g., in models of search and matching, Cahuc and Zylberberg, 2004: ch. 7), to name a few examples.[1] The availability of formal models and testable predictions has then attracted experimental economists to studying bargaining and especially the empirical relevance of the proposed models. Bargaining has even received its own chapter in the first volume of *The Handbook of Experimental Economics* (Kagel and Roth, 1995: ch. 4).

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[1] For a more complete list of references we also cite McDonald and Solow (1981), Diamond (1982), and Blanchard and Diamond (1994). In addition, note that a few classical papers assume a fixed split of the surplus from bargaining without explicitly mentioning the Nash bargaining solution (e.g., Mortensen, 1994, and Mortensen and Pissarides, 1994).

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The main motivation for our study stems from the lack of consensus in the experimental literature concerning bargaining. Even after having received more than half a century of attention from the economics profession, bargaining remains a black box that produces unexpected results for any of the reigning paradigms. Advocates of strategic thinking claim that the observed results are essentially in line with game-theoretical predictions (Binmore et al., 1985; Binmore, 2007), while at the same time, advocates of other-regarding preferences stress that social preferences organize the collected data better (Güth et al., 1982; Güth and Tietz, 1990; Anbarci and Feltovich, 2013). We believe that experimental studies of bargaining have put unjustifiably large emphasis on strategic models of sequential bargaining and have ended up testing joint hypotheses which include the usual assumptions behind any model from non-cooperative game theory (e.g., optimization, stable preferences, full understanding of the game) and which typically remain unchallenged. It is surprising how the handbook survey (Roth, 1995) ignores the early literature on unstructured bargaining and dedicates only two pages to it (to its shortcomings) as opposed to the structured models. Consequently, it summarizes a literature that has tested and failed to find conclusive support to sequential models of bargaining. Neelin et al. (1988), for instance, find strong regularity in observed behavior, but reject both the Stahl-Rubinstein theory (the non-cooperative workhorse model of bargaining) and the equal-division model (the simplest possible version of other-regarding behavior).

In this paper, we report experimental results on unstructured bargaining from laboratory sessions. We have designed a series of symmetric and asymmetric treatments (in terms of possible payoffs and disagreement outcomes) with a minimal set of restrictions in each of which a randomly selected pair of participants has 5 minutes to reach an agreement. Participants were allowed to interact with each other (through the computer): they could chat, send and decide over proposals in any moment during the 5-minute frame.

This unstructured design creates an intuitive conflict situation for participants and allows us to explore bargaining behavior without having to impose and to explain a strategic environment whose successful implementation would not only rely on the usual payoff-bridging principle (Bardsley et al., 2009: ch. 3) but also on participants' cognitive and strategic sophistication. One could also say that instead of relying and testing non-cooperative game-theoretical models of bargaining, we approach the bargaining problem through the properties of its outcome or axioms.[2] The axiomatic approach has "a strong comparative advantage in analyzing behavior in environments whose structures cannot be observed or described precisely" (Crawford, 2003). Moreover, looking at bargaining through the lenses of axiomatic game theory constitutes an alternative way to studying fairness.[3]

We search for empirical support for seven well-known axioms (or properties) and six bargaining solution concepts including some of the most widely-used ones in axiomatic bargaining theory.[4] We rely on 12 treatments that create a sequence of bargaining situations for which the analyzed solution concepts predict different sequences of bargaining outcomes. Our empirical method differs from the usual path in that we do not estimate utility functions representing social preferences.[5] We organize the experimental data and discuss fairness with the help of axiomatic bargaining solution concepts and the axioms that characterize them.

Our approach contributes to the experimental literature discussed below with data from a within-subject design that includes a variety of bargaining situations for systematic analysis. We collected our observations at Waseda University (Tokyo, Japan) and at Paris 1 University (Paris, France), in two metropoles far from each other. Surprisingly enough, our findings are robust to the possible cultural differences between them.[6]

In order to ease understanding, our experimental design (described in detail in section 2) relies on *meaningful context*. In particular, our design includes terms with a clear meaning in common everyday language (like "farms" and "selling"), but they are unlikely to evoke strong emotions or connotations. We dedicate a separate section (section 6) to a brief discussion on context and to experimental results from sessions based on an alternative, arguably less context-rich bargaining environment which does not seem to alter our results. In conclusion, our findings are robust both across cities and experimental designs.

Our experimental study also aims at complementing the theoretical literature on bargaining. We wish to contribute to the so-called Nash program which consists of (i) defining a solution, (ii) identifying the properties (or axioms) of this solution, and verifying whether a set of properties uniquely identifies the solution (axiomatic characterization), and (iii) con-

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[2] Andreoni and Miller (2002) take a similar path to ours when testing the generalized axiom of revealed preference using experimental data collected with the help of dictator games.

[3] Moulin (2003) offers an excellent summary of the axiomatic approach related to the fair-division problem from economic theory. In addition, a possible next step in our research project could be to explore how non-standard utility functions (e.g., Fehr-and-Schmidt type utility functions representing social preferences, Fehr and Schmidt, 1999) would alter predictions from cooperative bargaining theory and whether our experimental data could be organized in a different way with their help.

[4] We consider the properties of strong efficiency, symmetry, scale invariance, individual rationality, independence of irrelevant alternatives, monotonicity, and midpoint domination. In terms of solutions, we analyze the Nash bargaining solution, the Kalai-Smorodinsky bargaining solution, the equal-division solution, the egalitarian solution, the deal-me-out solution, and a proportional solution that takes disagreement payoffs as a reference (refer to section 3 for details).

[5] For example, Anbarci and Feltovich (2013) show that a specific form of other-regarding preferences organizes best the collected experimental data from the Nash-demand game and an unstructured bargaining game.

[6] Following the seminal work on cross-country comparisons in experimental economics by Roth et al. (1991), we define possible cultural differences in a residual way: as differences that can not be attributed to variables other than the city in which the data was collected. In other words, we do not formulate or test any specific research hypothesis related to the culture of our subjects.

structing a non-cooperative game that yields the proposed solution as the equilibrium outcome (strategic characterization). As "[t]heoretical analyses usually yield definite predictions only under strong assumptions, which are reasonable for some applications but unrealistic and potentially misleading for many others" (Crawford, 2003), we believe that identifying (in the experimental laboratory) the features of unstructured bargaining environments in which certain properties that characterize a theoretical solution arise more naturally is a reasonable way of extending the Nash program.

Consistently with the early – and somewhat forgotten – works on symmetric, unstructured bargaining environments (Nydegger and Owen, 1974; Roth and Malouf, 1979, 1982; Roth and Murnighan, 1982; Roth et al., 1981), our data confirm strong efficiency, symmetry, independence of irrelevant alternatives and monotonicity, and rejects scale invariance. Participants seem to have a preference for equal monetary payoffs when the opponent's payoffs are observable, and this creates conflict with scale invariance.

Concerning individual rationality, we identify two tendencies in behavior. On the one hand, consistently with previous works (Anbarci and Feltovitch 2013, 2015; Kroll et al., 2014), bargaining agreements are *under-responsive* to changes in disagreement outcomes. This possibly is due to the relatively high occurrence of equal-division agreements. Even in situations in which the equal-division outcome is not individually rational (in 5 out of our 12 treatments), a significant fraction of participants still agree upon it. On the other hand, somewhat surprisingly, the equal-division agreement is rare in treatments where one of the participants would have to give away 62% or more of their disagreement payoff for an equal division of payoffs. In the rest of treatments, participants give away at most 44% of their disagreement payoff for equal division.[7]

We conclude that bargaining solutions that satisfy strong efficiency, symmetry, independence of irrelevant alternatives and monotonicity explain reasonably well the agreements observed in the experimental laboratory. Three well-known solutions that satisfy all these properties are (i) the equal-division solution, where both bargainers obtain the same payoff, the (ii) deal-me-out (DMO) solution, which delivers the individually rational agreement that is closest to the equal division of payoffs (Sutton, 1986; Binmore et al., 1989, 1991), and (iii) the egalitarian solution, that gives bargainers the same increase in payoffs compared to the disagreement payoffs (Myerson, 1977; Roth and Malouf, 1979).[8] With the help of the axiom of midpoint domination and our experimental data we are able to refine this list further and discard the egalitarian solution (and the considered, but less well-known proportional solution).[9]

The most frequent agreement in our sample is the equal-division agreement. In the ranking of organizing the data, the equal-division solution is followed very closely by the deal-me-out in terms of frequencies. When all observed agreements are taken into consideration, the theoretical solution that best explains the data (in terms of average Euclidean distance) is the deal-me-out solution, followed by the egalitarian solution. Although the overall most frequent agreement involves equal division of payoffs, in treatments where the equal division is not individually rational we observe that (i) the frequency of the equal-division outcomes drops considerably, and (ii) the other successful agreements are mostly individually rational. These two tendencies seem to be responsible for the result that the (average) Euclidean distance of successful agreements is smaller to the deal-me-out outcomes – which are always individually rational and coincide with the equal-division outcomes when those are individually rational.

In summary, the deal-me-out solution arises as a good predictor for outcomes in our unstructured bargaining environment, just like in the much more structured and constrained setup of the alternating-offer bargaining game (Binmore et al., 1989, 1991). The overall predictive success of deal-me-out depends on the opportunity cost of equality for the bargainers. When that opportunity cost is zero, deal-me-out coincides with the equal-division solution, and when the opportunity cost is high enough (62% or more), deal-me-out outperforms the equal-division solution in terms of the (average) Euclidean distance to observed agreements, while the equal-division solution outperforms deal-me-out in terms of observed frequency.

As for the poor predictors, our experimental results dethrone the Nash bargaining solution and the Kalai-Smorodinsky solution which – to the best of our knowledge – have been used by theorists disproportionately too often. Based on casual observations, Thomson (2009) reminds us that "[t]he Nash solution satisfying many invariance conditions, it is not much of a surprise that it should have come out [in theoretical research] often. On the other hand, the monotonicity axioms that have generally led to the Kalai-Smorodinsky and equal-division solutions are readily understood and endorsed by the man on the street." The experimental results from our 12 treatments suggest that scale invariance is yet another invariance condition that lacks strong empirical support.

As for the inclusion of the bargaining solutions into high-level models of vertical integration, and search and matching, researchers seem to prefer solutions that have the property of scale invariance because it allows to write the bargaining problem in terms of an *object* and not in terms of *payoff*. For example, in search and matching models where wages are the result of bargaining between employers and workers, the agreement reached can be invariantly expressed in terms of the wage, in terms of utility and in terms of working hours as long as the applied solution concept is scale invariant – which is the case of the Nash bargaining solution and the Kalai-Smorodinsky solution. Results and agreements could, however, change drastically if one used a scale variant solution like the equal-division one.

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[7] Our 12 treatments have been designed to test the overall importance of the above-mentioned seven properties, and do not allow for a precise sensitivity test on individual rationality. Further research with a new design is needed to explore this cut-off value that seems to be the opportunity cost of equality or participants' willingness to pay for equality.

[8] In line with the theoretical literature, we refer to the third bargaining rule as *egalitarian*, although the experimental literature tends to call this solution and the corresponding outcomes as *equal gains*. One could argue that *libertarian* is a more appropriate term.

[9] The axiom of midpoint domination requires that the bargaining solution Pareto-dominate randomized dictatorship.

2. Experimental design

We ran five sessions at LEEP, Paris 1 University (Paris, France) and five at Waseda University (Tokyo, Japan). Participants were recruited with ORSEE (Greiner, 2015) in Paris and through online ads on the university website in Tokyo. Both the main experiment and the post-experimental questionnaire were implemented with zTree (Fischbacher, 2007). Participants interacted anonymously in randomly matched pairs and played 10 (in two sessions in Tokyo) or 12 rounds (in all five sessions in Paris and in four sessions in Tokyo) of bargaining. Our observations stem from the *usual* convenience samples: participants were volunteer undergraduate and graduate students (except for one unemployed participant in Paris) who received monetary performance-dependent compensation for participation.[10] Each round of bargaining occurred with a new randomly and anonymously assigned partner (stranger matching). 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. The experimental sessions lasted for about 90 minutes.[11]

In our experiment, participants were owners of virtual chicken farms and earned real money by selling virtual eggs (laid by virtual hens) at a fixed price (1 euro cent in Paris, 1 yen in Tokyo) under different conditions to the experimenter.[12] We have used the intuitive framing story of chicken farms to create some context to make the relatively complex bargaining problem easier to understand. Our goal was to make the experimental design (including the story, the instructions, and the computer screens) as intuitive as possible. Given that the answers to our research questions are based on statistical comparisons across treatments, the context that we have created is unlikely to introduce a significant bias into our conclusions.[13] Section 6 offers further discussion on context and reports experimental results, as a robustness check for all our findings, based on an arguably less context-rich design.

Participants were paid their accumulative earnings in cash (plus the show-up fee) at the end of each experimental session.[14] For the sake of clarity and simplicity, we present results related to earnings in EMU (experimental monetary units). In Paris 1 EMU equals 1 euro cent, while in Tokyo 1 EMU equals 1 yen.

In each round, each pair of matched participants could distribute 150 (virtual) hens by reaching an agreement. They had 5 minutes to do so, during which they were allowed to send numerical proposals and also text messages to each other without any further constraint. The computer interface allowed participants to send new or withdraw earlier proposals, to accept or reject previously received proposals, and to quit bargaining at any time during the round.

At the beginning of the round, participants were randomly assigned to a farm (a role) with a number of characteristics. Farms differed in terms of technology (the number of eggs laid by each hen), taxation (egg productions was heavily taxed on certain farms if production reached a pre-specified limit), and the hens allocated in case of disagreement. In our experimental design each round corresponds to a different bargaining situation and treatment. Participants in different sessions faced the same bargaining situations in the same order. At the beginning of each round, they were informed about the characteristics of their own farm and those of the opponent. In order to keep the changing characteristics of the farm 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. Table 1 provides a summary of our treatments.

By relying on a within-subject design with stranger matching, we wish to keep our experimental design as close as possible to axiomatic bargaining theory. Although the subsequently presented statistical analysis does allow for some unobserved subject-specific effects and we estimate possibly different bargaining powers as modeled in theoretical work, our approach consists in looking for the axioms that the representative bargainer would agree to. In other words, the observations of our interest are individual bargaining outcomes.

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[10] Paris: 102 participants, aged 18-40 (mean 22.2), 54% male, average earnings 11.25 euros plus 7 euros as show-up fee. The modal reported major in our subject pool in Paris is economics (34%), followed by law (9%), and communication studies (6%). Tokyo: 108 participants, aged 18-28 (mean 20.6), 65% male, average earnings 1104 Japanese yen plus 700 Japanese yen as show-up fee. The modal reported faculty for our subjects in Tokyo is Political Science and Economics (19%), followed by Humanities and Social Sciences (16%), Education (11%), Commerce (11%) and Culture, Media and Society (10%).

[11] The English translation of the experimental instructions and a sample screen are in Appendix A.1. The French and the Japanese versions, the zTree files and the collected data are freely available from the authors upon request.

[12] Note that our design puts bargaining parties in a horizontal situation – in which two farmers decide how to divide a scarce resource. This is because we wish to test the theoretical axiom of symmetry for which we need at least one treatment with identical bargaining positions across the two parties. Section 5 offers a brief discussion on asymmetric solutions to the bargaining problem and presents some related statistical results from our database.

[13] For an excellent survey on the effects of context and a careful methodological discussion we refer to Alekseev et al. (2017). They cite existing examples from the literature for experimental designs that talk about *firms*, *war*, *gold mines*, being a *supervisor* at workplace or a *manager at a power plant*, in order to successfully create meaningful context to ease participants' cognitive load created by the complex strategic environment induced in the laboratory.

[14] The profession has not yet concluded the debate on how to choose the monetary-incentives scheme for laboratory experiments (e.g., Azrieli et al., 2018; Cox et al., 2015; Cubitt et al., 1998). Both theoretical and empirical evidence exist both in favor and against paying participants for all the decisions they make during a session. Our choice was primarily motivated by its simplicity. The presented regression analysis controls for possible income effects.

Table 1
Treatment summary. EGGS PER HEN: number of eggs laid by each hen; TAX (%): tax rate; UNTAXED: maximum number of monetary units untaxed; OUTSIDE OPT: number of hens in case of disagreement.

TREATMENT (ROLE)	EGGS PER HEN		TAX (%)		UNTAXED		OUTSIDE OPT	
	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
1	1	1	–	–	–	–	30	30
2	1	2	–	–	–	–	30	30
3	1	2	–	66	–	150	60	60
4	2	1	–	–	–	–	90	30
5	1	2	–	–	–	–	90	30
6	2	1	66	–	150	–	30	30
7	2	1	66	–	210	–	90	30
8	1	2	66	–	45	–	30	90
9	1	2	66	–	105	–	90	30
10	2	1	66	–	90	–	30	90
11	1	1	–	–	–	–	90	30
12	1	1	66	–	75	–	30	30

3. The bargaining problem: definitions and hypotheses

This section introduces the theoretical solutions to the bargaining problem that we consider and their properties. The formal definitions are followed by a brief explanation of the method that we use to test their empirical relevance. The presentation relies on the notation from Kalai and Smorodinsky (1975).

A two-person bargaining problem consists of a pair (a, S), where S is a closed convex subset of $\Re^2_+$, $a = (a_1, a_2)$ is a vector in $\Re^2_+$, and the set $S \cap \{(x_1, x_2) | x_1 \geq a_1 \text{ and } x_2 \geq a_2\}$ is nonempty and bounded. The set S represents the set of feasible *payoff* combinations. The vector a represents the pair of payoffs in case of disagreement, and we will refer to it as the outside option payoffs or the payoffs at disagreement.[15] We denote by $f(a, S) = (f_1(a, S), f_2(a, S))$ the payoff vector representing the result of the negotiation or the agreement in the bargaining problem (a, S). In theory, this function f is called a solution. The axiomatic approach to solving bargaining problems consists of defining properties of the solution (called axioms) and analyze under which conditions the listed properties are compatible and if so, how. If a list of properties pins down a unique solution, then we say that the solution is axiomatically characterized by means of the corresponding list of axioms. Nash (1950) in his seminal work proposed five properties or axioms (that characterize the so-called Nash bargaining solution):

1. *Strong efficiency*: $f(a, S)$ is a payoff vector in S, and, for any x in S, if $x \geq f(a, S)$, then $x = f(a, S)$.
2. *Individual rationality*: $f(a, S) \geq a$.
3. *Scale invariance*: For any real numbers c_1, c_2, d_1, and d_2 such that $c_1 > 0$ and $c_2 > 0$, if
$$S' = \{(c_1x_1 + d_1, c_2x_2 + d_2) | (x_1, x_2) \in S\}$$
and
$$a' = (c_1a_1 + d_1, c_2a_2 + d_2),$$
then
$$f(a', S') = (c_1 f_1(a, S) + d_1, c_2 f_2(a, S) + d_2).$$
4. *Symmetry*: If $a_1 = a_2$ and $\{(x_2, x_1) | (x_1, x_2) \in S\} = S$, then $f_1(a, S) = f_2(a, S)$.
5. *Independence of irrelevant alternatives (IIA)*: For any closed convex set S', if $S' \subseteq S$ and $f(a, S) \in S'$, then $f(a, S') = f(a, S)$.

In order to find the outcome that the (symmetric) Nash bargaining solution prescribes to a bargaining problem, one has to maximize the so-called symmetric Nash product over the set of feasible payoff combinations that are individually rational:

$$\max_{x \in S, x \geq a} (x_1 - a_1) \cdot (x_2 - a_2).$$

Kalai and Smorodinsky (1975) suggested a monotonicity axiom as an alternative of the controversial independence of irrelevant alternatives. Let $m_i(a, S)$ denote the maximal payoff that player i can get in any feasible individually rational allocation, so

[15] In some applications outside options (deadlock) and disagreement points (breakdown) might differ, but in our experiment we follow Nash's original formulation and treat them as identical.

$$m_i(a, S) = \max_{x \in S, x \geq a} x_i.$$

For any number z_1 such that $a_1 \leq z_1 \leq m_1(a, S)$, let $h_2(z_1, S)$ denote the highest payoff that player 2 can get in a feasible payoff vector where player 1 gets z_1. That is,

$$h_2(z_1, S) = max\{x_2 | (z_1, x_2) \in S\},$$

and $h_1(z_2, S)$ is defined similarly.

6. *Individual monotonicity*: For any closed convex set S', if $m_1(a, S') = m_1(a, S)$ and $h_2(z_1, S') \leq h_2(z_1, S)$ for every z_1 such that $a_1 \leq z_1 \leq m_1(S, d)$ then $f_2(a, S') \leq f_2(a, S)$. Similarly, if $m_2(a, S') = m_2(a, S)$ and $h_1(z_2, S') \leq h_1(z_2, S)$ for every z_2 such that $a_2 \leq z_2 \leq m_2(a, S)$ then $f_1(a, S') \leq f_1(a, S)$.

The axioms of strong efficiency, symmetry, scale invariance, individual rationality, and individual monotonicity characterize the Kalai-Smorodinsky bargaining solution. To compute the outcome for a bargaining problem according to the Kalai-Smorodinsky bargaining solution, one has to look for a strongly efficient and individually rational pair of payoffs x_1 and x_2 that also satisfies the following equation:

$$\frac{x_1 - a_1}{x_2 - a_2} = \frac{m_1(a, S) - a_1}{m_2(a, S) - a_2}.$$

Sobel (1981) discussed a new property that he called symmetric monotonicity and that has been referred to in the subsequent literature as *midpoint domination*. It has been used in alternative characterizations of both the Nash bargaining solution and the Kalai-Smorodinsky bargaining solution (Moulin, 1983; Karos et al., 2018).

7. *Midpoint domination*: $f(a, S) \geq \frac{1}{2} m(a, S)$.

Beside the Nash and the Kalai-Smorodinsky bargaining solutions, we consider four additional efficient solutions[16]:

- The proportional solution that prescribes efficient outcomes that are proportional to the disagreement payoffs whenever $a \neq (0, 0)$.
- The equal-division solution which assigns an efficient outcome with the same payoff to each of the bargaining parties.
- The deal-me-out solution (Sutton, 1986; Binmore et al., 1989, 1991) which recommends individuals to distribute resources according to the equal-division solution as long as it does not imply one of the agents to be worse off than in the disagreement point. In that case, the agent in question receives her disagreement payoff and the partner keeps the rest.
- The egalitarian solution which proposes that both agents gain the same in terms of the difference of final outcome minus the disagreement distribution. Put it differently, the difference in final payoffs is equal to the difference in the payoffs at disagreement.[17]

Each of these solutions induces a payoff distribution and satisfies a number of properties.[18] Note that our study does not cover all the existing bargaining solutions, nor all the existing axiomatic characterizations. We have chosen the six most frequently-used bargaining solutions and their "typical" axiomatic characterization (Table 2).

In terms of our experimental design, *weak Pareto efficiency* requires that participants in each pair agree upon a distribution of all the available 150 hens.[19] Any agreement that involves less than 150 hens would be strictly Pareto-dominated by an agreement where all the 150 hens are distributed. In particular, disagreements are also strictly Pareto-dominated.

Individual rationality requires that participants agree upon a distribution of hens that yields each of them at least the same earnings as their outside option, which is the payoff they would get in case of disagreement.

[16] These solutions are weakly efficient in the sense of Pareto, as they lie in the upper-right frontier of S but they could belong to horizontal or vertical segments of the frontier. More formally, there cannot exist a vector of payoffs in S that provides strictly higher payoff to both bargainers than any of the solutions proposed, although for some particular shapes of S there could exist the possibility of finding a vector of payoffs in S where one of the bargainers' payoffs is greater than at the solution. The Nash and the Kalai-Smorodinsky bargaining solutions also satisfy strong efficiency. That is, there cannot exist a vector of payoffs in S where at least one of the bargainers' payoffs is greater than at the solution.

[17] According to Roth and Malouf (1982), this equal-gains solution is the proportional solution with equal weights proposed by Kalai (1977), Myerson (1977), Roth and Malouf (1979) and Roth (1979a, 1979b). For the situations considered in our experiment, this egalitarian or proportional solution with equal weights is equivalent to the maximin solution, because the payoffs obtained by players are not truncated from above as in the experiment by Roth and Malouf (1982).

[18] Table B.15 in Appendix B lists the suggested bargaining outcome by each of the considered solution concepts.

[19] Note that the bargaining problem that we are considering is a so-called division problem (Peters, 1992, p. 4), where bargainers decide how to share a certain amount of a given object, in our case 150 hens. The size of the "cake" is fixed throughout all our 12 treatments. What do change across treatments, as we modify the rules about eggs and taxes, are the possible monetary gains and the utility derived from the objects to be divided.

Table 2
Solutions and axioms. PAR EFF: weak Pareto efficiency; INDIV RAT: individual rationality; SCALE INVAR: scale invariance; SYMM: symmetry; IIR: independence of irrelevant alternatives; INDIV MON: individual monotonicity; MIDP DOM: midpoint domination. ◯: the solution listed in the row satisfies the axiom listed in the column; ×: the solution listed in the row does not satisfy the axiom listed in the column.

SOLUTION CONCEPT	PAR EFF	INDIV RAT	SCALE INVAR	SYMM	IIR	INDIV MON	MIDP DOM
Nash BS	◯	◯	◯	◯	◯	×	◯
Kalai-Smorodinsky BS	◯	◯	◯	◯	×	◯	◯
Equal division	◯	×	×	◯	◯	◯	×
Proportional wrt disagr.	◯	◯	×	◯	◯	◯	×
Egalitarian	◯	◯	×	◯	◯	◯	×
Deal-me-out	◯	◯	×	◯	◯	◯	×

Scale invariance means that an agreement in terms of hens does not depend on scale or technology (i.e., the number of eggs per hen) obtained by each participant. Previous studies (e.g., Nydeggen and Owen, 1974; and Roth and Malouf, 1979, 1982; Roth and Murnighan, 1982) found an equality bias in agreements in unstructured bargaining environments. Moreover, this equality bias seems to depend on the information about one's own and the opponent's payoffs. In our experimental design this bias would mean that participants whose hens lay more eggs agree upon receiving a smaller number of hens so that a more equal final distribution of payoffs is obtained. We will refer to this bias as *interpersonal comparisons of utility* (ICU).

Symmetry requires that in a perfectly symmetrical bargaining situation (treatment 1) participants agree upon receiving an equal number of hens.

Independence of irrelevant alternatives and *individual monotonicity* are related to how the agreement depends (or does not depend) on taxes in our design. If the farmer's maximum untaxed income is higher or equal than the gains when her farm has the same characteristics but there is no tax, then the tax is considered irrelevant in the sense of IIA. We use data from treatments where one farm is taxed and the tax is irrelevant to check the axiom of IIA. The axiom of IIA is supported by the experimental data as long as taxes have no significant effect on agreements in the treatments when the tax is irrelevant.

However, if the farmer's maximum untaxed income is smaller than the gains that farmer obtains when having the same characteristics but without the tax, then taxes are not considered irrelevant according to the definition of IIA. We use data from treatments where one farm is taxed and the tax is not irrelevant to check the axiom of individual monotonicity. The axiom of individual monotonicity is supported by the experimental data if taxes have a significant effect on agreements (negative on one's own gains and positive on the opponent's gains) in the treatments when the tax is not irrelevant.[20]

Note that our experiment incorporates treatments in which the outside options are increased for both agents or to only one of them (as compared to treatment 1) to check whether IIA and/or monotonicity interact/s in any way with individual rationality. Considering the most asymmetric (unequal) cases in terms of outside options, we have designed treatments where taxes are paid by the agent with the better technology (more eggs per hen) and treatments were taxes are paid by the agent with the worse technology (less eggs per hen). This will allow us to check whether IIA or monotonicity interact with interpersonal comparisons of utility.

Midpoint domination requires that the solution Pareto-dominate randomized dictatorship, which is the process in which a uniform lottery assigns the outside option to one of the bargaining parties and, given that as a constraint, a number of hens that gives the largest possible earnings to the other. In other words, bargaining parties should earn at least half of what they can get in any feasible individually rational allocation.

4. Results

Tables B.12, B.13, and B.14 in Appendix B offer a summary of the outcome of our experiment by listing all observed agreements (in terms of hens) and their frequency by round and city. Except for the initial and final rounds (rounds 1 and 12) in which equal division dominates, we observe a lot of heterogeneity. In what follows, we organize the data with the help of the theoretical solutions to the unstructured bargaining problem and the axioms behind those solutions. We present and analyze the data from Paris and Tokyo jointly, but often report descriptives separately as well. It is remarkable that the observations and main results do not differ much across the two cities.

4.1. Pareto efficiency

Table 3 shows the number of agreements as a percentage of the number of bargaining pairs (first block of three columns) and the number of efficient agreements as a percentage of total agreements (second block) by treatment and city. We

[20] In our experimental design, we have set the maximum untaxed income to coincide with the earnings from the Nash bargaining solution. We will discuss in the next section that the agreements reached during the equivalent treatments without taxes are below the maximum untaxed income level except in treatments 8 and 10. Hence, taxes are theoretically irrelevant in all treatments with taxes except in treatments 8 and 10.

Table 3
Observed number agreements as a percentage of all possible agreements, and efficient agreements as a percentage of observed agreements.

TREATMENT	AGREEMENTS			EFFICIENT AGREEMENTS		
	PARIS	TOKYO	ALL	PARIS	TOKYO	ALL
1	100	94.44	97.14	90.20	100	95.10
2	80.39	94.44	87.62	97.56	100	98.91
3	78.43	75.93	77.14	95	100	97.53
4	78.43	77.78	78.10	100	100	100
5	78.43	94.44	86.67	100	100	100
6	84.31	94.44	89.52	100	100	100
7	80.39	77.78	79.05	97.56	100	98.80
8	74.50	81.48	78.10	100	100	100
9	88.24	85.19	86.67	100	100	100
10	84.31	93.33	90.48	100	100	100
11	82.35	96.30	87.36	100	100	100
12	98.04	100	98.85	98	100	98.84
ALL	83.99	88.40	86.19	98.05	100	99.05

Table 4
Reaching an agreement. Dependent variable: 1 if agreement is reached, 0 otherwise. Odds ratios from logit regression. Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%.

equal number of EGGS PER HEN	2.61***	(0.52)
EQUALITY in conflict with IR	0.59***	(0.08)
diff. in OUTSIDE OPTIONS	0.99***	(0.00)
FIRST-OFFER SIGNAL	2.14***	(0.23)
diff. in ACC. EARNINGS	1.00	(0.00)
CONSTANT	6.00***	(0.69)
PSEUDO R-SQUARED	0.0751	
NUM. OBS.	2042	

observe that the vast majority of bargaining pairs were able to reach an agreement, with the lowest percentages being in Paris in treatment 8 and in Tokyo in treatment 3 (both around 75%). These are situations in which a distribution of hens that would yield equal payoffs to the bargaining parties is not individually rational (for one of them). Practically all observed agreements are efficient (i.e., they distribute all the 150 hens): agreements are always efficient in Tokyo and 98% of the agreements are efficient in Paris.

Given that most agreements are efficient, understanding how and why efficiency works goes through understanding why and how participants manage to reach an agreement. Table 4 shows the result from a logit regression for agreements (the dependent variable takes value 1 if agreement is reached, and 0 otherwise). The model includes five regressors. First, we consider the possibility that differences in productivity (number of eggs per hen) could make it harder to reach an agreement (treatments 1, 11, and 12). Second, we consider the possibility that agreements are more difficult to reach if the distribution of hens that guarantees equality in payoffs is not individually rational (treatments 3, 4, 7, 8, and 11). Third, we also consider the possibility that if the number of hens at disagreement is very unequal then it could be more difficult to reach an agreement. Fourth, we follow Young (1995), who argued that bargainers have a coordination problem to solve that includes to correctly anticipate what the opponent is going to agree to. Expectations about what the others do, and signaling of what one is willing to agree to are important components of one's bargaining abilities.[21] We define FIRST-OFFER SIGNAL as

$$\frac{\text{first offer to opponent - opponent's outside option}}{\text{150 - sum of outside options}}$$

in order to measure the signal sent by one's first proposal in the bargaining process. A very low value of this variable means that the participant is willing to fight for a deal that favors her. Larger values correspond to more generous first offers. Finally, we allow and control for possible income effects by entering (the difference of) accumulated individual earnings in our regression.

As it can be seen in Table 4, all our regressors, except for the one related to accumulated earnings, are significant. Agreements are significantly easier to reach in treatments where either there is equal number of eggs per hen, or where distributing according to equal payoffs does not enter in conflict with individual rationality. The size of these two effects is

[21] This logic suggests that bargaining happens in two stages: 1) choose the starting offer, then 2) compromise.

Table 5
Proportion of individually-rational agreements.

TREATMENT	PARIS	TOKYO	ALL
1	92.16	100	96.08
2	100	100	100
3	42.5	51.22	46.91
4	32.5	61.90	47.56
5	95	98.04	96.70
6	100	100	100
7	48.78	76.19	62.65
8	76.32	86.36	81.71
9	95.56	100	97.80
10	97.67	100	98.95
11	73.81	85.29	78.95
12	100	100	100
ALL	80.54	89.28	85.02

rather large and very similar: the odds of reaching an agreement roughly double when one or the other condition holds. It is significantly easier to reach an agreement when the difference in outside options is smaller and also for participants who are sending more tempered (first-offer) signals.

One might argue that the timing of offers, rejections and acceptances plays an important role in determining the success and the outcome of the bargaining process. Even though we approach the problem of bargaining axiomatically here, our experimental design does impose an important constraint on the otherwise free and unstructured bargaining environment: if an agreement happens, it must do so in at most five minutes. For that reason, although our main concern is to test the relevance of axioms instead of identifying typical bargaining "strategies", we have studied the distribution of agreements across time. Fig. B.7 in Appendix B offers a visual summary for the two cities separately. The aggregate distribution in both cities seems to be bimodal: a large number of decisions occur in the very first 30 seconds, and many others around the end of the allocated five minutes. It is important to note that agreements in the final 30 seconds are far more rare than in any other earlier timeframe of the same length. This suggests that our experimental design managed to balance important practical considerations related to the usual time constraint for experimental sessions in the laboratory and the cognitive burden that the analyzed tasks and conflict situations imposed on participants.[22]

All our treatments have been designed to make sure that several mutually-beneficial agreements exist, that is bargaining parties could improve upon the disagreement payoffs by simultaneously accepting such an allocation of the 150 hens in the available five-minutes bargaining time. In the majority of pairs that were unable to reach an agreement (64%), we find that the party with the lower outside option refuses to receive less payoff than her partner, even when the partner first offers a distribution of hens that yields more monetary payoff than the disagreement outcome.[23] We conjecture that this might be a sort of "demonstration of power" bias in unstructured bargaining environments. People are willing to sacrifice part of their payoff to avoid losing relative stakes, and (wasteful) disagreements remind the opponent that each bargaining party has veto power although exercising it might have different opportunity cost (Navarro and Veszteg, 2011).

4.2. Symmetry

The only treatment with symmetric roles in our experiment is treatment 1. In Paris, 44 of the 51 bargaining pairs (86%) agreed on the equal distribution of hens in that situation. In Tokyo, 50 of the 54 bargaining pairs (93%) did so. In Tokyo all those agreements were efficient, while in Paris 40 of them. We do not have a more plausible explanation for the few unequal and inefficient agreements than the possible first-round confusion.[24]

4.3. Individual rationality

A bargaining agreement is said to be individually rational if both bargaining parties obtain at least as much payoff as they would enjoy without reaching an agreement. In our experiment overall, most agreements were individually rational: 80% of them in Paris, and 89% of them in Tokyo. Nevertheless, the proportion of individually rational agreements fluctuates considerably from treatment to treatment. Individually-rational agreements are minority in treatments 3, 4, and 7 in Paris, and their proportion is below 80% in those treatments even in Tokyo (Table 5).

[22] On average, it took 2.5 minutes, 3.5 offers, and 5 messages to reach an agreement both in Paris and in Tokyo. Given that communication is not our primary concern in this paper, we postpone the detailed analysis of participants' interaction and focus on bargaining outcomes.

[23] In those pairs where bargaining did not lead to an agreement, in 64% (65% in Paris, 63% in Tokyo) of the cases the stronger bargaining party sent an individually rational but biased first proposal according to which the proposer would have obtained a higher payoff than her partner.

[24] One participant in Paris was even able to get 130 hens by an agreement that left her partner with an outcome below the disagreement level. In spite of the stranger-matching protocol and the experimenters' explicit request to keep interaction in the chat box anonymous, the participant convinced her partner that they could "re-catch later on" and balance payoffs then.

Recall that treatments 3, 4, 7, 8, and 11 have been designed such that an equal-division solution would not be individually rational. In particular, individual rationality would imply that in treatment 3 one of the participants obtains *at least* 120 EMU while the other earns *at most* 90 EMU. In treatments 4 and 7, one of the participants would obtain *at least* 180 EMU, while the other *at most* 60 EMU. Note that in treatment 7 the maximum untaxed income for the favored participant is 210 EMU and in all those three treatments the favored participant is the one obtaining two eggs per hen.

The classical references on the bargaining problem (Nash, 1950, 1953; Kalai and Smorodinsky, 1975; Kalai, 1977) consider the property or axiom of individual rationality as too obvious to be discussed. Nash (1950), for instance, restricts the bargaining problem to the subset where both bargainers obtain a higher payoff than in their disagreement point.[25] Similarly, Kalai and Smorodinsky (1975) consider feasible agreements where both agents obtain at least their utility at disagreement: "we can disregard all the points of S that fail to satisfy this condition because it is impossible that both players will agree into such a solution" (sic, p. 514, Assumption 4).

As highlighted in the analysis of efficiency above, the treatments where disagreement payoffs are very unequal have a low frequency of agreements (or efficiency). It turns out that they also have a low frequency of individual rationality. The majority of non-individually-rational agreements were reached by pairs where the less favored participant would start the bargaining by proposing an equal division of payoffs (58% in Paris, 51% in Tokyo) and refusing to accept anything that would give her less.[26] This behavior is consistent with the choice of equal division as a threat point in line with Nash (1953).[27] Note that individual rationality is violated as a considerable number of the favored participants (in treatments 3 and 4) accept proposals that give them a smaller amount of money than what they would have obtained by quitting. This is an important evidence that interpersonal comparisons of utility (ICU) not only disrupts scale invariance (as discussed in the next subsection) but also individual rationality (although at a minor scale). In each of treatments 3, 4, 7, 8, and 11, and in both cities, there was at least one participant proposing a distribution of hens that was not individually rational, but was more equal division than the outside-option payoffs. In other words, at least some participants seem to have *preferences for equality* or to display inequality aversion.

In order to illustrate the above claim statistically, we define the following inequality ratio for each pair of participants i and j who reached an agreement:

$$iq = \max\left\{\frac{u_i}{u_j}, \frac{u_j}{u_i}\right\},$$

where u_i and u_j are the monetary payoffs obtained by participants i and j, respectively, according to their agreement. If this inequality ratio is smaller for agreements that are not individually rational than for agreements that are, then we can confirm that participants have a taste for equality and are willing to sacrifice some monetary gains for it. Fig. 1 shows the box plot of the inequality ratios for individually rational (IR) and non-individually-rational (non IR) agreements for treatments 3, 4, 7, 8, and 11 in which the equal division distribution is not individually rational.

Both in Tokyo and Paris, all three quartiles of the inequality-ratio distribution are statistically different across categories (p-values < 0.01), significantly smaller for non-individually-rational agreements.[28] This confirms our claim that when individual rationality results in very unequal distributions of money, some participants choose alternative threats to trigger quitting or to block unequal proposals from their bargaining partners, and some participants end up accepting more equal payoffs even though they could have obtained a higher payoff in case of disagreement.

In summary, individual rationality is far less of an obvious or non-problematic axiom than assumed by the seminal theoretical solutions to bargaining. Although we have found evidence for individual rationality traded off for equality by many participants, our data also offer empirical support for individual rationality as a property because a significant number of bargaining pairs reach an individually-rational agreement even in the more asymmetric rounds. The OLS regression estimates shown in Table 6 – and discussed further in detail in the subsequent subsections – suggest that outside options have a significant effect on the final agreement and that effect has the expected sign: a higher outside option tends to increase one's number of hens at an agreement, and a higher outside option for the opponent tends to decrease it. This is in line with findings presented by Anbarci and Feltovich (2013, 2015). The coefficient that they estimate for one's own outside option is around 0.35, meaning that a higher outside option allows a participant to obtain a higher number of hens in an agreement, although the responsiveness of the outcome is considerably below 1. What our experimental findings add to these existing results is that outside options do have a significant impact on bargaining outcomes, but the size of the effect is typically rather small (0.10 of one's payoff, and −0.09 of the opponent's). It is in the most asymmetric and most extreme

[25] By scale invariance then the problem gets 0-normalized, so that both agents' payoff in case of disagreement is equal to 0.

[26] In Paris, 76% of the above-mentioned first proposals of equal-division of payoffs turned into final agreement. In Tokyo, 84% of them.

[27] Although it seems natural to consider individual rationality with respect to the monetary payoffs that bargaining parties would obtain in case of disagreement, participants in our experiment were free to choose their "threat points" as imagined by Nash (1953). Nash (1953) studies a non-cooperative bargaining game where players first choose a strategy that will be used if no agreement is reached (a threat) and afterwards inform each other of their chosen threats before the non-cooperative (demand) game starts. Individual rationality would then be defined with respect to the *threat strategies* chosen by the players. In our experimental design, we assigned a number of hens to each participant in case of disagreement and these numbers were known to both players.

[28] The reported p-values are for Pearson's chi-square test for testing the equality of percentiles.

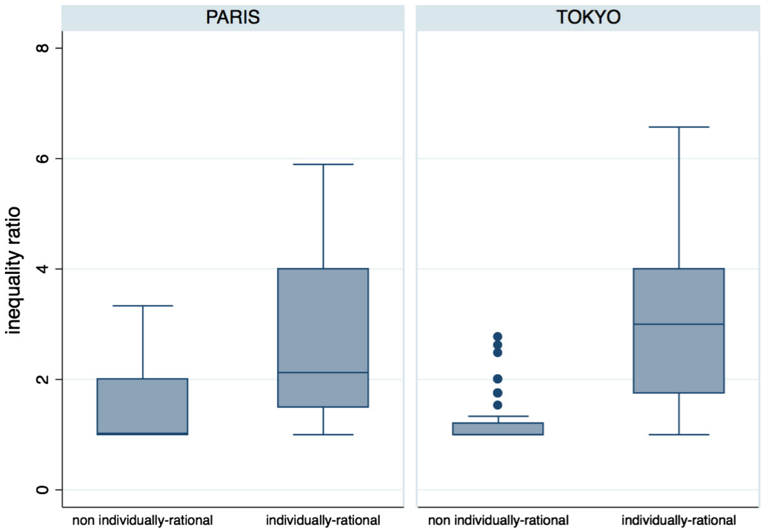

Fig. 1. Equality vs. individual rationality. Box plot for agreements in treatments 3, 4, 7, 8, and 11. IR: individually-rational agreements. INEQUALITY RATIO: $iq = \max\{\frac{u_i}{u_j}, \frac{u_j}{u_i}\}$.

Table 6
Explaining the final agreement. Dependent variable: number of hens or experimental monetary units obtained in the agreement. OLS coefficient estimates. Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%. OUT OPTION: outside option measured in the same measurement unit as the dependent variable (hens or earnings).

	HENS		EARNINGS	
EGGS PER HEN	−16.09***	(1.06)	40.35***	(1.89)
EGGS PER HEN opponent	19.53***	(1.06)	29.49***	(1.55)
TAXED	0.52	(0.85)	−2.63*	(1.55)
TAXED (TRTS 8 & 10)	−7.98***	(1.58)	−10.92***	(1.37)
TAXED opponent	−1.69*	(0.92)	−0.62	(1.12)
TAXED opponent (TRTS 8 & 10)	6.97***	(1.42)	9.66***	(2.41)
OUT OPTION	0.07**	(0.02)	0.06**	(0.02)
OUT OPTION (TRTS IR VS. EQ)	0.27***	(0.02)	0.21	(0.02)
OUT OPT opponent	−0.09***	(0.02)	−0.22***	(0.03)
OUT OPT opponent (TRTS IR VS. EQ)	−0.26***	(0.02)	−0.03	(0.02)
ACC EARNINGS	0.03***	(0.00)	0.04***	(0.00)
ACC EARNINGS opponent	−0.03***	(0.00)	−0.04***	(0.00)
CONSTANT	69.71***	(2.13)	5.18*	(2.89)
R-SQUARED	0.6708		0.7124	
NUM. OBS.	2110		2110	

situations, when individual rationality would lead to a very unequal distribution of payoffs, that effect size of the outside options increases to 0.29 in absolute value.

4.4. Scale invariance

In our experiment bargaining parties were required to decide how to distribute 150 hens, but it was eggs (laid by those hens) that led directly to monetary gains. The axiom of scale invariance requires the distribution of the 150 hens to be independent of changes in the way participants derive value from hens, as long as those changes are positive affine transformation. In other words, if bargaining is about hens, for its outcome (in terms of hens) it should not matter how much money each of those hens generate.

We explore the effect of our treatment variables on bargaining outcomes with the help of a simple regression model. All our regression models include accumulated earnings beside the treatment variables, in oder to control for possible income effects in decision-making. Note that the regressors for outside options are always measured in the same measurement unit (hens or earnings) as the dependent variable of the model. First, we regress the number of hens one receives in a specific bargaining round (that has ended in an agreement) on productivity (number of eggs per hen), on taxes (whether taxes are to be paid or not), on outside options, and on accumulated earnings in order to control for possible income effects. Table 6 contains the coefficient estimates and it shows that productivity (number of eggs per hen) has a large significant negative effect on the bargaining outcome, and that the opponent's productivity has a significant positive effect of similar size. This finding is consistent with previous results that have identified a bias towards equal division distributions in unstructured bilateral bargaining environments (Nydegger and Owen, 1974; Roth and Malouf, 1979, 1982; Roth and Murnighan, 1982; Roth et al., 1981).

One can also make pairwise treatment-to-treatment comparisons to explore this effect.[29] For example, by comparing treatments 1 and 2, we see that in treatment 1 the large majority of participants agreed on an equal number of hens, 75, while in treatment 2 the majority settled on a distribution that gives 50 hens to the participant obtaining 2 eggs per hen (hence 100 EMU) and 100 hens to the participant obtaining 1 egg per hen (hence also 100 EMU). If scale invariance held, we would have the majority of agreements in treatment 2 still assigning 75 hens to each bargaining party. Similarly, we see that in the majority of agreements in treatments 4, 5, and 6 the more productive (or favored) participant obtains 50 hens and the least productive participant obtains 100.

We have also compared the average agreement across treatments with the help of formal statistical tests: a parametric t-test and the non-parametric Wilcoxon rank-sum test.[30] The pairwise comparisons between treatments 1 and 2, treatments 11 and 4, and treatments 12 and 6 show that the differences are statistically significant (p-values < 0.01 for all tests and pairs). Interestingly, the average deal does not differ between treatments 11 and 5 in either city (t-test p-values ≥ 0.08; Wilcoxon p-values > 0.22). This is probably due to the outside options which favor the participants with worse technology (1 egg per hen). The regression analysis reported in Table 6 controls for all our treatment variables simultaneously.[31]

4.5. Independence of irrelevant alternatives and monotonicity

The coefficient estimates from the second regression model in which agreements are expressed in earnings (Table 6) indicate that taxes generally have no significant impact on bargaining outcomes except in treatments 8 and 10, where the effect is of a loss of more than 10 units of earnings (when one is required to pay tax). In order to see why treatments 8 and 10 are special, recall that taxes in our experiment were calibrated for the Nash bargaining solution (which does not typically yield the same result as the equal-division solution) in such a way that the (Nash) bargaining outcome without tax remains a feasible option even after the introduction of the tax. As we have argued in the introduction, the bargaining outcomes observed in the laboratory are closer to the predictions by the deal-me-out solution and the equal-division solution than to the predictions by the Nash bargaining solution. Given that our treatments to test the property of independence of irrelevant alternatives have been calibrated for the Nash bargaining solution, it could be the case that the observed bargaining outcomes in treatments without tax are infeasible in the corresponding treatment with tax (and taxes are therefore not irrelevant). It turns out, however, that it is not the case, except for treatments 8 and 10, which we use to test monotonicity. Note, for example, that the equal-division solution yields 100 EMU to each participant in the treatments where one of the participants can obtain two eggs per hen. Treatments 8 and 10 have an upper bound for untaxed earnings of 45 and 90, respectively, so that an agreement in which both participants obtain 100 EMU is simply impossible.

For these reasons, if independence of irrelevant alternatives is satisfied, the tax should have no impact on the bargaining outcomes, except again for treatments 8 and 10. If individual monotonicity holds, in those two treatments the participant who is required to pay tax has to obtain less earnings than in similar situations without the tax. The results of the second regression reported in Table 6 support both properties; our data are in line with the axiom of independence of irrelevant alternatives and the axiom of individual monotonicity.

A treatment-to-treatment comparison of the modal agreement leads to the very same conclusions (for more details refer to Tables B.12, B.13 and B.14 in Appendix B). For example, treatments 1 and 12 are identical except that in the latter one of the bargaining parties is required to pay a tax if she receives more than 75 hens (which equals 75 EMU for these two treatments). We observe that, in these two treatments, the overwhelming majority of agreements both in Paris and in Tokyo were the equal division (in these cases it coincides with the Nash bargaining solution). Similarly, by comparing treatment 2 to treatments 3 and 6, we observe that at least 40% of the pairs agree to obtain an equal number of eggs (and equal monetary earnings) in both cities in treatment 2, while in treatments 3 and 6 the proportion of pairs that agree on such a distribution of hens is less than (or equal to) that in both cities. Equal-division outcomes remain modal in treatments 4 and 7, and also in 5 and 9.

As for individual monotonicity, that is treatments 8 and 10, note that in treatment 4 the bargaining party who obtains one egg per hen gets more than 45 EMU in practically all agreements.[32] Recall, however, that the tax limit for the participant

[29] For the pairwise comparisons, see Tables B.12, B.13 and B.14 in Appendix B where we report the bargaining outcomes from the laboratory by treatment and city.

[30] We have also computed confidence intervals for the non-parametric rank statistics with the help of clustered standard errors (for subjects) based on Somers' D (Newson, 2006). None of the qualitative results reported in the text changes with this alternative approach.

[31] We have checked the robustness of our regression results with a subject-specific fixed-effects model, a subject-specific random-effects model, a restricted Tobit model, and crossed-effect models that not only introduce fixed or random effects for the decision-maker, but also for her partner. As compared to the discussed OLS results, the changes in the estimated coefficients and their statistical significance are very small. Refer to Tables B.19 and B.20 in Appendix B for further details.

[32] The exceptions are 1) one agreement in Paris yielding exactly 45 EMU, and 2) another agreement also in Paris yielding 40 EMU to the participant obtaining one egg per hen.

Table 7
Proportion of agreements that satisfy midpoint domination.

TREATMENT	PARIS	TOKYO	ALL
1	86.27	100	93.14
2	46.34	21.57	32.61
3	100	100	100
4	70	73.81	71.95
5	97.5	100	98.90
6	100	98.04	98.94
7	82.93	88.09	85.54
8	86.84	93.18	90.24
9	97.78	100	98.90
10	97.67	100	98.95
11	100	100	100
12	100	100	100
ALL	89.11	88.91	89.00

obtaining one egg per hen in treatment 8 is 45. This means that the tax is not irrelevant, it does remove relevant alternatives from the bargaining set. Similarly, note that in all the agreements in treatment 5 the participant obtaining two eggs per hen gets more than 90 EMU in the overwhelming majority of agreement, but the tax limit in round 10 is 90 for that participant.[33]

Pairwise comparisons confirm monotonicity by looking at the modal structure. In treatment 4, the equal-division solution (where each participant obtains 100 EMU) is the most frequent one. In treatment 8, the taxpayer obtains at most about 70 EMU from 115 hens (close to the equal-division outcome for that treatment). In treatment 5 the equal-division outcomes, where both participants obtain 100 EMU, is agreed upon in the majority of deals. In treatment 10, the taxpayer obtains at most about 97 EMU from 55 hens (the equal-division outcome for that treatment), except for an extreme agreement in Paris where the taxpayer obtained 127 EMU from 100 hens.

Just like in the subsection of scale invariance, we have also compared the average agreement across treatments with the help of formal statistical tests for each city separately: a parametric t-test and the non-parametric Wilcoxon rank-sum test.[34] The pairwise comparisons of earnings show no statistically significant differences in the average agreements between treatments 1 and 12 (except for role B in Paris, where the p-values are 0.08 for the t-test and 0.01 for the Wilcoxon test), and treatments 2 and 3, 2 and 6, 4 and 7 (except for Tokyo, where the p-values are 0.06 both for the t-test and the Wilcoxon test), and 5 and 9. As for individual monotonicity, the pairwise comparisons of earnings show statistically significant differences in the average agreements between treatments 4 and 8 (with p-values < 0.01 in both cities and tests), and 5 and 10 in Tokyo (p-values ≤ 0.01 for both tests). In Paris, the latter two treatments produced statistically identical agreements on average (p-values > 0.28 for both tests). As noted earlier, although these pairwise comparisons offer some informative insights into our database, it is the regression analysis reported above that controls for all our treatment variables simultaneously and that is able to offer a "clean" test for the empirical relevance of the studied axioms.

4.6. Midpoint domination

Among the considered solution concepts, it is only true in general for the Nash bargaining solution and the Kalai-Smorodinsky bargaining solution that the outcome gives to each party at least half of the payoff that is attainable in the (personally) best possible individually-rational agreement. Across the 12 treatments included in our experimental design, it is only the equal-division solution that fails to satisfy midpoint domination in treatments 2, 4, 7, and 8, and the deal-me-out outcome in treatment 2.

Overall, 89% of the observed agreements satisfy midpoint domination. At the same time, our data suggest that it is not a universal property. It lacks support especially in treatments 2 and 4, where the proportion of agreements satisfying it falls to roughly 30% and 70%, respectively (Table 7).

Fig. 2 shows the box plot of the inequality ratios for agreements that satisfy (MD) and that do not satisfy midpoint domination (non MD) for treatments 2, 4, 7, and 8 in which the equal-division agreement violates midpoint domination.

Both in Tokyo and in Paris, all three quartiles of the inequality-ratio distribution are statistically different across categories (p-values $= 0.0000$), significantly smaller for agreements that do not satisfy midpoint domination.[35] Similarly to our findings on individual rationality, the statistical results here suggest that agreements that do not satisfy midpoint domination are significantly and much more equal than those that do. We conjecture then that participants have preferences for equality

[33] In treatment 5, the exceptions are 1) three agreements in Paris and 2) six agreements in Tokyo giving exactly 45, 3) two agreements in Paris giving 40 and 42 each, and 4) seven agreements in Tokyo giving between 35 and 43 hens to the participant obtaining two eggs per hen.

[34] We have also computed confidence intervals for the non-parametric rank statistics with the help of clustered standard errors (for subjects) based on Somers' D (Newson, 2006). None of the qualitative results reported in the text changes with this alternative approach.

[35] The reported p-values are for Pearson's chi-square test for testing the equality of percentiles.

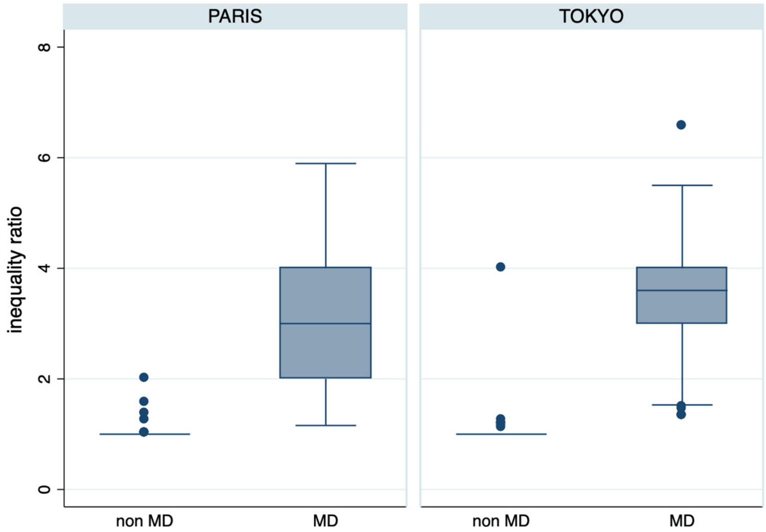

Fig. 2. Equality vs. midpoint domination. Box plot for agreements in treatments 2, 4, 7, and 8. MD: agreements satisfying midpoint domination. INEQUALITY RATIO: $iq = \max\{\frac{u_i}{u_j}, \frac{u_j}{u_i}\}$.

that disturb the performance of midpoint domination, as we did in the case of individual rationality explained before. Based on the empirical performance of this axiom we are able to refine the set of bargaining solutions supported by our data as explained in the next section.

5. A solution to the bargaining problem?

Our data confirm the empirical relevance of the axioms of strong efficiency, symmetry, independence of irrelevant alternatives, and monotonicity. Scale invariance is invalidated. Midpoint domination is not supported as a general axiom either, but our experimental design is unable to deliver deeper insight into why it fails. As for individual rationality, it is supported by the data in treatments where the disagreement payoffs are not asymmetric. However, treatments with very asymmetric disagreement payoffs produce a large heterogeneity in agreements, together with a low frequency of individually-rational agreements. These features of the data make it difficult to construct a model based on a "representative pair of agents" and a "universal solution" in line with the existing theoretical literature that typically explores and links its solution concepts to a certain combination of (characteristic) properties. What we can do is to identify a set of solutions that satisfy the empirically supported properties (i.e., strong efficiency, symmetry, independence of irrelevant alternatives, and monotonicity). This set includes the equal-division solution, which is not individually rational, and the deal-me-out, the egalitarian, and the proportional solutions, which are all individually rational. In addition, our relatively weak findings related to midpoint domination suggest that the egalitarian and our proportional solutions have less empirical support than deal-me-out and equal-division. The pronounced failure of midpoint domination in treatment 2 points at the overall success of deal-me-out.[36]

Instead of looking at and testing the underlying properties, we now look at the empirical relevance of the theoretical bargaining solutions directly by computing the (average) Euclidean distance between the outcomes that they predict and the observed agreements. Table 8 shows the ranking for the two cities separately. The deal-me-out solution outperforms all the other solutions that we have considered. The egalitarian solution comes overall second, followed by the Nash bargaining solution and the Kalai-Smorodinsky solution. The overall performance of the latter two is almost exactly the same, although Nash outranks Kalai-Smorodinsky in Paris and falls behind it in Tokyo. The equal-division solution performs very poorly under this measure in both cities.[37]

Although it is not the center of the empirical distribution of agreements (as measured by the Euclidean distance), the equal-division solution is the modal outcome and hence constitutes an important focal point. Table 9 shows the ranking of solutions according to their frequency with which they coincide with observed agreements. Note that percentages add up to more than a hundred because in some treatments different solutions yield the same result.

The two bargaining solutions that satisfy the properties supported by the data (equal-division and deal-me-out) together account for 50% of all successful agreements in Paris (257 out of 514) and for 46% in Tokyo (248 out of 541). Given that the analyzed 12 treatments do not cover all possible cases that our treatment variables can generate, nor constitute a

[36] Recall that both the egalitarian and the considered proportional solution fail to satisfy midpoint domination in general, but in our 12 treatments they both induce outcomes that do satisfy this property.

[37] For a more nuanced, but somewhat less clear ranking, refer to Tables B.16 and B.17 in Appendix B which show the Euclidean distances by treatment in Paris and Tokyo, respectively.

Table 8
Empirical explanatory power of theoretical solution concepts measured by the average Euclidean distance (from observed agreements). Solutions sorted from higher to lower explanatory power for each city.

Paris		Tokyo		all	
solution concept	distance	solution concept	distance	solution concept	distance
deal-me-out	13.52	deal-me-out	10.03	deal-me-out	11.73
egalitarian	17.33	egalitarian	13.11	egalitarian	15.17
Nash BS	18.67	Kalai-Smorodinsky BS	15.71	Kalai-Smorodinsky BS	17.29
Kalai-Smorodinsky BS	18.96	Nash BS	15.98	Nash BS	17.29
equal division	20.30	equal division	20.78	equal division	20.55
proportional wrt disagr.	24.65	proportional wrt disagr.	21.34	proportional wrt disagr.	22.96

Table 9
Empirical explanatory power of theoretical solution concepts measured by their observed frequency. Solutions sorted from higher to lower explanatory power for each city.

Paris		Tokyo		all	
solution concept	% freq.	solution concept	% freq.	solution concept	% freq.
equal division	45.14	equal division	45.84	equal division	45.50
deal-me-out	41.44	deal-me-out	44.55	deal-me-out	43.03
Nash BS	28.02	Nash BS	27.36	Nash BS	27.68
egalitarian	22.71	egalitarian	24.03	egalitarian	24.36
proportional wrt disagr.	20.04	proportional wrt disagr.	18.67	proportional wrt disagr.	19.34
Kalai-Smorodinsky BS	12.06	Kalai-Smorodinsky BS	13.31	Kalai-Smorodinsky BS	12.70

Table 10
Payoffs at disagreement (disagr), at the equal-division outcome (EqDiv), and at the deal-me-out outcome (DMO) in the "difficult" treatments.

treatment	disagr	EqDiv	DMO
3	60–120	100–100	90–120
4	180–30	100–100	180–60
7	180–30	100–100	180–60
8	30–180	68.67–68	50–180
11	90–30	75–75	90–30

balanced collection, it is useful to look at what happens from treatment to treatment (refer to Table B.15 in Appendix B for more data). Note that the treatments in which at least half of the agreements can be identified by one of the two here considered solutions are treatments 1, 2, 3, 5, 6, 9, and 12. In these situations, the equal-division solution performs very well. In treatments 4, 7, 8, and 11, the considered solutions do not account for even half of the agreements. Recall that these are our "difficult" treatments. For example, treatment 11 creates a situation in which both participants obtain one egg per hen, and the number of hens at disagreement are 90 and 30. Treatments 4, 7, and 8 are such that the participants obtaining two eggs per hen has 90 hens at disagreement. Neither of the two solutions (deal-me-out or equal division) seem to perform well here. More interestingly, treatments 3, 4, 7, 8, and 11 are the treatments were the deal me-out and the equal-division solutions would yield different agreements. Except for treatment 8, equal-division agreements are more frequent than deal-me-out agreements. Table 10 shows payoffs at disagreement, at the equal-division solution and at the deal-me-out outcomes for treatments 3, 4, 7, 8, and 11.

Treatment 8 yields the exact same inequality at disagreement as treatments 4 and 7. What makes treatment 8 different is that the agent who accepts to earn less payoff for the sake of equality sacrifices more monetary units than in any other treatments. In treatments 4 and 7 the favored agent at disagreement would give away 80 EMU in Paris and 80 EMU in Tokyo in order to accept an equal-division agreement, while in treatment 8 this amount would be of 122 EMU. In treatment 3, it would be only 20 EMU. In percentage terms, accepting the equal-division outcome in treatments 3 and 11 implies giving away 17% of the disagreement payoff, in treatments 4 and 7 that is 44%, and in treatment 8 that is 62%. The equal-division outcome in treatments 3 and 11 accounts for 32% of the successful agreements (in the two cities together), for about 19% in treatments 4 and 7, and finally we did not observe any equal-division agreement in treatment 8 in any city. We conjecture that individuals that have preferences for equality over individual rationality are willing to agree on an equal division deal as long as the amount that has to be given away (as compared to the disagreement payoff) is small.

In treatment 10, the equal-division and the deal-me-out solution prescribe the same outcome (54 and 96, with a payoff of 96 to each party), but it is observed in less than 13% of the agreements in any of the two cities. We do not have a clear explanation for this failure of the otherwise rather successful bargaining solutions.

Additional axioms, like the property of strong individual rationality (Myerson, 1977) could be helpful in differentiating between the equal-division solution and deal-me-out.[38] The deal-me-out solution does not satisfy strong individual rationality but satisfies individual rationality, while the equal-division solution does not satisfy either type of individual rationality. In our database, 79% of all agreements is strongly individually rational, and only 6% is weakly individually rational without being strongly so as well (refer to Table B.18 in Appendix B). As discussed earlier, individual rationality varies considerably across treatments. Treatments 3, 4, 7, 8, and 11 which put individual rationality to a serious test, have a much larger (4-20%) proportion of agreements that are only weakly individually rational, but those agreements still remain a minority. Although this argument is not conclusive, it supports the equal-division solution based on the axiom of individual rationality.

For an alternative measure of the empirical success of the analyzed solution concepts, we have regressed the observed bargaining outcomes on the predicted ones.[39] Interestingly, when all six solution concepts are included in the analysis, the ones that contribute significantly to explaining the observed outcomes are the equal-division solution, deal-me-out, and the Kalai-Smorodinsky solution (in decreasing order of explanatory power). After stepwise backward removal of insignificant regressors, we find that deal-me-out still beats the Kalai-Smorodinsky solution, but the equal-division solution performs worse than both (although their importance, measured through the sum-of-squares, turn out to be very similar). Combinations of the analyzed solution concepts manage to explain roughly 61% of the observed variation in bargaining outcomes.

All the discussed solutions, except for the solution that is proportional to disagreement payoffs, have asymmetric versions where players have an exogenously determined weight (or some sort of bargaining power). For example, the equal-division solution has an asymmetric version where bargainers obtain payoffs u_i and u_j on the Pareto frontier of the bargaining problem (i.e., an efficient agreement) and such that the ratio $\frac{u_i}{u_j}$ is equal to the ratio of the corresponding exogenously given weights. According to the asymmetric version of the egalitarian solution, bargainers obtain payoffs u_i and u_j on the Pareto frontier of the bargaining problem such that the ratio $\frac{u_i-a_i}{u_j-a_j}$, where a_i and a_j are the corresponding disagreement payoffs, is equal to the ratio of the corresponding weights. One's bargaining power or weight can, for example, be written as $p_i = \frac{u_i-a_i}{(u_i-a_i)+(u_j-a_j)}$ (Kalai, 1977). For this definition to make sense, we should only use observations with individually rational agreements. Given the observed frequency of equal division and egalitarian agreements, it is not surprising that the empirical distribution of Kalai's measure for bargaining power peaks at 50%. The distribution is symmetric (somebody's gain is somebody else's loss) and extreme values are rare (refer to the histogram in Fig. B.5 in Appendix B).

As opposed to economic or market power, bargaining power is typically defined with the help of bargaining outcomes (Bowles and Gintis, 2007). The danger of estimating the theoretical power indices from data is that ex post any efficient outcome can be rationalized. There is little value in fitting or calibrating a sufficiently flexible model to empirical observations if those estimates do not carry over across different (bargaining) situations.[40] Recall that we have observed our participants making decisions in a number of bargaining situations (with randomly assigned partners). We propose to measure bargaining power with the subject-specific fixed effects from a regression model that includes the same dependent and independent variables as the one reported in Table 6.[41] Apart from offering a robustness check for our statistical results, this approach considers all the observed agreements (including those that are not individually rational) when computing a proxy for bargaining power which essentially is an individual-specific fixed number (of hens) that can not be explained by our treatment variables (refer to the histogram in Fig. B.6 in Appendix B). With this approach the modal value for bargaining power remains 0, and an advantage or disadvantage of more than 10 hens (out of 150) is extremely rare. In summary, we do not find empirical support for the extensive use of asymmetric solution concepts for unstructured bargaining problems.

Although our experimental design in unable to pin down a single best bargaining solution, the empirical evidence that we report here suggests that the equal-division and deal-me-out solutions are more successful in organizing behavior in the laboratory than the frequently-used Nash and Kalai-Smorodinsky solutions. This finding has important implications for the conclusions and predictions of models that embed a bargaining problem (refer to the literature review in the introduction). Checking the extent of these implications is beyond the scope of this paper, but we have reconsidered the popular model by McDonald and Solow (1981) and recalculated its wage predictions which arise from bargaining between a firm and a trade union. Refer to Appendix C for details.

6. Context

Experimental economists have been weary of context since the early years when the induced-value method was introduced as the ultimate tool to achieve control and guarantee the internal validity of experimental results (Smith, 1976, 1982). As a consequence, experimental settings over the past four decades have been even more sterile and neutral than most un-

38 Intuitively, a solution satisfies strong individual rationality if both agents strictly gain from the agreement as compared to outside options whenever there are strict gains from agreeing. In other words, a solution satisfies strong individual rationality if it is individually rational and yields *strictly* higher payoffs than outside option payoffs to both agents whenever outside option payoffs are strictly Pareto dominated in S.

39 Table B.21 in Appendix B reports the estimated coefficients and the results of the analysis of covariance.

40 This is a serious problem that behavioral and experimental economics are reluctant to acknowledge. An illustration of the problem and a notable treatment, for example, is offered by Hargreaves Heap et al. (2014).

41 The Hausman test suggests the use of fixed effects instead of mixed effects at the usual significance levels (p-value = 0.0278).

dergraduate textbooks on economic theory.[42] In implementing the bargaining problem with the help of two imaginary chicken farms whose owners might be subject to taxation, our experimental design follows the game-theoretical tradition of using lively examples to make abstract and often complex problems lucid and accessible.[43] Our experiment is not more about hens and eggs than the "prisoners' dilemma" is about prisoners, the "marriage market" is about marriage, or the "lemons market" is about lemons. Our way to convey the bargaining problem to participants is a mere *example* meant to reduce cognitive burden by creating some meaningful context. It should not be mistaken for any effort to increase the external validity of the experimental findings.

The positive effect of context on understanding experimental instructions has recently been reported by Duersch and Müller (2017) related to auctions, by Ramalingam et al. (2018) related to public goods, and examined carefully in general by Alekseev et al. (2017) who survey numerous experimental designs. The meticulous discussion on methodology by Alekseev et al. (2017) culminates in a three-level classification of context. The context used in our main experiments belongs to the second level, or to the category of so-called *meaningful context* "that can be related to real-life situations, [...] but do[es] not evoke strong emotions or connotations. Meaningful context can enhance understanding of an environment and reduce confusion among participants" (Alekseev et al., 2017, p. 56).[44]

In this section, we offer a robustness test to our previously reported experimental results by studying bargaining behavior under a theoretically isomorphic yet less context-rich environment. Note that both our main experimental design and the one discussed in this section induce a specific empirical decision-making situation apt to test axiomatic bargaining theory. Although our ideal ultimate aim is to give a general verdict about the empirical validity of the analyzed axioms, even if we keep the bargaining context fixed, we can not possibly run and study all possible related experimental designs.[45] Similarly, creating a perfectly context-free experimental design is an elusive goal (Loewenstein, 1999; Loomes, 1999). The robustness test that we have performed relies on a specific experimental design which consists in replacing references to *hens*, *farms* and *taxation* (in the main experiment) by references to *tokens*, *collection* and *exchange (redemption) rates*.

Encouraged by anonymous referees and the editor of the journal, we have carried out two additional experimental sessions in both cities using a design in which bargaining happens over 150 tokens to be exchanged for real money at the end of the experiment. In order to create a logically equivalent set of bargaining situations without using the word "tax", the exchange rules occasionally change depending on the total number of tokens to be exchanged.[46]

42-42 volunteers have participated in these experimental sessions in each city, in October and November in 2018. All our previous findings are confirmed through the *token* treatments. In particular, bargaining leads to an agreement in 87% with an overall efficiency level of 99%. In treatment 1, 86% of the agreements is symmetric. When considering the entire set of agreements over our 12 treatments, we find that individual rationality is respected in 86% of them, with treatments 3, 4, 7, 8, and 11 being more challenging and with a ratio of individually rational agreements below 75%. Midpoint domination receives a 92% support overall, although treatments 2, 4, 7 and 8 show similar results to those observed through our original design. The same regression analysis (with two models similar to the ones reported earlier in Table 6) falsifies scale invariance (Table 11), and together with binary comparisons across treatments confirms independence of irrelevant alternatives and monotonicity. In terms of the Euclidean distance, deal-me-out clearly outperforms all the others. It is followed by the egalitarian solution, by the Nash and the Kalai-Smorodinsky bargaining solutions very close to each other, and finally by the proportional and the equal-division solution concepts at the end of the ranking. In terms of the observed frequencies, deal-me-out and equal division are close competitors at the top of the ranking, followed by the egalitarian solution and the Nash bargaining solution, while the proportional and the Kalai-Smorodinsky solutions perform very poorly.

In summary, the results discussed in the main text have proven to be robust to changes in the context of the unstructured bargaining environment.

7. Concluding remarks

We have analyzed data from a series of experiments in Paris and Tokyo on unstructured bilateral bargaining with symmetric and asymmetric treatments. Our experimental design allows us to check well-known properties proposed by Nash

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[42] In the typical experiment, market interaction happens around unspecified "imaginary goods", public goods appear as "public accounts" on which experimental monetary units can be invested, strategies in strategic games are labeled by letters or numbers carrying no meaning, and bargaining usually concerns a certain number of "tokens" with a specific monetary value.

[43] Context can also be helpful when directly considering theoretical models and results, as "[i]t is often difficult to assess how reasonable an axiom actually is in its abstract setting; we must seek its meaning in concrete contexts, looking particularly for cases where it leads to peculiar outcomes. [...] In this way its real limitations become apparent" (Luce and Raiffa, 1957, p. 123).

[44] Chou et al. (2009) use the concept of *recognition* (borrowed from psychology, Goldstein and Gigerenzer, 2002) to describe how subjects formulate their understanding of the strategic environment in the experimental laboratory. Arguably, *meaningful context* aids *recognition* which is a different concept from *framing*, "a process of formulating mental states that carry value" (Chou et al., 2009).

[45] For instance, bargaining might happen in money, in some specific tangible good, or in earning prospects. Even theoretically, the bargaining set might shrink in the same way due to taxation, to changing technology, or to mutating preferences.

[46] For example, in treatment 3 in Tokyo participants in role B were able to exchange tokens for 2 yen each but only up to 75 tokens. After that, each additional token was exchanged for 0.67 yen only. In monetary terms, this is equivalent to having hens that lay 2 eggs on the farm where a 66% tax is levied on income units above 150 yen. The English translation of the experimental instructions and a sample screen are in Appendix A.2. The French and the Japanese instructions, the zTree files, the generated data and the detailed statistical results for these experiments are available upon request.

Table 11
Explaining the final agreement. Dependent variable: number of tokens or experimental monetary units obtained in the agreement. OLS coefficient estimates. Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%. OUT OPTION: outside option measured in the same measurement unit as the dependent variable (hens or earnings).

	TOKENS		EARNINGS	
EXCHANGE RATE	−11.62***	(1.76)	57.97***	(3.07)
EXCHANGE RATE opponent	11.26***	(1.96)	14.34***	(2.22)
REDUCED RATE	−0.21	(1.44)	−3.60	(2.41)
REDUCED RATE (TRTS 8 & 10)	−1.02	(2.92)	−8.63***	(2.73)
REDUCED RATE opponent	0.50	(1.32)	−1.32	(1.58)
REDUCED RATE opponent (TRTS 8 & 10)	1.00	(2.98)	7.50	(4.87)
OUT OPTION	0.22***	(0.04)	0.16***	(0.05)
OUT OPTION (TRTS IR VS. EQ)	0.11**	(0.04)	0.21***	(0.06)
OUT OPT opponent	−0.21***	(0.03)	−0.52***	(0.06)
OUT OPT opponent (TRTS IR VS. EQ)	−0.11***	(0.04)	−0.04	(0.06)
ACC EARNINGS	0.02***	(0.00)	0.03***	(0.00)
ACC EARNINGS opponent	−0.02***	(0.00)	−0.03***	(0.00)
CONSTANT	75.30***	(2.20)	10.75***	(3.05)
R-SQUARED	0.5734		0.7538	
NUM. OBS.	876		876	

(1950, 1953) and Kalai and Smorodinsky (1975). In light of the observed agreements, we conclude that solutions that best explain the data are the ones that satisfy the axioms of strong efficiency, symmetry, independence of irrelevant alternatives, monotonicity, and that do not satisfy scale invariance or midpoint domination. As for individual rationality, we have not found such a clear-cut conclusion. A significant proportion of our participants seem to display preferences for equality over individual rationality. From what is observed in the relevant treatments, where equality comes into conflict with individual rationality, these preferences for equality depend on the amount of money that the favored participant has to give away. According to our data, it seems that if equality does not impose an opportunity cost higher than (around) 45% of the disagreement payoff, then 41% of successful deals are not individually rational, and are more equal than the individually rational ones. In those treatments, the deal-me-out and the equal-division solutions organize well the observations from the laboratory. Whether it is one or the other that explains the agreements depends on how strongly the favored participant cares for equality. If accepting equality implies that she has to give away more than 62% of her disagreement payoff (treatment 8), then individual rationality is a binding property. For those cases the agreement proposed by the egalitarian solution, which is also individually rational and satisfies the properties with empirical support listed above, seems to represent best how the bargaining problem is solved, followed closely by the deal-me-out solution.

In summary, bargaining situations with very unequal disagreement payoffs pose a challenge to the involved parties who would be more or less willing to trade off individual rationality for equality. Given the modality of the equal-division solution, we speculate that bargaining is often about in which direction and how far to deviate from the split that guarantees the same payoff to the bargaining parties. Highly asymmetric outside options could justify large deviations (in line with individual rationality), however the weaker bargaining party might fail to recognize or acknowledge that, and consequently bargaining could break down. Our experimental data show a significant increase in the number of disagreements in treatments where the disagreement payoffs are very unequal. Although rejection is wasteful, it might be a last resort unless one is willing to lose stake. This "demonstration of power" effect is similar to what we found in structured (ultimatum-style) bargaining environments (Navarro and Veszteg, 2011). A fine-tuned experimental design could confirm or refute this claim of ours, and could measure people's willingness to pay for equality.

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Appendix A. Instructions

This is the original set of instructions in English based upon which the Japanese and French translations were made. The screenshots included here are in French.

A.1. Main experiment (with context)

Welcome to our experiment!

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 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.

This experiment consists of 12 rounds and interaction will take place in randomly formed pairs. The computer will randomly assign you a partner in each round.

You are going to face similar decision-making scenarios in each round.

The general environment

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. You will receive 1 real Japanese yen for each imaginary egg that you produce and sell during the experiment.

Your earnings are going to depend on the number of hens you have on your farm, on the number of eggs each hen lays and on the amount of tax that you might be required to pay.

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 amount of tax) 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.

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 minutes 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's imagine, for example, that each hen on your farm lays 2 eggs and that you are required to pay some tax to the government if the value of eggs that your farm produces exceeds a certain limit. Imagine that this limit for non-taxable income is 100 yen and that you are required to give 1/3 of the excess above 100 yen to the government.

Under these circumstances, if you had 50 hens, they would lay $2 * 50 = 100$ eggs which is worth 100 yen. Given that this does not pass the limit of 100 yen, you would not have to pay tax to the government. So in the end, you would earn 100 yen.

If you had 110 hens, however, they would lay $2 * 110 = 220$ eggs which is worth 220 yen. This does pass the limit of 100 yen, therefore you would be required to give $(220 - 100) * 1/3 = 40$ yen to the government. So in the end, you would earn 180 yen.

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 characteristics of your farm and your partner's. These characteristics are eggs per hen, limit of non-taxable income, tax rate, and the number of hens you get in case you do not reach an agreement. Remember that these characteristics may change from round to round, and that your partner is going to see the same information 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 eggs, tax to be paid and final earnings, 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.

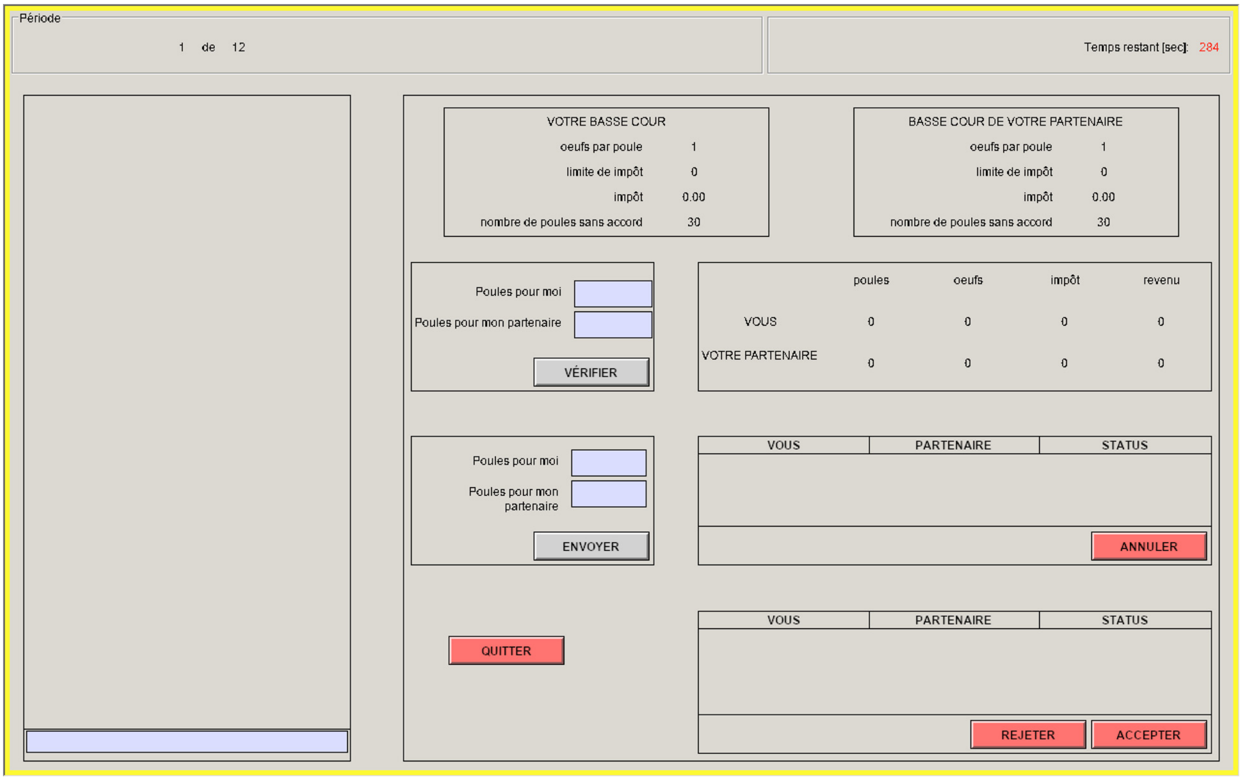

Fig. B.3. (For interpretation of the colors in the figure, the reader is referred to the web version of this article.)

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 limited 5 minutes 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. Do not forget that you will have to choose the correct keyboard setting when entering text in the chat box and when entering numbers for a proposal.

A.2. Robustness-check experiment (without context)

Welcome to our experiment!

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 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.

This experiment consists of 12 rounds and interaction will take place in randomly formed pairs. The computer will randomly assign you a partner in each round.

You are going to face similar decision-making scenarios in each round.

The general environment

You and your partner are asked to imagine that you collect tokens. Your goal is to sell those tokens to the experimenter at the end of each round. Your earnings, that is the amount of money that you will receive for each token is going to depend on the exchange rules that vary from round to round.

At the beginning of each round, the computer will randomly determine the exchange rules for you and also for your partner. Note that your exchange rules might differ from those of your partner. It is also possible that those rules specify different exchange rates for different number of tokens. At the beginning of each round, you will be informed about the exchange rules, both yours and your opponent's.

Your decision task in each round is to reach an agreement with your partner on how to allocate 150 tokens between you and your partner. You are going to have at most 5 minutes 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 tokens. Note that the number of tokens that your partner gets, if you do not reach an agreement, may be different from the number of tokens 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's imagine, for example, that the computer has determined the following exchange rules for you.

- The first 50 tokens are exchanged for 2 yen each.
- Each token after the 50th token is exchanged for $4/3 = 1.33$ yen.

Under these circumstances, if you had 50 tokens, they would be worth 100 yen, given that the first 50 tokens are exchanged for 2 yen each. So at the end of the round, you would earn 100 yen.

If you had 110 tokens, however, the first 50 of them would be worth 2 yen each, while the remaining $(110 - 50) = 60$ tokens would be worth $4/3 = 1.33$ yen each. Therefore, at the end of the round, you would earn $(50 * 2) + (60 * 1.33) = 180$ yen.

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 your exchange rules and your partner's. These tables also show the number of tokens you get in case you do not reach an agreement. Remember that these exchange rules and the number of tokens in case of disagreement may change from round to round, and that your partner is going to see the same information on her screen.

Remember that in each round you have 150 tokens to assign between the two of you. If you would like to check the consequences of a specific split in terms of earnings (in yen), 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 limited 5 minutes 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. Do not forget that you will have to choose the correct keyboard setting when entering text in the chat box and when entering numbers for a proposal.

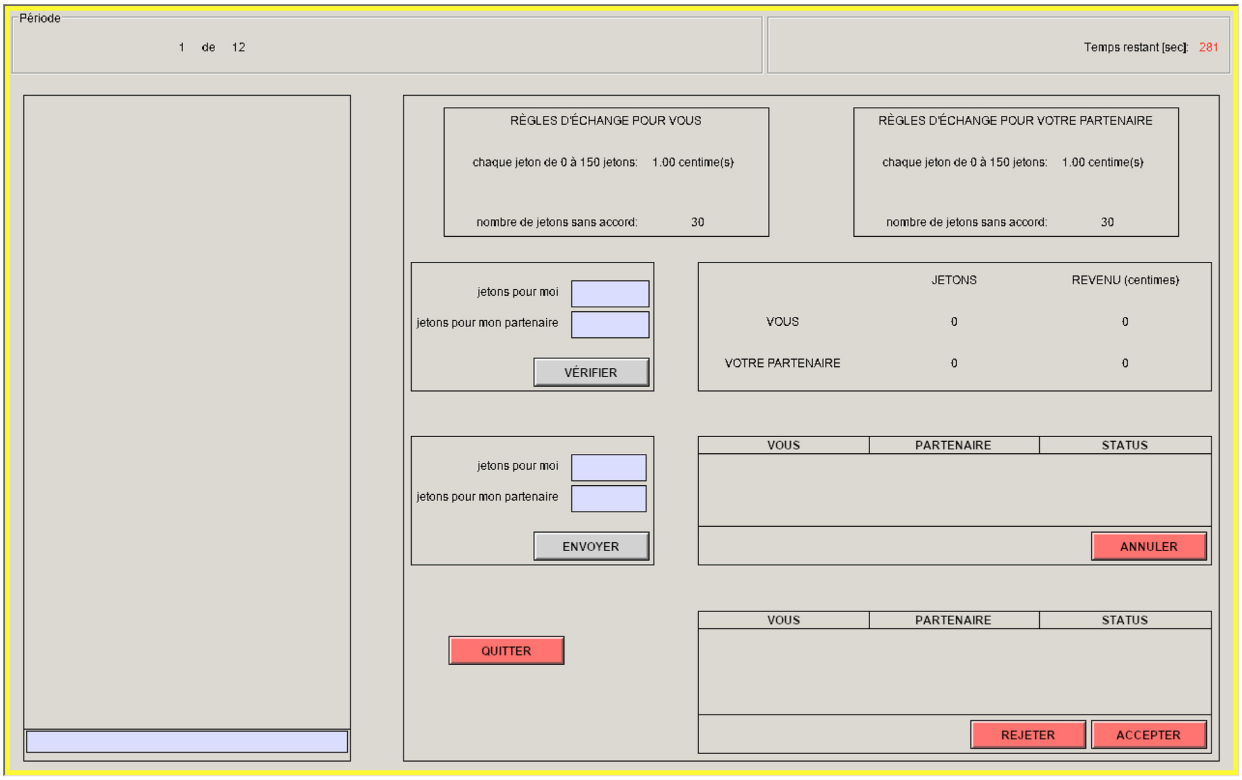

Fig. B.4. (For interpretation of the colors in the figure, the reader is referred to the web version of this article.)

Appendix B. Additional tables and figures

B.1. Bargaining outcomes

Table B.12
Bargaining outcomes from treatments 1 to 4. N/A indicates that no agreement was reached.

TREATMENT 1				TREATMENT 2			
PARIS		TOKYO		PARIS		TOKYO	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
75–75	40/51	75–75	50/54	100–50	20/51	100–50	39/54
15–15	2/51	70–80	1/54	75–75	9/51	75–75	6/54
80–70	2/51	N/A	3/54	90–60	4/51	50–100	1/54
20–130	1/51			70–80	2/51	70–80	1/54
30–30	1/51			80–70	2/51	80–70	1/54
35–35	1/51			50–50	1/51	86–64	1/54
50–100	1/51			76–74	1/51	87–63	1/54
60–0	1/51			85–65	1/51	90–60	1/54
85–65	1/51			99–51	1/51	N/A	3/54
90–60	1/51			N/A	10/51		

TREATMENT 3				TREATMENT 4			
PARIS		TOKYO		PARIS		TOKYO	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
100–50	16/51	100–50	20/54	50–100	11/51	100–50	9/54
90–60	7/51	90–60	9/54	75–75	8/51	90–60	9/54
75–75	5/51	75–75	5/54	100–50	7/51	50–100	9/54
50–100	3/51	85–65	5/54	90–60	2/51	95–55	3/54
80–70	3/51	80–70	1/54	75–75	4/51	91–59	2/54
70–50	1/51	88–62	13/54	60–90	2/51	55–95	1/54
75–45	1/51	N/A	13/54	65–85	2/51	58–92	1/54
76–74	1/51			80–70	2/51	60–90	1/54
85–65	1/51			105–45	1/51	65–85	1/54
95–55	1/51			110–40	1/51	70–80	1/54
99–51	1/51			58–92	1/51	75–75	1/54
N/A	11/51			70–80	1/51	87–63	1/54
				N/A	11/51	92–58	1/54
						93–57	1/54
						98–52	1/54
						N/A	7/54

Table B.13
Bargaining outcomes from treatments 5 to 8. N/A indicates that no agreement was reached.

TREATMENT 5				TREATMENT 6			
Paris		Tokyo		Paris		Tokyo	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
100–50	28/51	100–50	25/54	50–100	20/51	50–100	29/54
105–45	3/51	105–45	6/54	60–90	7/51	75–75	6/54
90–60	2/51	95–55	5/54	55–95	4/51	55–95	4/54
101–49	1/51	110–40	3/54	70–80	3/51	60–90	4/54
108–42	1/51	115–35	2/54	75–75	3/51	65–85	3/54
110–40	1/51	90–60	2/54	65–85	2/51	40–110	1/54
50–100	1/51	101–49	1/54	53–97	1/51	45–105	1/54
75–75	1/51	102–48	1/54	80–70	1/51	51–99	1/54
90–60	1/51	104–46	1/54	85–65	1/51	59–91	1/54
91–59	1/51	107–43	1/54	90–60	1/51	70–80	1/54
95–55	1/51	109–41	1/54	N/A	8/51	N/A	3/54
N/A	11/51	75–75	1/54				
		98–52	1/54				
		99–51	1/54				
		N/A	3/54				

TREATMENT 7				TREATMENT 8			
Paris		Tokyo		Paris		Tokyo	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
100–50	9/51	100–50	9/54	50–100	9/51	45–105	9/54
50–100	7/51	90–60	7/54	45–105	8/51	55–95	7/54
75–75	7/51	50–100	5/54	60–90	6/51	60–90	6/54
90–60	5/51	95–55	5/54	115–35	3/51	50–100	5/54
60–90	4/51	70–80	3/54	40–110	2/51	40–110	3/54
95–55	4/51	91–59	3/54	90–60	2/51	110–40	2/54
105–45	1/51	105–45	2/54	100–50	1/51	35–115	2/54
110–40	1/51	110–40	2/54	105–45	1/51	47–103	2/54
55–95	1/51	102–48	1/54	38–112	1/51	90–60	2/54
80–60	1/51	104–46	1/54	53–97	1/51	112–38	1/54
80–70	1/51	60–90	1/54	55–95	1/51	42–108	1/54
N/A	10/51	85–65	1/54	58–92	1/51	54–96	1/54
		94–56	1/54	70–80	1/51	57–93	1/54
		97–53	1/54	75–75	1/51	59–91	1/54
		N/A	12/54	N/A	13/51	80–70	1/54
						N/A	10/54

Table B.14
Bargaining outcomes from treatments 9 to 12. N/A indicates that no agreement was reached.

TREATMENT 9				TREATMENT 10			
PARIS		TOKYO		PARIS		TOKYO	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
100–50	29/51	100–50	26/54	45–105	14/51	45–105	14/54
105–45	6/51	105–45	9/54	50–100	12/51	40–110	12/54
90–60	2/51	110–40	4/54	54–96	5/51	50–100	9/54
95–55	2/51	101–49	1/54	55–95	4/51	54–96	7/54
0–150	1/51	102–48	1/54	40–110	2/51	55–95	2/54
102–48	1/51	103–47	1/54	53–97	2/51	31–119	1/54
103–47	1/51	106–44	1/54	100–50	1/51	32–118	1/54
104–46	1/51	109–41	1/54	43–107	1/51	39–111	1/54
110–40	1/51	115–35	1/54	47–103	1/51	43–30	1/54
80–70	1/51	90–60	1/54	60–90	1/51	44–106	1/54
N/A	6/51	N/A	8/54	N/A	8/51	48–102	1/54
						52–98	1/54
						53–97	1/54
						N/A	2/54

TREATMENT 11				TREATMENT 12			
PARIS		TOKYO		PARIS		TOKYO	
DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.	DEAL	FREQ.
100–50	11/51	100–50	14/36	75–75	46/51	75–75	34/36
75–75	10/51	105–45	7/36	70–80	2/51	70–80	1/36
105–45	8/51	75–75	4/36	60–80	1/51	90–60	1/36
90–60	3/51	110–40	2/36	74–76	1/51		
95–55	3/51	95–55	2/36	N/A	1/ 51		
110–40	2/51	103–47	1/36				
102–48	1/51	104–46	1/36				
104–46	1/51	82–68	1/36				
87–63	1/51	91–59	1/36				
93–57	1/51	96–54	1/36				
97–53	1/51	N/A	2 /36				
N/A	9/51						

Table B.15
Agreements recommended by well-known theoretical solutions and their frequencies by treatment and city. NASH: Nash bargaining solution, KS: Kalai-Smorodinsky bargaining solution, PROP: proportional with respect to disagreement, EQDIV: equal division (in earnings), EGAL: egalitarian, DMO: deal-me-out.

TREATMENT 1			
SOLUTION		PARIS	TOKYO
ALL	75–75	40/51	50/51

TREATMENT 2			
SOLUTION		PARIS	TOKYO
NASH, KS, PROP	75–75	9/41	6/51
EQDIV, DMO	50–100	20/41	39/51
EGAL	60–90	4/41	1/51

TREATMENT 3			
SOLUTION		PARIS	TOKYO
NASH, PROP	75–75	5/40	5/41
EQDIV	100–50	16/40	20/41
DMO	90–60	7/40	9/41
EGAL	80–70	3/40	1/41
KS	78–72	0/40	0/41

TREATMENT 4			
SOLUTION		PARIS	TOKYO
NASH, KS	105–45	1/40	0/42
EQDIV	50–100	11/40	9/42
DMO	90–60	4/40	9/42
EGAL	100–50	7/40	9/42
PROP	112.5–37.5	0/40	0/42

TREATMENT 5			
SOLUTION		PARIS	TOKYO
NASH, KS	105–45	3/40	6/51
EQDIV, DMO	100–50	28/40	25/51
EGAL	110–40	1/40	3/51
PROP	112.5–37.5	0/40	0/51

TREATMENT 6			
SOLUTION		PARIS	TOKYO
NASH, PROP	75–75	3/43	6/51
EQDIV, DMO	50–100	20/43	29/51
EGAL	60–90	7/43	4/51
KS	66–84	0/43	0/51

TREATMENT 7			
SOLUTION		PARIS	TOKYO
NASH	105–45	1/41	2/42
EQDIV	50–100	7/41	5/42
DMO	90–60	5/41	7/42
EGAL	100–50	4/41	9/42
KS	102–48	0/41	1/42
PROP	114–36	0/41	0/42

TREATMENT 8			
SOLUTION		PARIS	TOKYO
NASH	45–105	8/38	9/44
PROP	37.5–112.5	0/38	0/44
EQDIV	116–34	0/38	0/44
DMO	60–90	6/38	6/44
EGAL	51–99	0/38	0/44
KS	42–108	0/38	1/44

TREATMENT 9			
SOLUTION		PARIS	TOKYO
NASH	105–45	6/45	9/46
KS	102–48	1/45	1/46
EQDIV, DMO	100–50	29/45	26/46
EGAL	111–39	0/45	0/46
PROP	114–36	0/45	0/46

TREATMENT 10			
SOLUTION		PARIS	TOKYO
NASH	45–105	14/43	14/52
PROP	37.5–112.5	0/43	0/52
EQDIV, DMO	54–96	5/43	7/52
EGAL	40–110	2/43	12/52
KS	42–108	0/43	0/52

TREATMENT 11			
SOLUTION		PARIS	TOKYO
NASH, KS, EGAL	105–45	8/42	7/34
EQDIV	75–75	10/42	4/34
DMO	90–60	3/42	0/34
PROP	112.5–37.5	0/42	0/34

TREATMENT 12			
SOLUTION		PARIS	TOKYO
NASH, PROP, EQDIV, DMO, EGAL	75–75	46/50	34/36
KS	66–84	0/50	0/36

B.2. Additional statistical analysis

Table B.16
Average Euclidean distance from observed agreements to each of the solution considered in Paris. Nash: Nash bargaining solution, KS: Kalai-Smorodinsky bargaining solution, prop: proportional with respect to disagreement, EqDiv: equal division (in earnings), egal: egalitarian, DMO: deal-me-out.

treatment	Nash	KS	prop	EqDiv	egal	DMO
1	10.37	10.37	10.37	10.37	10.37	10.37
2	22.08	22.08	22.08	15.19	15.60	15.19
3	24.37	22.05	24.37	17.30	20.57	15.87
4	44.09	44.09	54.34	34.05	37.72	29.95
5	10.29	10.29	20.33	5.06	16.79	5.06
6	25.39	17.00	25.39	11.94	12.73	11.94
7	35.72	31.90	48.10	42.44	29.35	24.22
8	24.30	27.87	33.64	77.37	21.40	23.11
9	10.56	7.83	22.97	6.25	18.73	6.25
10	8.06	11.77	17.88	9.14	14.34	9.14
11	16.23	16.23	26.16	26.87	16.23	15.96
12	0.63	12.31	0.63	0.63	0.63	0.63
all	18.67	18.96	24.65	20.30	17.33	13.52

Table B.17
Average Euclidean distance from observed agreements to each of the solution considered in Tokyo. Nash: Nash bargaining solution, KS: Kalai-Smorodinsky bargaining solution, prop: proportional with respect to disagreement, EqDiv: equal division (in earnings), egal: egalitarian, DMO: deal-me-out.

treatment	Nash	KS	prop	EqDiv	egal	DMO
1	0.14	0.14	0.14	0.14	0.14	0.14
2	29.06	29.06	29.06	7.96	15.45	7.96
3	24.25	21.04	24.25	11.11	18.90	10.76
4	34.68	34.68	45.29	43.10	27.61	21.55
5	8.24	8.24	16.85	5.16	13.59	5.16
6	27.87	18.36	27.87	8.32	13.03	8.32
7	24.24	20.94	36.30	54.21	18.92	17.51
8	18.77	21.86	27.26	84.08	16.91	19.80
9	5.81	4.58	16.45	4.03	12.39	4.03
10	6.58	8.21	12.62	11.48	9.41	11.48
11	11.19	11.19	20.96	32.07	11.19	16.51
12	0.79	13.12	0.79	0.79	0.79	0.79
all	15.98	15.71	21.34	20.78	13.11	10.03

Table B.18
Proportion of individually-rational agreements. S: strongly individually-rational agreements; W: weakly individually-rational agreements that are not strongly individually-rational; I: agreements that are not individually rational.

treatment	Paris			Tokyo			all		
	S	W	I	S	W	I	S	W	I
1	90	2	8	100	0	0	95	1	4
2	100	0	0	100	0	0	100	0	0
3	25	18	58	29	22	49	27	20	53
4	23	10	68	40	21	38	32	16	52
5	90	5	5	94	4	2	92	4	3
6	100	0	0	100	0	0	100	0	0
7	37	12	51	60	17	24	48	14	37
8	61	16	24	73	14	14	67	15	18
9	91	4	4	98	2	0	95	3	2
10	95	2	2	100	0	0	98	1	1
11	67	7	26	85	0	15	75	4	21
12	100	0	0	100	0	0	100	0	0
all	75	6	19	83	6	11	79	6	15

Table B.19
Explaining the final agreement. Dependent variable: number of hens obtained in the agreement. Coefficient estimates from regressions with subject-specific fixed effects (FE), subject and opponent-specific crossed fixed effects (RC FE), subject-specific random effects (RE), subject and opponent-specific crossed random effects (RC FE), and censored tobit between 0 and 150 (TOBIT). Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%.

	FE	CR FE	RE	CR RE	TOBIT
EGGS PER HEN	−15.83***	−14.89***	−16.05***	−15.93***	−16.08***
EGGS PER HEN opponent	18.66***	17.99***	19.47***	19.34***	19.54***
TAXED	1.05	0.62	0.56	0.50	0.52
TAXED (TRTS 8 & 10)	−8.31***	−7.29***	−7.99***	−7.86***	−7.98***
TAXED opponent	−1.15	−1.36	−1.66*	−1.65*	−1.69*
TAXED opponent (TRTS 8 & 10)	6.51***	6.33***	6.94***	6.90***	6.97***
OUT OPTION	0.08***	0.09***	0.07***	0.07***	0.07***
OUT OPTION (TRTS IR VS. EQ)	0.27***	0.26***	0.27***	0.27***	0.27***
OUT OPTION opponent	−0.09***	−15.83***	−0.09***	−0.10***	−0.09***
OUT OPTION opponent (TRTS IR VS. EQ)	−0.28***	0.26***	−0.26***	−0.26***	−0.26***
ACC EARNINGS	0.03***	0.03***	0.03***	0.03***	0.03***
ACC EARNINGS opponent	−0.02***	−0.02***	−0.03***	−0.03***	−0.03***
CONSTANT	70.30***	70.64***	69.75***	69.77***	69.69***
(OVERALL) R-SQUARED	0.6695	0.7454	0.6708	0.6708	0.1231
NUM. OBS.	2110	2110	2110	2110	2110

Table B.20
Explaining the final agreement. Dependent variable: experimental monetary units obtained in the agreement. Coefficient estimates from regressions with subject-specific fixed effects (FE), subject and opponent-specific crossed fixed effects (RC FE), subject-specific random effects (RE), subject and opponent-specific crossed random effects (RC FE), and censored tobit between 0 and 150 (TOBIT). Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%.

	FE	CR FE	RE	CR RE	TOBIT
EGGS PER HEN	39.70***	40.45***	40.31***	40.34***	−40.38***
EGGS PER HEN opponent	27.79***	27.70***	29.34***	29.25***	29.51***
TAXED	−1.64	−2.10	−2.55*	−2.57*	−2.64*
TAXED (TRTS 8 & 10)	−10.88***	−9.86***	−10.90***	−10.79***	−10.91***
TAXED opponent	0.48	0.08	−0.52	−0.50	−0.62
TAXED opponent (TRTS 8 & 10)	8.75***	8.92***	9.58***	9.58***	9.66***
OUT OPTION	0.08***	0.09***	0.06	0.06	0.05**
OUT OPTION (TRTS IR VS. EQ)	0.21***	0.20***	0.21***	0.21***	0.21***
OUT OPTION opponent	−0.22***	−0.23***	−0.22***	−0.22***	−0.22***
OUT OPTION opponent (TRTS IR VS. EQ)	−0.04	−0.23***	−0.03	−0.03	−0.03
ACC EARNINGS	0.03***	0.03***	0.04***	0.04***	0.04***
ACC EARNINGS opponent	−0.03***	−0.03***	−0.04***	−0.04***	−0.04***
CONSTANT	2.76	6.94	5.39	5.45***	5.12*
(OVERALL) R-SQUARED	0.7696	0.7964	0.7392	0.7392	0.1337
NUM. OBS.	2110	2110	2110	2110	2110

Table B.21
Explaining the final agreement with the help of theoretical solutions. Dependent variable: number of hens obtained in the agreement. (1): OLS estimates and ANOVA results, (2): OLS estimates and ANOVA results with backward removal of insignificant regressors. NASH: Nash bargaining solution, KS: Kalai-Smorodinsky bargaining solution, PROP: proportional with respect to disagreement, EQDIV: equal division (in eggs), EGAL: egalitarian, DMO: deal-me-out. Robust standard errors clustered around participants. Estimated coefficients significantly different from zero at ***1%, **5%, and *10%. SS: partial sum of squares.

	(1)		(2)	
	COEFF.	SS	COEFF.	SS
NASH	1.01	251	–	–
KS	0.27***	1689	0.33***	23386
PROP	−0.92	382	–	–
EQDIV	0.17***	6134	0.21***	22433
EGAL	0.27	347	–	–
DMO	0.35***	2467	0.46***	23798
CONSTANT	−12.42	–	0.06	–
R-SQUARED	0.6117		0.6109	
TOTAL SS	1004780		1004780	
NUM. OBS.	2110		2110	

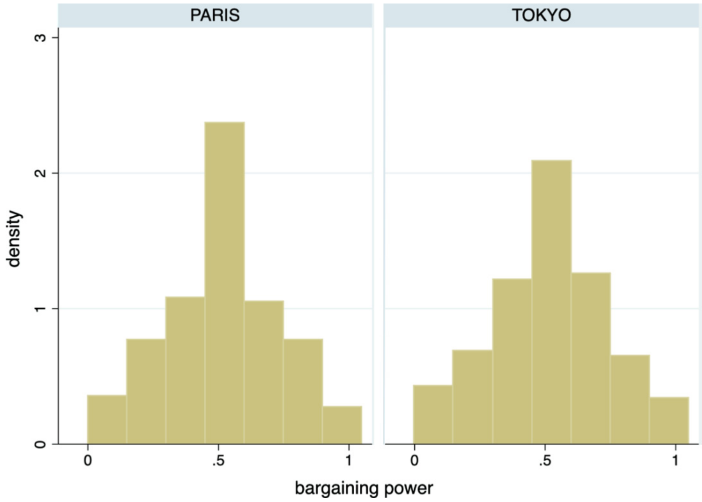

Fig. B.5. Distribution of bargaining power measured through Kalai's weights.

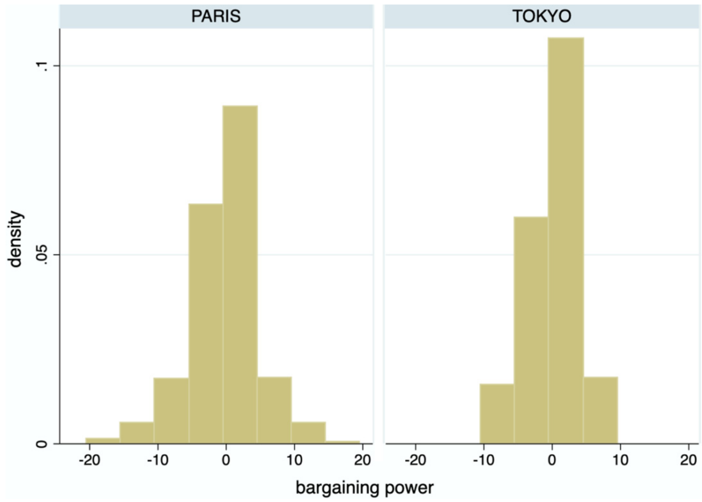

Fig. B.6. Distribution of bargaining power measured through subject-specific fixed effects.

Fig. B.7. Timing of agreements. Frequency histogram and Epanechnikov kernel estimates.

Appendix C. The McDonald-Solow model with different bargaining solutions

Consider a firm and a trade union bargaining over wage w and employment L. The union represents a pool of workers denoted N, we will assume $L \leq N$.[47] The firm's profit is given by its revenues minus costs: $R(L) - w \cdot L$. For simplicity, only labor costs are considered. The trade union's payoff function is given by the expected utility of a union member $\frac{L}{N} \cdot v(w) + \frac{N-L}{N} v(\bar{w})$, where $v(w)$ is the representative worker's utility function on income (for simplicity worker's income equals salary). Each worker has a probability to work equal to $\frac{L}{N}$ and obtains unemployment benefits given by $\bar{w}$ if unemployed. To keep the computations simple, the labor-economics literature often assumes that workers are risk-neutral, therefore $v(w) = A \cdot w$ for some $A > 0$. Disagreement payoffs are equal to 0 for the firm, $R(0) = 0$, and to the per capita unemployment utility for the union, $v(\bar{w}) = A \cdot \bar{w}$.

The Pareto frontier of the bargaining problem, S, is the solution to the following maximization problem.

$$\begin{array}{ll} \max\limits_{w \geq 0, 0 \leq L \leq N} & R(L) - w \cdot L \\ \text{such that} & \frac{L}{N} A w + \frac{N-L}{N} A \bar{w} \geq v \end{array}$$

where $v \in \Re$. Note that the above problem is equivalent to $\max\limits_{0 \leq L \leq N} R(L) - \frac{N}{A} v + (N-L)\bar{w}$, because $\frac{L}{N} A w + \frac{N-L}{N} A \bar{w}$ is monotonically increasing in w. Pareto efficiency then requires that the employment level L maximize $R(L) - \bar{w} L$ in $[0, N]$, since N, A, and $\bar{w}$ are given. Let L^* denote such an optimal employment level.[48]

The bargaining set S is then given by $\{(u, v) \in \Re^2$ such that $u \leq R(L^*) + (N - L^*)\bar{w} - \frac{N}{A} v\}$, and the Pareto frontier by $\{(u, v) \in \Re^2$ such that $u = R(L^*) + (N - L^*)\bar{w} - \frac{N}{A} v\}$. Recall that disagreement payoffs are 0 for the firm and $A\bar{w}$ for the union. Note that the bargaining problem is essential (in the sense that there is a possibility for a mutually beneficial agreement) if and only if $\bar{w} < \frac{R(L^*)}{L^*}$ (which means that $R'(L^*) < \frac{R(L^*)}{L^*}$ if $L^* < N$).

With the bargaining problem well defined, we can now consider the wage level that different bargaining solutions yield.

- The Nash and the Kalai-Smorodinsky bargaining solutions both yield

$$w^N = w^{KS} = \frac{1}{2} \frac{R(L^*)}{L^*} + \frac{1}{2} \bar{w};$$

- the equal-division solution yields

$$w^{EqDiv} = \frac{N}{N+A} \frac{R(L^*)}{L^*} - \frac{N-L^*}{L^*} \frac{A}{N+A} \bar{w};$$

- the egalitarian solution yields

$$w^{egal} = \frac{N}{N+A} \frac{R(L^*)}{L^*} + \frac{A}{N+A} \bar{w};$$

- and, finally, the deal-me-out solution yields

$$w^{DMO} = \begin{cases} \bar{w} & \text{if } w^{EqDiv} < \bar{w} \\ w^{EqDiv} & \text{if } \bar{w} \leq w^{EqDiv} \leq \frac{R(L^*)}{L^*} \\ \frac{R(L^*)}{L^*} & \text{otherwise.} \end{cases}$$

Note that the Nash and the Kalai-Smorodinsky bargaining solutions do not depend on A, which is the multiplier in the worker's utility function, because of the scale-invariance property. At the same time, the other three solutions considered here critically depend on A.

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[47] The notation follows chapter 7 in Cahuc and Zylberberg (2004). For more details on the maximization problem, refer to Danthine and Navarro (2013).

[48] If L^* is an interior solution to the maximization problem, it satisfies that $R'(L^*) = \bar{w}$, so the marginal productivity at L^* is exactly equal to the unemployment benefit.

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